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IDENTIFICATION OF A SCHOOL HEARING SCREENING PROTOCOL

Towards the Identification of a Contextually-relevant School Hearing Screening Protocol
in the Western Cape

by

Tracey-Lee Cloete

Student number: CPDTRA002

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School of Health and Rehabilitation Sciences

Faculty of Health sciences

University of Cape Town

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Supervisors: Prof. H. Kathard & Ms. L. Petersen
Division of Communication Sciences and Disorders

Declaration

I, Tracey-Lee Cloete, hereby declare that the work on which this dissertation is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university. The referencing format and style used in this thesis: *American Psychological Association (APA)*.

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Preface

This research study stemmed from my experience as a community-based Audiologist in the Mitchell's Plain sub-district in Cape Town, South Africa. During this time, I worked closely with the local school nurses and witnessed first-hand the many challenges that these health workers are faced with. Through my collaborative work with the Mitchell's Plain school health nurses I identified the urgent need for a contextually relevant hearing screening protocol to assist the school nurses in improving the current state of the school-based hearing screening service. I therefore embarked on this research process taking on the role of a 'clinician-researcher' who had prior relationships with the primary research participants i.e. the local school nurses. This prior connection with both the research site and participants had clear implications (both positive and negative) for the research process, and was thus acknowledged and appropriately managed when conducting the study and writing this research report (Refer to Chapter 3 for further information). Although there is an enormous amount of evidence in support of the conduct of routine hearing screening in our schools, little research has been done to translate the theory into a reality. The present study therefore served to address this shortcoming using a collaborative approach in which the main stakeholders in the provision of the screening service i.e. the school nurses had a definite voice, contributing to the selection of the most appropriate hearing screening protocol for use in a school setting. It is hoped that by recognizing the value of the school nurses' perspective and incorporating this into the decision-making process, it will improve the applicability of the screening protocol. This in turn may facilitate the implementation and sustainability thereof.

Cape Town, February 2011

Tracey-Lee Cloete

Abstract

Aims and objectives. To identify a contextually relevant school-based hearing screening protocol for grade 1 learners. In order to meet the study's primary aim, two specific objectives were identified; (i) to propose a contextually relevant hearing screening protocol for use in a school setting, and (ii) to determine the applicability of the proposed hearing screening protocol for the typical school context in the Western Cape, South Africa.

Background. Hearing loss has been found to constitute a major barrier to learning and its adverse effects on school-aged children have been well documented. The need for early identification of hearing loss is thus particularly important in this population, particularly for Grade R/1 learners, for which routine school-based hearing screening is strongly recommended. However, due to various contextual challenges such screening programs are lacking in South African schools whilst the prevalence of hearing loss in the school-aged population is on the rise. This situation must be addressed as failure to do so will only serve to perpetuate the impact of unidentified hearing loss in the classroom.

Research design. A sequential mixed methods research design was used, including both quantitative and qualitative methods of data collection and analysis.

Methods. Different research methods were applied in a novel methodological framework devised by the researcher. To identify a contextually relevant screening protocol, a combination of a focus group discussion with school nurses, a systematic review, and the Delphi method was utilised. To determine the applicability of the protocol a combination of direct observation, a second focus group discussion with school nurses and measures of test performance (i.e. inter-tester reliability, sensitivity and specificity) were utilised.

Results. Based on the focus group interview with the school nurses, their context-specific

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needs included the need for a hearing screening protocol that was quick and easy to administer whilst yielding reliable results. The results of the systematic review and Delphi method indicated that a screening protocol comprising otoscopy, otoacoustic emissions and tympanometry is contextually relevant. The proposed protocol was field tested in four primary schools in Mitchell's Plain and the findings of the observation and second focus group interview with the nurses showed that this screening protocol is appropriate for use in typical South African schools. With regard to the test performance, a sensitivity value of 57.14% and a specificity value of 97.03% was obtained when field testing the proposed protocol. Inter-tester reliability measures indicated sufficient reliability with a Cohen's Kappa of 0.6415; Observed agreement of 0.9474; Positive agreement of 0.6667 and Negative agreement of 0.9714.

Conclusion. The results of this study indicated that the proposed screening protocol is contextually-relevant for school-based screening in the Western Cape, but may require further refinement and validation before it can be formally implemented.

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**Towards the Identification of a Contextually-relevant School Hearing Screening Protocol
in the Western Cape**

The following chapter will provide an introduction to the subject of this research study, the rationale for conducting the study as well background to the context in which it took place. The following sections will thus be presented here:

- 1.1. Focus of the study
- 1.2. Rationale for this study
- 1.3. School health context in South Africa

1.1. Focus of the Study

This study aimed to identify a contextually relevant school-based hearing screening protocol for grade 1 learners. In order to meet the study's primary aim, it was translated into two research questions; (a) *Which hearing screening protocol would be relevant for use in a South African school screening program?*, (b) *Will the proposed screening protocol be appropriate when implemented in the field?* In answering these research questions, two specific research aims were identified as well as objectives that assisted the researcher in realising these aims.

These research aims and objectives were:

Aim 1: To identify a contextually relevant hearing screening protocol for use in a school setting.

Objective 1.1: To identify and describe the context-specific needs for a school-based hearing screening protocol.

Objective 1.2: To identify and select two hearing screening tests that met the context-specific needs.

Objective 1.3: To select the most suitable screening protocol that met the requirements for a

contextually-relevant protocol.

Aim 2: To determine the applicability of the proposed screening protocol for the typical South African school context.

Objective 2.1: To describe the implementation of the initial field test of the proposed protocol.

Objective 2.2: To determine the test performance of the proposed screening protocol.

In order to adequately address these research aims, the researcher was required to devise a suitable methodology as no pre-existing design was entirely appropriate. Therefore, an exploratory approach, which centers on generating new information, was adopted in devising the study's design (Teddlie & Tashakkori, 2009). Furthermore, to facilitate understanding of the study's aims and objectives, it should be noted that the terms *program* and *protocol* is not used interchangeably in this report. The term *program* is used to refer to a comprehensive plan of action that must be followed for a specific purpose, for example; in order to identify hearing loss as early as possible, the hearing screening *program* includes school-based screening, appropriate referrals and follow-up testing to determine an individual's hearing status. The term *protocol* on the other hand is used to describe the set of tests forming part of the school-based screener and the sequence of these tests. The present study thus aimed to propose a suitable screening protocol and it is hoped that the inclusion of such a protocol, which is both accurate and appropriate for the school setting, will eventually lead to improved school-based hearing screening programs in our local schools.

1.2. Rationale for This Study

Hearing loss has been found to constitute a major barrier to learning and its adverse effects on school-aged children have been well documented (Kibel & Wagstaff, 1995; Northern & Downs, 1991; North-Mattiasen & Singh, 2007). Experts agree that the general development of learners is largely dependent on the development of learning skills and the accuracy with which environmental information is received and comprehended (Kibel & Wagstaff, 1995). It is thus not surprising that various cognitive, psychological, social, medical and communicative problems, such as hearing loss, can adversely affect the internalisation of information and so act as barriers to learning (Kibel & Wagstaff, 1995).

For this reason the need for early identification of a hearing loss is particularly evident in the practice of paediatric Audiology, based on the principle that the best outcomes for a hearing-impaired child are achieved when the hearing loss is determined and managed as early as possible (Northern & Downs, 1991; Omondi, Ogol, Otieno & Macharia, 2007). In order to achieve early identification of hearing loss and timely intervention, the routine hearing screening of infants and school-aged children is strongly recommended (Serpanos & Jarmel, 2007; Western Cape Education Department, 2002); and if implemented, hearing loss as a learning barrier can be identified and its effects reduced (Western Cape Education Department, 2002).

The need for school-based hearing screening is also reinforced when one considers the high prevalence of hearing loss and middle ear disorders in the school-aged population, especially in developing countries. A number of studies aimed to determine such prevalence figures and their findings are summarised in Table 1.

Table 1**Prevalence rates in studies of hearing loss and/or middle ear disorders in school-aged children**

Country	Reference	Age range of participants	Prevalence rate
South Africa	Bhoola and Hugo (1995)	4-5 years	13-14.3% for middle ear disorders
South Africa	Meyer, Hugo, Louw & Grimbeek (1989)	4-16 years	Up to 43% for middle ear disorders
Sierra Leone	Seely, Gloyd, Omope Wright and Norton (1995)	5-15 years	4 % for bilateral profound hearing loss 9 % for hearing loss greater than 25dBHL
Tanzania	Minja and Macheмба (1996)	5-19 years, mean age of 12.1 years	27.7% for outer and middle ear disorders
Malaysia	Saim, Saim, Saim, Razsymah and Sani (1997)	5-6 years	13.8% for middle ear disorders
Egypt	Taha, Pratt, Farahat, Abdel-Rasoul, Albtanony, Elrashiedy, Alwakeel, Zein (2010)	6-12 years	20.9% for hearing loss
India	Mann, Sharma, Gupta, Nagarkar and Dharamvir (1998)	12-14 years	6.31% for hearing loss in urban area of which 5.33% due to otitis media 32.8% for hearing loss in rural area of which 33.5% due to otitis media
United States of America (USA)	Bess, Dodd-Murphy and Parker (1998)	Children in Grades 3, 6 & 9. Approximately 8-14 years	5.9% for mild-profound hearing loss
United Kingdom	Fortnum, Summerfield, Marshall, Davis & Bamford (2001)	3 years 9-16 years	0.91-1.07% for hearing loss in 3 year old group 1.65-2.05% for hearing loss in 9-16 year old group

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Recent data on the prevalence of hearing loss in South Africa's paediatric population is limited, although the estimated annual rate of infant hearing loss is 6, 612 on a national scale, with the reported prevalence of sensori neural hearing loss¹ estimated to be 10% (Pillay, Moonsamy & Khoza-Shangase, 2010). The information derived from the studies in Table 1 revealed an interesting trend i.e. the prevalence rates of hearing loss and middle ear disorders in school-aged children are generally higher in developing countries than in developed countries. The finding is also emphasised by McPherson and Swart (1997 cited in Theunissen & Swanepoel, 2008) who stated that developing countries have three to four times the prevalence rate reported in developed countries. Smith (2003) suggested that this trend as well as the negative impact of hearing loss is magnified in developing countries where there are generally limited services, less trained staff and insufficient awareness about issues pertaining to hearing healthcare. Jacob, Rupa, Job and Joseph (1997) also suggested that this discrepancy in the prevalence rates may be due to (a) the absence of regular hearing screening programs, (b) ignorance about hearing loss, (c) the lack of accessible healthcare, and (d) the impact of poverty and malnutrition.

Furthermore, when considering school health issues in developing countries, one cannot neglect the impact of HIV/AIDS on the school-aged population. It has been reported that children living with HIV/AIDS, even when on anti-retro viral treatment commonly suffer from middle ear infections which in turn may cause conductive hearing loss (North-Matthiassen & Singh, 2007). Similarly, the increase in overall rates of tuberculosis in Africa (in adults and children) may lead to an increase in the use of ototoxic medications, resulting in more cases of

¹ Sensori neural hearing loss occurs when there is damage to the sensory cells of the cochlea or the fibres of the auditory nerve (Roush, 2001).

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sensori neural hearing loss in the affected paediatric population (Copley & Friderichs, 2010; McPherson & Olusanya, 2008; Middelkoop, Bekker, Morrow, Zwane & Wood, 2009).

Furthermore, if one considers the vast impact of diseases such as HIV/AIDS and TB, it is not surprising that a large proportion of a developing country's health resources are allocated to the identification and management thereof (McPherson, 2008). School health services are thus not considered a health priority in such contexts, thereby affecting resource allocation and subsequent service provision.

Referral rates for hearing loss in the Western Cape Province of South Africa are provided by North-Matthiassen and Singh (2007) who conducted a hearing profile of school-aged children in the Western Cape and revealed that the hearing screening referral rate from typical state primary schools in the Western Cape is quite significant i.e. 13.8%. If one assumes that this referral rate does not include false positives² and applies it to the classroom situation, it would suggest that 13.8% of learners at the researched schools may be disadvantaged in the classroom where learning and communication occur via the aural medium. This may in turn affect other areas of the child's development such as their language, social, psychosocial and behavioural development (North-Matthiassen & Singh, 2007). These findings provide further evidence for the urgent need of routine hearing screening in South African schools.

Fortunately, the value of such a screening service is recognised in South Africa and in an attempt to identify school-aged children with possible hearing problems, hearing screening services were included as part of the country's School Health Services (National school health

² False positives refer to a screening test result that indicates that an individual has a condition (e.g. hearing loss) when s/he does not (Johnson & Danhauer, 2002).

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policy and implementation guidelines, Department of Health [DOH], 2002). Hearing screening protocols were thus included in the school nurses' operational handbook and basic training was provided in this regard (E. Lawrence, personal communication, February 2007; School Health Operational Handbook, Department of Health [DOH], 2003). By including hearing screening as part of the school health service, the Department of Health expected routine hearing screening to become an established part of the school health service package. However, personal contact with the school health workers in the Cape Metropole (Western Cape) indicated that many school health teams did not conduct routine hearing screening (J.Davis, personal communication, August 2006). Similar findings were also obtained for other provinces in the country as stated in the South African Health Promotion Directorate's report on school health week 01-05 March 2010 (Health Promotion Directorate, 2010). The Health Promotion Directorate³ examined the school health assessment coverage in each of the nine provinces and their findings revealed that routine hearing screening is only conducted in two of the nine provinces these being; the Gauteng and Mpumalanga provinces. Similar findings were also reported for other developing countries (Gell, White, Newell, Mackenzie, Smith, Thompson & Hatcher, 1992).

The shortcomings in South Africa's school health service and the provision of health services in general are as a consequence of many factors, which mostly stem from the discriminatory practices of the apartheid⁴ era. From 1948 to 1994, racial discrimination in South Africa affected people's health in a number of ways, including; the social conditions that people lived in, which often caused poor health; the segregation of health services and, unequal spending on health services resulting in limited resources for non-white South Africans (Hassim, Heywood & Berger, 2007).

³ The National Health Promotion Directorate is a government organization that aims to strengthen policy as a means of enabling health environments (Coulson, 1999).

⁴ Apartheid refers to the total separation of people on the basis of their skin colour (Oxford mini school dictionary, 2007).

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Now, more than ten years after South Africa's first democratic elections, the country is still recovering from the effects of these apartheid laws. Some of the consequences include; competition for limited resources in the healthcare system, challenges of integrating previously fragmented services, inequity in the accessibility of certain health services and, variation in the value attached to community-based services such as school health (National school health policy and implementation guidelines, DOH, 2002; Gell et al., 1992). In order to address these and other health concerns, the national health system has been restructured to strengthen the different levels of service delivery, including school health services. The *School health context in South Africa* section later in this chapter provides in depth information about the levels of service delivery in the national health system.

When reviewing the success of hearing screening programs it is also important to consider accepted screening guidelines that should govern the development and management of screening programs. To ensure that a screening program is of benefit to the general population, Wilson and Jungner (1968) proposed basic screening principles which screening programs should adhere to. These principles include the fact that: (i) the condition to be screened must be an important problem, (ii) there should be appropriate follow up testing & treatment available for cases identified, (iii) there should be a recognisable latent stage to the condition, (iv) the screening test must be suitable to target group and context, (v) the natural history of the condition should be understood, (vi) there should be agreement on who to treat as patients, (vii) the screening program must be cost-effective and (viii) case-finding should be an ongoing process.

Although hearing loss is important enough to warrant a screening program as recommended in the first screening principle, many of the other screening principles are not successfully adopted. For instance, screening principles two and four are often not adequately applied in

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practise affecting the effectiveness of the entire screening program. The current situation in the Western Cape is a case in point, where a lack of an appropriate, standard screening protocol reportedly affecting the success of the screening program (E. Lawrence, personal communication, February 2007; J. Davis, personal communication, February 2007). This situation is also evident in other parts of the country. For instance, the authors of the Health Promotion Directorate report on school health week 01-05 March 2010 concluded that a lack of standard assessment guidelines and protocols is amongst the primary reasons for the current state of the screening service in South African schools (Health Promotions Directorate, 2010). This lack of uniformity and the related shortcomings must be addressed as it hampers the inclusion of routine hearing screening in many South African schools.

The reason for this lack of a standard hearing screening protocol could be that the prescribed protocols are not generally appropriate for use in a school setting. Thus, school nurses (or other screening personnel) are presented with a number of screening methods that do not necessarily meet their contextual needs, forcing them to apply different methods in different situations (J. Davis, personal communication, February 2007). So although school nurses are required to deliver a school-based hearing screening service, they are often ill equipped to do so.

In order to better understand the need for a hearing screening protocol that is appropriate for use in schools, one must consider previous studies that have focussed on the application of various screening protocols in the school context. Such studies investigated screening protocols that included screening tests like otoacoustic emissions (Dille, Glatke & Earl, 2007; McPherson, Kei, Smyth, Latham & Loscher, 1998; Sideris & Glatke, 2006; Taylor & Brooks, 2000); pure-tone screening (Beppu, Hattori & Yanagita, 1997; Berg, Papri, Ferdous, Khan & Durkin, 2006; Sideris & Glatke, 2006); tympanometry (Blomgren, Haapkylä & Pitkäranta, 2007); parental

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questionnaires (Gomes & Lichtig, 2005; Hammond, Gold, Wigg & Volkmer, 1997) and the voice test (Prescott, Omoding, Fermor & Ogilvy, 1999). The studies' findings primarily reported on the technical aspects of the test performance for each test included in the protocol and used this information to make inferences about the protocols' suitability for the typical school context.

Although such technical information about the screening tests is useful a number of limitations were noted when reviewing this body of literature. These limitations include the fact that the broad contextual challenges were usually not described in the studies; the relevant health workers were not consulted when determining the contextual needs; and the specific goals of the screening programs were often unclear. These limitations will be discussed.

Firstly, for many of the studies the major contextual issues and determinants of the screening program resources (e.g. relevant school health policies, competing health demands affecting financial and human resources, etc.) were not considered when identifying and assessing the application of a screening test or protocol. To address this issue in the present study, the selection of an appropriate protocol was based on a thorough understanding of the broad contextual challenges which include systemic challenges such as; poverty which affects health needs and access to health services; competing health demands which affects the available resources; lack of awareness of the significance of health issues and school health programs, which affects the prioritization of such services (Akukwe, 2007; Department of Health, 2002; Gell et al., 1992).

Secondly, for the studies conducted in developing countries, (Berg, Papri, Ferdous, Khan & Durkin, 2006; Gomes & Lichtig, 2005; Prescott, Omoding, Fermor & Ogilvy, 1999; Sideris & Glatke, 2006) most of the researchers considered common challenges such as financial and staff constraints. However, for the most part their information pertaining to these issues was obtained

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from related literature and in some cases previous clinical experience. Although useful information may be obtained from such sources, it could be argued that the most reliable source of information regarding current contextual challenges is the health workers functioning in that context on a daily basis. Thus, by failing to include the resident health workers' input, the researcher's understanding of the context under investigation may be incomplete. The present study therefore aimed to address this shortcoming by devising appropriate methods of gathering the relevant information including the input of the research school health workers, and effectively applying this information to facilitate the selection of an appropriate hearing screening protocol.

Thirdly, in order to determine the suitability of the screening protocol one needs to understand the specific goals of the screening program. For instance, *does the program aim to identify middle ear disorder, hearing impairment or both, or does the program aim to screen all learners or at risk groups only?* Such program goals must be specified as they will determine what constitutes a "suitable screening protocol" for that particular program e.g. if the program aims to identify middle ear disorder, a suitable protocol would be one that includes a test that enables the tester to identify such disorders. For most of the reviewed studies these kind of program goals were not specified making it difficult to draw conclusions regarding the suitability of the proposed protocols for school-based screening programs. This lack of information also made it difficult to draw conclusions about the suitability of the proposed protocols for the South African school context. Thus for the present study the general goals of the screening program were specified in order to determine the screening protocol that met those goals.

Furthermore, the researcher recognized the fact that the identification of a problem such as the lack of a hearing screening protocol is only the first step to improving current screening

practice in schools. Even the development of an appropriate protocol is insufficient unless the protocol is adopted into practice. For this reason the present study not only focused on proposing a screening protocol but it also addressed issues pertaining to the practical implementation of such a protocol in South African schools. This kind of information is essential and will serve to bridge the gap between policy and practice.

1.3. School Health Context in South Africa

Schools are a key site for health programs and numerous studies have shown that school health and education programs can be a cost-effective means of addressing the health and safety needs of the school-aged population (Schneider, 2006). This concept has been adopted in South Africa where the development of Socially Responsive Schools has been identified as a priority for the National Department of Health (Social Capital Project: Operational Plan document, Department of Health [DOH], 2005/2006). A socially responsive school refers to a school that not only focuses on the curriculum but also places emphasis on the school environment, community participation, policy development and the provision of appropriate health and social services (Social Capital Project: Operational Plan document, DOH, 2005/2006; Swart & Reddy, 1999).

The socially responsive schools initiative stemmed from the changing model of health delivery in South Africa. Historically, the system of apartheid influenced the delivery of health services in the country (prior to 1994), systematically depriving the majority of the population of adequate resources and access to healthcare. The new model of health delivery aims to address these discrepancies and is thus based on the Primary Health Care approach which emphasises the

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importance of accessible and affordable healthcare for all (Comprehensive Service Plan for the implementation of Healthcare 2010: Draft for consultation, Department of Health [DOH], 2006).

The reshaped health system comprises of various levels of healthcare, including:

- Primary level care delivered through the District Health Service (DHS), constituting the patients' first contact with healthcare. This level of healthcare includes community based services such as local clinics and day hospitals or community health centres (CHC's) servicing different health districts.
- Secondary level care, which is the next level of service delivery, includes level 1 district hospitals that are staffed by general practitioners providing care for common conditions that need hospital management.
- Tertiary level care which includes specialist services making use of advanced techniques and servicing patients referred from secondary level services (Comprehensive Service Plan for the implementation of Healthcare 2010: Draft for consultation, DOH, 2006; Hassim, Heywood & Berger, 2007).

The revised national health system aims to provide equal access to quality healthcare by optimising the use of allocated resources (Comprehensive Service Plan for the implementation of Healthcare 2010: Draft for consultation, DOH, 2006). For this reason, the DHS has been significantly strengthened to form the foundation of effective and efficient public health services (Comprehensive Service Plan for the implementation of Healthcare 2010: Draft for consultation, DOH, 2006). In the Cape Metropole the DHS is underpinned by the proposed eight sub-districts, each with its health facilities, as prescribed in the Healthcare 2010 Service Plan that serves as a

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guide for the implementation of this primary health care approach to service delivery

(Comprehensive Service Plan for the implementation of Healthcare 2010: Draft for consultation,

DOH, 2006). The eight sub-districts are depicted in Figure 1.



Figure 1: The eight sub-districts in the Cape Metropole (Metropole District Health Services: Annual Report 2003-2004, Department of Health [DOH], Western Cape).

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Currently, school health forms part of the restructured DHS, which incorporates primary level care such as preventive and promotive health interventions (Comprehensive Service Plan for the implementation of Healthcare 2010: Draft for consultation, DOH, 2006). Hearing screening as well as other forms of health screening form part of such preventive interventions. School health service providers thus make use of health promotion and prevention strategies to achieve the best possible level of health (mental, physical and social well-being) for children of school age; and to enable children to derive full benefit from their education (Adnams & Wagstaff, 1995).

In order to achieve the aims of school health, various policies have been proposed to inform and support the development and implementation of school health programs. These policies include the Health Promoting Schools Initiative originally a World Health Organisation initiative (World Health Organisation [WHO], 2009), the Youth and Adolescent Health Policy (DOH, 2001) and the National School Health Policy (NSHP) (DOH 2002). Such policies also aimed to address the constraining factors affecting the implementation of school health in South Africa which, as mentioned earlier in this chapter, include limited resources, both financial & human; systemic challenges and a general lack of awareness of the importance of school health services (National school health policy and implementation guidelines, DOH, 2002). Chapter 4 will include further discussion of these policies.

In 2008 in the Western Cape there was a total of 945, 864 learners of which 91, 853 were in Grade 1. These learners should ideally be targeted for universal health screening, however, the total number of public service staff (including school nurses) is a mere 8,971. The ensuing service delivery challenges are thus obvious (Western Cape Education Department, Annual

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Report: 2008/2009). With this in mind, the need for school health policies and clear implementation guidelines for service provision cannot be overlooked.

Therefore, if one were to identify a hearing screening protocol that is appropriate for use in South African schools, the relevant contextual factors and school health policies must be considered. Failure to do so will result in the selection of yet another screening protocol that is not implemented because it does not address the contextual challenges or adhere to established guidelines. This in turn will only serve to perpetuate the impact of unidentified hearing loss in the classroom.

It should be noted that due to time and resource constraints, this study is limited to one sub-district in the Western Cape. This particular sub-district is situated approximately 20 kilometers from the City of Cape Town and can be characterised as being a historically disadvantaged area⁵. Refer to *Chapter 3* for a more detailed description of the sub-district used as research site. As a result of its disadvantaged history, the sub-district is still generally under-resourced and in urgent need of improved health services, including school health services. The focus of this study was thus on improving the state of school-based audiological services by proposing a suitable protocol for hearing screening and field-testing it in one sub-district to assess its application. Based on the outcome of the field test, the protocol can then be refined and field-tested in other contexts.

⁵ In this case a historically disadvantaged area refers to an area that was disadvantaged by unfair discrimination during the apartheid era in South Africa (Ramma, 2009).

Chapter 2

Theory and Literature Review

The following chapter will provide an overview of the theoretical underpinnings related to proposing a protocol and secondly the ongoing dialogue in the literature pertaining to school hearing screening protocols. The chapter will include the following sections:

- 2.1. Review of the theory pertaining to the identification of a program, protocol or tool
- 2.2. Review of the theory pertaining to hearing screening
- 2.3. Review of the literature related to common hearing screening tests
- 2.4. Review of the literature pertaining to the identification of a contextually relevant hearing screening protocol

2.1. Review of the Theory Pertaining to the Identification of a Program, Protocol or Tool

Green (2007) when writing about the development of policies suggested that the process of developing policies and plans is greatly influenced by three key factors. These factors include: (a) the context in which the development of policy occurs, (b) the decision processes used to develop the policies, and (c) the stakeholders in the policy outcome. This viewpoint can also be applied to the process of developing health programs as the context, strategies for decision-making and relevant stakeholders must be considered throughout the development process (Regional Network for Equity in Health in East and Southern Africa [EQUINET], 2007).

For this reason, a number of health planning models incorporate these three key factors in the series of steps used to develop a health program. For instance, Green (2007) proposed a

planning model that outlines the planning process involved in the development and implementation of a program. This model is depicted in Figure 2.



Figure 2: Health planning model (Green, 2007)

In Figure 2, the model illustrates that one needs to firstly understand the current context or situation before the specific aims can be determined. Once the context-specific aims are determined the possible courses of action are identified and assessed, and having decided on the most appropriate alternative, action is taken to implement it. The cycle then starts again with a reassessment of the situation to determine if any change occurred (Green, 2007). Although this planning model appears to be comprehensive it does not explicitly incorporate the stakeholders in a given context.

Conversely, EQUINET (2007) proposed a planning model (termed the *Spiral model*) based on the understanding that real change will only take place when a community or population

becomes dissatisfied with aspects of their lives. The spiral model thus incorporates the experiences of the stakeholders in the planning process and is depicted in Figure 3.

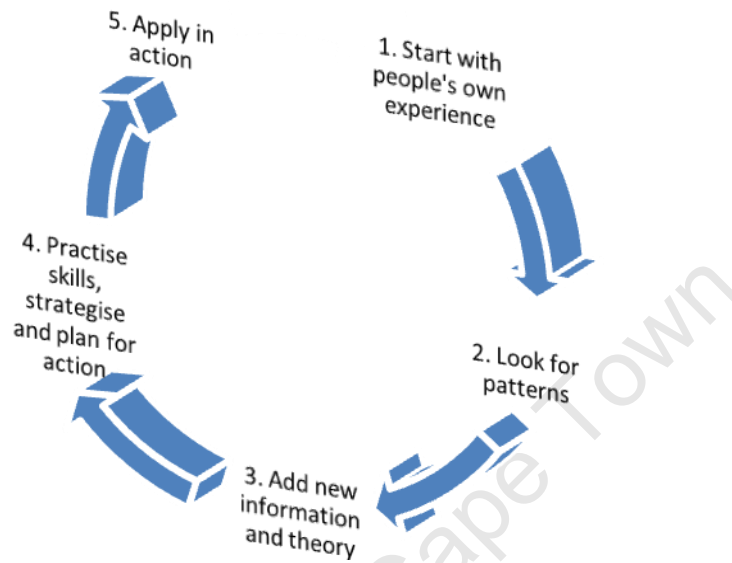


Figure 3: The spiral planning model (EQUINET, 2007)

The planning model in Figure 3 clearly considers the importance of the relevant stakeholders and suggests that the stakeholders' experiences be understood (through identification of patterns and acquisition of new information) before a plan for action is developed and applied. Although this planning model clearly addresses the limitation of Green's (2007) model, it does not leave room for evaluation of the health program following its application. This evaluation step is crucial as it provides one with information about the success of the implemented activity or program. Based on an evaluation, one can determine; if objectives were met, how they were met, and if there is a need for changes to the activity or program to improve the success rate (Green, 2007).

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Despite the limitations noted here both these planning models have merit and can very easily be combined to form a more comprehensive planning model. This kind of modification is acceptable as Green (2007) concludes that no planning system, in practice, needs to conform to any single planning model in its “pure form” Green (p35). It is thus acceptable to combine and modify models to suit one’s specific planning needs. Furthermore, if one considers the series of steps involved in these planning models, it is apparent that many of these steps are very similar to those involved in the development of a context-specific intervention protocol or tool, as the decision-making process is also a systematic one that relates to both the context and relevant stakeholders.

For example, Wang, Mannell, Newell, Zhang and Han (2007) aimed to develop and evaluate disyllabic⁶ Mandarin speech audiometry test materials. In their attempt to develop these test materials they firstly examined the context and identified an urgent need. It was found that standardized Mandarin speech test materials had not been developed previously and this affected the quality of the audiological assessments conducted in mainland China (Wang et al. 2007). Secondly, these researchers gathered more technical and contextual information from the related theory and literature. This included technical information about the rules of developing speech test materials as well as technical and contextual information pertaining to the Mandarin language. Thirdly, this information was used to develop the contextually-relevant test materials. The fourth step involved the field testing or implementation of the test materials under standard test conditions. The tester and testees were carefully selected to ensure that the sample was representative of the context for which the test was intended. The fifth and final step involved the evaluation of the test materials, including the measurements of reliability and validity to validate

⁶ Disyllabic words refer to words with two syllables (Chalker & Weiner, 1998).

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the test performance. This systematic validation of the test required a large representative sample and the test performance was examined on multiple levels (Wang et al., 2007).

If one were to consider the planning models proposed by Green (2007) and EQUINET (2007) as well as the test development process followed by Wang et al. (2007), the general process involved in developing or identifying a contextually-relevant program, protocol or tool becomes evident. This process is depicted in Figure 4.

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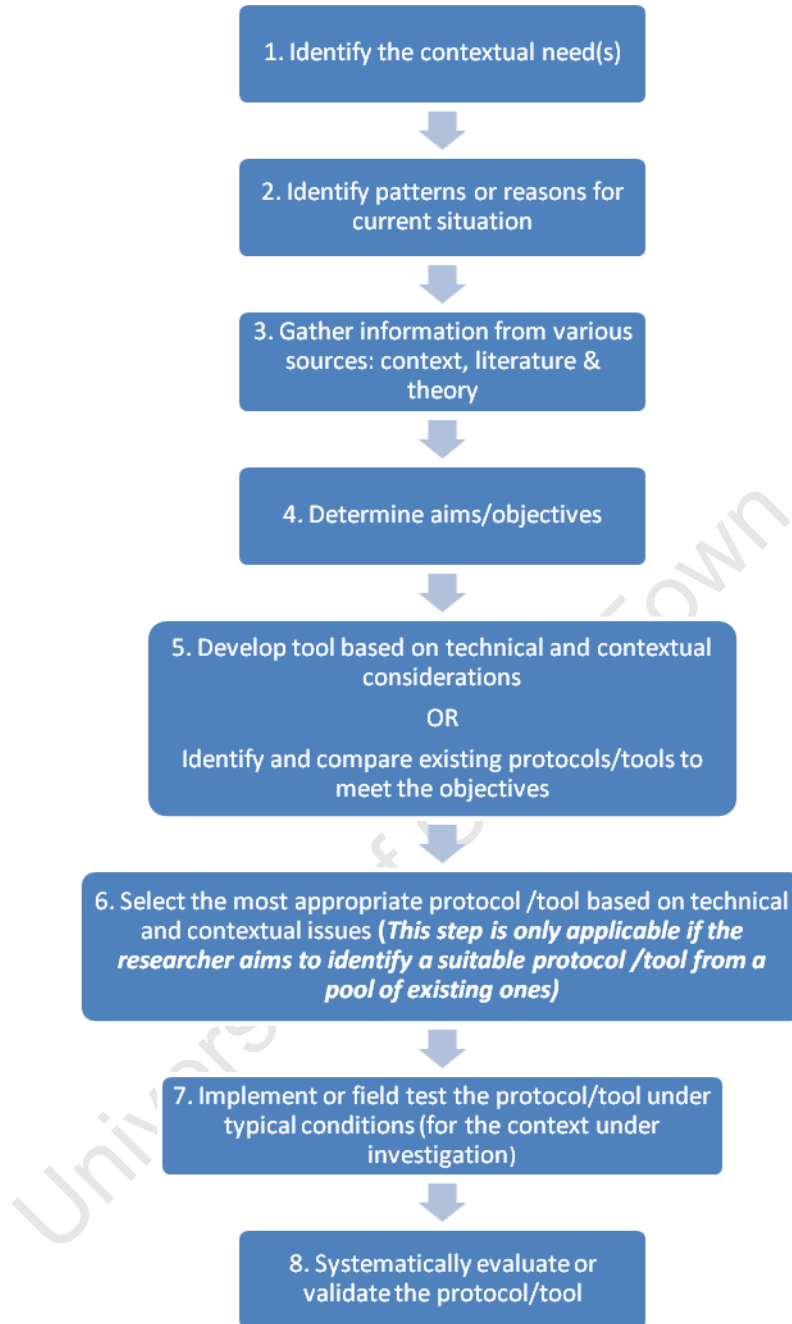


Figure 4: The general process involved in developing or identifying a contextually-relevant program, protocol or tool

The researcher applied this comprehensive process in identifying a contextually-relevant screening protocol. If one compares this study process to the eight-step process involved in developing or identifying a contextually-relevant program, protocol or tool (as depicted in Figure 4), it should be noted that this study followed the process from step 1 to step 7. However, step 8 of the process i.e. *a systematic evaluation of the protocol* was not completed in this study as it would have required a larger sample, application of the protocol in multiple settings and a more rigorous assessment of the protocol's validity and reliability, which were beyond the resources and scope of this study.

To further facilitate the process of identifying an appropriate protocol, the theory pertaining to hearing screening requires review. Such information is essential as the selection of an appropriate screening protocol is linked to context-specific screening program goals, which are in turn based on a thorough understanding of the context and theory related to the screening process (as depicted in Figure 4).

2.2. Review of the Theory Pertaining to Hearing Screening

Screening is defined as the preliminary acquisition of information for the early detection of a condition (Hayes & Northern, 1996). The process usually involves the application of certain rapid and simple tests and procedures on a generally large population, to identify individuals with a high probability of having the target condition (which in this instance is a hearing loss) from individuals who probably do not (Hayes & Northern, 1996).

Although information gained from screening tests is invaluable it must be noted that one cannot make a diagnosis based on screening test results. The screening process actually forms the initial part of a much more complex identification and intervention process (Johnson &

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Danhauer, 2002). Before a hearing loss can be accurately diagnosed and managed, a screening process is required to identify those individuals with a high probability of having a hearing loss. In terms of school-based hearing screening this means that the screening test allows the tester to separate the learners who require referral and further audiological investigation from those learners who do not (Muir Gray, 1997). In cases where further investigation is warranted the diagnostic procedure should be conducted by an audiologist, who can then formulate a more specific diagnosis regarding the learner's hearing. Furthermore, the diagnosis can assist the clinician in confirming the presence of hearing loss and so facilitate early management of remediable cases to minimise the impact of hearing loss (Fitzpatrick, Graham, Durieux-Smith, Angus & Coyle, 2007; Northern & Downs, 1991; Omondi, Ogol, Otieno & Macharia, 2007). Thus, the importance of early identification of hearing impairment and intervention is critical and requires the inclusion of hearing screening services in schools.

Although the benefits of a screening service have been well-documented, it must be emphasized that the way in which such a service is implemented can affect the overall benefit and impact of the service. This implementation is influenced by: the screening approach used and the guidelines that govern the implementation of the screening service (McPherson & Olusanya, 2008).

Firstly, the approach to screening can either incorporate universal hearing screening in which all individuals in the population are screened or risk-based screening in which screening is only conducted on individuals who present with risk factors for acquiring a hearing loss, for example recurrent middle ear infections (McPherson & Olusanya, 2008). The risk-based screening approach is often adopted for school-based hearing screening programs in developing countries as it requires fewer resources. This is of course an important factor when implementing

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screening programs in a resource-constrained context such as South Africa. However, the application of the risk-based screening will also result in missed cases of hearing loss as all individuals with a hearing loss may not exhibit obvious risk factors (McPherson & Olusanya, 2008). Furthermore, if one considers the fact that universal newborn or infant hearing screening has not been established in South Africa (Early Hearing Detection and Intervention Programmes in South Africa: Position statement year 2007, Health Professions Council of South Africa [HPCSA], 2007), the need for a universal school screening program for younger learners should not be overlooked, as such a program can serve as a safety net for those children who were not screened as infants.

It is evident that such contextual considerations are important when deciding on the screening approach and subsequent program goals. This point was emphasized by Swanepoel (2004) who conducted a study aimed at improving infant hearing screening services in a South African community. Swanepoel (2004) concluded that decisions pertaining to the screening approach and pass/fail criteria usually become a compromise between the effectiveness of the screening program and the costs of screening. Therefore, the final decisions should be made with careful consideration to the context-specific needs and challenges of the community for which the screening program is intended.

Secondly, with regard to guidelines for the planning and implementation of screening services, the set of screening principles proposed by Wilson & Jungner (1968) must be considered to ensure that screening services are appropriate. Refer to *Chapter 1* for a summary of these principles.

When considering these principles in light of the research aim, principles 4 (pertaining to appropriate screening tests) and 7 (pertaining to cost-effectiveness of the program) are of particular interest as these principles relate to the features of a contextually-relevant screening program or protocol. For this reason, these two screening principles will be considered throughout the literature review as the guidelines for determining the suitability of the screening tests included in the review.

2.3. Review of the Literature Related to Common Hearing Screening Tests

This section includes a description of the general classification of hearing screening tests, which is followed by a brief review of the main features of five commonly used tests. The review of the literature pertaining to school-based hearing screening protocols revealed an array of hearing screening tests, both objective and behavioral in nature. Objective tests refer to those measures that do not require active participation from the testee. Instead, the estimation of hearing sensitivity or middle ear functioning is based on the identification of involuntary physiological changes in the auditory system, in response to the presence of certain stimuli (Martin & Clark, 1996). Behavioral tests however rely on the voluntary responses from the testee following the presentation of an acoustic stimulus (Martin & Clark, 1996). For the purpose of this discussion, five of the most commonly used and most commonly cited screening tests for school-based screening are included and the distinction between objective and behavioral tests is used to classify the screening tests forming part of the review. Thus, the behavioral tests include (a) the pure-tones test, (b) voice test, and (c) questionnaires while the objective tests include (a) oto-acoustic emissions (OAEs) and (b) tympanometry.

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With regard to test performance, the literature often reported the test's sensitivity and specificity as outcomes measures. The sensitivity and specificity measures of a test relate to its ability to accurately separate individuals with a hearing loss (i.e. sensitivity) from those without a hearing loss (i.e. specificity) (Martin & Clark, 1996). In other words, sensitivity represents the percentage labeled "positive" on the screening test that do in fact have a hearing loss; and specificity is the percentage labeled "negative" on the test who truly do not present with a hearing loss (Martin & Clark, 1996). An effective screening test should have high sensitivity and high specificity rates (Hayes & Northern, 1996).

The first hearing screening test to be discussed is the pure-tones test which is commonly used to screen the hearing of school-aged children. It is suggested that most normally developing children in this population should be able to co-operate successfully with this test if the tester is sufficiently skilled (McCormick, 1993). With pure-tone testing, tones are presented to the testee via earphones and s/he is required to respond each time the signal is heard. Based on these responses the tester can determine whether or not the testee's hearing levels meet the preset "pass" criteria (McPherson & Olusanya, 2008).

With reference to the pure-tones test performance, Sabo, Winston and Macias (2000) reported a sensitivity value of 87% and specificity of 80% when administering the test in the grade school population in Arizona. They, along with other researchers like Krueger and Ferguson (2002) recommended that pure-tone testing be continued in the school-aged population as it remains an effective screening test. However, one of the main limitations of this test is the fact that the pure-tones test relies on the cooperation of the testee, without which reliable test results are unattainable (McPherson & Olusanya, 2008).

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Secondly, the voice test is another behavioral hearing test in which the testee's hearing status is determined by his/her ability to detect the tester's voice at varying levels of intensity (Prescott, Omoding, Fermor & Ogilvy, 1999). Eekhof, de Bock, de Laat, Dap, Schaapveld and Springer (1996) found the sensitivity and specificity values of the voice test to be 90% and 80% respectively, suggesting that this screening test is able to correctly identify those people in need of further testing. Similar findings were reported by Prescott, Omoding, Fermor and Ogilvy (1999) who conducted a school-based study in Cape Town. Their findings show a sensitivity value of 83% and specificity value of 97.8%. Although these findings are promising, Eekhof et al. (1996) emphasised that there is often a high degree of variation between the results obtained by different testers when using the voice test. This has important implications for the reliability of the test results. Refer to Prescott et al. (1999) for more information on the voice test procedure.

Thirdly, questionnaires have been utilized as a hearing screening tool in the school-aged population with the main advantages relating to its simplicity and low cost (Newton, Macharia, Mugwe, Ototo & Kan, 2001). Newton et al. (2001) evaluated the use of a screening questionnaire in Kenyan school children and reported 100% sensitivity for hearing losses that exceed 40dBHL and specificity of less than 75%. This suggests that the questionnaire may not be sensitive to mild hearing losses and may miss cases of unilateral hearing loss due to the nature of the screening tool, which does not allow for ear-specific evaluations. Furthermore, Hammond, Gold, Wigg and Volkmer (1997) compared a hearing screening questionnaire to pure-tone audiometry and reported sensitivity of 56% and specificity of 52% for the questionnaire. Their findings suggest that the screening questionnaire should not be used in isolation for any hearing screening program.

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Fourthly, OAEs is an objective indicator of hearing status that is commonly applied in the paediatric population (McPherson & Olusanya, 2008). For the OAE test, an acoustic stimulus is presented into the testee's ear and in response to this signal the cochlea generates a low intensity response which is measured in the ear canal. The test result (pass/fail) gives the tester information regarding the functioning of the cochlea, which in turn informs him/her about the testee's hearing sensitivity (Martin & Clark, 1996; McPherson & Olusanya, 2008). The OAEs test performance has been well-documented in literature pertaining to hearing screening, and it has often been described as a fast, efficient screening test that yields accurate results (Yin, Bottrell, Clarke, Shacks & Poulsen, 2009). Test sensitivity has been reported to range from 60-100% with specificity values ranging from 91-95% (McPherson & Smyth, 1997; Sabo, Winston & Macais, 2000; Taylor & Brooks, 2000 & Yin et al., 2009). Although these outcomes measures seem mostly adequate, it was suggested that the use of OAEs alone may not be effective in detecting children with mild cases of middle ear dysfunction (Lyons, Kei & Driscoll, 2004).

Finally, tympanometry is a screening test that is commonly applied to detect cases of middle ear dysfunction in the school-aged population. It involves the insertion of a probe into the testee's ear canal and as soon as a seal is obtained, the test runs automatically yielding results that indicate tympanic membrane functioning as well as middle ear status (Roush, 2001). However, the test does not provide information regarding hearing status. In the related literature, the sensitivity of tympanometry has varied from 70-90% and the specificity from 54-98% (Blomgren, Haapkylä & Pitkäranta, 2007). Although these values are not consistently high, it is recommended that tympanometry be included (with a *hearing* screening test) in school-based hearing screening protocols given the high prevalence of otitis media in the school-aged population (Minja & Machemba, 1996).

Based on the review of common screening tests, it is evident that each test has its technical benefits and limitations making the selection of the most appropriate screening test a contentious process. Therefore, the final selection of the most suitable screening test must not only be based on the technical aspects of the test but should also be based on the specific context in which the test will be used as well as the goal(s) of the screening program. For the South African situation, the constraining contextual factors have been described earlier in the Introduction chapter. When considering those contextual challenges the specific protocol and goals of the school hearing screening program must be appropriate given these circumstances. If not, it will affect the success of the program (Regional Network for Equity in Health in East and Southern Africa, 2007).

2.4. Review of the Literature Pertaining to the Identification of a Contextually Relevant Hearing Screening Protocol

It is suggested that any screening program requires clear, context-specific goals for it to be effective (McPherson & Olusanya, 2008). With this in mind, the proposed goals for a school hearing screening program based in a developing country include the following:

- To identify all children with mild to profound auditory impairment.
- To identify children with ear disease; this applies to the at risk population only, considering the fact that the equipment for immittance testing is not readily available.
- To use screening tests that are simple to perform by non-expert staff, given the human resource constraints, yield accurate results even in sub-optimal testing conditions, do not depend on special appointments and is inexpensive given the financial constraints.

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- To make appropriate referrals for further management based on accurate screening test results.
- To ensure that adequate, accessible referral facilities are in place.
- To ensure that follow up appointments are kept. This is affected by the accessibility of follow up services and outreach efforts to the clients.

(McPherson & Olusanya, 2008)

For the most part, these goals are similar to those described for screening programs that are established in developed countries. However, the main difference pertains to the discrepancy in available resources. For instance, in developed countries school health services are more appropriately prioritised and so adequate resources (both human and financial) are allocated to such services (Gell et al., 1992). Subsequently, more universal screening programs are implemented as opposed to the high risk screening approach that is often adopted in developing contexts. Furthermore, since school-based screening services are more established in developed countries, the relevant stakeholders are more aware of the importance of these services (Olusanya, 2001). This in turn impacts on the level of support that the school health workers receive as well as the level of parental involvement and learner attendance at follow up appointments. Apart from these factors, developed countries share most of the primary program goals previously listed for developing countries.

These screening program goals are not novel ones. McPherson & Olusanya (2008) reported that the debate regarding the precise contextually-appropriate goals of school screening has been a long-standing one among many hearing health professionals. In addition, the implementation of contextually-appropriate programs and screening protocols has also been attempted in the past.

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For instance, Bu, Li and Driscoll (2005) aimed to develop a hearing screening questionnaire for school-aged children in China to suit the Chinese context. For this reason contextual issues such as language and the high population figures in China were considered when developing the screening protocol. The tool used in the protocol was thus appropriately translated and simple enough for mass screening of large numbers. When considering these findings in light of the screening guidelines highlighted in the *Review of the theory pertaining to hearing screening* section (i.e. principles 3, 5 & 6), the screening protocol appears to adhere to these guidelines as it is appropriate for both the population and context for which it is intended. However, the cost-effectiveness of the protocol would have to be established as well as the technical aspects of the tool's performance.

Berg, Papri, Ferdous, Khan and Durkin (2006) also aimed to identify a suitable screening tool for children in rural Bangladesh with special consideration for the lack of resources including professional services in that context. Their focus was thus on determining a hearing screening tool that required no special expertise and could be easily administered by community health workers. These researchers identified conditioned play audiometry as a feasible method of screening older school-aged children (i.e. 6-9 years) and a protocol including OAEs and tympanometry for pre-school children aged 2-5years. Their findings compare well with that of Yin et al. (2009) who sought to identify a valid and efficient hearing screening tool for American school nurses to utilise, given the time constraints that they often have to contend with. They too suggested that OAEs is an appropriate screening tool for this context. If one were to view these findings in light of the screening guidelines discussed in the previous section, it appears that both protocols (i.e. protocol including conditioned play audiometry and protocol including OAEs)

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adhere to these guidelines. However, special care must be taken to ensure that the relevant resources are available for the implementation of the selected protocols.

Prescott et al. (1999) on the other hand aimed to evaluate the suitability of the voice test for use in South African schools. They specifically considered contextual challenges such as limited access to audiological equipment and the lack of human resources. Based on their findings these researchers recommended that primary health care workers be trained to administer the voice test in schools where other audiological services are not available. However, when relating these findings to the screening guidelines previously discussed, the cost-effectiveness of the voice test comes into question. As previously mentioned in the *Review of the theory pertaining to hearing screening* section, the reliability of results obtained with the voice test is often poor. Thus, although the cost of implementing such a protocol is minimal, the effectiveness of the test is questionable and may result in inappropriate referrals, which could end up costing the client more, both financially and emotionally. Similarly, if unnecessary referrals are made for further testing it will have financial implications for the referral centre (Development in practice, Better health in Africa: experience and lessons learned, The International Bank for Reconstruction and Development [IBRD], 1994). The voice test may thus not be a good option for school-based screening.

The studies reviewed in this section form part of a large body of literature focussed specifically on the identification of a suitable hearing screening tool or protocol for use in the typical school context. Their findings are especially useful as they've clearly considered contextual issues in their decision-making. However, upon review of these and other related studies it became apparent that most of the related research focussed on testing a pre-selected protocol rather than identifying one. Therefore the emphasis was more on evaluating the

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protocol's performance in a given context and not on the process of identifying a contextually relevant protocol, as is the case in the present study.

Furthermore, in a number of studies (Bento, Albernaz, Francesco, Wiikmann, Frizzarini & Castilho, 2003; Beppu, Hattori & Yanagita, 1997; Berg et al., 2006; Bu, et. al., 2005; Krueger & Ferguson, 2002; Yin et al., 2009), two or more protocols were field tested and the test performance was compared to determine the more suitable protocol. The comparison was for the most part based on outcomes measures only with no real emphasis on qualitative feedback from the testers. This can be viewed as a limitation in these studies as valuable information pertaining to the administration of the protocol, its suitability and recommendations for future implementation can be obtained from the testers.

It also became evident that although the context was considered when the researchers selected an appropriate screening tool or protocol, the actual stakeholders functioning in that specific context (e.g. school nurses or community health workers) were not part of the selection or evaluation process. Instead, the research team independently selected the tool(s) or protocol(s) and the stakeholders were then involved in field testing it. Although valuable information was still obtained, one could argue that the screening tool or protocol is not completely contextually-responsive if one does not collaborate with the health workers who form an integral part of the context. Furthermore, it is important for researchers to base their decisions regarding the most appropriate protocol on the context-specific needs identified by the stakeholders, and not only the researchers themselves, as failure to do so could impact on the future implementation of the protocol.

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The current school hearing screening service in the Western Cape is a case in point, where the stakeholders' needs were not sufficiently recognised. The South African Department of Health previously aimed to implement a school-based hearing screening protocol that addressed the contextual challenges that school nurses supposedly contend with (E. Lawrence, Personal communication, February, 2007). This hearing screening protocol was clearly outlined in the School Nurses' Operational Handbook (School health services operational handbook, Department of Health, 2003) and as a set of implementation guidelines for the school health team, this protocol appeared to be fairly comprehensive. However, its impact was questionable due to an apparent mismatch between the context-specific requirements and the proposed protocol. For example, the handbook included the screening procedure for pure-tone audiometry but the nurses did not always have the necessary equipment or skills to conduct the test (J.Davis, Personal communication, February, 2007) making it impossible to meet any program goals.

In an attempt to resolve this issue, the school nurses may resort to other screening methods that do not require expensive equipment, such as the voice test. However, such tests may not always yield reliable results (as previously discussed in the *Review of the literature related to common hearing screening tests* section), which may in turn impact on the effectiveness of the screening protocol and so the nurses' ability to meet the program goals. One can thus reasonably conclude that although less costly (than a protocol using pure-tone screening equipment), the protocol that includes tests like the voice test may still be a waste of time and valuable human resources in an already constrained context. In this way a mismatch between the screening protocol and the contextual needs can lead to poor implementation of the proposed protocol, resulting in limited success in meeting program goals and ultimately a sub-optimal screening service (Edwards-Miller & Taylor, 1998).

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With this in mind, the present study aimed to contribute towards the improvement of the current school hearing screening service in the Western Cape by addressing the mismatch between the contextual needs and the proposed screening protocol. This was achieved by identifying a contextually-relevant screening protocol through a systematic selection process; collaborating with the relevant stakeholders when selecting the most suitable protocol; and considering both outcomes measures and qualitative feedback following the implementation of the protocol. It is hoped that this research process will serve to address the shortcomings of previous research efforts and initiate advancement in the identification of a hearing screening protocol that is effectively implemented and sustained in the South-African school environment.

University of Cape Town

Chapter 3

Methodology

The chapter will provide an overview of the research process followed in order to achieve the research aims. For this purpose, the methodology chapter will include the following sections:

- 3.1. Research design including an overview of the five specific research objectives.
- 3.2. Ethical considerations in conducting this study.
- 3.3. Description of research site and research populations.
- 3.4. Discussion of the methodology relevant to each research objective in terms of criteria for participant selection; sampling and recruitment; data collection instruments, methods and procedure; and strategies used to establish rigour, trustworthiness, reliability and validity. This format was used to present the methodology as the study included a number of different objectives and research methods.

3.1. Research Design

The researcher set out to achieve the following aims and objectives:

Aim 1: To identify a contextually relevant hearing screening protocol for use in a school setting.

Objective 1.1: To identify and describe the context-specific needs for a school-based hearing screening protocol.

Objective 1.2: To identify and select two hearing screening tests that met the context-specific needs.

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Objective 1.3: To select the most suitable screening protocol that met the requirements for a contextually-relevant protocol.

Aim 2: To determine the applicability of the proposed screening protocol for the typical South African school context.

Objective 2.1: To describe the implementation of the initial field test of the proposed protocol.

Objective 2.2: To determine the test performance of the proposed screening protocol.

In order to address these research aims, the study followed a sequential research design, using a mixed methods approach. In the sequential design the different strands of the study occur in chronological order, with each strand emerging from the previous one (Teddlie & Tashakkori, 2009). This research design was appropriate for the present study as each step of the study was dependent on the results of the previous step. Furthermore, the mixed methods approach meant that both quantitative and qualitative methods of data collection and analysis were employed in a complimentary manner (Patton, 2002). The value of this approach lies in the fact that the quantitative data contributes to the technical development of practices whereas the qualitative information defines the personal and social frameworks in which health care is provided (Borkan, 2004). In addressing the research aims five separate but interrelated objectives had to be met and this was achieved by combining the different quantitative and qualitative research methods. As previously discussed in *Chapter 2*, this study's methodology is based on the *Process of identifying a contextually-relevant program or protocol*, depicted in Figure 4. The methodological framework including the primary research aims, underlying objectives and related research methods are presented in Figure 5.

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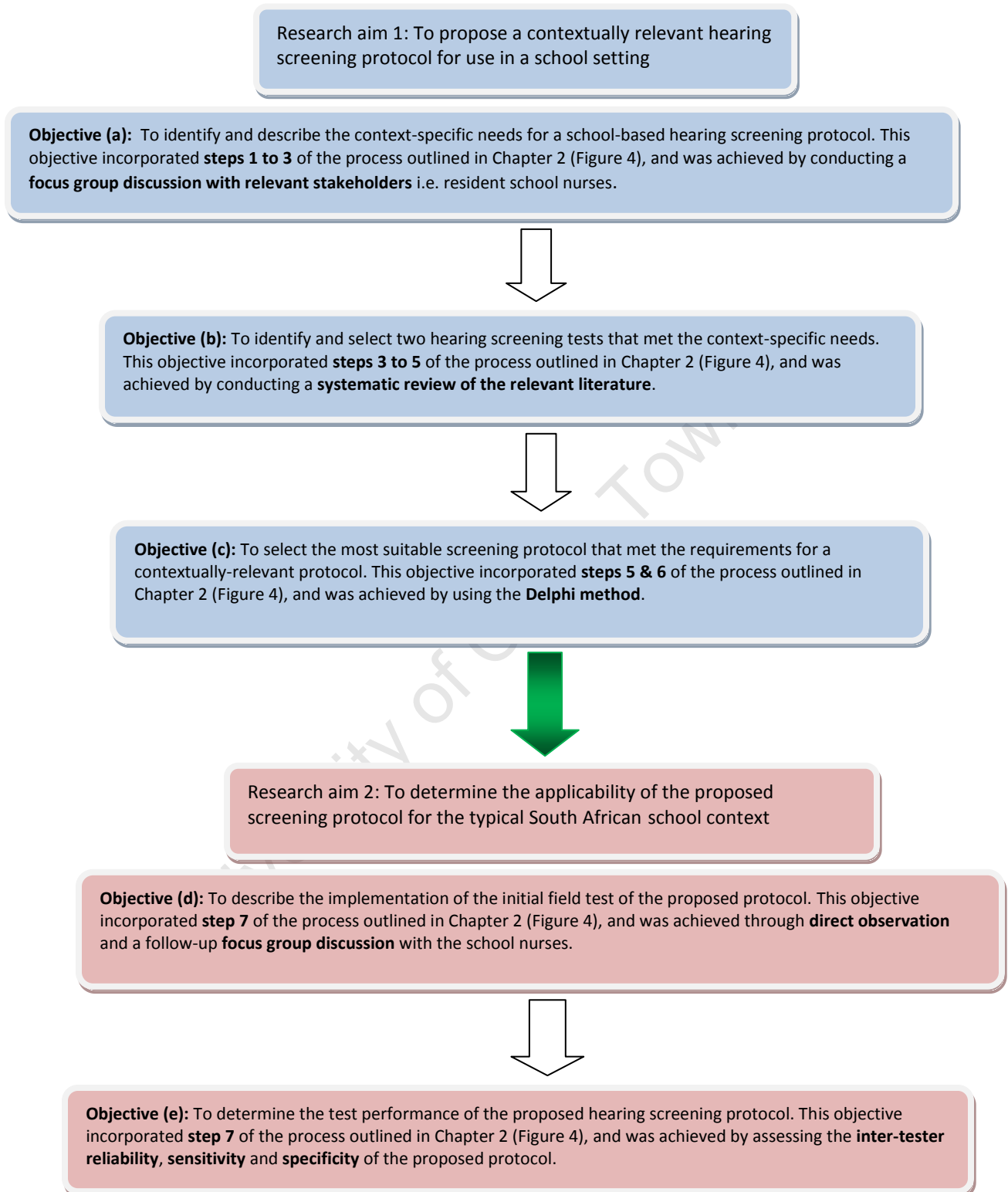


Figure 5: Methodological framework of the research process: research aims, objectives and methods

3.2. Ethical Considerations When Conducting this Study

Throughout the implementation of this research study, the researcher paid careful attention to ethical issues. Included here, are the critical ethical considerations maintained throughout the research process:

1. **Informed consent:** In order for social science research to be considered ethical, all participants must provide their informed consent prior to their inclusion in the research study (Patton, 2002). This implies that the participant is fully aware of the research procedure, the rationales and ultimate research aims when giving their consent (Lo, 1995). In the present study, the researcher ensured that all participants gave their informed consent. This included obtaining consent from:
 - The sub-district CHC facility manager to conduct research on the school health team (refer to Appendix A1 for consent letter given to the CHC facility manger). This applied to all aspects of the study.
 - The individual members of the school health team (refer to Appendix A2 for a copy of the consent letter given to the members of the school health team). This applied to all aspects of the study.
 - The individual members of the expert panel (refer to Appendix A3 for the consent form given to the expert panel members). This applied to objective (c).

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- The Western Cape Department of Education to conduct research at the participating schools (refer to Appendix A4 for the letter of consent obtained from the Western Cape Department of Education). This applied to objective (d).
- The principals of the participating schools (refer to Appendix A5 for consent letters given to the participating schools' principals). This applied to objective (d).
- The parents of the participating learners (refer to Appendix A6 for the English consent letter given to parents and Appendix A7 for the Afrikaans letter given to parents). This applied to objectives (d) and (e).
- The participating learners i.e. assent (refer to Appendix A6 & Appendix A7). This applied to objectives (d) and (e).
- The medical superintendent of the tertiary institution used for diagnostic assessments (refer to Appendix A8 for the consent letter given to the medical superintendent). This applied to objective (e).
- The head of the Audiology department at the tertiary institution (refer to Appendix A9 for the consent letter given to the Audiology department). This applied to objective (e).
- The research assistant used for the diagnostic assessments (refer to Appendix A10 for consent letter given to research assistant). This applied to objective (e).

Furthermore, all observations were carried out in an overt manner without any deception of participants (Patton, 2002).

2. **Non-maleficence:** To ensure that participants were not harmed in any way (Coughlin & Beauchamp, 1996), all testing procedures used during the study followed standard protocols and all methods were non-invasive. Furthermore, data collection methods were of reasonable duration so as not to exhaust the participant. Where necessary, breaks were incorporated into the sessions.
3. **Beneficence:** All participants identified as having otological or possible audiological problems were referred for further investigation and treatment. This was necessary to ensure that participants with hearing problems received adequate treatment for conditions identified by the study (Coughlin & Beauchamp, 1996).
4. **Confidentiality and privacy:** All participants were advised of their confidentiality. All biographical details of the participants were replaced by participant numbers as soon as the information was no longer necessary. This was done to protect their anonymity and the confidentiality of their study records (Kitzinger, 2000).
5. **Ethics committee:** The research proposal for the present study was submitted to the University of Cape Town Faculty Ethics Committee to obtain full ethical clearance before commencement of any aspect of the study. Refer to Appendix A11 for a copy of the clearance letter from the Ethics Committee.

3.3. Description of Research Site and Participants

3.3.1. Research site.

In order to achieve the research objectives, it was necessary to choose a site and sample that would best answer the research question (Hupcey, 2005). A form of purposive sampling namely

typical case sampling was used to select the particular health sub-district that would constitute the research site. This sampling strategy involves selecting cases that are most typical, normal or representative of the group or situation under investigation (Teddlie & Tashakkori, 2009).

Typical case sampling was considered an appropriate sampling strategy as the sub-district shared the features and contextual challenges that are common to many districts in developing countries e.g. financial and human resource constraints in the health system, similar demands on the health resources, etc. (Swart & Reddy, 1999). The sub-district under investigation is located approximately 20 kilometers from the City of Cape Town and in 2004 the population was estimated to be 424, 399. The current health services in the sub-district includes ten local clinics and three CHCs as well as school health services aimed at addressing the health needs of the school-aged child, from Grade R to Grade 12 (Mitchell's Plain Services Directory, WC-NACOSA).

3.3.2. Description of research participants.

Firstly, in order to address the primary research aims, the researcher required the input of the local school health team functioning in the sub-district. This school health team included three professional nurses and two enrolled nursing assistants at the start of this study. The professional nurses are qualified to provide comprehensive nursing and medical care following 4-5 years of training and the enrolled nursing assistants are qualified to provide basic nursing care following 1 year of training (School Health Operational Handbook, DOH, 2003).

Secondly, the researcher required the participation of learners of four mainstream primary schools in the sub-district. The schools in this sub-district are all government subsidized and

include learners who are primarily from coloured and black racial groups⁷ (Mitchell's Plain Services Directory, WC-NACOSA). The sampling and recruitment of these populations will be described in the relevant sections.

3.4. Methodology for Each Research Objective

The methodology for each research objective is described separately and uses the following organizational framework:

1. Criteria for participant selection
2. Sample size (where applicable)
3. Recruitment and sampling
4. Data collection instruments (where applicable)
5. Data collection methods and procedure
6. Data management (where applicable)
7. Data analysis
8. Strategies used to establish rigor, trustworthiness, reliability and validity

The outline for objective (b) will however not follow this sequence as the methodological structure of this objective differs from the other objectives. The format for this objective will be described in the relevant section.

⁷ The terminology used to classify the different racial groups is derived from South Africa's apartheid era.

3.4.1. Objective (a): To identify and describe the context-specific needs for a school-based hearing screening protocol.

3.4.1.1. Criteria for participant selection:

- Participants must be school nurses forming part of the school health team functioning in the health sub-district under investigation
- Participants must have been involved in school health for at least 2 years, thus having sufficient experience and background knowledge (Durrheim & Wassenaar, 1999). This level of experience was considered appropriate as the nurses would have a better understanding of the context-specific needs if they have been functioning in that specific context for a significant amount of time.
- Participants must be willing to share the relevant information.

3.4.1.2. Sample size.

Five school nurses were included in the sample. The proposed size of the group was determined by the number of school nurses in the sub-district's school health team but was also theoretically appropriate for the composition of a focus group, which Kitzinger (2000) considers to be between four and eight members. It is furthermore suggested that the sample size is often influenced by the research question/topic (Hupcey, 2005). Thus, if the research question is very specific, the researcher would require a smaller sample size that includes participants with in depth knowledge of the research topic (Patton, 2002). Since the research objective is very specific, focusing on the context-specific need of the school nurses conducting hearing screening on site, the sample size of five school nurses was deemed appropriate.

3.4.1.3. Recruitment and sampling.

Complete collection or criterion sampling was employed to achieve this research objective as it involved the recruitment of all members of a group of interest who meet a specified criterion (Teddlie & Tashakkori, 2009). Since the research question sought to identify the context-specific needs in the school setting, and the school-based health workers were most knowledgeable having the greatest experience related to the research topic, the researcher selected the entire school health team functioning in the sub-district.

3.4.1.4. Data collection method and procedure.

The district's school health team formed a focus group. The intention of this focus group was to generate data in a social context by capitalizing on the communication between participants and accessing their subjective experience (Kelly, 1999; Kitzinger, 2000). For this purpose, a focus group discussion guide was used to obtain the desired information, whilst leaving room for the group members to share any additional views and suggestions pertaining to the school health context.

3.4.1.4.1. Focus group pilot study.

Before implementing the focus group discussion with the school nurses, a pilot study was conducted. The purpose of the pilot study was to ensure that the proposed interview guide & methods of data collection were appropriate (Kanjee, 1999). Due to work obligations and time constraints, nurses were unavailable for the pilot study. A group of four school-based community health workers (CHWs) were thus recruited instead. These CHWs formed part of the school health team and worked closely with the school nurses in the district, by assisting in the provision of basic health services. For this purpose, they were specifically trained by accredited

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training providers (Comprehensive Service Plan for the implementation of Healthcare 2010: Draft for consultation, DOH, 2006). The CHWs were considered equivalent to the school nurses with regard to their understanding of the context-specific needs in a school setting because of their significant involvement in the provision of school health services.

Based on the findings of the pilot study two changes were made. Firstly, instead of the researcher facilitating the group and managing the audio-visual equipment used to capture the data, two research assistants were recruited to manage the audio-visual equipment and take notes manually, allowing the researcher to focus on the facilitation of the group discussion. Secondly, the focus group discussion guide required revision as it yielded some repetitive responses. Refer to Appendix B for the revised interview guide with the recommended changes. Once the revision to the focus group discussion guide was completed the focus group session was conducted with the participating school nurses.

3.4.1.4.2. Focus Group Discussion Procedure.

Four school nurses formed the focus group, facilitated by the researcher who was supported by two research assistants. These research assistants were final year Audiology students who focused on the same research topic for their undergraduate thesis. The researcher acted as moderator between the school nurses and in so doing facilitated discussion that was of relevance to the research topic. To ensure that the desired information was obtained, the revised focus group discussion guide was utilized (Refer to Appendix B). Although the focus group was guided by the researcher who determined the topic of discussion beforehand, various strategies were utilized to ensure that the discussion (and actual data) still came from the school nurses.

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These strategies included:

- Giving the school nurses a clear explanation of the purpose of the group discussion and its value as an opportunity for individual expression and group ownership of the problem and solutions (Sim, 1998).
- Reminding the school nurses of the fact that the group was a safe environment for expression of their views. Confidentiality issues were clearly explained.
- Generating interest in and discussion about the topic without leading the group to confirm a prior theory or support existing expectations (Sim, 1998). Thus, the researcher directed discussion from general issues (as outlined in the interview schedule) to more specific topics by encouraging the nurses to elaborate on initial statements, whilst all the while monitoring the verbal and non-verbal cues presented to the group
- Ensuring that the discussion occurred amongst the school nurses, rather than between the researcher and the nurses. The researcher thus attempted to strike a balance between being an active and passive facilitator, only interjecting when necessary, for example to clarify issues.

The focus group discussion was both audio-taped (using the Olympus DS-2200 Digital Voice Recorder) and video-recorded (using the Sony DCR HC26E Digital Video Camera Recorder Handycam) to ensure that all relevant data was accurately recorded. Manual note-taking was also utilized. This was done to protect against the effects of machine failure and to add value to the

data collected (Sim, 1998). All forms of data capturing were conducted in an unobtrusive manner so that group participation and interaction was not hindered by it.

3.4.1.5. Data management.

Using the Olympus Transcription kit which was specifically designed for the transcription of qualitative data, the research assistants transcribed the voice (audio) recording of the focus group discussion for transcription purposes. The transcription was then checked by the primary researcher to ensure the accuracy of the transcribed interview. After checking the transcription against the audio-visual recordings and field notes, the researcher filled in all gaps on the transcriptions, reconstructing what was said in cases where information was missed in the transcription from the video footage. Then, after careful consideration of the overall purpose of the focus group interview and the research question, it was decided that certain aspects of the discussion e.g. slight pauses in the discussion or elements of humor, were irrelevant and thus excluded from the rest of the data analysis process. Once the researcher was satisfied with the written representation of the focus group discussion, the data was summarized using a provisional classification system. In this classification system, the researcher grouped the data according to the school nurses' responses related to each discussion point in the focus group discussion guide. Each school nurse was then given a copy of this summarized transcript to validate the findings. Refer to Appendix C for a copy of this summarized transcript.

3.4.1.6. Data analysis.

To analyse the data, a combination of both deductive and inductive methods of qualitative analysis was utilized (Teddlie & Tashakkori, 2009). This approach to data analysis is considered effective as qualitative analysis includes the segmenting of data into relevant preliminary

categories (i.e. a deductive process) while simultaneously generating categories from the data (i.e. an inductive process) (Boeije, 2010). For this reason, a framework approach was firstly utilized to organize the data in order to illuminate the main categories arising from the focus group interview (Patton, 2002; Pope, Ziebland & Mays, 2000). Although this framework approach was used to reflect the original accounts of the people studied, it essentially started deductively based on the assumption that the study included pre-set aims, thereby allowing the researcher to identify categories in the initial stages of the analysis (Pope, Ziebland & Mays, 2000). Secondly, to further develop the categories and construct the related theoretical explanations, thematic analysis was applied (Aronson, 1994; Pope, Ziebland & Mays, 2000). This part of the process was more inductive using the emerging data from the nurses to shape the answer to this particular research objective.

In summary, a series of steps were followed in order to move from a descriptive record of the data to an explanation thereof. Firstly, following the data preparation process, the data in the transcript was provisionally grouped in terms of the nurses' responses related to the different topic areas in the interview guide. The next step was to establish categories through a coding process (Pope, Ziebland & Mays, 2000). The categories were then further refined and reduced in number by grouping together the related categories to produce sub-themes (Aronson, 1994). Thereafter the main themes were identified by bringing together the sub-themes containing components of the nurses' ideas and experiences (Aronson, 1994). Refer to Appendix D for a flowchart of this analytic process (including categories).

3.4.1.7. Strategies used to establish rigor and trustworthiness.

The strategies used to establish rigor and trustworthiness, as well as the rationale for applying each strategy are summarized in Table 2.

Table 2**Strategies used to establish rigor and trustworthiness in objective (a)**

Strategy	Rationale
Use of information-rich participants who had the relevant information and were willing to share this information. In this study the school nurses made up the study sample. They had first-hand knowledge of the context-specific needs and were willing to share this information.	Improves the credibility of findings (Patton, 2002).
Pilot study was conducted using school health CHWs who routinely work with the school nurses.	Increases the dependability of the focus group discussion guide used (Teddlie & Tashakkori, 2009).
Combination of recording methods used, including video recording, voice recording and manual note-taking.	Gives more complete account of the data (Daly, McDonald & Willis, 1992).
Allowing the participants to review the data i.e. member checking	Enhances the credibility and trustworthiness of the findings (Teddlie & Tashakkori, 2009).
More than one person involved in the data transcription and analysis process. The researcher was assisted by a group of final year Audiology students who acted as research assistants, guided by a senior researcher.	Enhances the accuracy of the recorded data and interpretation (Daly, McDonald & Willis, 1992).

The next objective of the research study was to identify hearing screening tests that met the contextual needs of the school nurses.

3.4.2. Objective (b): To identify and select two hearing screening tests that met the context-specific needs.

In order to identify two hearing screening tests that are suitable for application in a school environment, a systematic review of the related literature was conducted. This step of the research process supplemented objective (a) in the identification of a contextually-relevant screening test as the focus group in objective (a) revealed the contextual needs whilst the systematic review was a rigorous process of selecting screening tests that adequately met the contextual needs.

It was decided to select two different tests thereby providing alternative options with varying strengths and weaknesses. By systematically comparing the different aspects of both screening tests, it is possible to ensure that the selected test is in fact the most effective one for the purpose of this study (Hirsch & Riegelman, 1996). In addition, the inclusion of more than two tests may result in a more difficult final test selection process. A systematic review was deemed the most effective method of obtaining the required information, as the researcher could systematically evaluate and interpret all available research evidence relevant to hearing screening tests (Glasziou, Irwig, Bain & Colditz, 2001).

It is also suggested that a systematic review of literature is especially useful in health research, where the solution of practical problems often calls for the application of the results of many methodologically-sound studies (McDonald & Daly, 1992). Thus, in order to answer the research question, the researcher identified and appraised all the studies related to school-based hearing screening, and those of acceptable quality and applicability were synthesized to facilitate the selection of the most suitable hearing screening tests (Glasziou et al., 2001).

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The following methodology discussion will include:

3.4.2.1. Literature search (including *search terms & search strategies*).

3.4.2.2. Study selection (including *initial screening phase and appraisal of the literature*).

3.4.2.3. Data extraction.

3.4.2.4. Data synthesis (including *Model for data synthesis*).

3.4.2.5. Strategies used for validation of findings.

3.4.2.1. Literature search.

3.4.2.1.1. Search terms.

Before searching for the relevant literature, the research question was carefully considered to ensure that it was sufficiently focused to facilitate the identification of related studies (Magarey, 2001). It was also suggested that a well-constructed clinical question should clearly state four main components which includes the patient group under investigation; interventions used; comparative interventions and the outcomes used to measure the effect (Meade & Richardson cited in Magarey, 2001). Using these components as a guide, the research question was systematically broken down and presented in a simple Venn diagram. In this diagram, the components of the research question are presented as three overlapping circles where the patient group is school-aged children; the interventions and comparative interventions are translated into various hearing screening tests and the outcomes measures are taken as the sensitivity, specificity and other outcomes measures of the various hearing screening tests. The fact that the circles are overlapping indicate that the primary focus for the literature search includes an overlap of the components of the research question i.e. the search aimed to identify hearing screening tests

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conducted on school-aged children for which specific outcome measures were reported. The venn diagram is depicted in Figure 6.

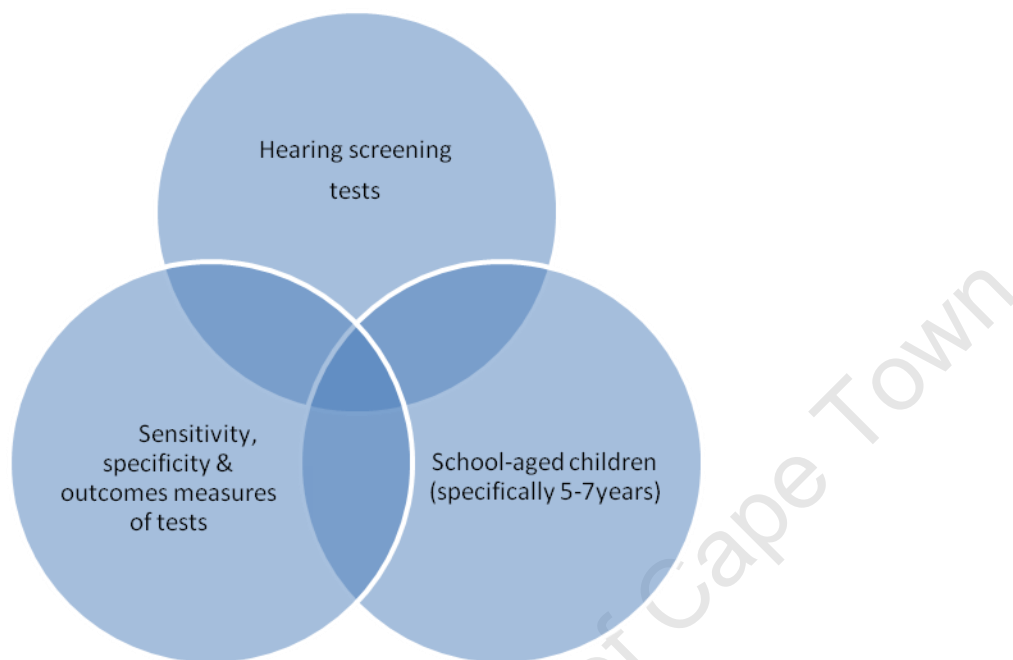


Figure 6: Venn diagram for literature search

The search terms stemmed from the main components in the Venn diagram as well as synonyms thereof (Glasziou et al., 2001). These terms included:

- Hearing screening
- School-based hearing screening
- Detection of hearing loss in schools
- Hearing screening tests
- Pure-tone screening

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- Screening audiometry
- Immittance testing
- Otoacoustic emissions (OAEs)
- Automated Auditory Brainstem Response (AABR)
- Sensitivity and specificity measures of OAEs
- Sensitivity and specificity measures of AABR

Studies from January 1998-July 2008 were included as they offered the most recent and relevant findings pertaining to hearing screening practice given the fact that this study's literature search was conducted from 2007 to 2008. Furthermore, by extending the search to include studies over a 10 year period the researcher was able to consider past and current trends in hearing screening practice as well as determine the tests that have consistently yielded good outcomes for school-based screening.

3.4.2.1.2. Search strategies.

After the search terms and criteria were confirmed, two search bases were utilised to retrieve relevant studies, which included searching electronic databases and searching the literature by hand. Firstly, electronic databases were used as such databases include large volumes of information that can be retrieved in a convenient and timely manner. Therefore, Cumulative Index of Nursing and Allied Health Literature (CINAHL), Excerpta Medica on line (EMBASE) and Database of Abstracts and Reviews (DARE) were used to identify eligible studies. The use of three databases was considered acceptable as Minozzi, Pistotti and Forni (2000) suggest that

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at least two databases must be used to ensure a comprehensive literature search. Furthermore, the specific databases were carefully selected. CINAHL was selected as its records are derived from over 1700 nursing, allied health and consumer health journals making it a useful source of information related to the present study. Similarly the EMBASE database was considered useful as it includes all the fields of medicine and indexes 3500 journals (Gehanno, Paris, Thirion & Caillard, 1998). Its coverage is complimentary to Medline⁸ and other databases in the areas of European literature. Thus, the inclusion of EMBASE allowed the researcher to identify journal articles that may not have been included in other databases.

The DARE database was also selected as it provided the researcher with structured summaries of quality-assessed reviews of health care interventions making it a very useful resource for conducting a systematic review in the present study (Petticrew, Song, Wilson & Wright, 1999). Furthermore, the literature search was limited to English language reports. The results of this initial search were then utilised in what is known as a 'snowballing' strategy (Glasziou et al., 2001). This simply means that the bibliographies of the relevant papers were searched for relevant articles that were missed in the initial search (Glasziou et al., 2001).

Secondly, the researcher searched the literature by hand to identify unindexed or very recent journals. Since the aim of the systematic review is to identify all studies pertaining to a chosen topic, both published and unpublished studies must be considered (Magarey et al., 2001). Thus, for the present study, South African-based experts in the Audiology field were also consulted and upon their recommendations unpublished theses related to hearing screening were identified. The snowballing strategy was again applied to identify additional articles for review.

⁸ Medline is an electronic bibliographic database containing more than eight million records from over 3500 biomedical journals and periodicals, covering the period from 1966 to present (Gehanno, Paris, Thirion & Caillard, 1998).

3.4.2.2. Study selection.

3.4.2.2.1. Initial screening phase.

To ensure that the selection of studies is appropriate, it is recommended that at least two reviewers be used (Glasziou et al., 2001). Thus in the present study, the primary investigator was supported by a group of six final year Audiology students together with a senior researcher. The reviewers independently searched, read and screened studies that could potentially be included in the review. The inclusion criteria for this initial screening process included the following:

- The study participants had to be school-aged/ pre-school aged children⁹
- The screening tests included in the study had to be used for the identification of hearing loss
- The study had to include some form of outcome measures with which the screening tests were evaluated e.g. sensitivity and specificity values.

To ensure that all the reviewers were in agreement throughout the process, regular meetings were scheduled to discuss the papers previously retrieved and its eligibility for inclusion. In addition, the junior researchers regularly consulted with their research supervisor (a senior researcher) to ensure that they were adequately guided throughout the systematic review process. Following the initial screening phase of the review, the next step was an appraisal of the literature to evaluate the integrity of the studies' research designs and their relevance to the review question (Magarey et al., 2001).

⁹ In order to increase the range of screening tests included in the review, this search criterion was later extended to include all paediatric groups.

3.4.2.2.2. Appraisal of the literature.

The appraisal of the literature involved a detailed evaluation of the methodologies reported in the retrieved studies to ensure that only the relevant and methodologically-sound studies were included in the review (Glasziou et al., 2001). To ensure that the appraisal included valid and standardized selection procedures, the appraisal process involved two stages. Firstly, in stage one of the appraisal process the inclusion criteria for selection were specified and based on these criteria the second stage of the appraisal process involved the final selection of the studies to be included in the review.

Stage one: Identification of criteria for selection.

For this stage of the appraisal process it is recommended that a checklist that specifies the inclusion criteria be used to appraise each study (Glasziou et al., 2001; Magarey et al., 2001). Such a checklist was proposed by the Cochrane Methods Working Group on Screening and Diagnostic Tests (CMWGSdT) (cited in Glasziou et al., 2001) and was used as a basis for the appraisal checklist used in this study.

To ensure that the appraisal checklist was appropriate for a specific study, it is suggested that the checklist may vary according to the research design. Thus, for the present study the major appraisal issues in the checklist included; the appropriate selection of participants and the inclusion of an independent, blind comparison with the 'gold standard' measure (Glasziou et al., 2001). In addition, appraisal issues related to the applicability of the study were also considered in the checklist and included the study setting, participants and specific tests used in the selected studies. Refer to Appendix E1 for a copy of the *Checklist for assessing the quality of research*

studies used in the present study. This checklist was adapted from the comprehensive checklist developed by the Cochrane Methods Working Group on Screening and Diagnostic Tests (cited in Glasziou et al., 2001). Refer to Appendix E2 for a list of adaptations made to the checklist.

Stage two: Selection process.

With the aid of the adapted checklist, the same two groups of independent reviewers appraised the studies in order to select the most appropriate studies for the final review. This selection process was facilitated by a novel grading system that the researcher included in the adapted checklist. This grading system allowed the two groups of reviewers to approach the reviewed literature in a systematic and uniform manner. In the grading system, the researcher separated the checklist items into three distinct categories, based on how fundamental each item was in the evaluation of the methodological quality of each study.

The first category included items considered *essential* elements of a good quality research design for comparing diagnostic and screening tests as well as the elements that made the reviewed study comparable to the present study. This category was marked as group 1. The second category, marked group 2, included items that *added to the quality* of the study but was not considered essential aspects to the study's design. Finally group 3 included items yielding any *additional or extra information* pertaining to the study. All decisions regarding the level of importance of each item was based on the criteria set by the Cochrane Methods Working Group on Diagnostic and Screening Tests, which was also used to develop the appraisal checklist (Glasziou et al., 2001). With regard to the specific criteria for inclusion, a study had to meet all the criteria specified in group 1 of the checklist thereby ensuring that the selected studies demonstrated all the essential features of a quality research design. Regular meetings were also

scheduled to discuss the ‘scoring’ of each study, degree of concurrence and resolve any discrepancy in scores.

3.4.2.3. Data extraction.

Once consensus was reached regarding the final selection of studies, data were extracted from the selected studies. To facilitate this process data extraction tables based on the preset quality criteria were developed As described in the section above; ‘Appraisal of Literature. The data extraction tables thus documented the specific data that was collected from each study and included information regarding the participants, study setting, study design, tests evaluated and outcome measures (Magarey et al., 2001). These data extraction tables are presented in Appendix F1, F2 and F3 for the study descriptors, quality criteria and applicability criteria, respectively.

3.4.2.4. Data synthesis.

Although quantitative analysis is often used for a systematic review, it is suggested that a comprehensive synthesis of the relevant studies is also sufficient for data analysis and ultimately for decision-making (Glasziou et al., 2001). This is especially important as the present study’s scope was such that it did not allow for a more quantitative analysis process such as the meta-analysis (Magarey et al., 2001). A meta-analysis is usually conducted to combine small-scale studies that are very similar and are usually lacking in statistical power. When combining these studies in the meta-analysis it then produces more convincing results (Margery, 2001).

For this reason, data from various studies can only be combined in a meta-analysis if they have the same characteristics such as participant characteristics and the same screening tests under review. Since the review in the present study included studies that evaluated a number of

different screening tests in various age groups, a meta-analysis was not a viable option (Magarey et al., 2001). After careful consideration of the information in the data extraction tables, the purpose of the systematic review and the overarching research question, it was decided that the most appropriate method for synthesizing the data would be through graphical representations of the data to demonstrate and compare the various features of the screening tests under investigation as well as the overall suitability of each screening test (Magarey et al., 2001; Reid, 1993).

3.4.2.4.1. Model for data synthesis.

In order to demonstrate and compare the suitability of the different screening tests, a rating system was required in which each screening test was rated according to the relevant literature (i.e. evidence), in a way that would allow one to understand the link between the strength of the evidence and the recommended rating. However, such a rating system did not exist for this specific purpose. The researcher together with a research consultant therefore devised a model for this kind of rating.

To facilitate the development of this model for rating an existing framework was considered. This framework was proposed by Harbour and Miller (2001) who reported on a system for grading recommendations in Evidence-based Guidelines Development and suggested four key stages in developing recommendations. These stages included:

1. Evaluating the methodological quality of the evidence base.
2. Compiling an evidence table of studies of an acceptable standard.
3. Making considered judgments about the relevance and applicability of the evidence.

4. Assigning a grading recommendation to the strength of the evidence base.

The researcher followed a similar process in developing the rating system for determining the suitability of the screening tests in the review. In so doing, the researcher ensured that the design process was rigorous and that the ratings for test suitability were based on the best available evidence. This researcher-generated rating system involved a three-step process, which is summarized in Figure 7.

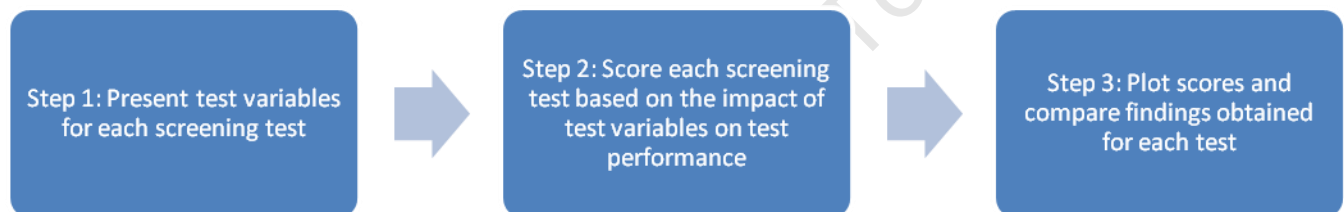


Figure 7: Three steps of the research-generated rating system used to determine the suitability of screening tests

Firstly, a representation of the most frequently reported test variables was created for each screening test under investigation. The test variables included:

- Test time
- Ease of administration
- Ease of interpretation of results
- Sensitivity to background noise

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Secondly, a rating system was devised in which a score was allocated to each screening test based on the impact of each test variable on the test's performance. In this rating system, a score of 0 was given to a screening test for which a test variable, such as test time had a "high level of significance". Alternatively, a score of 1 represented a "fairly high level of significance"; 2 represented a "moderate level of significance" and a score of 3 represented a "low level of significance". Based on this rating system, a score of 0 was the least desirable score and a score of 3 was the most desirable score. It should be noted that all decisions regarding the significance of the test variables as well as the subsequent rating for each test variable was based on careful consideration of the relevant literature which served as the evidence base (W. Wilson, personal communication, December 2009).

The researcher furthermore used a table to facilitate the scoring process by entering the possible scores for each test variable into the table. Thus, if a screening test was placed in a certain cell in the table (based on the related literature), one could easily see which score corresponds to that particular cell. Refer to Appendix G for the table used to facilitate this scoring process. There were, however, instances in which the literature was not in agreement regarding the significance of a test variable for a particular screening test. For example, one study may indicate that pure-tones required a moderate degree of expertise for the correct administration, whereas another study may indicate that minimal expertise was required. In such cases, pure-tones will have a score of 2 and a score of 3 in the table for that one variable. These scores would then be averaged, resulting in a score of 2.5 which was considered the final rating for pure-tones for that particular test variable.

Thirdly, following the scoring process, the scores for each test variable were then plotted on a series of graphs depicting the ratings for each screening test under investigation. This graphical

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representation of the scores made it easier to directly compare the various features of the tests under review. This in turn facilitated the selection of the most suitable screening tests based on the most favourable scores depicted on the graphs (W. Wilson, personal communication, December 2009).

3.4.2.5. Strategies used to establish rigor, reliability and validity.

The strategies used to establish rigor, reliability and validity, as well as the rationale for applying each strategy are summarized in Table 3.

Table 3

Strategies used to establish rigor, reliability and validity in objective (b)

Strategy	Rationale
Systematic appraisal of the literature using a recognized appraisal checklist as a guide	Improved accuracy and reliability of the findings (Kumar, 2005).
Appraisal checklist has sound theoretical basis	Enhanced the validity of the developed checklist (Kumar, 2005).
Use of existing framework for devising the rating system used for data synthesis	To ensure that the process of developing the rating system was rigorous and systematic (Harbour & Miller, 2001).
Information included in the rating process had an obvious and logical link to the research objective and represented the intended issues (Kumar, 2005). This was achieved by using the relevant literature and nurses' feedback in objective (a).	Enhanced the face and content validity of the rating system (Kumar, 2005).

The next step of the research study was to determine which of the two screening tests identified in objective (b) would be better suited for a school-based hearing screening protocol. For this reason, each of the selected screening tests was included in a screening protocol to devise two protocols, namely Protocol A and Protocol B. Objective (c) involved a systematic comparison of these two protocols to identify the most suitable screening protocol. The Delphi method was used to achieve this objective.

3.4.3. Objective (c): To select the most suitable screening protocol that met the requirements for a contextually-relevant protocol.

3.4.3.1. Criteria for participant selection.

- All participants had to have at least five years working experience in their respective fields, having established themselves through clinical work and/or scholarly activities, as this enhanced their competency in carrying out the required task (Durrheim & Wassenaar, 1999; Johnson & Danhauer, 2002).
- School health participants were required to be either a qualified school nurse or school doctor and health professionals giving audiological input had to be registered Audiologists with in depth knowledge of audiological screening test procedures and the elements of effective screening protocols
- Participants had to be willing to share the relevant information.

3.4.3.2. Sample size.

Due to the fact that the individuals included in the panel had in depth knowledge of the research topic it eliminated the need for a large sample group (Patton, 2002). Furthermore, it is

suggested that a group of four participants is sufficient for application of the Delphi method (Waltz, Strickland & Lenz, 2005).

3.4.3.3. Recruitment and sampling.

To achieve this objective, a modified version of the Delphi method was employed. Since the Delphi method required a group of experts (Waltz, Strickland & Lenz, 2005), an expert panel of health professionals was established. In this instance, an expert was operationally defined as a recognized professional who is suitably experienced and knowledgeable about one or more of the relevant areas of clinical practice, which for the present study included the fields of paediatric audiology, audiological screening and school health (Johnson & Danhauer, 2002; Waltz, Strickland & Lenz, 2005). Furthermore, it is suggested that the inclusion of experts with varying areas of interest pertaining to the research question, as well as varying perceptions and demographics was beneficial as it served to avoid biases resulting from panel membership (Waltz, Strickland & Lenz, 2005). Since the researcher sought to gain input from individuals who are experts in the field of school health and/or audiology, a form of purposive sampling, namely key informant sampling was used. This sampling strategy was considered appropriate as it involved the inclusion of participants with special expertise much like the expert panel required for this objective (Marshall, 1996).

3.4.3.4. Data collection instrument.

A rating scale was designed to elicit the panel's opinions or ratings for the hearing screening protocols under investigation (refer to Appendix H for a copy of the rating scale). The scale took the form of a structured, formal questionnaire with closed-ended questions using Likert scale response formats (Waltz, Strickland & Lenz, 2005). The Likert scale was deemed appropriate for

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the present study as it provided the respondents with a series of statements for which they could indicate their degree of agreement by selecting the appropriate number in the scale provided. For the present study, a rating scale of 0 to 4 was used, with 0 indicating the least impact of the question and 4 indicating the greatest impact. The respondents were then required to select one of the pre-determined response options by circling the number that corresponded with their response (Johnson & Danhauer, 2002).

This type of scale is not only quick and easy to administer but also yields data that is fairly straightforward to interpret, tabulate and analyse (Johnson & Danhauer, 2002). In addition, the rating scale included a cover page that provided a set of instructions regarding the rating session. Given the varied areas of expertise included in the panel, the cover page outlined both audiological and contextual information pertaining to the school health system (refer to Appendix I for a copy of the cover page). All information and instructions were standardized thereby ensuring that all participants were exposed to uniform stimuli.

In order to scrutinize the items of the specially designed rating scale for its relevance, clarity and general adequacy for inclusion, it was necessary to pilot the scale with a sample group that was comparable to the study participants (Waltz, Strickland & Lenz, 2005). The rating scale was thus pre-tested on a group of three final year Audiology students and one postgraduate Audiology student with adequate knowledge in the relevant content area. From the pilot study, it was evident that items 1, 6, 11 and 14 on the rating scale required some revision as it resulted in some uncertainty from the respondents. These items were appropriately revised and rephrased for the expert panel session.

3.4.3.5. Data collection method and procedure.

The Delphi method was considered the most suitable data collection technique as it was designed to structure group opinion and discussion; generate group consensus; and compute the judgments of experts (Waltz, Strickland & Lenz, 2005). It was also appropriate because of its adaptability to a variety of data collection settings and needs (Waltz, Strickland & Lenz, 2005). This adaptability was especially important in the present study as all the elements of the Delphi method was not entirely suited to the research question and research setting under investigation. Refer to Appendix J for a description of the steps for the Delphi method as summarised by Waltz, Strickland and Lenz (2005) as well as the specific steps selected for implementation in the present study's design.

As part of the data collection procedure, each participant was given an instructional letter stating the focus of the study, purpose of the consensus panel and the structure of the rating session (refer to Appendix K for an outline of this instructional letter). In addition, these handouts included a brief summary of each of the screening protocols under investigation, including all the relevant test information to assist them in the rating process. Furthermore, a summary of the school nurses' needs and concerns (as determined in objective (a) of the study) were included. The panel was also informed of the need for data capturing tools that included a voice recorder (Olympus DS-2200 Digital Voice Recorder) and a video recorder (Sony DCR HC26E Digital Video Camera Recorder Handycam). With their permission these recorders were set up in unobtrusive positions for the data collection. Thereafter, each member of the expert panel were given two identical rating scales, one representing their responses for screening protocol A and the other scale represented their responses pertaining to protocol B.

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Following the completion of the rating scales, a panel discussion was included to ensure that the group reached consensus regarding the screening protocol to be implemented in the schools. This discussion was important as the outcome of the rating scales could reveal disagreement amongst raters regarding the most suitable screening protocol. In addition it is suggested that when applying the Delphi method one includes some way of achieving stability in the results. For the standard Delphi method this usually involves the repeated application of the questionnaire or scales to the expert group. This is however, a time-consuming and often costly exercise (Okoli & Pawlowski, 2004). The repeated application of the scale was also considered unnecessary as the ultimate goal of this specific research objective was simply for the expert panel to reach consensus regarding the best screening protocol and this was easily achieved by conducting a panel discussion. For the panel discussion, the issues highlighted in the rating scale served as a discussion guide to obtain the desired information, whilst leaving room for the group members to share any additional views and suggestions (Patton, 2002; Rubin & Rubin, 2005). The discussion was recorded for analysis using the same audio-visual recording equipment and techniques described in objective (a).

3.4.3.6. Data Analysis.

The data generated in this research objective included both quantitative data from the rating scales and qualitative data obtained from the panel discussion. The data analysis therefore included careful scrutiny of the rating scale responses and a qualitative analysis of the panel discussion.

3.4.3.6.1. Representation of the rating scale responses.

Due to the Likert-type response format used in the rating scale, ordinal data was obtained (Clason & Dormody, 1994). For this reason, percentage scores and statistical analysis could not be applied to the data. Instead, it was decided that the most appropriate method for synthesizing the data was through graphical representations of the raters' responses, to demonstrate and compare their views regarding different features of the two screening protocols under investigation. In so doing, the researcher could easily identify the protocol most favorably rated by the majority of the expert panel members as well as the perceived strengths and weaknesses of each protocol. A radar chart was used to graphically present each rater's responses to each item in the rating scale. This was deemed an appropriate approach as the radar provided a simplified presentation of multiple performance indicators making simultaneous comparison of responses between raters and protocols possible (Mosley & Mayer, 1999). For practical reasons, the scale items were each reworded to shorten them for the graphical representation. This made it more legible without altering the meaning of the items.

3.4.3.6.2. Qualitative analysis of the panel discussion data.

With regard to the panel discussion, the charge of the expert panel was to reach an agreement regarding the most applicable hearing screening protocol to be implemented in the study. This decision was based on the issues highlighted in the rating scale. After completion of the discussion the researcher was left with a single conclusion, thus precluding the need for data analysis in that regard.

Qualitative analysis was also conducted to highlight themes or patterns that arose during the course of the panel discussion, thereby providing an understanding of the process followed in

reaching the conclusion and any relevant factors involved. For the analysis of this qualitative data, the researcher used a process of content analysis. Content analysis is defined as a research technique used for the objective and systematic description of the actual content of a text to determine the presence of certain words, concepts or themes (Graneheim & Lundman, 2004; Silverman, 2001). There are two types of content analysis including (a) conceptual analysis which involves establishing the presence and frequency of concepts in a text, and (b) relational analysis which builds on conceptual analysis by assessing the relationships between concepts in a text (Graneheim & Lundman, 2004; Research Methods and Theory, <http://www.colostate.edu/Depts/WritingCenter/references/research/content/page2.htm>). Using a combination of conceptual and relational content analysis, the researcher followed a series of steps to analyse the data.

Firstly, the researcher used conceptual analysis to identify the concepts to be analysed, which in this instance included the panel members' viewpoints regarding the benefits, limitations and suitability of the two screening protocols under investigation. Secondly, by using relational analysis, the text was scrutinized and categories were generated through a coding process. Relational analysis was again utilized for the final step of the data analysis in which the categories were refined and related categories were grouped together to form the sub-themes, from which the main themes were later derived (Waltz et al., 2005).

3.4.3.7. Strategies used to establish rigor, trustworthiness, reliability and validity.

The strategies used to establish rigor, trustworthiness, reliability and validity, as well as the rationale for applying each strategy are summarized in Table 4.

Table 4**Strategies used to establish rigor, trustworthiness, reliability and validity in objective (c)**

Strategy	Rationale
Representative and information-rich sample used in the present study as the sample included experts in the fields of Paediatric Audiology and School Health.	Enhanced the credibility of the findings (Waltz, Strickland & Lenz, 2005)
A pilot study was conducted to pre-test the rating scale. The pilot study sample included a group of three final year Audiology students and one postgraduate Audiology student with adequate knowledge in the relevant content area	Increased the reliability of the rating scale (Kanjee, 1999).
Standard instructions and stimuli were used for all participants	Increased the reliability of the scale and facilitated comparison across respondents (Johnson & Danhauer, 2002; Waltz, Strickland & Lenz, 2005).
The rating scales completed anonymously and independently by all participants	Enhanced the accuracy of the information obtained (Mulder & Viljoen, 2003)
Scale items were based on the contextual needs identified in objective (a) of the study and the systematic review of related literature in objective (b).	Enhanced the content validity of the rating scale (Kielhofner, 2006).

The next step of the research study was to field test the selected hearing screening protocol in a school setting and determine the outcomes of this field test.

3.4.4. Objective (d): To describe the implementation of the initial field test of the proposed screening protocol.

To achieve this objective, the researcher used a two-step process, which included:

1. Direct observation of the nurses implementation of the proposed hearing screening protocol
2. A focus group discussion to determine the nurses' perceptions regarding the suitability of the hearing screening protocol

3.4.4.1. Recruitment and sampling.

The sampling process for this objective included sampling for:

- The participating schools
- The screening sample
- The observer and the focus group.

Since the description of the recruitment and sampling process includes different groups of participants the information pertaining to the criteria for participant selection and sample size have been integrated into the descriptions of the recruitment and sampling strategies used for each group of participants.

3.4.4.1.1. Participating schools and the screening sample.

A process of cluster sampling was employed to select the participating schools and the screening sample, which involved randomly selecting groups that occurred naturally in the population i.e. clusters. More specifically, multistage cluster sampling was used in which schools

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were randomly selected in the first stage of sampling and then specific learners were randomly selected within these clusters in the second stage of sampling (Teddlie & Tashakkori, 2009). This sampling strategy was considered appropriate as the researcher randomly selected the participating schools in the first stage of the sampling and then randomly selected the participating learners within the schools. With regard to the participating learners that formed the screening sample, the researcher focused on grade 1 learners as grade 1 screening is one of the school nurses' priority areas (School Health Operational Handbook, DOH, 2003). Using grade 1 class lists from the four participating schools, grade 1 learners were randomly selected to form part of the screening sample. This random sampling technique ensured that the study sample was representative of the population under investigation (Hirsch & Riegelman, 1996).

Four primary schools were selected to participate in this study as the school health team was divided into four work groups. Given the time and staff constraints, this arrangement made the screening process more manageable. A screening sample size of 100 grade 1 learners was considered appropriate as some researchers suggest that the minimum number of participants in a quantitative design should be at least 30 (Bailey, 1994; Leedy & Ormond, 2005). Similarly, the sample size was considered suitable for the purpose of field testing the screening protocol, as it was large enough to ascertain the effect of the protocol without overloading the school nurses. It is furthermore suggested that in a population that is homogenous with respect to the variable under study, a small sample size can provide the researcher with a reasonable level of accuracy of study results (Kumar, 2005). For the present study the population under investigation, Grade 1 learners in the selected sub-district, was considered to be fairly homogenous with respect to their hearing status and for this reason the sample size of 100 was considered sufficient.

3.4.4.1.2. The observer.

Purposive sampling was utilized in recruiting the observer as the researcher adopted the role of passive, nonparticipating observer in order to accurately document the school nurses' implementation of the hearing screening protocol. By taking on the role of observer, the researcher ensured that all the observations were carried out as intended and in so doing correctly captured the activities and behavior under study (Patton, 2002).

3.4.4.1.3. The focus group discussion.

Since the aim of the focus group was to determine the school nurses' perceptions regarding the implemented screening protocol, the participating school nurses were the only members of the group. Thus all group members giving feedback had sufficient exposure to the implemented protocol as well as a thorough understanding of the key issues raised in the previous focus group session.

3.4.4.2. Data collection instruments.

The instrumentation for this objective included:

- A sound level meter used to measure the noise levels in the test environments.
- Hearing screening equipment used by the school nurses.
- An observation schedule used by the observer.
- A focus group discussion guide.

3.4.4.2.1. Sound level meter.

The Brüel and Kjær Integrating Sound Level Metre Type 2239A was utilised for all noise measurements. Refer to Appendix L1 for outline of the sound level meter settings used.

3.4.4.2.2. Hearing screening equipment.

For hearing screening purposes, the following screening equipment and pass/fail criteria was utilised:

- Welch Allyn Oscope to perform otoscopy. When performing otoscopy, examination of the outer ear and tympanic membranes were included. If no abnormalities were detected for the pinna, external auditory meatus and tympanic membrane it was considered a 'pass' (Swart; Lemmer; Parbhoo & Prescott, 1995). However, if any abnormalities were identified these were noted on the record sheet and if the learner presented with ear discharge or impacted wax the learner was excluded from the screening sample to obtain immediate treatment. For other abnormalities such as inflammation of the tympanic membrane the condition was noted and the screening protocol was completed. These learners were then scheduled to have their diagnostic assessments, for objective (e), conducted as early as possible and the appropriate intervention was provided immediately afterward. Refer to Appendix L2 for a list of the abnormalities of the outer ear and tympanic membrane.
- Bio-logic AuDX Evoked Otoacoustic Emissions Measurement System to perform OAEs test. Distortion Product OAEs (DPOAEs) were used in which two pure tone stimuli (also known as the *primaries*) are presented to the learner's ear. Although both transient -evoked OAEs (TEOAEs) and DPOAEs can be used ring screening purposes,

DPOAEs were selected in this study as the distortion product technique has a wider useful frequency range than TEOAEs (Kemp, 2002). For testing purposes, the DPOAE system default protocol was applied which included specific collection parameters. Refer to Appendix L3 for a summary of these collection parameters. The default protocol was considered suitable as it included appropriately low stimulus levels and the typical F1/F2 ratio. Furthermore, no low stimulus frequencies were included to reduce the effects of low frequency loss associated with transient middle ear problems and to reduce the impact of low-frequency ambient noise on test results (Eisermann et al., 2008; Kemp, 2002; McPherson et al., 1998). According to the AuDX user's and service manual, the system default DPOAE protocol stops the test when the conditions for an overall test "Pass" or a "Refer" occur. For an overall "Pass" result to occur the response obtained must be at least 6dB above the noise floor for at least three of the four test frequencies (AuDX User's and Service Manual, 2005).

- GSI38 Tympanometer to perform tympanometry

When using this piece of equipment, the test sequence runs automatically. Once the tester correctly inserts the probe into the learner's ear, the test will run and once completed the relevant data will appear on the machine's screen. Specific normative data was then utilised for interpretation purposes. Refer to Appendix L4 for details of the test specifications, normative data and information used to classify tympanometry results.

Furthermore, all the relevant screening equipment was calibrated at the time of data collection to ensure that the test results were accurate (Clark & Newton, 2008).

3.4.4.2.3. Observation schedule.

An essential feature of this research objective was to determine the suitability of the proposed screening protocol. Thus all items included in the observation schedule were related to the contextual needs identified in the school nurses' focus group discussion in objective (a) of the present study, as well as literature related to hearing screening; the selected screening protocol and common test variables.

The observation schedule thus included 4 sections, namely:

- Tester factors
- Testee factors
- Environmental factors
- General observations related to the implementation of the screening protocol. An evaluation rating scale was included to facilitate the classification of the researcher's observations. This scale was developed by the researcher specifically for this purpose.

The rating scale comprised of 5 possible scores for each item observed, with scores ranging from 1-5. Each score reflected varying levels of acceptability regarding the tester, testee and environmental factors. A score of 5 indicated a high degree of acceptability whereas a score of 1 reflected a low degree of acceptability for a specific item on the schedule. In order to increase the objectivity of the scoring process, a brief descriptor with specific criteria was associated with each score. Thus a score of 1 would for instance correspond to a description such as "inadequate knowledge base, inadequately prepared, unsatisfactory use of screening equipment, relies on constant support, inability to communicate results and poor understanding of administrative

process”. Refer to Appendix M for copy of the observation schedule and corresponding rating scale.

3.4.4.2.4. Focus group discussion guide.

Refer to *Data collection methods and procedure* section for a description of the focus group discussion guide.

3.4.4.3. Data collection methods and procedure.

Prior to the implementation of the proposed hearing screening protocol, the school nurses received training to equip them to conduct the tests forming part of the selected protocol. The details of this training program are summarized in Appendix N. In field testing the proposed hearing screening protocol, the researcher sought to ascertain the ease with which the school nurses could implement it as well as the practical feasibility of utilizing such a protocol in a school setting. This data was gathered through a two-step process, Firstly, direct observation was utilized which allowed the researcher to view the screening process in the natural context in which it would ordinarily occur, with those individuals who would naturally form part of that context (Hupcey, 2005). Thereafter, a second focus group session was conducted with the school nurses to obtain feedback regarding the applicability of the screening protocol.

3.4.4.3.1. Direct observation.

In order to gather the data the researcher attended the schools together with the school nurses for the field testing of the hearing screening protocol. The school health team was divided into the pre-existing work groups which ideally included one professional nurse and one enrolled nursing assistant in each group. Due to the school nurses’ work obligations, the four test days were scheduled over a period of two weeks, approximately two weeks after their training session.

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They were thus advised to review their training handouts prior to the implementation of the screening protocol. Since the school nurses had an established working relationship with their respective schools, they each already had a designated workspace at the school. This workspace was used for screening purposes to ensure that the observation of the implemented protocol was under their typical working conditions.

Before screening commenced at each screening site, the researcher explained the specially designed administration forms to be completed for each learner. This included a screening record sheet to include the screening test results for each learner and a space for the nurses to comment on the perceived test variables (refer to Appendix O1 for a copy of the screening record sheet); and a letter to parents informing them of the test results and the next step of the study which involved the diagnostic assessment for each learner. This letter outlined the diagnostic assessment procedure, test site and appointment details (refer to Appendix O2 for a copy of the letter given to parents). The learners who failed the screening test were to be scheduled for the earliest diagnostic assessment dates so that they could be referred for further management if indicated. Each nurse was also provided with a brief summary of the screening procedure and related norms should they require the additional support (refer to Appendix P for a copy of the screening procedure summary).

The researcher then measured the background noise levels in the test environment to ascertain the suitability of the workspace for hearing screening purposes (Frank, 2000). Once the noise measures were completed and the environment was considered suitable, the researcher adopted the role of unobtrusive observer, giving the nurses' time and space to set up the screening equipment and identify the learners to be screened. Due to the proposed size of the screening sample; 100 learners, it was previously decided to screen 25 grade 1 learners at each

participating school. Whilst the school nurses implemented the screening protocol, the researcher merely observed and documented the relevant information according to the pre-determined observation schedule.

The effect of the observer's presence was however considered as it may have influenced the nurses' behavior. This phenomenon is known as reactivity effects and should be minimized to ensure the accuracy of the researcher's observations (Polgar & Thomas, 1991; Wallace, 2005). In order to minimize the reactivity effects, the researcher utilised a number of strategies whilst observing. Firstly, it is suggested that participants acclimatize to an observer's presence after approximately ten minutes (Waltz et al., 2005). Thus, the researcher was present in the test environments for at least 15 minutes before the actual data collection commenced. Furthermore, Hupcey (2005: 224) reported that the reactivity affects usually decrease over time. Therefore, by prolonging the observation period it enhanced the "truth value" of what is observed Hupcey (p224), and so the trustworthiness of the data was enhanced (Teddlie & Tashakkori, 2009). With this in mind, the researcher was present for the duration of the hearing screening at each school. Furthermore, due to the previous working relationship between the researcher and the school nurses, a degree of proximity existed between the observer and the participants. This proved beneficial as it served to reduce the behavioural changes on the part of the nurses when the researcher was present.

3.4.4.3.2. Focus group discussion.

The observation of the nurses' implementation of the screening protocol was later supplemented by a second focus group session with the school nurses. This focus group discussion served as a self-report session in which the nurses shared their views regarding the

applicability of the proposed hearing screening protocol. The data generated from this focus group discussion was considered useful as it provided additional information about the outcome of the field testing process. Furthermore, since the nurses were providing this information it came from a different perspective than that of the observation data (previously obtained) thereby providing a more complete description of the suitability of the protocol for the school setting.

Before implementing the focus group procedure with the school nurses, a pilot study was conducted to ensure that the proposed focus group discussion guide and methods of data collection were appropriate (Kanjee, 1999). The findings of this pilot study are summarised in Appendix Q. From the pilot study it was evident that various items on the guide required clarification in order to yield appropriate responses. The focus group discussion guide also yielded some repetitive responses, thus requiring some revision. The revised interview guide was then used for the focus group session (refer to Appendix R for a copy of the revised interview guide). The focus group discussion was both audio-taped (using the Olympus DS-2200 Digital Voice Recorder) and video-recorded (using the Sony DCR HC26E Digital Video Camera Recorder Handycam) to ensure that all relevant data was accurately captured (Rubin & Rubin, 2005).

3.4.4.4. Data analysis.

The data generated in this research objective included both quantitative data from the observation rating scales and qualitative data obtained from the focus group session. The data analysis therefore included careful scrutiny of the observation scale findings and a qualitative analysis of the data obtained from the focus group.

3.4.4.4.1. Representation of observation findings.

Because a structured observation schedule and rating scale were utilised, a numerical value (rating) was attributed to the observations emphasized in the predetermined schedule. This simplified the data preparation and analysis process significantly (Patton, 2002). A Microsoft Excel spreadsheet was developed to summarize the ratings obtained for the four testers for each item included in the observation schedule. Thereafter, a radar graph was used to display this data making it easier to compare ratings and therefore identify patterns in the observations (Patton, 2002). This in turn allowed the researcher to make inferences about the applicability of the screening protocol in the school setting (Polgar & Thomas, 1991; Patton, 2002).

In addition, the hearing screening results recorded on the test record sheets were summarised on an Excel spreadsheet, including the learner's name, pass/fail result and reason for failing (if applicable). In so doing, it provided the researcher with easy access to the screening data for review and comparison purposes when the diagnostic assessment results were added in objective (e) of the present study.

3.4.4.4.2. Qualitative analysis of focus group discussion data.

The same process as was used in the analysis of the panel discussion data in objective (c) was utilized for the qualitative analysis in this objective. The data analysis process for the second focus group was thus more deductive than the process followed for the data analysis of the initial focus group conducted in objective (a).

3.4.4.5. Strategies used to establish rigor, trustworthiness, reliability and validity.

The strategies used to establish rigor, trustworthiness, reliability and validity, as well as the rationale for applying each strategy are summarized in Table 5.

Table 5**Strategies used to establish rigor, trustworthiness, reliability and validity in objective (d)**

Strategy	Rationale
Representative and information-rich sample used in the present study as the sample included the school nurses functioning in the sub-district.	Enhanced the credibility of the findings (Waltz, Strickland & Lenz, 2005).
A non-obtrusive observation style was adopted.	To reduce reactivity effects (Wallace, 2005).
The observation schedule and rating scale items were based on the contextual needs identified in objective (a) of the study and relevant literature	Enhanced the content validity of the rating scale (Kielhofner, 2006) and minimized any form of bias related to the classification of observations (Hupcey, 2005).
A pilot study was conducted prior to the focus group discussion with the nurses.	Increased the dependability of the interview guide used for the focus group session (Teddlie & Tashakkori, 2009).
A combination of research methods and recording strategies were used. The research methods included direct observation and a focus group discussion, and the recording strategies included audio-visual recordings and manual note-taking.	Gives more complete account of the data (Daly, McDonald & Willis, 1992).
A process of member checking was included after the focus group discussion.	Enhances the credibility and trustworthiness of the findings (Teddlie & Tashakkori, 2009).
Use of a combination of different data types i.e. triangulation. This was achieved by integrating the ratings obtained on the observation schedule and the qualitative data obtained from the focus group discussion.	This served to validate the findings of objective (d) as the strengths of one approach compensated for the weaknesses of another approach (Patton, 2002).

Following the field testing of the proposed screening protocol, the next stage of the research process was to determine the test performance of the proposed protocol.

3.4.5. Objective (e): To determine the test performance of the proposed hearing screening protocol.

This objective was achieved by:

1. Determining the inter-tester reliability of the hearing screening protocol.
2. Obtaining reference measures of the participants' otological and audiological status.
3. Comparing test results obtained from the hearing screening protocol with that of the reference measures to determine the sensitivity, specificity and predictive value of the hearing screening protocol.

3.4.5.1. Recruitment and sampling.

The recruitment and sampling process for this objective included sampling for:

- The independent tester for inter-tester reliability
- The screening sample for inter-tester reliability
- The sample for diagnostic assessment

Since the description of the recruitment and sampling strategy includes different groups of participants the information pertaining to the criteria for participant selection and sample size have been integrated into the descriptions of the recruitment and sampling strategies used for each group of participants.

3.4.5.1.1. Independent tester for inter-tester reliability.

In order to determine the inter-tester reliability of the screening protocol it was necessary to include a second screening session following the school nurses' screening conducted in objective (d) of the study. In this second screening session, the screening protocol had to be conducted by an independent tester who is competent and knowledgeable about the testing procedures involved in the study (Hripcsak & Heitjan, 2002; Patton, 2002). It was assumed that these criteria would be met by an individual who was qualified to conduct the screening tests independently and had at least two years experience practicing the screening tests in a clinical setting. Two forms of purposive sampling namely key informant sampling and the convenience sampling strategy were used in this instance. The former sampling strategy involves the inclusion of participants with special expertise whereas the latter involves the selection of the most accessible participants (Marshall, 1996). Since the researcher was conveniently located in the screening site and furthermore met the stipulated criteria, it was decided that the researcher would act as the independent tester. It was however noted that this dual role as researcher and independent tester could be a source of bias. Measures were thus taken to eliminate such bias (Refer to *Strategies used to establish reliability and validity*).

3.4.5.1.2. Screening sample for inter-tester reliability.

To ensure that there were no changes in the patient factors when assessing the inter-tester reliability, the second screening session was conducted on 45 of the same 100 learners that were previously screened by the school nurses. The 45 participants were randomly selected by the researcher to ensure that the sample was representative of the population group under investigation (Hirsch & Riegelman, 1996). Furthermore, according to Walter, Eliasziw and Donner (1998), 45 participants are sufficient to obtain reliability values of 40% or higher, using

two tests per participant. The selected number of participants was also deemed appropriate as many authors suggest that at least 30 participants are required for studies in which some form of statistical data analysis is to be done (Bailey, 1994; Leedy & Ormond, 2005). Similarly, the sample size was considered suitable as it was large enough to ascertain the inter-tester reliability of the protocol, whilst still being manageable for the testers given the time constraints in the study. In order to ensure consistency and generalisability of the results, it was necessary to include an equal number of learners from each of the four participating schools' screening samples i.e. 11-12 learners from each school screening sample (Hirsch & Riegelman, 1996).

3.4.5.1.3. Sample for diagnostic assessments.

In order to obtain a reference standard for the participants' otological and audiological status, diagnostic audiometric (pure-tone) testing was to be carried out on the same 100 grade 1 learners who underwent hearing screening in objective (d) of the study.

3.4.5.2. Data collection methods and procedure.

In order to achieve this objective, two kinds of data were collected i.e. data for determining the inter-tester reliability and data regarding the reference standard. Firstly, one of the focal areas of this research objective was the agreement between the testers' judgment of the hearing screening test results. This measure is termed the inter-tester reliability of the screening protocol (Sim & Wright, 2005) and was determined by comparing the test results obtained by each nurse to the results obtained by the independent tester.

To obtain this data the researcher attended the schools together with the school nurses for the implementation of the hearing screening protocol. To ensure that the test results were not contaminated by changes in any test variables, the researcher made use of the same test

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environment utilized by the school nurses when they carried out their screening in objective (d). Similarly, to eliminate the effect of potential changes in the child's otological and audiological status, it was decided to repeat the second screener immediately after the initial screener was conducted by the school nurses. This was of particular significance as the occurrence of middle ear infection and associated hearing loss can fluctuate dramatically in the school-aged population (Kielhofner, 2006), thereby yielding very different screening test results from one week to the next. To administer both screening tests on the same day was also logistically easier and only caused minimal interference with the learner's classroom attendance during the school week, as s/he was only required to leave class for one session. Furthermore, to avoid bias the researcher was blinded to the screening test results obtained by the school nurses.

Secondly, the researcher sought to obtain reference measures of the participants' otological and audiological status by conducting diagnostic assessments on the participating learners. With regard to the timeframe, the earliest appointments for the participants' diagnostic assessments were one week after the school screening ended. The participants who failed the school-based screening were given the earliest diagnostic appointment dates to ensure that they received the necessary treatment as indicated after the assessment.

The participants then underwent standard audiometric testing with a test battery that included; otoscopy, standard tympanometry (using 226Hz probe tone) including results related to ear canal volume, middle ear pressure and tympanic membrane compliance, standard pure-tone audiometry including the presentation of pure-tone stimuli at 250Hz, 500Hz, 1000Hz, 2000Hz, 4000Hz & 8000Hz. Masking and bone conduction testing was applied where necessary. The pass/fail criteria used for the otoscopy and tympanometry was the same as that used for hearing screening, which is specified in *Section 3.4.4.2.2*. For the pure-tone audiometry test, the learner

was considered to have normal hearing if s/he presented with hearing thresholds of 15dB HL or less across all test frequencies (Clarke & Newton, 2008). For all diagnostic testing the researcher and research assistants conducting the tests were blinded to the screening test results obtained by the school nurses to avoid any bias.

All testing took place in a soundproof, clinical environment to obtain the most accurate results (Kibel & Lachman, 1995). Following the testing, all test results were immediately recorded on a specially designed audiological assessment form (refer to Appendix S for a copy of this form). Thereafter feedback of the test results was given to participants and caregivers. If cases of hearing loss or otological conditions were identified, these participants were appropriately referred for further examinations and treatment (Kibel & Lachman, 1995).

3.4.5.3. Data analysis.

The data analysis for this objective included the analysis of the inter-tester reliability of the screening protocol as well as the analysis of the sensitivity, specificity and predictive values of the protocol.

3.4.5.3.1. Analysis of inter-tester reliability.

The inter-tester reliability measure is often expressed as a percentage reflecting the proportion of agreements to disagreements between two or more testers (Maxwell & Satake, 2006). In order to obtain this percentage, findings were summarised in a Microsoft Excel spreadsheet, illustrating all screening test results obtained by the school nurses and comparing these to the screening test results obtained by the independent tester, for the 45 learners tested. Refer to Appendix T1 to view this spreadsheet. To avoid confusion, each school nurse was allocated a number corresponding to the sequence in which their screening sites were visited, for

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example, the nurse who conducted testing at the first school visited by the researcher was referred to as Nurse 1 and so on.

To further analyze the inter-tester reliability, the total number of learners screened by both the independent tester and school nurses were then converted into a measure of the total number of ears tested for each screening test. Once the test results were presented in the spreadsheet format, one could tally the number of agreements (i.e. cases where both the school nurse and independent tester obtained the same result for a particular learner) and disagreements (i.e. cases where the school nurse and independent tester did not obtain the same result for a particular learner) between the two testers (Johnson & Danhauer, 2002).

The information from this Microsoft Excel spreadsheet was then used to conduct a comprehensive analysis by inserting the data into the DAGstat Diagnostic and Agreement Statistics spreadsheet. This program was applicable as it was specifically designed to provide statistics for the assessment of diagnostic tests and inter-tester reliability when these investigations yield data that can be summarised in a 2X2 contingency table (Mackinnon, 2000). Once the information was included in the DAGstat spreadsheet, the relevant statistics were automatically computed.

To improve the accuracy of the inter-tester reliability measure, it was important to consider the agreement that could be expected to occur by chance (Sim & Wright, 2005). For this purpose, the Cohen's Kappa statistic was considered appropriate as it compares the observed agreement (i.e. the observed proportion of observations [by different raters] that were classified as being the same) with the 'chance' agreement to yield a measure that reflects the 'true' agreement between results of tests conducted by independent testers (Riegelman, 2005; Sims &

Wright, 2005). However, Cicchetti and Feinstein (1990) suggest that a single coefficient will result in an incomplete description of the relationship between the judgments of two testers. Thus, an additional index of ‘specific agreement’ is also considered which quantifies the degree of agreement for each category of positive and negative results separately. Thus, in a dichotomous case, one can calculate positive and negative specific agreement (Hripcsak & Heitjan, 2002).

3.4.5.3.2. Analysis of sensitivity, specificity and predictive values.

The data from the school-based screening was compared to the reference data obtained from the diagnostic assessments to determine the sensitivity, specificity and predictive value of the hearing screening protocol. Once all test results were matched, each participant was given a participant number thereby eliminating the need for any personal details. This data was then transferred onto a Microsoft Excel spreadsheet, similar to the one constructed for the recording of the hearing screening results (utilised in objective (d) of the present study), making direct comparisons between the screening results and the reference standard possible. Refer to Appendix T2 for a copy of this spreadsheet. This spreadsheet was used for later analysis.

It was decided that the sensitivity, specificity and predictive values be calculated using only the tests related to hearing sensitivity (and not the entire protocol) which included OAEs and pure-tone testing. This was deemed appropriate for two reasons. Firstly, in the diagnostic test battery tympanometry was conducted on all participants tested but during the hearing screening phase of the study, the recommended protocol suggested that tympanometry only be conducted on those participants who failed OAEs. This made a direct comparison of tympanometry results difficult. Secondly, the diagnostic testing must include a reference standard for the measures

used in the screening protocol (Johnson & Danhauer, 2002). With regard to tympanometry, the reference standard for middle-ear disorder identification is considered to be the findings of an Ear, Nose and Throat specialist on myringotomy (Taylor & Brooks, 2000). This was not practically feasible and could thus not form part of the study.

Thus, although the importance of including both otoscopy and tympanometry in both the hearing screening and diagnostic protocols is recognised (Martin & Clarke, 1996), the analysis of sensitivity, specificity and predictive values was only applied to the results obtained from the OAEs test and the corresponding pure-tone test results for each participant. It should also be noted that this data analysis was only applied to the screening results obtained by the school nurses (and not the results obtained by the independent tester) as the purpose of the analysis process was to determine the applicability of the screening protocol for a school-based program run by the school nurses.

When considering the sensitivity, specificity and predictive values of the OAEs test in the school-based screening protocol, the importance of each outcomes measure should not be overlooked. According to Johnson and Danhauer (2002), there are four possible outcomes when comparing screening and diagnostic tests: (a) *true positives* in which case the results of both the screening test and the diagnostic test indicate presence of a hearing loss, (b) *true negatives* in which case both the screening test and the diagnostic test indicate the absence of hearing loss, (c) *false positives* in which case the screening test indicates the presence of a hearing loss and the diagnostic test confirms the absence of a hearing loss, and (d) *false negatives* in which case the screening test indicates the absence of a hearing loss whereas the diagnostic test confirms that a hearing loss is in fact present (Johnson and Danhauer, 2002). Ideally, effective tests should have more true positives and true negatives and fewer false positives and false negatives. In other

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words, the tests should have acceptable levels of sensitivity and specificity (Johnson and Danhauer, 2002). For the present study, these outcomes measures were determined for the proposed protocol in a typical school context.

In addition, the researcher aimed to establish the probability that an individual does not have a hearing loss given that they have a negative test result, and furthermore the probability that a hearing loss is present given a positive test result (Hirsch & Riegelman, 1996). These outcome measures are respectively known as the negative and positive predictive values of a test (Hirsch & Riegelman, 1996). In order to obtain these values, a direct comparison was made of the results obtained from the implemented screening protocol with the clinical diagnosis determined by the reference standard measure (Hirsch & Riegelman, 1996).

To determine the sensitivity, specificity and predictive values of the screening protocol, the Microsoft Excel spreadsheet containing the relevant data was reviewed and data was transferred onto the DAGstat statistical spreadsheet for further analysis. Using decision-matrix analysis, it was possible to determine the rate of correct positive responses (i.e. sensitivity) and the rate of correct negative responses (i.e. specificity) (Johnson & Danhauer, 2002). Refer to Figure 8 for an illustration of the decision-matrix used.

		OAE screening test		Totals
		Positive	Negative	
Diagnostic audiometry	Positive	True positives	False negatives	
	Negative	False positives	True negatives	

Figure 8: The decision matrix used to determine the sensitivity and specificity values

Sensitivity was then calculated by dividing the total number of true positives by the sum of the number of true positives plus false negatives as indicated in Figure 8. Conversely, specificity was computed by dividing the total number of true negatives by the sum of the false positives plus true negatives (Muir Gray, 1997). To ensure accuracy and save time, the DAGstat statistical spreadsheet is set up in such a way that these calculations were automatically performed once the relevant raw data is inserted. In addition, the use of the sensitivity and specificity measures was automatically applied in a predictive value formula to determine both the positive and negative predictive values (Johnson & Danhauer, 2002). Refer to Appendix U for a summary of the predictive values formulae.

3.4.5.4. Strategies used to establish reliability and validity.

The strategies used to establish reliability and validity of findings, as well as the rationale for applying each strategy is summarized in Table 6.

Table 6**Strategies used to establish reliability and validity in objective (e)**

Strategy be specific	Rationale
Minimal variance between the two screening sessions for inter-tester reliability as the researcher kept the screening sample, screening protocol, administration and instructions constant between all testers.	Enhanced the reliability of the measure (Johnson & Danhauer, 2002).
The researcher was blind to the nurses screening test results when screening the selected learners.	Reduced the potential bias of having the researcher act as independent tester (Teddlie & Tashakkori, 2009)
Diagnostic assessment procedures were conducted in accordance with approved standards based on the American Speech-Language-Hearing Association (2005) guidelines.	To ensure that accurate, reliable and valid test results were obtained (Roush, 2001)
An independent research consultant was involved in determining outcomes measures	Reduced potential bias (Teddlie & Tashakkori, 2009).

This chapter served as a comprehensive account of the research design and research process used to achieve the aims of this study as described in the *Introduction* chapter. In order to ensure that both the research design and research process was appropriate (for achieving the aims of the study and for the research context) and methodologically sound, a specially designed research methodology was used. This methodology was based on the *process involved in developing or identifying a contextually-relevant protocol* (as depicted in Figure 4 in *Chapter 2*), and the relevant theory pertaining to the selected research design and research methods.

Chapter 4

Results and Discussion

In this chapter the results for each of the five research objectives will be presented and discussed. This will be followed by a comprehensive review of the impact of the proposed hearing screening protocol with reference to its relevance and general performance in the present study. The chapter will thus include the following sections:

- 4.1. Presentation and discussion of the results for each objective
- 4.2. Relevance of the proposed hearing screening protocol
- 4.3. General performance of the proposed protocol

4.1. Presentation and Discussion of the Results for Each Objective

4.1.1. Objective (a): To identify and describe the context-specific needs for a school-based hearing screening protocol.

Two overarching themes were identified, namely: screening program resources and human resources. The findings related to these themes provide a comprehensive summary of the current situation and challenges with which the school nurses' are faced. The conclusion regarding the nurses' context-specific needs was derived from these findings. In order to facilitate understanding of the following discussion the sub-themes together with the resulting themes are presented in Figure 9.

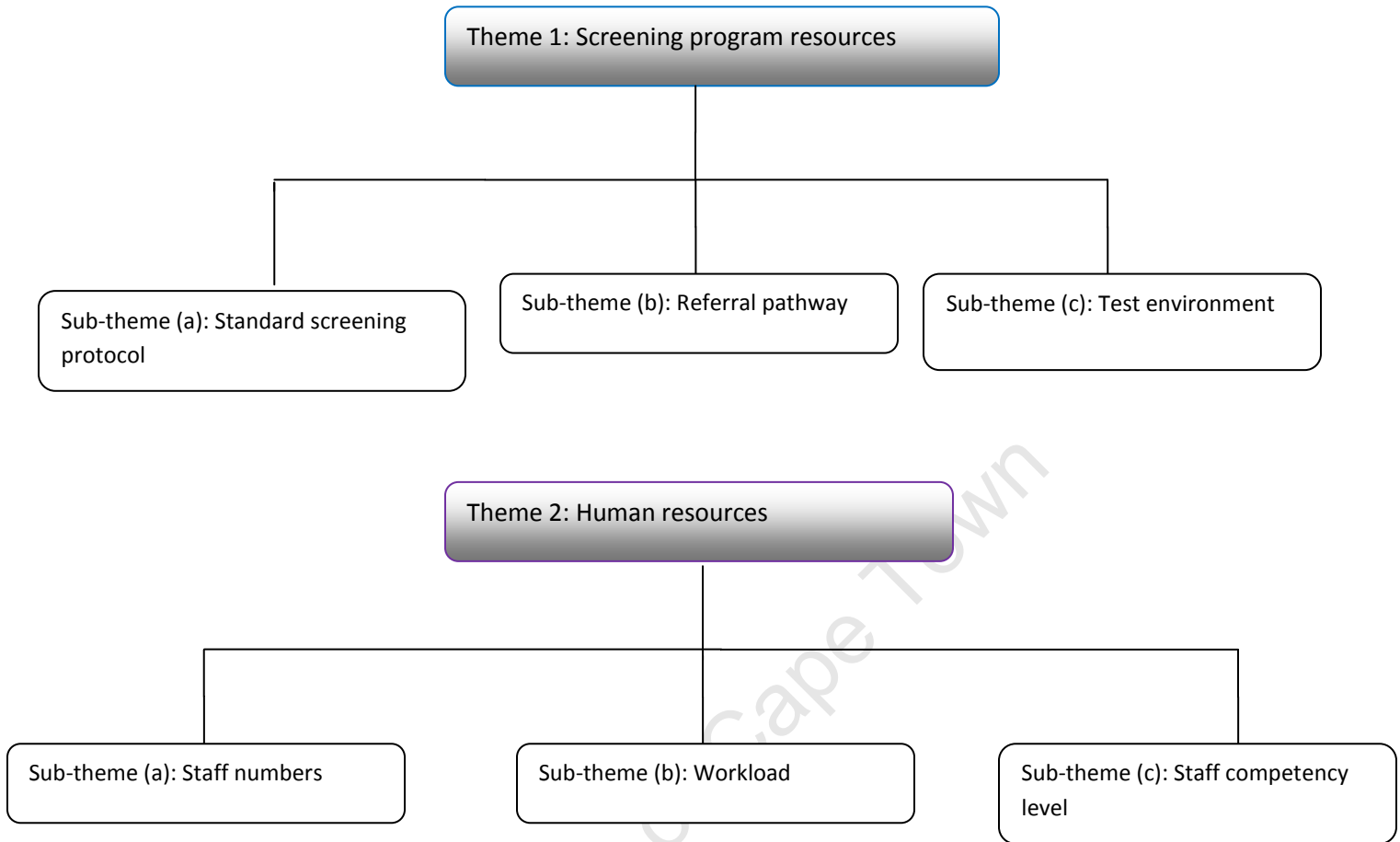


Figure 9: The themes and sub-themes derived from the focus group data in objective (a)

4.1.1.1. Theme 1: Screening program resources.

Screening program constraints appeared to be one of the primary reasons for the current state of the school’s hearing screening service. This included the lack of a standard hearing screening protocol, an effective referral pathway, and an adequate test environment for hearing screening. Thus, *screening program resources* were considered an important context-specific need.

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4.1.1.1.1. Sub-theme (a): Standard screening protocol.

Firstly, the nurses reported that the lack of a standard hearing screening protocol was a major concern for them. Since hearing screening formed part of the school health service package, hearing screening protocols were included in the School Nurses' Operational Handbook (DOH, 2003) and basic training was provided in this regard (E.Lawrence, personal communication, February 2007). The handbook included screening audiometry and the rattle test as screening methods and the voice test was also later prescribed (School Health Operational Handbook, 2003). Since the nurses were seemingly equipped to perform hearing screening, it was assumed that all school nurses functioning at this level performed routine screening, using a standard screening protocol.

The nurses however reported that this was not the case. In the focus group discussion, they stated that a "concrete" (Nurse 2) method does not exist leaving many school nurses to "do their own thing" (Nurse 1). The school nurses are also not quite comfortable with screening audiometry, with many thinking that the test itself requires too much time, and for this reason they seem to be resorting to other, seemingly simpler screening methods such as the voice test. However, even these simpler methods are not used by all the nurses.

This is confirmed by the extracts below:

Nurse 1: We used to use, [or] I use the one [screening test] with the words [voice test]..."

Nurse 2: "I never used that [words test]...for Audiology [hearing screening] we never really had anything concrete."

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This lack of consistency could be due to the fact that the nurses are unhappy with the voice test's performance. Their feedback implied that the voice test does not yield consistently reliable and accurate results thereby reducing their ability to identify all learners with hearing loss. This is confirmed by the extract below:

Nurse 1: “[words test] was not really working...I would say we don't [identify all learners with possible hearing loss], we don't definitely...”

The nurses' viewpoint is shared by Pirozzo, Papinczak and Glasziou (2003) who conducted a systematic review of the relevant literature to determine the accuracy of the voice test. They reported that although the test is simple, it has a low level of sensitivity when conducted on children and the lack of consistency in the test results was of particular concern, especially in primary care settings such as schools.

Based on the school nurses' feedback they were aware of the importance of conducting routine hearing screening in schools and thought that a more appropriate protocol for screening was necessary to enable them to do so. The nurses furthermore reported that the screening protocol should not only yield accurate results but should also be quick and easy to administer and interpret. Such a screening protocol would in turn allow them to implement the universal hearing screening program for the target group (i.e. Grade R & Grade 1 learners) as originally envisioned and described in the operational handbook (School Health Operational Handbook, DOH, 2003).

4.1.1.1.2. Sub-theme (b): Referral pathway.

Another important resource for an effective screening program is the referral pathway between the school-based audiological service and audiological services at district or secondary levels of service delivery. The school nurses reported that this kind of referral pathway is currently not in place. According to their feedback, a community-based Audiologist was previously employed to function in the sub-district and was not only involved in managing the school hearing screening program, but also served as their primary referral centre, should a learner fail the school-based screening test or should the school nurse fail to conduct the screening test. The Audiologist would then attend to the learner and refer the learner on to secondary or tertiary level institutions if further testing or management was required. According to the school nurses, this system worked well but since the community-based Audiologist is no longer employed there, it leaves a significant gap in the hearing screening program. There are no other support services available to them as was confirmed by the extract below:

Nurse 1: “I don’t feel like that [like we have support], honestly no. The only support we had was the CHC [Community Health Centre] Audiologist and she left....now if we have a problem that needs a referral to an audiologist we go to the clinic then they refer [to tertiary hospital]. You just have to follow the system.”

A similar trend was noted in the evaluation of KwaZulu-Natal’s school health services (Edwards-Miller & Taylor, 1998), highlighting the need for an effective referral pathway. These researchers reported that out of 156 learners seen by one of the school nurses in the province, 108 were given a letter of referral for further evaluation/management of the problem. Due to the fact that these follow up tests could only be conducted at a tertiary level institution outside the community, only 53% of these learners actually received the necessary treatment. It was

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suggested that one of the primary reasons for this shortcoming was the lack of specialist services in the area. Thus since the school nurses in the area could not refer learners to an accessible referral centre it resulted in poor coverage of the referrals which potentially led to a significant number of undiagnosed cases of hearing loss.

The referral pathway from the school to tertiary institution is clearly ineffective, which is a cause for concern when one considers the process of hearing loss identification and intervention, as described in Figure 4 in *Chapter 2*. In this process screening should be followed by appropriate referrals and prompt action to confirm hearing status and manage the learner accordingly. However, if the pathway does not include a referral centre that is accessible and affordable, the learner in need of further testing and/or management (based on the screening results) will not receive the necessary services and subsequent benefits of early identification of the hearing loss (Störbeck & Pittman, 2008).

This gap in school health screening programs must be urgently addressed, particularly when considering the changing model of health delivery in South Africa. Based on the emerging model the emphasis is on providing a comprehensive package of care to those members of the community requiring health services within the home and school environment, and so increase the accessibility and affordability of healthcare for all (Comprehensive Service Plan for the implementation of Healthcare 2010: Draft for consultation, DOH, 2006; Power & Kibel, 1995). In order to align the school hearing screening service with this model, the current referral criteria and pathway must be addressed.

4.1.1.1.3. Sub-theme (c): Test environment.

According to the nurses, another factor that contributed to the lack of accurate hearing screening results is the unacceptable noise levels in the school-based test environments.

Nurse 1: “.....it’s difficult sometimes to do the hearing test with the audiometer in school because the school is close to the main road....or its interval....or other outside noise interferes.”

For this reason, it is important to ensure that the ambient noise level in the selected test environment is acceptable. According to the American National Standards Institute (ANSI) document, *Maximum allowable ambient noise levels for 20dB HL screening level* (ANSI S3.1-1991 in Katz, 2002), the uppermost limit for acceptable ambient noise levels are 41.5dBSPL at 500Hz; 49.5dBSPL at 1000Hz; 54.5dBSPL at 2000Hz and 62dBSPL at 4000Hz.

If however, the test environments have unacceptably high levels of noise, the screening may yield a significant number of false positive results, or the nurses may not be able to screen at all. Similarly, high levels of ambient noise may also distract the learners thereby affecting their ability to concentrate on the required task which may involve listening for and responding to a test stimulus (McPherson & Olusanya, 2008).

4.1.1.2. Theme 2: Human resources.

Human resource constraints also appeared to be one of the primary reasons for the current state of the school’s hearing screening service. Specifically, the school nurses attributed this unsatisfactory situation to the inadequate number of individuals who make up the school health team, their workload, and the insufficient level of competency of staff members’ skills pertaining to hearing screening. Thus, *human resources* were considered an important context-specific need.

4.1.1.2.1. Sub-theme (a): Staff numbers.

With regard to the make-up of each school health team the school nurses reported that each team varies and is based on the staff: learner ratio in a given district. The school health team is ordinarily headed by a professional nurse, and the team may include a combination of professional nurses (PNs), staff nurses (SNs) and enrolled nursing assistants (ENAs), all affiliated to the local CHC (National school health policy and implementation guidelines, DOH, 2002; van Coeverden de Groot & Greenfield, 1995).

The participating school nurses reported that their school health team initially included a group of eight staff members, divided into four smaller teams with two nurses in each team. Each smaller team would then include one PN and one SN/1ENA and this team would then service a specified area in the sub-district. According to the school nurses, these teams together service approximately 51 primary schools annually. They furthermore reported that, since the start of this study one PN had resigned from her post in January 2008, resulting in an increase in the remaining staff members' workload. This concern was voiced by one of the school nurses in the transcript extract below:

Nurse 1: “...we cover about 51 schools, primary schools in the district and if we are full staff competency then we can manage to do that but if we not then we have some uncovered areas...So there's a lot of pressure on us”.

In order to alleviate some of the school nurses' workload, CHWs were introduced into the school health system. These CHWs work closely with the school nurses in the district, by assisting in the provision of basic health services and health promotion (Comprehensive Service Plan for the implementation of Healthcare 2010: Draft for consultation, DOH, 2006). Their scope of practice is however rather limited and although they may conduct some basic screening tests

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(for example, eye tests using the eye chart), they are primarily involved in health education (Comprehensive Service Plan for the implementation of Healthcare 2010: Draft for consultation, DOH, 2006).

This was also confirmed by the school nurses:

Nurse 1: “They just do the very basics, they do the weights and the heights, the visual acuity and the health education. Primarily they function under school health education.”

Thus, despite the CHWs input the school nurses still feel that they are under a significant amount of pressure. This kind of pressure is also shared by school nurses working in other parts of the country. In KwaZulu-Natal the school health services were evaluated in May 1998 (Edwards-Miller & Taylor, 1998) and researchers reported that insufficient school health staff was a serious problem in the province. This shortcoming together with the high enrolment figures at schools resulted in poor coverage of schools in the area and a less comprehensive school health service package (Edwards-Miller & Taylor, 1998). Similarly, researchers suggest that on a national level school health nurses and related health practitioners experience many hurdles including disproportionate personnel-to-patient ratios.

For instance, Ramma (2009) conducted a study in which the implementation of the National School Health Policy was evaluated in two primary schools in Cape Town. The findings indicated that the current school health team: learner ratio in schools that are similar to the schools included in the present study is 1 team: 3,000 Grade R/1 learners and 1 team: 16, 400 learners (Grade R-12).

Such disproportionate ratios unavoidably increases the amount of pressure placed on nurses which often restricts them from working to their full potential, thereby affecting the efficiency

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and effectiveness of the services provided (Pillay, 2009). Given these staff shortages, one can deduce that school health services and related staffing issues are not prioritised appropriately making the provision of effective school health services very challenging. This explains the nurses' feedback pertaining to poor coverage of screening in schools in the sub-district under investigation.

4.1.1.2.2. Sub-theme (b): Workload.

When considering the school health service package, school nurses were initially required to complete comprehensive general screening of all Grade R and Grade 1 learners, including an abdominal examination, eye test, hearing screening and ear examination, skin examination, height-weight measures, mouth, throat, dental examinations; screening of motor abilities and personal hygiene issues. In addition, they were required to provide health services to learners with specified health needs as well as general health promotion activities with all learners and educators where necessary (School Health Operational Handbook, DOH, 2003). In terms of hearing screening this meant that the nurses were initially required to conduct universal hearing screening on the target group, which included grade R and Grade 1 learners as well as high risk hearing screening for learners in other grades. More recently however the service package has been revised to accommodate for the reduction in staff numbers and the subsequent reduction in the amount of time spent at each school (V. Kruger, personal communication, March 2008).

Nurse 2: "...we mainly focus on the Grade R's and the Grade 1's, and we do a superficial screening compared to the one we did before. We just sort of do the head part, we test the eyes, we check their ears to exclude wax and we do height and weight [measures]...We used to do a more complex screening where we do the whole gross motor and all of that but we don't do that now because government says there is too few of us to do all of that at one school..."

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Nurse 1: "...if they walk in you do a quick assessment...it's just very, very basic."

The nurses reported that they spend approximately two weeks at each school for the year, providing basic health services. They furthermore stated that this revised service package was not only less comprehensive than the previous one, but also less effective. Hearing screening is one of the services that is no longer deemed a priority area. According to the school nurses they occasionally conduct basic hearing screening in "high risk" cases but manage to routinely examine the learners' ears, i.e. perform otoscopy, for any visible signs of abnormality. In addition, the school educators are given information about the indicators of hearing loss to enable them to identify learners with possible hearing problems. In some instances, the school nurse may conduct informal hearing screening on the learner using the voice test, but in other cases these learners may be referred to a tertiary hospital for basic hearing assessments. The current hearing screening protocol is briefly outlined in the extract below:

Nurse 1: "We have a form that is primarily for the teachers because they are there to observe the children so obviously when they educate the kids they can detect which one has a hearing problem...once they detect and then the form comes to us, we look into the ears....then we refer the child so that is the way we are doing things at the moment....I sometimes use the one [screening test] with the words [voice test]...but we cannot detect properly"

Based on this feedback it would appear that the nurses' current workload makes it difficult for them to perform routine hearing screening in the schools, and in the instances where screening is conducted, the screening methods are considered ineffective and unreliable. Therefore, learners with possible hearing loss may be missed and unreliable test results may lead to inappropriate referrals.

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In addition to the school nurses' workload, they also reported that the Western Cape Department of Health recently set certain targets for each school health team to meet. For instance, one of the requirements is that 780 Grade R/1 learners must be screened by the end of each school term (V. Kruger, personal communication, March 2008). It was quite apparent that these expectations placed a lot of pressure on the nurses and could in turn affect the quality of the services provided at each school. Their concerns are shared in the extract below:

Nurse 1: “...we a bit unhappy at the moment because they haven't come into the areas [the sub-districts], they just gave us an amount according to the estimation of the population of Mitchell's Plain and then they say you have to screen so much Grade R/1 learners by [specified date]...”

Nurse 1: “...because of this time limitations and to reach target...and doing this Audiology examination [audiometry] would take such a lot of time. We do what we can do but they [Department of Health regulations] want us to get the stats out....now at the moment it's just about quantity and not quality, it puts a lot of pressure on us...”

Similar views were shared by school health teams in KwaZulu-Natal. When evaluating the school health services in this province, it was reported that school nurses were unable to provide all the services that they would like to and were required to. Given their workload and general constraints they were unable to provide both preventative and promotive services effectively (Edwards-Miller & Taylor, 1998). Similarly, Pillay (2009) reported that an increased workload for nurses, often resulting from severe staff shortages, has been shown to contribute to nurses' dissatisfaction in South Africa as it affected their productivity as well as clinical outcomes.

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4.1.1.2.3. Sub-theme (c): Staff competency level.

Another constraint pertaining to the human resources was the nurses' perceived level of competency in the skills pertaining to hearing screening. Although many of the school nurses generally thought that they were adequately equipped to conduct basic hearing screening including: otoscopy; audiometry and in some cases the voice test, they were not all equally confident in their abilities and thought that additional training would be beneficial. These views are shared in the extracts below:

Nurse 2: "I just have a problem with the normal ear examination. There's a lot of times I still struggle...I'm sure it only comes with years [of experience] and [we need] more training....then we'll be able to do the audiometry."

Nurse 1: "I personally feel that I'm not [equipped to conduct hearing screening], I know how to work the audiometer because we received training but my concern is still detecting children [properly]..."

According to the School Nurses' Operational Handbook (DOH, 2003), the school nurse must be informed and knowledgeable about the following issues in order for the school-based hearing screening program to be effective:

- Signs and symptoms of hearing problems
- Procedures & protocols for hearing screening (including otoscopy & screening audiometry)
- Use, maintenance and care of screening equipment
- Ideal testing environment
- Test variables and how to manage these variables (including factors that can lead to a false reading)

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- Criteria for referral (including knowledge of basic ear pathologies)

If the school nurses are not competent in these areas, it can reduce the effectiveness of the screening program. School nurses may for example, fail to detect cases of possible hearing loss due to a poor understanding of the screening procedures and protocols. Another possibility is that the nurses may not fully understand the criteria for referral thus resulting in an unacceptably high over-referral rate (Gell et al., 1992). Bearing this in mind, the school nurses' needs regarding additional training and support should be addressed.

In order to address these challenges and ensure that school nurses provide school-aged children with the best audiological care possible, their context-specific needs must be met. After careful consideration of the nurses' feedback regarding their current work situation and primary concerns, the researcher extracted the following representation of their context-specific needs. These needs are categorised as: the needs pertaining to screening program resources and the needs pertaining to human resources, and is summarised in Figure 10.

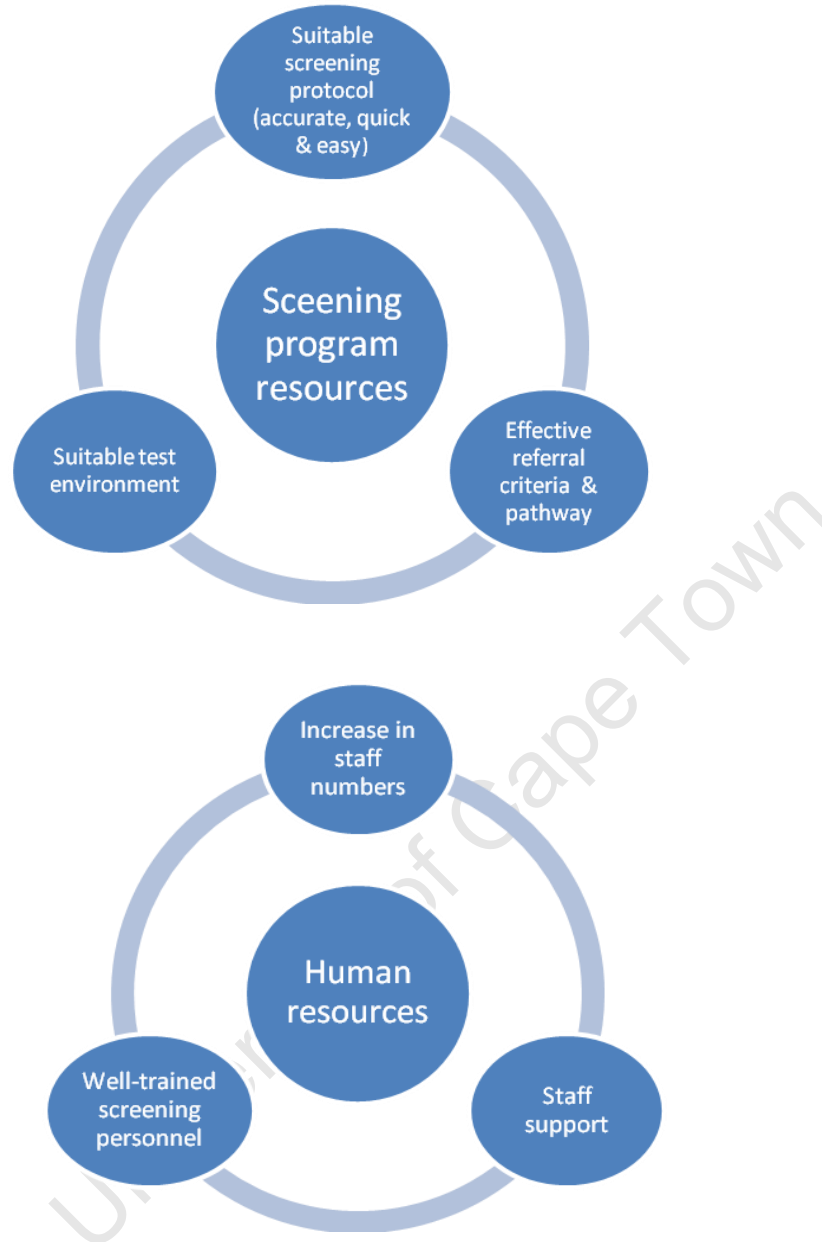


Figure 10: The school nurses' context-specific needs

Since the present study generally aimed to improve the state of school-based hearing screening services in the sub-district, all the nurses' needs were considered. However, one of the more critical context-specific needs was for a screening protocol that was: quick and easy to administer and interpret given the human resource constraints and the need for universal

screening of the target population, reliable and valid, yielding accurate results and clear referral criteria, and considerate of noise in the typical school context.

Therefore the specific focus of the study is on addressing the need for a suitable screening protocol that meets the contextual needs identified in objective (a). For this purpose the next step of the study was to identify hearing screening tests that could form part of such a contextually-relevant protocol. In this case *screening tests* are defined as the specific tools designed to separate those individuals who are possibly affected by a condition from those who are not, whilst the *screening protocol* refers to the set of screening tests forming part of the screening process and the sequence of these tests.

4.1.2. Objective (b): To identify and select two hearing screening tests that met the context-specific needs.

Following the systematic appraisal of the related literature pertaining to hearing screening tests a total of 33 studies were included in the final review. From these studies, specific data was extracted and synthesized to enable the researcher to make certain inferences. The information derived from this data synthesis process included:

- A summary of the hearing screening tests included in the review.
- The frequency with which each test is used in the reviewed studies.
- The sensitivity and specificity of the hearing screening tests reviewed.
- A rating of the suitability of each screening test based on test time, ease of administration, ease of interpretation of results and sensitivity to background noise.

4.1.2.1. *The hearing screening tests included in the review.*

The systematic review included an array of hearing screening tests, both objective and behavioral in nature. The behavioral tests included the pure-tones test (reported in 7 studies); voice test (reported in 3 studies); video test¹⁰ (reported in 1 study) and questionnaires (reported in 4 studies). The objective tests included Oto-acoustic emissions (OAEs) (reported in 14 studies); Automated Auditory Brainstem Response (AABR) (reported in 3 studies) and Immittance test (reported in 1 study). Refer to Appendix F for the data extraction tables containing information for each study included in the review.

4.1.2.2. *The frequency with which each test is used (across reviewed studies).*

OAEs was the screening test of choice in 14 of the 33 reviewed studies. Other screening tests commonly used were pure-tone testing (7 studies) and parental questionnaires (4 studies). This information is in agreement with the present study's findings in objective (a), in which the school nurses indicated that pure-tone testing was sometimes utilised in the schools. The frequency distribution of these tests as well as the remaining screening tests included in the review is illustrated in Figure 11.

¹⁰ The video test is similar to the pure-tone test but instead of presenting the tones with an audiometer via earphones, a specialised video is used to present the stimuli in the freefield (Bento et al., 2003).

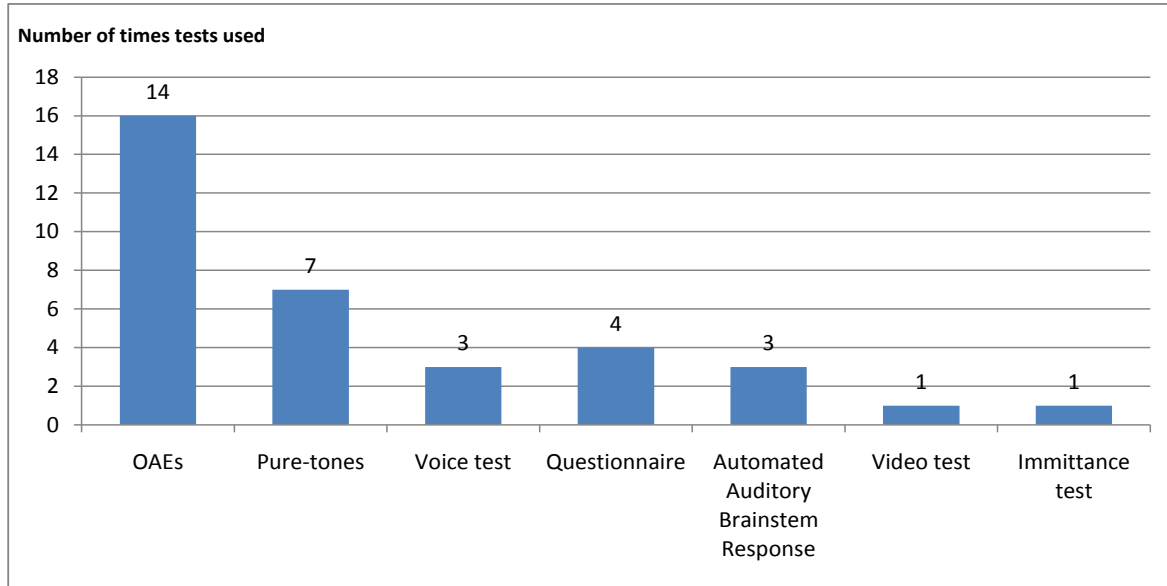


Figure 11: Distribution of hearing screening tests evaluated in the review

4.1.2.3. The sensitivity and specificity of the hearing screening tests reviewed.

The sensitivity and specificity values of the screening tests included in the review are summarised in Table 7. The figure illustrates the varying levels of sensitivity and specificity reported in the different studies for each screening test. However, only 20 of the 33 reviewed studies reported sensitivity values and 21 of these reviewed studies reported specificity values. This resulted in limited data for certain screening tests such as the pure-tones test where only two of the seven studies related to pure-tone screening reported on sensitivity and specificity values.

Table 7

Sensitivity and specificity of the screening tests in identifying risk of hearing loss

Screening Tests	Results for the reviewed studies										
	Sensitivity					Specificity					
OAEs	65	81	93	97	100	55	67	82	90	91	95
Pure-tone screening	86	87				70.2	80				
Voice test	80	83	90			70	90	96	98		
Questionnaires	10	19.7	56	100		52	75	94	97		
Video test	100					79.8					
AABR	90	99	100			90	93				
Immittance test	52					74					

From these results it is evident that five out of the seven screening tests consistently show substantial levels of both sensitivity and specificity for correctly identifying risk of hearing loss.

This includes:

- OAEs with sensitivity and specificity levels that are mostly between 80-100%, as reported in six of the reviewed studies
- Pure-tone testing with sensitivity and specificity levels of approximately 70-87%, as reported in two of the reviewed studies
- Voice test with sensitivity levels that are above 80% and specificity levels that range from 70-100%, as reported in four of the reviewed studies
- Video test with a sensitivity level of 100% and a specificity level of approximately 80%, as reported in one of the reviewed studies
- AABR with sensitivity and specificity levels that range from 90-100%, as reported in three of the reviewed studies

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The studies for the remaining screening tests i.e. questionnaires and immittance test did not show consistently substantial levels of sensitivity and specificity for these tests, and for this reason the screening questionnaires and the immittance test were excluded from the rest of the analysis process. Another interesting finding is the high variation of the sensitivity and specificity values across different studies for certain screening tests. For example, in Table 7 the questionnaire is depicted as having a sensitivity value of 100% in one study, but 56% is then reported in a second study and 10% in yet another study. This degree of variation is problematic as one cannot safely deduce that the measure is “sensitive” in the detection of hearing loss, regardless of the 100% sensitivity reported in the first study. Furthermore, the results of the video test and immittance test (previously excluded from the analysis) must be interpreted with caution as these sensitivity and specificity values reflect findings from one study. For this reason, the reproducibility of the results is questionable and may lead to inaccurate interpretation of the present study’s findings (Teddlie & Tashakkori, 2009). It was thus decided to exclude the video test from the rest of the analysis process and this lack of reproducible results also further justified the exclusion of the immittance test from the analysis.

Although the remaining four screening tests have consistently demonstrated sufficient levels of sensitivity and specificity, they may not be suitable for application in a school setting. For example, the AABR may have high levels of sensitivity and specificity but it may be too costly to implement and sustain such a screening program in a school setting as it requires expensive equipment and consumables such as disposable electrodes. This is an important factor, especially if one considers the resource constraints identified in the *Introduction* chapter as well as the feedback from participants on availability of resources. It is thus important that the suitability of the tests be examined to determine whether the test methods and administration accord with the

target population, context and contextual needs identified in objective (a). The screening tests that consistently showed acceptable sensitivity and specificity levels were thus further scrutinized to determine their suitability for use in a school setting, based on: test time, ease of administration, ease of interpretation of results, and sensitivity to background noise. The remaining tests included the voice test, AABR, OAEs and pure-tone screening.

4.1.2.4. Suitability of test features for a school setting.

As previously outlined in *Chapter 3*, the decision regarding the suitability of the screening tests involved a three-step process, which included:

1. A representation of the impact of frequently reported test variables.
2. Scoring of each screening test.
3. Graphical representations of scores for each screening test.

Since step one and two involved only preliminary aspects of the decision-making process, the outline of these steps are included in the appendices. Refer to Appendix V for the representation of the impact of the test variables and the scoring process involved. Step three however included the desired information pertaining to the suitability of the screening tests' features for a school setting and this information is discussed here.

4.1.2.4.1. Graphical representations of scores for each screening test.

A score was obtained for each test variable for each screening test in the review and these scores were graphically represented in Figure 12.

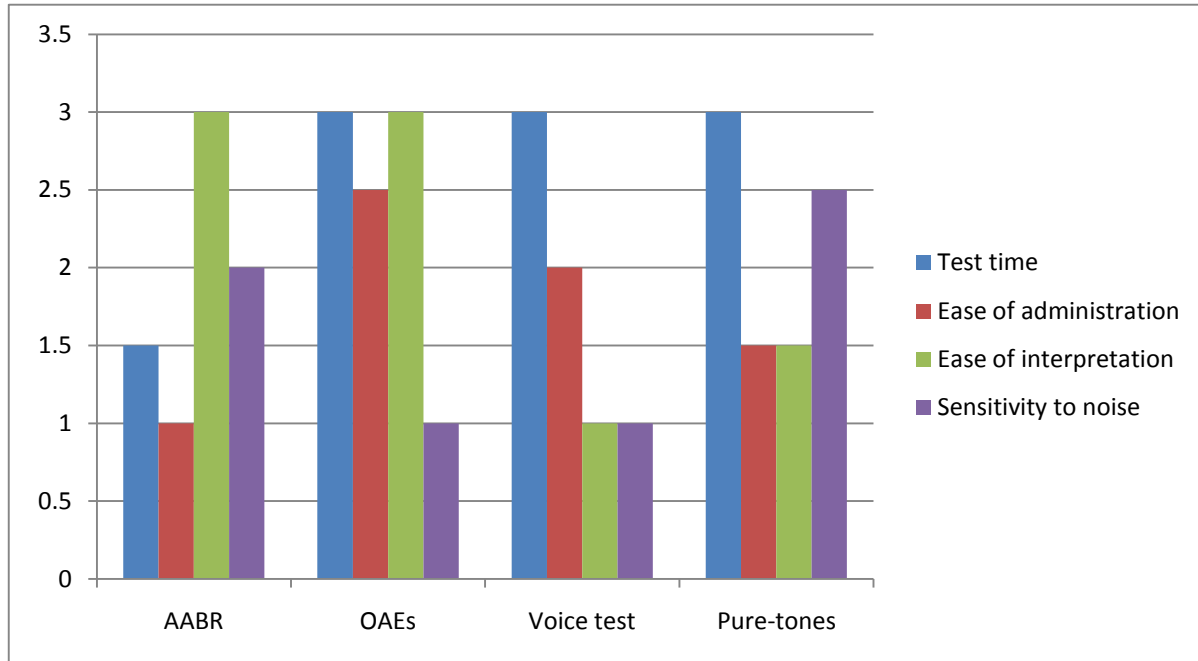


Figure 12: The scores for *test time*, *ease of administration*, *ease of interpretation* and *sensitivity to noise* for the reviewed screening tests

Based on this bar graph, one can compare the scores obtained for test time, ease of administration, ease of interpretation and sensitivity to noise for each test. Since the test variables included in the bar graph is directly related to the school nurses' requirements pertaining to a hearing screening protocol; as identified in objective (a) of the study, one can deduce that the test with the most favorable score also represents the test best suited for use in a school setting (W. Wilson, personal communication, December 2009).

4.1.2.4.1.1. Test time.

Based on Figure 12, AABR seems to require the most test time with a low score of 1.5, making it the least suitable screening test for this particular variable. This could be due to the amount of time required to prepare the learner for AABR, as the process involves many stages including adequate scrubbing of the learner's skin, and appropriate electrode placement (Watson,

McClelland & Adams, 1996). On the other hand, OAEs, the voice test and pure-tone screening have a score of 3, making them less time-consuming and therefore more suitable than AABR when considering this test variable.

4.1.2.4.1.2. Ease of administration.

Figure 12 shows that OAEs is the easiest screening test for a non-specialist to administer, followed by the voice test. AABR on the other hand requires a fairly high level of expertise. This could again be due to the patient preparation procedure which can be challenging if the appropriate training and practice is not provided (Watson, McClelland & Adams, 1996). Pure-tone screening has a score of 1.5, reflecting the need for only moderate levels of expertise. A possible explanation for this finding may lie in the behavioral nature of the test. Since the tester requires active participation from the learner, s/he must establish rapport and condition the learner appropriately so that s/he is responsive and compliant. In some cases, for example, with a difficult child, this may not be easily achieved thereby affecting the ease with which the test is administered (Roush, 2001).

4.1.2.4.1.3. Ease of interpretation.

Figure 12 indicates that the test results for both OAEs and AABR are the easiest to interpret and could thus be reliably interpreted by a non-specialist. This could be due to the objective nature of these tests as opposed to the behavioral nature of the voice and pure-tones test which earned scores of 1 and 1.5, respectively. The findings thus suggest that the interpretation of the behavioral test results requires some degree of subjectivity (and expertise). However, for OAEs and AABR the test machine simply indicates a 'pass' or 'fail' result which eliminates the need for the tester's own interpretation (Watson, McClelland & Adams, 1996).

4.1.2.4.1.4. Sensitivity to noise.

Based on Figure 12, the pure-tones test is the least sensitive to noise, making it the most suitable screening test in a relatively noisy test environment. The voice test and OAEs appear to be the screening tests that are most affected by background noise. With regard to the voice test this could be due to the test procedure in which the tester manipulates his or her voice to present words at varying loudness levels (Prescott, Omoding, Fermor & Ogilvy, 1999). Here, the effect of background noise may vary depending on the loudness of one tester's voice vs another tester's voice (Eekhof, de Bock, de Laat, Dap, Schaapveld & Springer, 1996). AABR scored more favourably than OAEs and the voice test, obtaining a score of 2. Based on this result it would appear that the AABR is only moderately affected by background noise.

The final step of the data synthesis process was to add all the scores (obtained for each test variable) for each of the screening tests to determine the final rating of *suitability* for each test. Based on the scoring system, a higher score represents a screening test that is more suitable for use in a school setting. These *suitability scores* are graphically presented in Figure 13.

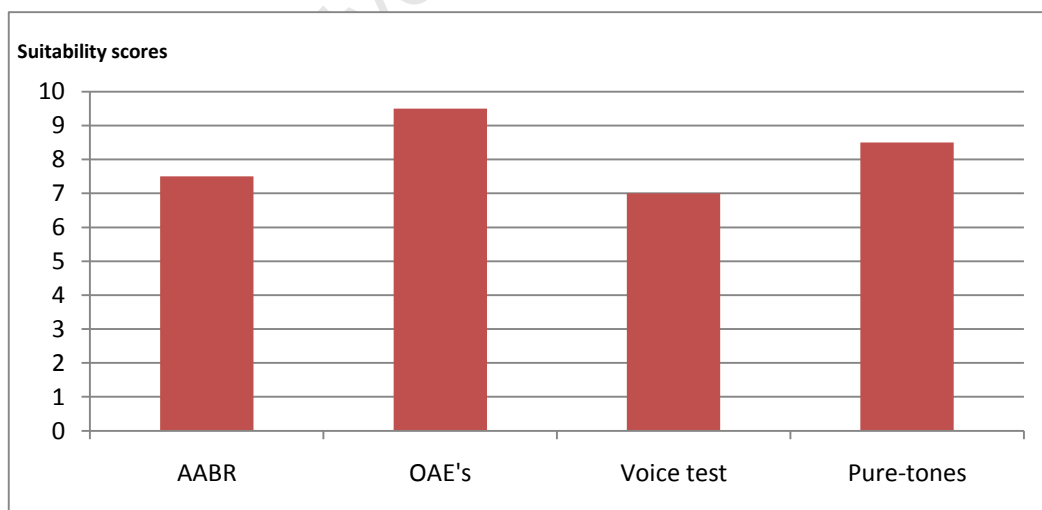


Figure 13: The overall *suitability score* of the reviewed screening tests

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When considering this rating of suitability, OAEs appears to be the most suitable screening test for use in a school setting, with a score of 9.5. The second highest rating was achieved by the pure-tone screening test; 8.5 indicating that it is also applicable for a school setting. Thus, based on the systematic review of the literature, OAEs and pure-tone screening were the two most suitable hearing screening tests for use in a school environment.

The next step of the research study was to determine which of these two screening tests would be better suited for a school-based hearing screening protocol. According to the reviewed literature when one uses either one of these screening tests, it will provide the tester with a good indicator of the learner's hearing sensitivity thereby indicating whether or not a learner is likely to have a hearing loss (Martin & Clark, 1996). The tests are however not direct measures of the learner's outer and middle ear status which could be considered problematic given the prevalence of outer and middle ear problems in the school-aged population.

Minja and Machelmba (1996) conducted a prevalence study in rural and urban Dar es Salaam, Tanzania and reported that 27.7% of the 802 primary school children in their sample were found to have middle ear disease and a further 15.7% of this sample had cerumen impaction. Similarly, Saim, Saim, Saim, Razsymah and Sani (1997) conducted a prevalence study amongst pre-school children in Malaysia and reported an overall prevalence rate for Otitis media with effusion of 13.8%. Although prevalence data is lacking for the South African context, middle ear outer and middle ear problems were found to be common in the paediatric population, including infants and older children (Copley & Friderichs, 2009). Furthermore, the long-term implications of undetected middle ear problems, including delayed speech, language and academic development, should also be considered (Pugh, Burke & Brown, 2004). If these findings and the possible presence of middle ear pathology is not considered in paediatric screening programs, the

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reliability of the test results can be called into question (Pugh, Burke & Brown, 2004). For instance, the learner could present with otitis media which results in a fail results on the hearing screening tests. The tester could mistakenly consider this a cochlear hearing loss and so manage the case accordingly (Jacob et al., 1997).

Despite the obvious benefit of including tympanometry as part of a school-based screening protocol, its inclusion is still a contentious issue as middle ear pathology is often transient with high rates of spontaneous recovery. Thus by including tympanometry testing it could result in over-referrals and increased follow-up costs (Gell et al., 1992). After careful consideration of this research debate, it was decided to include otoscopy (to examine the outer ear) and tympanometry (to measure the functioning of the tympanic membrane and give an indication of middle ear status) to both proposed screening tests to form two protocols designed to address the screening program goal, which is to identify learners with possible hearing loss and middle ear pathology.

These hearing screening protocols included:

Protocol A: Otoscopy → OAE's → tympanometry

Refer to Figure 14 for a flowchart of this screening protocol, including the follow up protocol if further testing is required. Here, the sequence of each test is very important. Firstly, the tester cannot insert any probe into the learner's ear canals without determining the status of the outer ear. For example, if the outer ear is painful due to infection, the learner may not tolerate the OAE probe in the ear. Similarly if the learner has impacted cerumen completely blocking the ear canal, any test's results may be compromised. It's thus important to identify and eliminate such problems before testing the learner's hearing. Secondly, in order for the learner to pass the OAEs test, the pathway from the outer ear to the cochlea must be relatively unobstructed. Thus, if a

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child has a significant middle ear problem, for example, glue ear, the OAE result will probably indicate a fail. The fail result can thus be caused by either a middle ear or cochlear problem. In order to determine the specific reason for the fail result, tympanometry can then be applied to assess the status of the tympanic membrane and functioning of the middle ear. Furthermore, when considering the pathway for the OAE test, the decision to test OAEs before tympanometry also makes the protocol more efficient as a pass result on the OAEs indirectly informs the tester about the learner's middle ear status. Thus, the sequence of testing is critical. It should however be noted that OAEs is not always sensitive to middle ear dysfunction and should thus be supplemented by tympanometry to more consistently identify both cochlear and middle ear problems (Driscoll, Kei & McPherson, 2001).

Protocol B: Otoscopy → tympanometry → pure-tone audiometry

Refer to Figure 15 for a flowchart of this screening protocol, including the follow up protocol if further testing is required. Here again the inclusion of otoscopy as the first procedure in the protocol is very important in order to identify, manage and/or eliminate problems in the learner's outer ear. The sequencing of tympanometry and the pure-tone screening test is however, of no real consequence to the efficiency and efficacy of the screening protocol, provided both tests are included. With these two screening protocols in mind, the researcher sought to determine the most applicable protocol for use in a school setting.



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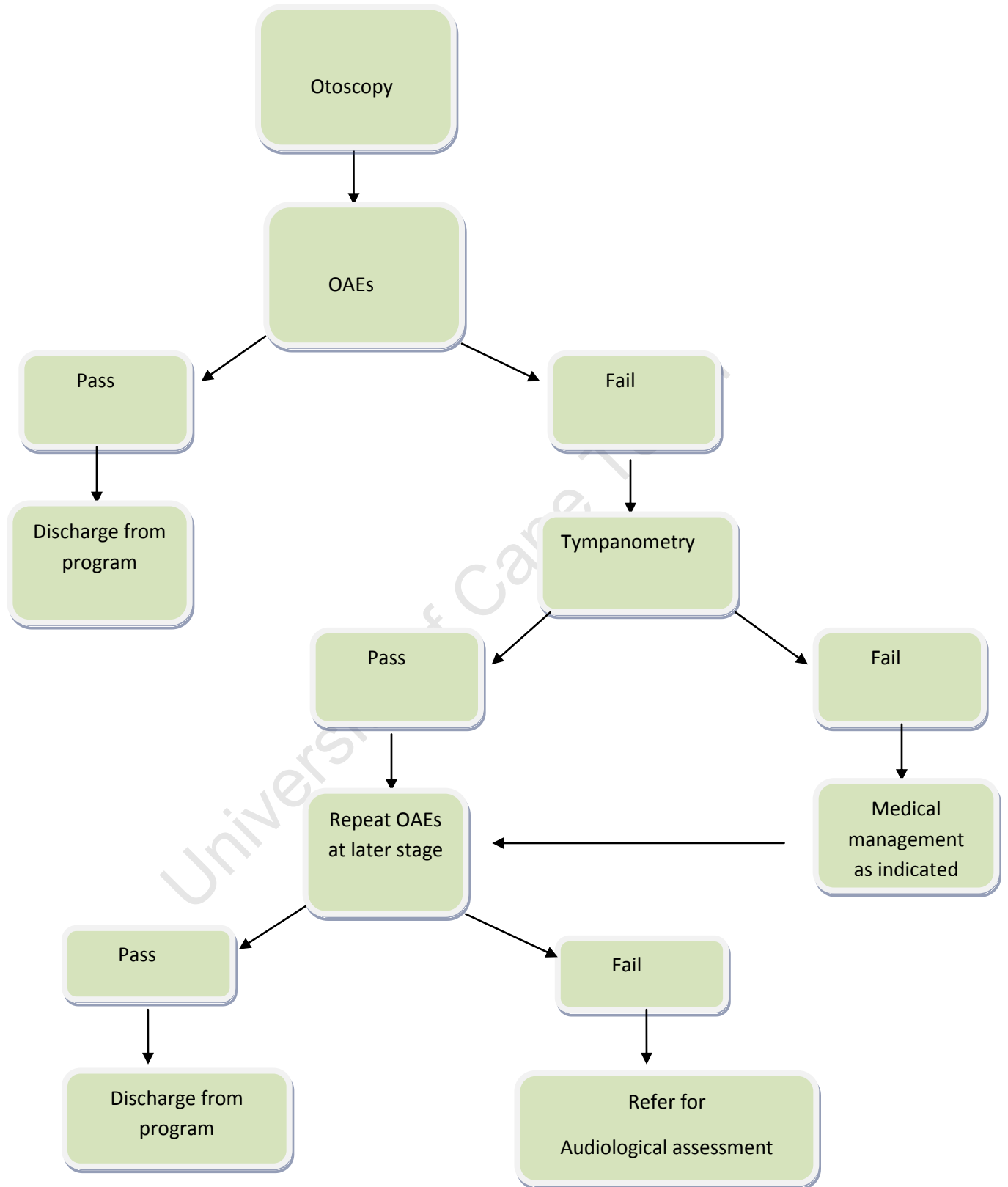


Figure 14: Flowchart of Protocol A

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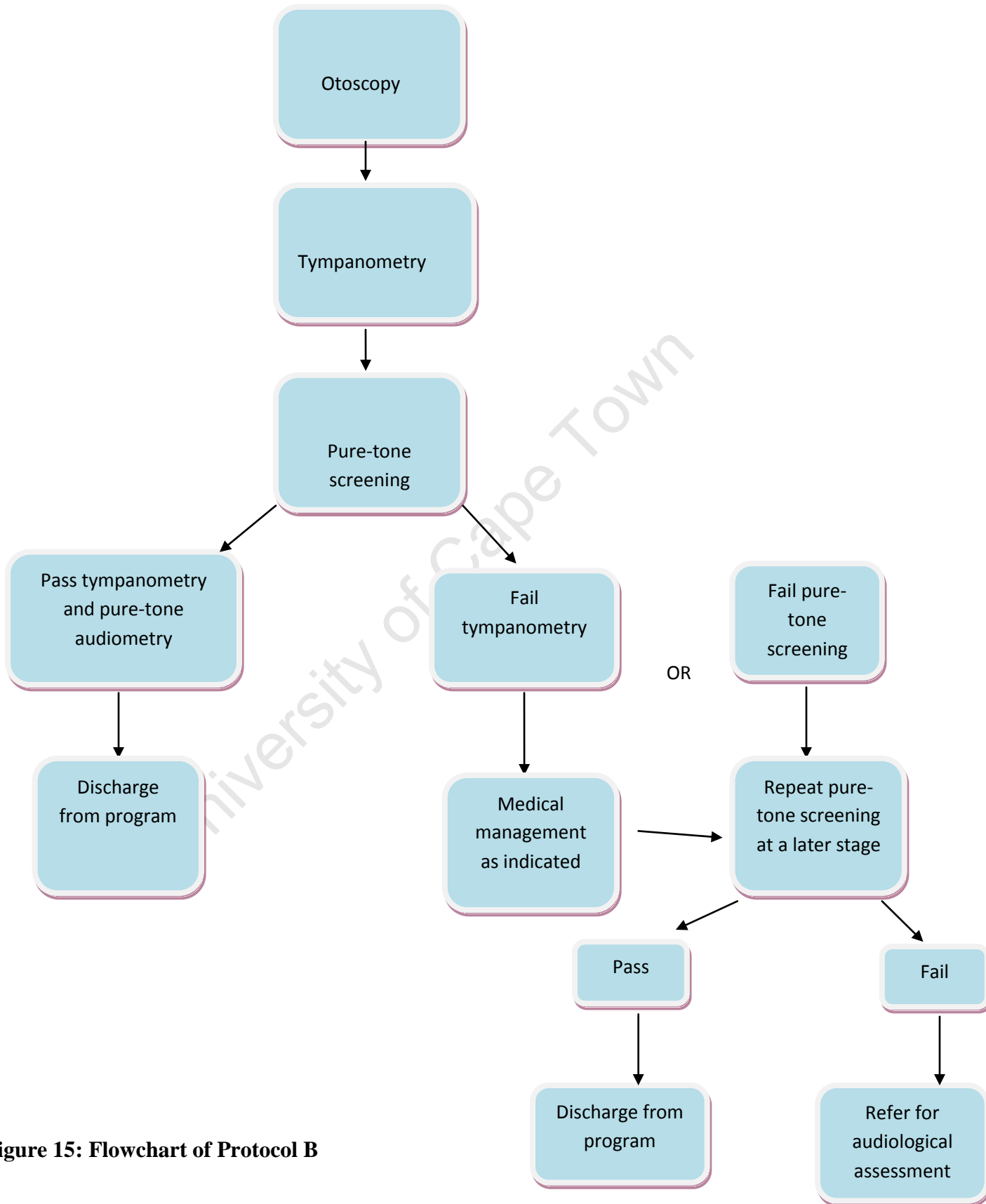


Figure 15: Flowchart of Protocol B

4.1.3. Objective (c): To select the most suitable screening protocol that met the requirements for a contextually relevant protocol.

By adhering to the participant selection criteria described in *Chapter 3*, the resulting sample comprised of two senior school nurses and two senior audiologists, thereby balancing the panel in terms of school health and audiological areas of expertise. The results for this objective include: the rating scale responses and the findings from the expert panel discussion.

4.1.3.1. Rating scale responses.

In order to compare each rater's responses to Protocol A (Figure 14) vs Protocol B (Figure 15), radar charts were constructed presenting the responses for each of the items on the rating scales for each protocol rated. Refer to Appendix W1, W2, W3 and W4 for the graphical representation of responses obtained for Raters 1, 2, 3 and 4, respectively. Although the raters' responses varied, the general trend suggested that Protocol A (including Otoscopy, OAEs and Tympanometry) is more suitable for implementation in a school setting. The ratings obtained by all raters for Protocol A are summarized in Figure 16. The response options were from 0 to 4, as marked in bold print in the radar, with 0 being the least favorable rating and 4 being the most favorable rating. The scores of 0 to 4 also correspond with the sequence of the circles on the radar. Furthermore, each line in the radar represents an item in the rating scale. Thus the description of each scale item is provided next to the corresponding radar line.

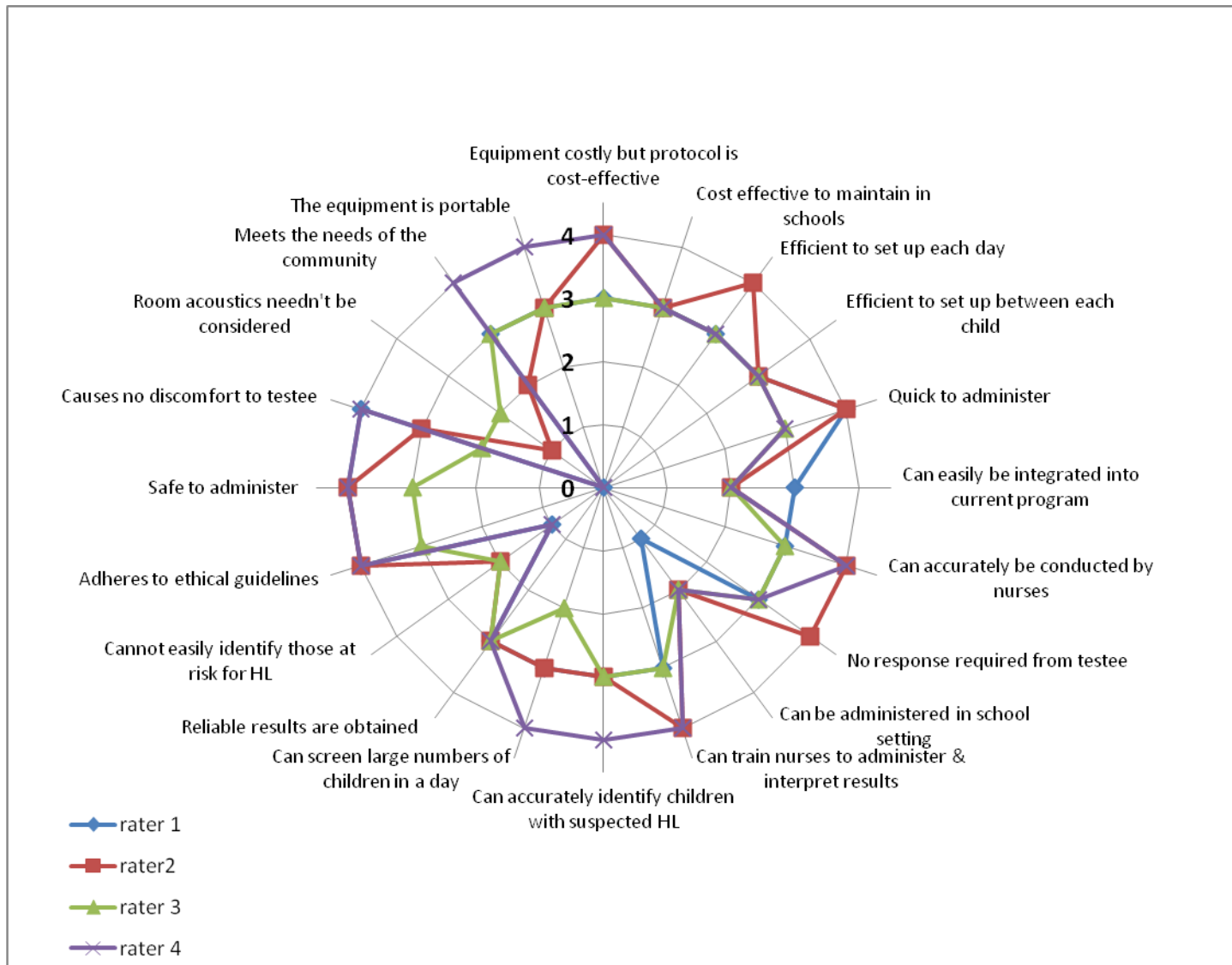


Figure 16: Rating scale responses obtained for Protocol A

Refer to Appendix W for an illustration of the rating scale responses for Protocol B. To ensure that the final decision regarding the most suitable protocol for implementation in Phase 2 of the study, was a true reflection of the experts’ judgment and that no misinterpretation occurred, a group discussion followed this rating process. In this discussion any differences of opinion or misinterpretations could be resolved, resulting in a single, collective decision.

4.1.3.2. Qualitative findings of expert panel discussion.

After analyzing the data, two broad themes were identified. These themes and the related sub-themes are illustrated in Figure 17.

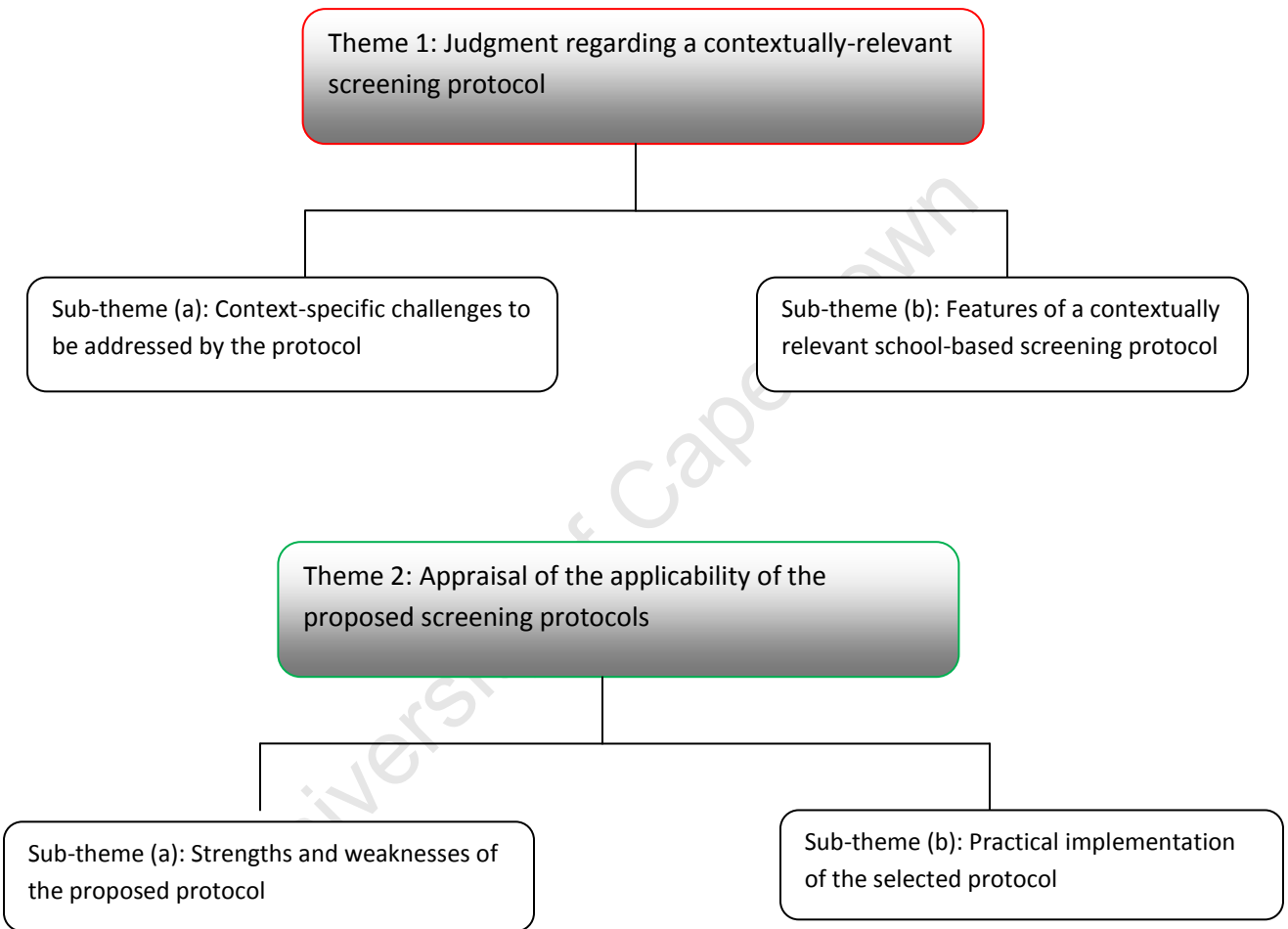


Figure 17: The themes and resulting sub-themes derived from the panel discussion data in objective (c)

4.1.3.2.1. Theme 1: Judgment regarding a contextually-relevant screening protocol.

In order to determine what constitutes a contextually-relevant hearing screening protocol, the context-specific challenges had to be reviewed. According to the panel, the challenges included:

- Staff constraints as the school health team is currently unable to cover all the schools in the sub-district. This often resulted in a large caseload.
- Time constraints as the caseload can often become unmanageable.
- The fact that the current hearing screening protocol, which includes the voice test and occasionally audiometry, relies on the learners' cooperation. This is often problematic as the learners do not always comply.
- A lack of a routine school-based hearing screening protocol.
- An inadequate test environment with unacceptably high levels of ambient noise.

These challenges are closely linked to the context-specific needs reported by the school nurses in objective (a) of the present study, which further confirms the significance thereof. With these challenges in mind, the panel deduced that a contextually-relevant school-based hearing screening protocol should include the following five features:

- It should not be too sensitive to background noise.
- It must be easy to administer and interpret, thereby requiring only one staff member per screening station.
- It must be quick to administer and interpret

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- It should not rely on the learner's active cooperation and compliance. Therefore an objective screening test is preferable
- It must yield accurate results allowing the tester to make the correct management decisions

It was suggested that if these challenges are adequately addressed by the proposed screening protocol, the school health team will be better equipped to conduct hearing screening routinely in schools. When comparing these features of a contextually relevant protocol to the raters' responses for Protocol A (depicted in Figure 14), it is evident that the raters consider Protocol A as having four out of the five features. The only feature for which Protocol A was considered sub-optimal was the one pertaining to its sensitivity to background noise.

4.1.3.2.2. Theme 2: Appraisal of the applicability of the proposed screening protocols.

In order to determine the applicability of the proposed screening protocols, the panel evaluated the degree to which each protocol addressed the challenges reported in Theme 1, and subsequently how each protocol compared to the model school-based screening protocol previously described. For this purpose, a number of strengths and weaknesses of each of the proposed protocols were highlighted. These are summarised in Table 8.

Table 8

Main strengths and weaknesses of each screening protocol

Protocol A		Protocol B	
<i>Strengths</i>	<i>Weaknesses</i>	<i>Strengths</i>	<i>Weaknesses</i>
Reduced test time	Sensitive to noise	Less invasive than probe insertion	Sensitive to noise
Objective test which is a benefit if language differences & non-compliant learners	More expensive equipment	Equipment is not as fragile as the OAE machine	Need to complete the entire protocol to get an idea of middle ear status
Easy to administer	Test relies on good seal to close off ear canal	Equipment less expensive	Test more time-consuming
Equipment is more compact and portable than that used for Protocol B			
Also indirectly screening the middle ear			
OAE machines guides tester when troubleshooting is required			
Easier to train a non-audiologist to conduct this protocol			

After careful consideration of the context-specific challenges and the applicability of each protocol, the expert panel selected Protocol A as the most suitable protocol for implementation in Phase 2 of the study. This result is consistent with the findings depicted in the radar chart (in Figure 16) in which Protocol A was rated more favorably than Protocol B. However, it should be noted that for three of the twenty items on the rating scale all the raters considered Protocol A to be less than ideal.

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These items included:

- The effect of test room acoustics
- Ease with which one can identify learners at risk for hearing loss when using the protocol
- Ease with which the protocol can be administered in a school setting

Similarly, these issues were highlighted in the panel discussion as *weaknesses* of Protocol A (Refer to Table 8) as the protocol in question includes a test that is sensitive to noise, and is thus affected by room acoustics, and the correct administration of the protocol, as well as the accuracy of the test results, in terms of identifying learners at risk for hearing loss, it relies on the tester obtaining a good seal. In order to overcome some of these shortcomings, the participants made a few suggestions for the practical implementation of Protocol A. Firstly, due to the fact that the test is sensitive to noise, it was recommended that the school nurses use the quietest room available for testing purposes. It was further suggested that the learners enter the test room individually as learners waiting in line may introduce additional ambient noise as well as distractions.

Since the test relies on a good seal, it was also suggested that the potential tester is well-trained prior to the implementation of the screening protocol. With regard to the cost involved, it was suggested that Protocol A required more expensive equipment. However, since the test time is reduced, more learners can be tested making the protocol more cost-effective. Similarly, it was recommended that the use of durable and re-usable probe tips may further reduce the cost of the screening program. Bearing these recommendations in mind, the next step of the study was to field test the proposed screening protocol.

4.1.4. Objective (d): To describe the implementation of the initial field test of the proposed protocol.

The results for this objective include the findings of the noise measurements taken at the schools, the observation of the nurses’ implementation of the proposed protocol, and the second focus group discussion conducted with the school nurses.

4.1.4.1. Noise measurement results.

The findings of the noise measurements obtained at each school are summarized in Table 9.

Table 9

Ambient noise levels in the four screening environments

Screening site	Range of measured noise levels (dBSPL)
School 1	50.3-54.3 (exceeded 70dB during break time)
School 2	47.6-53.3
School 3	39.5-45.6
School 4	37.5-40.4

The noise levels fluctuated considerably thus a range of the measured noise levels are included for each screening location. These noise levels were compared to the American National Standards Institute (ANSI) document that focuses on the maximum allowable ambient noise levels for 20dB HL screening level (ANSI S3.1-1991 in Katz, 2002). The ANSI levels are summarised in Table 10.

Table 10**ANSI maximum allowable ambient noise levels for 20dB HL screening level**

Centre frequency for octave band (Hz)	Maximum allowable ambient noise level (dBSPL)
500	41.5
1000	49.5
2000	54.5
4000	62.0

Based on this reference standard, schools 3 and 4 had acceptable ambient noise levels. However, the ambient noise levels in schools 1 and 2 were unacceptably high at times, resulting in the need to troubleshoot in order to reduce the effects of noise as a test variable.

4.1.4.2. *Observation of the nurses' implementation of the proposed protocol.*

In order to review and compare the findings of the researcher's observations, a radar graph was constructed presenting the rating for each of the items in the observation schedule for each test school rated. Refer to Appendix X for a copy of the completed observation scales for test schools 1, 2, 3 and 4. Figure 18 includes the graphical representation of the observation ratings.

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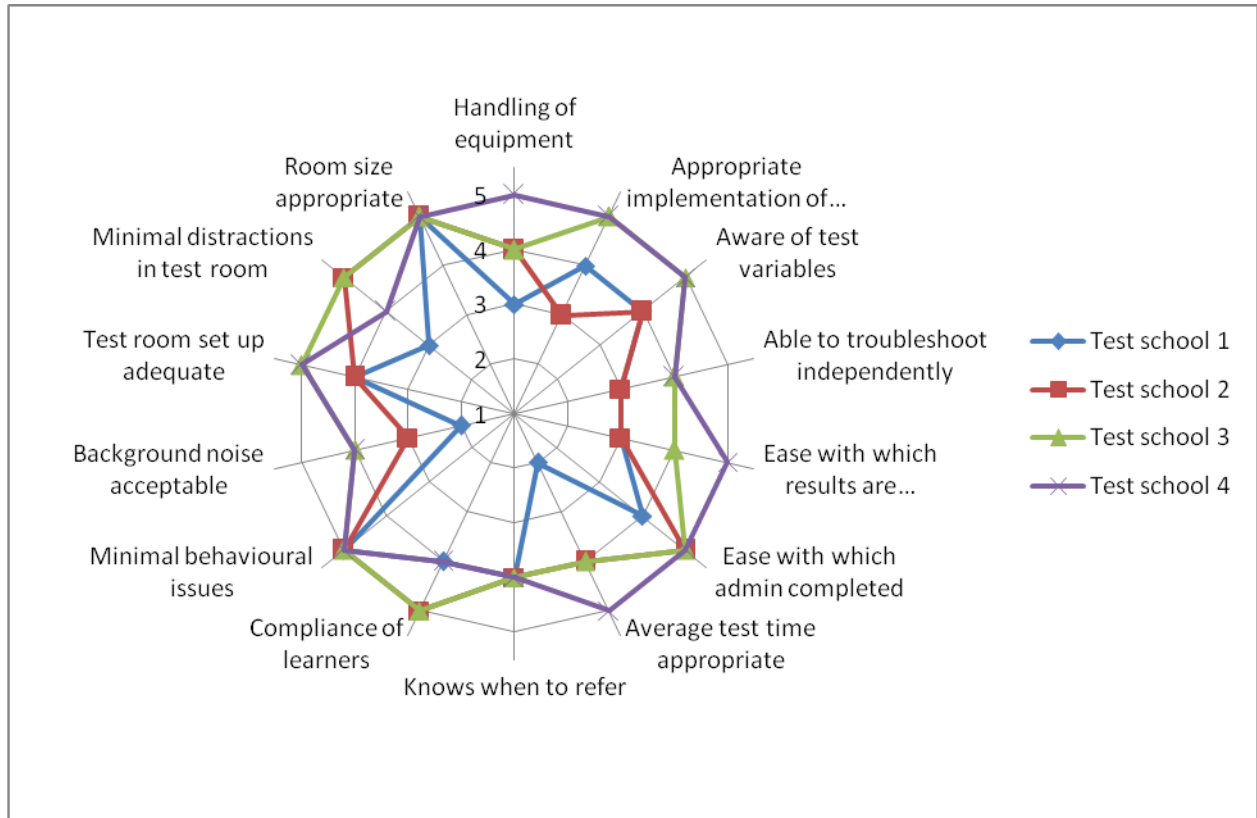


Figure 18: Observation ratings for nurses' implementation of the proposed protocol in the four test schools

In Figure 18 the rating options were from 1 to 5 (as marked in bold print in the radar), with 1 being the least favorable rating and 5 being the most favorable rating. These scores also correspond with the sequence of the circles on the radar. Furthermore, a rating of 3 was considered the cut-off for an acceptable outcome. Thus any rating below 3 was deemed unacceptable and a rating of 3 and above was considered acceptable.

Based on the findings in Figure 18, the ratings for all test schools reflected acceptable outcomes for twelve of the fourteen items on the observation schedule. This included items pertaining to *Tester factors* such as Handling of equipment, *Testee factors* such as the Compliance of learners, and *Environmental factors* such as Adequate test room set up. This result in turn implied that, for the most part, the proposed hearing screening protocol was suitable for routine hearing screening to be conducted by school nurses in a typical school setting. However, for two of the items, namely those items pertaining to background noise and test time, the ratings for test situation 1 indicated that the noise level and test time were unacceptable for effective hearing screening to take place in that school setting. The observation regarding the high levels of background noise is in agreement with the previous noise measurement findings that indicated unacceptably high ambient noise levels in School 1. Furthermore, the finding regarding test time may be directly linked to the background noise levels as the OAE user manual states that the test time may be prolonged if background noise levels are unacceptably high (AuDX User's and Service Manual, 2005). Thus, a change in the location of the test room should be considered in School 1.

4.1.4.3. Focus group discussion.

Based on the content analysis of the qualitative data, two overarching themes were identified namely; Applicability of the screening protocol, and Applicability of the screening personnel. To facilitate understanding, these themes together with the sub-themes are presented in Figure 19.

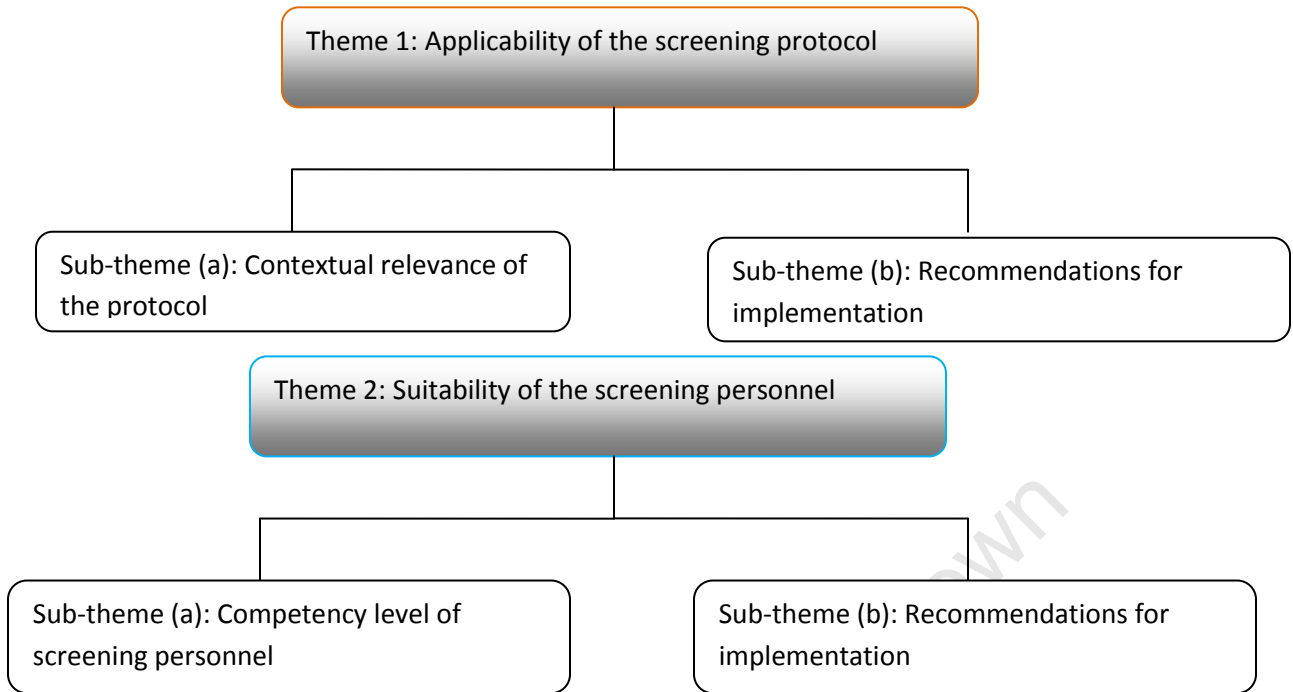


Figure 19: Themes and sub-themes emerging from the focus group data in objective (d)

4.1.4.3.1. Theme 1: Applicability of the screening protocol.

In order to fully understand the nurses' evaluation of the screening protocol with regard to how well it met their contextual needs, a review of their needs as determined in objective (a) of the present study is provided:

- A screening protocol that yields **accurate results**
- A screening protocol that is **easy to administer and interpret**
- A screening protocol that is **quick** enough to allow the tester to screen a large number of learners within a reasonable time-frame
- A **suitable test environment** with acceptably low ambient noise levels

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- An effective **training program** to help them feel more competent in performing hearing screening independently. Refer to *Theme 2: Applicability of the screening personnel* for nurses' feedback regarding the training program.
- **Effective referral pathway** to facilitate referrals and follow up. This particular need was however, beyond the scope of the present study and was thus not included in the focus group discussion.

The nurses' feedback pertaining to the contextual relevance of the proposed screening protocol is summarised in Table 11.

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Table 11

School nurses' evaluation of the applicability of the screening protocol

Contextual need	Relevant transcript extracts	Nurses' feedback
Screening protocol that yields accurate results	<p>Nurse 1: "This can guide you...how to refer the child..."</p> <p>"It [OAE's] makes such a difference to the testing process...it's effective"</p> <p>Nurse 2: "It [tympanometry] is helpful to check otoscopy findings before treatment."</p>	<p>The nurses felt that their hearing screening service improved because they were given a more structured method of testing the learners' hearing.</p> <p>They were secure and confident regarding test results obtained and thus were more confident about making appropriate referrals.</p> <p>Similarly, the nurses thought that the inclusion of tympanometry was very helpful as it could be used to confirm otoscopic findings.</p>
Protocol that is easy to administer and interpret	<p>Nurse 2: "I think it is user-friendly...it's simple like taking the temperature."</p> <p>Nurse 3: "very straightforward...no interpretation required cos the machine says if it's a pass or a fail."</p> <p>Nurse 2: "maybe just with the technique we should practise because we struggled sometimes..."</p>	<p>The nurses all agreed that the screening protocol was fairly easy to administer and interpret. They however occasionally struggled to obtain a seal, especially for tympanometry but felt that with more practise this issue would be resolved.</p>
Protocol that is quick to administer	<p>Nurse 1: "Testing went very quickly...quicker than vision screener¹¹ but only if environmental noise is excluded."</p> <p>Nurse 3: "Test time was good...I could test about 25 children in 2 hours."</p>	<p>The nurses were happy with the average test time when using the proposed screening protocol and thought that it would allow them to test a sufficient number of learners on a typical school day. However, in cases where the test variables such as noise could not be eliminated they noticed a marked increase in the overall test time.</p>
Suitable test environment	<p>Nurse 1: "Machine is very sensitive to noise, every noise and movement affected the test...need a quieter workspace but it's difficult at some schools."</p>	<p>In two test environments the nurses were unhappy with the background noise levels and felt that the test was also very sensitive to this noise. As previously mentioned this impacted on the test time and often left the nurse at School 1, which was found to have unacceptably high ambient noise levels, very frustrated. In the remaining schools the nurses were given relatively quiet workspaces which made testing much easier for them.</p>

¹¹ This refers to a screening test using an eye chart in which the learner is instructed to read aloud the letters on the chart which is held a certain distance from him/her. The size of the letters range from very big to very small and the results of the test allow the tester to identify the possibility of a visual defect (McGraw, Winn & Whitaker, 1995; Morad, Werker & Nemet, 1999).

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With regard to the practical implementation of the proposed screening protocol in a school setting, the nurses thought that it could be well-integrated into their existing service package. Based on their feedback, this screening protocol is a fast, efficient and feasible model for effective hearing screening in a school environment. Similar findings were reported by Yin et al. (2009) who investigated the application of OAEs as the first-line hearing screen for preschool children in Los Angeles. Their findings suggested that OAEs is a useful mass-screening tool for school-aged children. They further reported that testing conditions did not require a sound-treated environment but testers would still need to have fairly quiet workspaces (Yin et al., 2009). Based on these reports as well as the present study's findings, it would appear that the proposed screening protocol is applicable for a school setting, meeting most of the contextual needs highlighted in objective (a) of the study. It is, however, recommended that when implementing the protocol, school nurses obtain more suitable test rooms with acceptable levels of ambient noise. This will ensure that the test results are reliable and will also serve to reduce the test time (AuDX User's and Service Manual, 2005).

Another practical consideration when implementing this protocol is the nurses' existing workload. School nurses have both educative and clinical roles to play, which can result in a heavy workload (Pillay, 2009). For this reason, hearing screening cannot be something they do every day. However, the nurses suggested that if a specific day was set aside each week for hearing screening only, it may be more manageable.

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4.1.4.3.2. Theme 2: Suitability of screening personnel.

In order to fully understand the school nurses' perceptions regarding the screening personnel required for the implementation of the proposed screening protocol, their perceived level of competency was explored including:

- The effectiveness of training received
- Their ability to conduct the screening protocol independently
- Their general understanding of the protocol

Bearing these factors in mind, the nurses' feedback pertaining to the applicability of the screening personnel was reviewed and is summarised in Table 12.

University of Cape Town

Table 12

School nurses' feedback regarding the applicability of the screening personnel

Competency of personnel	Relevant transcript extracts	Nurses' feedback
Effectiveness of training	<p>Nurse 3: "The training certainly improved my knowledge...that day [day of school-based screening] I could really see it and I could do it myself..."</p> <p>Nurse 1: "when the machine was giving problems at one point, I still needed help..."</p>	<p>The nurses found the training to be helpful and sufficient in preparing them for the implementation of the screening protocol. In most cases they felt confident conducting the tests independently but felt they would need more practise in order to troubleshoot effectively.</p>
Ability to conduct tests independently	<p>Nurse 3: "...I could do it [screening tests] myself..."</p> <p>Nurse 2: "We were ok when we did it ourselves...just need one extra day for practising the technique [for tympanometry]"</p> <p>Nurse 1: "when the machine was giving problems at one point, I still needed help..."</p>	<p>The school nurses generally considered that they were capable of completing the screening protocol independently. They however, suggested that they would require more practise to improve their probe insertion technique to obtain a good acoustic seal for tympanometry. Similarly, they would require more exposure to the equipment in order to troubleshoot independently should problems with the equipment arise.</p>
Understanding the protocol	<p>Nurse 3: " I can explain to others now-we are testing the cochlea now or now we are testing the eardrum...I understand it"</p>	<p>School nurses reported that they had a good understanding of the tests in the screening protocol. They understood the test procedures, test variables as well as the purpose of each test.</p>

With regard to the practical implementation of the screening protocol, the school nurses generally felt that they were capable of implementing the screening protocol independently. This viewpoint is supported by Yin et al (2009) who suggested that school nurses were effective in implementing the screening program under investigation in their Los Angeles-based study. Based on the present study's findings, it is, however, recommended that the school nurses are given additional training as well as sufficient opportunity to practice the test procedures and troubleshooting strategies prior to the implementation of the protocol in a school setting.

In addition, the school nurses felt that additional screening personnel may be required to play a supportive role in managing the screening process. For example, the duties of support personnel may include collecting consent forms from educators; liaising with educators; and collecting and returning learners from their classrooms. In the present study, the school's CHWs often took on this supportive role and the school nurses generally felt that their input was invaluable in making the screening process run more efficiently.

Furthermore, considering the school nurses' workload and the limited amount of time they can dedicate to hearing screening, the need for support personnel should not be overlooked. It may even be worthwhile to consider training CHWs to conduct the screening tests thereby releasing the school nurses to perform other duties. A similar strategy was investigated by Srisuparp, Glebbur, Ngercham, Chonpracha and Singkampong (2005) who considered the use of support personnel to conduct newborn hearing screening. It was suggested that this is an appropriate and often necessary strategy to improve the coverage rates of existing screening

programs and improve the accessibility and sustainability of developing screening programs (Srisuparp et al., 2005).

This viewpoint is shared by Swart, Lemmer, Parbhoo and Prescott (1995) who conducted a survey of ear and hearing disorders in a group of Grade 1 schoolchildren in Swaziland. These researchers proposed that in-service training programs be implemented for primary care personnel to equip them with the necessary skills for identification and basic management, including making appropriate referrals, of audiological problems. Similarly, Messner, Price, Kwast, Gallagher and Forte (2001) evaluated the efficacy of a volunteer-based hearing screening program in California in which volunteers underwent a comprehensive training program to prepare them for conducting paediatric hearing screening. They reported that the use of volunteers is a viable option but it is suggested that the training of non-specialist personnel be supplemented by routine supervision and continuing education activities (Messner, et al., 2001; Swart et al., 1995).

In conclusion, the findings of objective (d), based on the researcher's observation of the nurses implementation of the protocol as well as the nurses' feedback regarding the applicability of the protocol, suggest that the proposed protocol is suitable for school nurses to implement in a typical school environment. However, many recommendations were suggested to facilitate the effective implementation of this protocol in a school-based hearing screening program. These recommendations also adhere to some of Wilson and Jungner's (1968) screening principles discussed in *Chapter 1* and included:

- The use of a relatively quiet workspace with acceptably low ambient noise levels to ensure that the screening tests is conducted appropriately

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- The inclusion of support services in the district to ensure that an effective referral pathway and follow up services are in place
- Sufficient opportunity for nurses to practice procedures and troubleshooting strategies prior to the implementation of the protocol, to ensure that screening test is conducted appropriately
- The need to establish strategies for the nurses to manage their workload which will allow for the implementation of routine school-based hearing screening. Examples of such strategies include; the use of support personnel such as community health workers to either play a supportive role in the screening program or to conduct the screening themselves, after adequate training, and setting aside a specific day each week for hearing screening.

If these recommendations are incorporated, the school nurses should be able to utilize this screening protocol to meet the initial program goals specified in their operational handbook prior to the introduction of the revised service package (which the nurses' considered inadequate). These initial program goals were to conduct universal hearing screening on all Grade R/1 learners, and to conduct risk-based screening on learners in higher grades.

The next stage of the research study was to determine the test performance of the proposed screening protocol.

4.1.5. Objective (e): To determine the test performance of the proposed hearing screening protocol.

The results for this objective include findings pertaining to the inter-tester reliability of the screening protocol, and the sensitivity, specificity and predictive values of the hearing screening protocol.

4.1.5.1. The inter-tester reliability of the screening protocol.

Contingency tables were developed to illustrate the distribution of the agreements and disagreements between the testers' results for both OAE's and tympanometry. The tables included results for OAE testing conducted by the four nurses as well as the tympanometry results for Nurses 2 and 4. Tympanometry was not conducted by Nurses 1 and 3 as all the participating learners passed the OAEs test at these screening schools. Therefore, based on the screening protocol it was not necessary to conduct tympanometry in these cases, refer to Figure 14 for the screening protocol. Refer to Appendix Y1, Y2, Y3, Y4, Y5 and Y6 for the contingency tables for Nurses 1, 2, 3 and 4, respectively.

Due to the empty cells in the contingency tables for Nurse 1's OAE results, Nurse 2's tympanometry results, Nurse 3's OAE results and Nurse 4's tympanometry results, the data in these cells could not be analysed mathematically (Mackinnon, 2000). For this reason, the results in the contingency tables were used to make inferences and findings indicated that there was perfect agreement between the independent tester and Nurses 1 and 3's OAE test results as well as perfect agreement between the independent tester and Nurses 2 and 4's tympanometry results. When considering the purpose of screening and its significant role in the process of identifying hearing loss, perfect agreement between the two testers' results is desirable.

For the remaining contingency tables, the DAGstat statistical spreadsheet was utilized for the analysis and findings representing the OAEs test results for Nurses 2 and 4. These results are summarized in Table 13 below.

Table 13

Kappa and related measures for Nurse 2 and Nurse 4

Participant	Measure	Value	Confidence Interval	Interpretation of data
Nurse 2 OAEs	Cohen's Kappa	0.5714	95%CI:0.1421-1.0007) p value 0.0098 z score 2.58	Value is below sufficient level of reliability
	Observed Agreement	0.8500	95%CI:0.6211-0.9679	Indicates good agreement between the nurse and independent tester's results
	Positive Agreement	0.6667	95%CI:0.3110-1.0223	Value indicates sufficient level of agreement
	Negative Agreement	0.9032	95%CI:0.7942-1.0122	Value indicates sufficient level of agreement
Nurse 4 OAEs	Cohen's Kappa	0.6415	95%CI:0.1901-1.0929 p value 0 z score 4.24	Value is below sufficient level of reliability.
	Observed Agreement	0.9474	95%CI:0.8225-0.9936	Indicates excellent agreement (Hripcsak & Heitjan, 2002)
	Positive Agreement	0.6667	95%CI:0.2311-1.1022	Value indicates sufficient level of agreement
	Negative Agreement	0.9714	95%CI:0.9318-1.0110	Value indicates sufficient level of agreement

For the Kappa coefficient, a value of ≥ 0.67 reflects a sufficient level of reliability (Hripcsak & Heitjan, 2002). For the agreement measures, a coefficient of 1 represents perfect agreement and 0 indicates agreement no better than that expected by chance. A negative coefficient indicates agreement worse than that expected by chance (Sim & Wright, 2005). Since perfect

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agreement between the testers' results is desirable, the high observed agreement values in Table 13 are a very promising result. However, Hripcsak and Heitjan (2002) suggest that observed agreement scores can be misleading. These researchers reported that a certain amount of agreement will always be due to chance but since the observed agreement indicator has not been "chance corrected" the resulting value will never reflect true agreement alone. These results should therefore not be considered in isolation.

The Cohen's Kappa coefficient on the other hand takes chance agreement into consideration but it is sensitive to prevalence, therefore if the prevalence of positive responses is low then Kappa will be low despite high observed agreement (Hripcsak & Heitjan, 2002). When applying this interpretation to the current test situation it is suggested that the low prevalence of hearing loss in the school sample may have resulted in the fairly low Kappa coefficient which in turn would incorrectly imply that the agreement between the testers is insufficient. Therefore, it is also recommended that specific agreement values be used to determine the level of agreement (Cicchetti & Feinstein, 1990). When reviewing the specific agreement values for Nurse 2 and Nurse 4, it is evident that in both cases the negative agreement values were acceptably high whereas the positive agreement values were lower for both nurses, but still sufficient. This implies that agreement between the nurses and the independent tester was high for negative test results but agreement for positive test results was moderate.

In order to determine a possible reason for this finding one needs to consider test variables that may affect the results obtained when using the OAEs test. One such variable is the insertion of the OAE probe for testing purposes. If inserted incorrectly, for example, inserted in such a way that the probe is pushed against the ear canal wall, the test may incorrectly yield a "fail" or positive result (AuDX User's and Service Manual, 2005). For this reason the tester should be

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adequately trained to insert the OAE probe correctly and also to identify and address test variables such as incorrect probe insertion. Based on the school nurses' feedback in objective (d) of the present study this is an area in which they indicated they would require additional opportunity for practicing and troubleshooting. This could be a possible explanation for the lower positive agreement obtained for the OAEs test for Nurse 2 and Nurse 4. If this is the case then the positive agreement value could be increased by simply providing the nurses with sufficient opportunity to practise the screening protocol prior to the implementation thereof.

Based on these results, one can conclude that the inter-tester reliability of the screening protocol is sufficient, with perfect agreement being reported for the OAEs test results obtained by Nurses 1 and 3 and the tympanometry test results obtained by Nurses 2 and 4. For the OAEs test results obtained by Nurses 2 and 4, the analysis revealed high negative agreement values along with sufficient positive agreement values. As previously noted, tympanometry was not conducted by Nurses 1 and 3.

In addition to the inter-tester reliability measure, the researcher sought to determine the sensitivity, specificity and predictive values of the screening protocol. For this reason reference measures were obtained for each participant. Due to poor participant attendance only 54 participants attended the diagnostic assessments sessions. In order to compare the results of the screening and diagnostic test, the total number of participants who completed both the screener and the diagnostic test were converted into a measure of the total number of ears tested under both conditions. This resulted in a total of 108 ears for further analysis.

4.1.5.2. The sensitivity, specificity and predictive values of the screening protocol.

The results for this section of objective (e) are presented in Table 14.

Table 14**Results table for sensitivity, specificity and predictive values**

Measure	Value	Confidence Interval
Sensitivity	57.14%	(95%CI: 0.1841-0.9010)
Specificity	97.03%	(95%CI:0.9156-0.9938)
Positive predictive value	57.14%	(95%CI:0.1841-0.9010)
Negative predictive value	97.03%	(95%CI:0.9156-0.9938)

When reviewing these results, it is evident that the screening tool has high specificity but has a moderate level of sensitivity. With a sensitivity of 57.14%, it suggests that 57 out of 100 individuals with a hearing loss will be correctly detected when conducting OAEs in the school setting. When comparing this sensitivity value to the related literature it would seem that the value obtained in the present study is low. A large body of research has been dedicated to evaluating the implementation of OAEs as a screening test in both clinical and non-clinical environments such as schools and results are promising. These researchers report sensitivity values of 93%-100% for OAEs (Proschel & Eysholdt, 1995; Richardson, Williamson, Reid, Tarlow & Rudd, 1998; Saleem, Ramachandran, Ramamythy & Kay, 2007; Xu, Li, Hu, Sun & Shen, 2003; Yin et al., 2009).

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This highlights the need to review possible reasons for the low sensitivity value obtained in the present study. For this purpose, the period between the school-based screening and the diagnostic tests must be considered. Ideally, the diagnostic test should have been performed immediately after the screening test to minimize the possibility of changes occurring in the participants' ear or hearing status prior to the diagnostic assessment, as this could lead to inaccurate interpretation of the results. Therefore, researchers like Sideris and Glatke (2006) set out to conduct the screening and diagnostic tests on the same day as was the case in their Arizona-based study that compared the test performance of OAEs and tympanometry to pure-tone audiometry and tympanometry and their findings indicated good agreement between the two protocols' results. However, in many similar studies this time period is not specified e.g. Bento, Albernaz, Di Francesco, Wiikmann, Frizzarini and Castilho, 2003 (2003) and Beppu, Hattori and Yanagita (1997).

In the present study, it was not practically feasible to shorten the period between the screening and diagnostic tests as the test site for the diagnostic assessments was a busy tertiary level hospital. The researcher was permitted use of the facilities for one morning per week and thus appointments for participant testing were spread over a period of six weeks. This was unavoidable as the researcher had to conduct the testing within the constraints of the local health system. Given this constraint, the learners who failed the school-based screening were given priority, obtaining the earliest appointments for diagnostic assessment.

Furthermore, participant attendance for the diagnostic assessment was very poor thus resulting in a number of re-scheduled appointments. This in turn meant that for some participants the period between the screening and diagnostic tests exceeded one month, a delay that may have contributed to the poor agreement between the two tests' results. The specific reason for the poor

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attendance at the tertiary hospital is debatable and may include the caregiver's work obligations, the fact that the appointment was forgotten or other competing demands. Since the researcher gave each participant a financial contribution towards traveling expenses, a lack of finances was not the most likely reason. However, regardless of the reason poor attendance at tertiary hospitals appears to be a common problem in developing countries. For example, Adhikari (2009) reported on a study conducted in rural schools in Nepal and found that attendance for follow up appointments at tertiary hospitals was poor. The researcher concluded that this poor attendance was due to ignorance and poverty.

The effect of this time delay between the screening and diagnostic tests cannot be underestimated if one considers the prevalence of temporary middle ear disease in the school-aged population. For instance a learner may have passed the screening test at school and later developed an ear infection which resulted in a "fail" when s/he underwent the diagnostic test. In this case the learner's ear/hearing status changed thereby changing the test result (Roush, 2001). If one fails to acknowledge this possibility, one can incorrectly assume that the screening test has poor sensitivity. Therefore, if the study is to be replicated in future, one must ensure that the period between the screening and diagnostic tests are kept to a minimum to ensure that an accurate estimation of the sensitivity of the OAE screening test is obtained.

Another contributing factor could be the discrepancy between the pass/fail criteria used for the screening test and that used for the diagnostic test. OAEs are generally not very sensitive to mild degrees of hearing loss and are typically absent when the learner's hearing loss exceeds 30-40dB HL (Kemp, 2002). Thus, some of the 'pass' results obtained during the screening phase of the study may have corresponded to cases of slight or mild hearing losses. With the diagnostic test on the other hand, a learner had to obtain hearing thresholds of 15dB HL or less to 'pass' the

test. This discrepancy in the pass criteria may have increased the disagreement between the two sets of data.

It is also suggested that the sensitivity index can vary substantially when applied to populations with different demographic and clinical features (Reid, Lachs & Feinstein, 1995). Whiting, Rutjes, Reitsma, Glas, Bossuyt and Kleijnen (2004) are in agreement stating that demographic features have strong associations with test performance, affecting sensitivity estimates more than specificity. They furthermore reported that disease severity and prevalence may affect estimates of test performance with sensitivity increasing in populations with more severe disease or increased disease prevalence (Whiting et al., 2004). Therefore, since the prevalence of hearing loss in this study sample was relatively low, this could possibly have reduced the sensitivity estimate.

Conversely, the specificity value of 97.03% was acceptable, suggesting that the OAEs test can correctly identify 97 out of 100 individuals who do not have a hearing loss (Hayes & Northern, 1996). Furthermore, the high negative predictive value suggests that approximately 97% of all the negative results were obtained from individuals who truly do not have a hearing loss. This in turn meant that the number of inappropriate referrals for follow up testing would be kept to a minimum when implementing this screening protocol in a school setting. When considering the financial implications of unnecessary referrals for both the referral centers and the patients themselves this is an advantageous result (Power & Kibel, 1995). Similar results were obtained by other researchers who reported specificity values of 91%-100% (Richardson et al., 1998; Sabo, Winston & Macais, 2000; Saleem et al., 2007; Taylor & Brooks, 2000; Yin et al., 2009).

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In conclusion, the study's findings indicated that for a school-based hearing screening protocol to be contextually-relevant, it must be:

- Quick and easy to administer and interpret given the human resource constraints and the need for universal screening of the target population.
- Reliable and valid, yielding accurate results and clear referral criteria.
- Considerate of noise in the typical school context.

The findings also showed that a hearing screening protocol including otoscopy, oto-acoustic emissions and tympanometry conducted by well-trained school nurses, or other support staff, is appropriate for South African schools, with some reservation. Further field-testing and refinement of the protocol is still required.

In this chapter, the results for each objective were presented and discussed to provide a comprehensive overview and explanation of the study's findings, in light of the relevant literature. From this discussion of the study's results, key issues were extracted and will be more generally explored in the following sections. These issues include: the relevance of the proposed screening protocol based on how well it adheres to local school health policies and addresses the contextual challenges described in *the Introduction* chapter and the general performance of the proposed protocol based on how well it adheres to the screening principles (also discussed in the *Introduction*).

4.2. Relevance of the Proposed Hearing Screening Protocol

In the South African context, the health needs of the school-aged child are derived from the primary health challenges which according to the National school health policy and implementation guidelines (DOH, 2002) include:

- Poverty and unhealthy living conditions
- Poor nutritional status
- High-risk behavior with regard to sexual activity and reproductive health
- Trauma and violence
- Substance abuse and risk-taking behavior
- Hearing, vision and speech impairment (pp. 17-18.)

It is suggested that the degree of benefit the learner receives from the education system is directly related to the success with which the health needs of the learner are addressed. School health services, including hearing screening services should thus be well planned and implemented to meet the health needs of a school-aged child and identify preventable health problems that may constitute barriers to his/her learning (National school health policy and implementation guidelines, DOH, 2002).

In order to ensure that the planning for service provision is relevant and appropriate it is recommended that health researchers and planners consider the social and political context of a situation when planning and/or evaluating health programs and interventions (Looman and Lindeke, 2005). Hence in an effort to remain relevant and appropriate, it is necessary to review

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the proposed screening protocol in light of the relevant school health policies. As discussed in the *Introduction* chapter, the Health Promoting Schools Initiative (WHO, 2009), the Youth and Adolescent Health Policy (DOH, 2001) and the National School Health Policy (NSHP) (DOH, 2002) have been introduced to inform and support the development and implementation of school health programs. Another important purpose of such policies, especially the NSHP was to ensure equity in the provision of school health services in light of the marked inequities inherited by the apartheid system. Discrepancies in the provision of school health services are thus still evident in South African schools but it is suggested that these gaps will eventually be minimized with the correct implementation of the proposed school health policies.

To facilitate this process, guidelines have also been recommended for the implementation of the NSHP (National school health policy and implementation guidelines, DOH, 2002). These implementation guidelines include the fact that:

- The policy should be implemented in a phased manner.
- Disadvantaged areas must be prioritized.
- The school health team should include at least one professional nurse (PN) and one enrolled nursing assistant (ENA).
- Personnel must focus on Grade R/1 assessments.
- Personnel must have access to referral facilities (i.e. referral pathway should be in place).
- Health promotion must be provided to Grade R/1 learners at least once per year.

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- The recommended school health team to learner ratio should be 1:5,000 for health assessments and 1:20, 000 for health promotion.
- A minimum of one school visit per year is required.

These recommendations which currently guide the provision of school health services in South Africa as well as the main health needs of school-aged children should be kept in mind when reviewing the relevance and appropriateness of the proposed hearing screening protocol. Firstly, it is evident that the screening protocol addresses one of the main health needs of the school-aged child which is hearing impairment. Thus, by identifying possible hearing loss as early as possible the condition can be treated and the negative effect on the learners' learning and general development can be reduced (Bento et al., 2003). Secondly, by conducting the screening protocol at the school thus making use of the existing infrastructure it makes the service accessible and affordable for all learners.

With regard to the recommendations derived from the NSHP (2003) and related policies one can deduce that a school-based program should meet the following requirements:

- It must be simple and easy to implement by one member of the school health team as the team may only comprise of one PN and one ENA.
- It must not be too time-consuming as the school health team have to service a large number of learners at each school, as dictated by the school health team: learner ratio, and the team may only be able to visit the school once per year.
- The program must target grade R/1 learners in the first instance.

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- It must give consideration to referral facilities and ensure that such facilities are in place in the event that referral is necessary.

When considering the proposed screening protocol in light of these requirements it is evident that the proposed protocol is suitable as it includes screening tests that were shown to be simple, quick and easy to administer by one member of the school health team. Furthermore, the protocol was proposed with Grade R/1 learners in mind in the hope of implementing a universal screening program in this specific population. With regard to the referral pathway, the need for referral facilities was considered when proposing the protocol and specific referral criteria were outlined when testing the protocol in the field.

The findings of the present study suggest that the referral pathway forming part of the screening service in the Mitchell's Plain sub-district is ineffective. Currently there are no audiological services available at the district level of service delivery, which makes it very problematic for the nurses when referrals need to be made for basic diagnostic testing. In such cases tertiary institutions make up the school nurses primary referral centre bypassing district and secondary levels of service delivery. This referral pathway is not efficient as tertiary level services are both expensive and inaccessible to the majority of the community members. Under such circumstances, patient attendance for the follow up services may be affected, as was shown in this study, and this in turn could impact on the effectiveness of the service (Olusanya, 2008). This is a major limitation of the current school health system and must be urgently addressed to improve the effectiveness of the school health program as a whole. However, with regard to the screening protocol, the general findings of this appraisal indicate that the proposed protocol sufficiently adheres to the relevant policies governing the provision of school health services in South Africa.

4.3. General Performance of the Proposed Screening Protocol

Akukwe (2007) stated that for a health program to be effective, it must have a set of operating principles to inform and support the implementation and evaluation of that program. Thus, if one were to re-visit the main screening principles or guidelines used to review the suitability of tests cited in the literature in *Chapter 2*, the following operating principles should be adhered to:

- The screening test should be appropriate for the target population and context.
- The screening program must be cost-effective.
- There should be strategies and sufficient resources to ensure implementation, which includes resources for referral and follow up services

Firstly, when considering the suitability of the screening protocol for the target population it is essential that the primary characteristics of the target population be reviewed. Since the target population for the proposed protocol is predominantly Grade R/1 learners one must consider the fact that learners in this age group may be easily distracted, which affects their ability to correctly complete a test that requires a voluntary response from them (Gell, 1992; Martin & Clarke, 1996). This in turn could affect the reliability of the test results obtained. The proposed screening protocol overcomes this potential problem as the protocol includes objective tests which do not rely on voluntary responses from the learner (Martin & Clarke, 1996).

Another characteristic of this target population is the high prevalence of middle ear problems in this age group (Minja and Machemba, 1996; Saim et al., 1997). The proposed screening protocol thus includes tests that can identify possible hearing loss; OAEs, as well as outer and

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middle ear problems; otoscopy and tympanometry. Furthermore, since OAEs can be affected by both cochlear dysfunction and conductive disorders in the middle ear, it is an ideal first level screen for the detection of both conditions (Roush, 2001). In addition, the screening tests are safe and non-invasive making it suitable for the screening population (Bu, Li & Driscoll, 2005).

Secondly, for a screening program to be cost-effective the increased cost of implementing a new screening protocol must be worth the additional benefit that will be obtained with the introduction of the new protocol (Riegelman & Pawlson, 1988). The benefits of the proposed screening protocol have been well-documented in the discussion of the results of objectives *b* and *c*, and include the fact that it is a protocol that is quick and easy to implement that can yield accurate results which in turn lead to correct identification of cases of possible hearing loss. Once identified such cases can be appropriately referred and managed to reduce the potential effects of hearing impairment.

With regard to the cost of implementing a new screening protocol the main expenses include the cost of equipment, the cost of consumables, and the cost involved in employing and training the screening personnel (McPherson & Olusanya, 2008). For the proposed screening protocol the researcher considered these expenses as the intention was to devise a protocol that was cost-effective. Current information indicates that the cost of the relevant screening equipment has decreased over time (McPherson & Olusanya, 2008) and the cost of consumables is reasonable, especially since most of these, for example, alcohol swabs, would already be available to the nurses.

With regard to screening personnel, the proposed screening protocol was proposed with school health staff, including nurses and CHWs in mind. Thus, the protocol is quick and easy to

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implement by non-specialist staff thus minimizing the training of personnel who are conveniently positioned in the targeted screening site. This approach will not only result in more accessible services but also more cost-effective provision of the screening service (Gelfand, 2001). However, regardless of the startup cost, it is suggested that the initial expense of a hearing screening program will always be less costly than the financial implications of hearing impairment to both the individual and the health system (Bamford, Uus & Davis, 2005). Yin et al (2009) estimated that early identification and management of children with hearing impairment would translate to a 10% reduction in the total cost of special education. It is thus advisable that the necessary funds be spent on an effective and appropriate screening protocol that will prove more cost-effective in the long-term rather than wasting valuable resources on inadequate protocols that eventually cost more financially and psychologically for the health services and the patients. However, since the focus of the study did not include the specific start-up costs for the proposed screening protocol this was not examined in greater detail.

Thirdly, with reference to the referral facilities for diagnosis and management it is suggested that screening programs are ineffective and unethical if there is not a well-developed infrastructure to cope with cases of possible hearing loss and middle ear disorder (McPherson & Olusanya, 2008). This view is supported by Lescouflair, (1975 cited in McPherson & Olusanya) who reported that the lack of such infrastructure was one of the primary reasons for the failure of many school-based screening programs in developed countries, but measures have since been taken to improve on this situation. For instance Stewart-Brown and Haslum (1987) conducted a survey of all the health districts in England and Wales to document the common hearing screening practices in those areas. Results from this survey revealed marked improvement in

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general screening practice following the implementation of their national committee's recommendations.

In the South African context, the Comprehensive Service Plan for the Implementation of Healthcare 2010: Draft for consultation (DOH, 2006) proposed that the DHS be strengthened to serve as the primary referral centre for community-based services such as the services provided in schools. Such district level services could be provided at CHC or district level hospitals. Thus, if learners were to fail the school-based screening test, they could be referred to the local CHC or district hospital for diagnostic testing and basic medical treatment for middle ear problems, and later to a tertiary level hospital for further management if indicated. In the Mitchell's Plain sub-district the framework for such a referral pathway is already appropriately situated, making the effective implementation of the proposed protocol possible. Figure 20 depicts the current framework for a referral pathway in the sub-district.

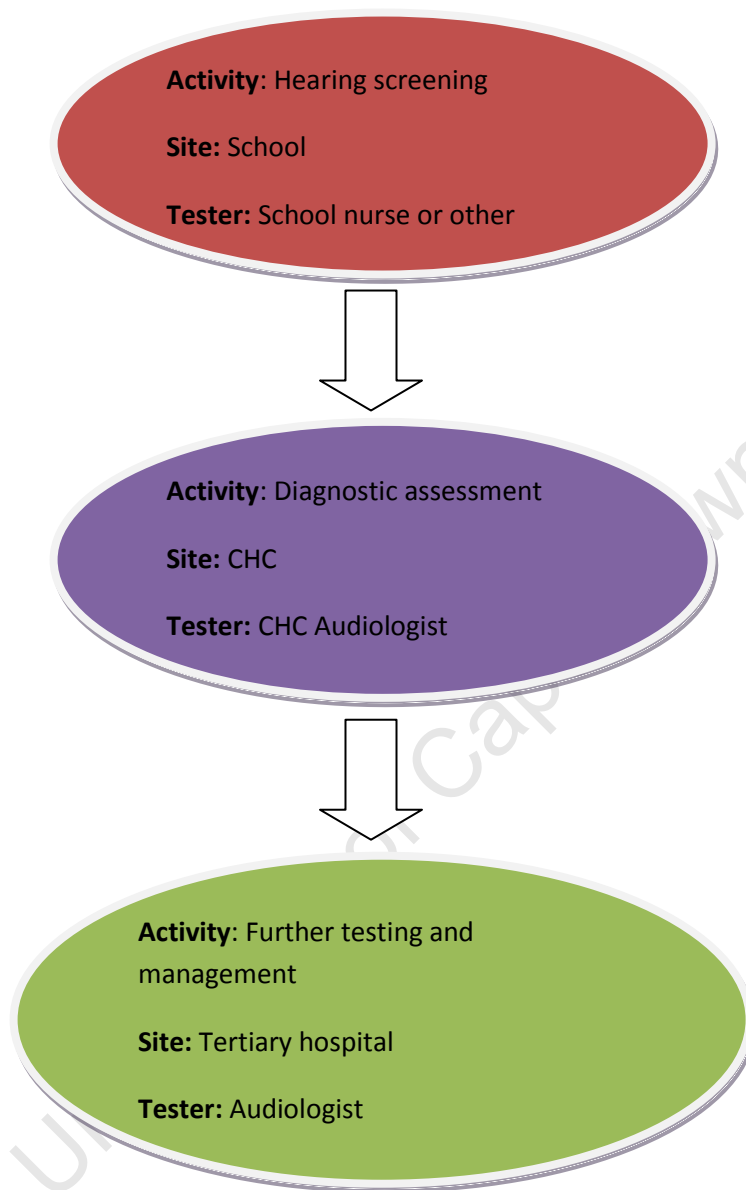


Figure 20: Framework for the referral pathway for school-based hearing screening in Mitchell's Plain

Although all the relevant positions in the framework in Figure 20 are present, the necessary role-players are no longer in place. Therefore, despite the fact that the Audiology department was established and fully functioning at the local CHC, the service is currently not being provided as the position of CHC Audiologist is no longer available. As noted earlier in this chapter, the

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resulting gap in the referral pathway has an adverse effect on the school-based screening service as nurses have to refer directly to tertiary level hospitals which are generally inaccessible for the majority of the community members. The current situation is unacceptable and action is urgently required if any school-based screening program is to be effectively implemented and sustained.

In conclusion, it is evident that the proposed protocol is contextually-relevant for typical South African schools, adhering to the relevant school health policies and screening principles. However, the cost-effectiveness of the protocol should be formally evaluated and the referral pathway forming part of the school hearing screening program requires proper implementation.

University of Cape Town

Chapter 5

Future Applications, Limitations and Research Implications

This chapter includes a critical discussion of the proposed screening protocol in terms of its suitability for application in other contexts as well as a review of the research methodology which was specifically designed for this study. This will be followed by a discussion of the present study's limitations and the future implications for relevant research and action. The chapter is thus divided into the following sections:

- 5.1. Applicability of the proposed protocol for other contexts
- 5.2. Critical review of the study's methodology
- 5.3. Limitations of the present study
- 5.4. Future implications

5.1. Applicability of Proposed Screening Protocol for Other Contexts

In order to determine the applicability of the screening protocol for other contexts, for example, developed countries, it is important that one considers the school health needs and broader challenges that are universal to all situations versus those needs and challenges that are context-specific. With regard to the school health needs, the discussion will focus specifically on the needs pertaining to the implementation of a school-based hearing screening program. As previously summarized in *Chapter 4*, the Mitchell's Plain school nurses highlighted the primary

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needs that they felt should be addressed in order for any hearing screening program to be effective in their work situation.

These needs included the need for: human resources, such as increased staff numbers, adequately trained screening personnel and sufficient support staff to improve the efficiency of the screening program, and screening program resources that included the need for a screening protocol that included tests that were valid, quick and easy to administer; a suitable test environment and an effective referral pathway. Although these needs can be considered universal for the implementation of any school-based hearing screening program, the degree to which such needs are met vary between developed and developing countries as the broader contextual challenges differ (Gell et al., 1992).

As previously mentioned in the *Introduction* chapter, the primary contextual challenges in the developing context include: systemic challenges, for example, poverty (National school health policy and implementation guidelines, DOH, 2002), competing health demands (Gell et al., 1992; National school health policy and implementation guidelines, DOH, 2002), lack of awareness of the significance of health issues and school health programs (Gell et al., 1992), and variation in the significance that stakeholders attach to school health services, affecting the prioritization of such services (Akukwe, 2007).

These contextual challenges have a definite impact on the implementation of school-based hearing screening services. For instance, the competing health demands and lack of awareness of the significance of school health in developing countries affects available financial and human resources as shown by Gell et al. (1992), who reported that staff constraints and staff training difficulties were considerable in most developing countries. For this reason it is suggested that

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screening methods should be simple enough to be taught to non-specialist staff such as CHWs (Prescott et al., 1999). When considering developed countries such as the United Kingdom, Australia and the United States of America, school-based hearing screening services are well established (Bento et al., 2003). In such situations, human resource constraints are not as significant as they are in developing countries. However, even in these contexts the training of support personnel for the purposes of hearing screening is recommended and OAEs in particular have been shown to be a valid, quick and easy test, minimizing personnel training needs whilst facilitating the effective implementation of the screening program (Roush, 2001).

With regard to the screening program resources such as the test environment it is suggested that “quiet, distraction-free” testing environments with all the necessary facilities, for example, electricity may not be readily available in developing countries (Gell et al., 1992, p.648). This may also be due to competing health demands and the relatively low priority that school health services hold in developing countries. In South Africa for instance reports on local school environments showed that 57% of the schools did not have electricity and approximately 5% of the school buildings were unsuitable for teaching and learning (National school health policy and implementation guidelines, DOH, 2002). In developed countries suitable workspaces are usually available and although the test rooms may not be completely sound-proof, testers often have a designated health room or a relatively quiet space such as the school library which can be used for testing (Roush, 2001).

Since the measurement of OAEs requires a relatively quiet workspace with acceptably low ambient noise levels, the use of rooms with poor environmental conditions can affect the accuracy of the test results (Roush, 2001). Testers should thus try to use the quietest room available and schedule testing during the quietest periods in the school day. Fortunately, the

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portability of modern OAE machines allows for some flexibility in how and when screening is conducted. In addition, most OAE machines are battery-operated, provided the battery is charged beforehand, which helps to overcome difficulties such as a lack of electricity on site. Similarly portable, battery-operated otoscopes and tympanometers are also available for screening purposes.

Another need pertaining to the screening program resources is that of the referral pathway, a component of the program which appeared to be a shortcoming in both developed and developing contexts, as concluded by Lescouflair (1975 cited in McPherson & Olusanya). More recent reports, however, indicate that the situation has improved in developed countries. For example, New Zealand's Ministry of Health in 2009, published their national vision and hearing screening protocols which included a comprehensive referral pathway between local schools and Audiology clinics. On the other hand, the findings discussed in *Chapter 4* revealed that the referral pathway in the Mitchell's Plain sub-district, as in other developing areas, is still cause for concern. This shortcoming however pertains to the broader screening program and not specifically to the test protocol under investigation.

In summary, in order to determine the applicability of the proposed screening protocol for different contexts one need only consider the core components of the protocol itself, which has been shown to be acceptable in terms of its ease of administration and interpretation, and general suitability for the school situation. Good reliability and specificity results were also obtained with this screening protocol. However, the poor sensitivity of the protocol is an important limitation suggesting that the protocol may need to be further refined before formal implementation in schools. Furthermore, although the protocol can be more readily implemented in a developed country (with less resource constraints), this study's findings including direct

feedback from the school nurses, as well as related literature have demonstrated that the protocol can be suitable for developing contexts provided the context-specific issues are considered.

5.2. Review of the Study's Methodology

The previous discussions included a detailed review of the findings related to the impact of the proposed protocol. In this section, the research process used to obtain these findings will be discussed. This process constituted the methodology of the study which allowed the researcher to translate knowledge of current healthcare delivery into action in an attempt to improve the quality of care (Akukwe, 2007). In this instance the researcher's knowledge of current school healthcare delivery revealed a need for routine hearing screening services and, in order to address this need, the researcher sought to identify and field test a contextually relevant screening protocol that could be implemented routinely in the school setting.

For this reason, a number of established methodologies related to developmental research designs were considered. However, when comparing these methodologies to the specific research objective, two limitations were identified. Firstly, in most cases contextual issues were not considered when formulating the study's design and are subsequently not considered in the development or selection of the health programs or interventions forming part of the study. This was a concern as a key element of any form of health planning or health research is the assessment of the existing situation including context-specific information and needs (Smith, 2008). Secondly, none of the reviewed methodologies fully addressed all the aspects of the current research objective.

Thus in order to address these limitations and so meet the present study's research objective, the researcher devised a novel, contextually appropriate research methodology based on the *Process of identifying contextually-relevant program or protocols* as summarized in Figure 4 in *Chapter 2*. Since the primary research objective was to propose a contextually relevant school-based hearing screening protocol, it called for special consideration of the contextual challenges, stakeholders in the context, relevant service providers, health planners as well as the general public affected by the screening service. The need for these considerations gave rise to a multi-layered research focus area in which the first layer is the screening protocol itself; the second layer is the screening program of which the protocol essentially forms part, and finally the third layer reflects the broader context in which the program is implemented. Refer to Figure 21 for a representation of these focal areas.

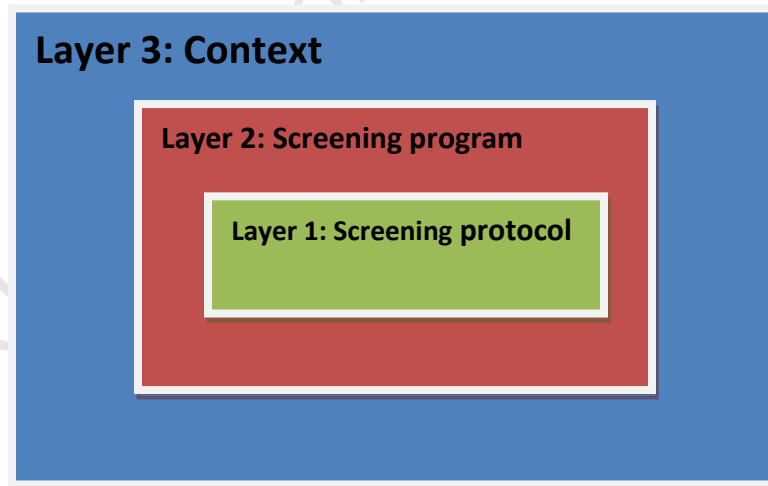


Figure 21: The study's multi-layered focus area

When considering the complexity of the research question, a mixed methods design was considered necessary as it allowed the researcher to use whichever methodological tools were

required to best answer the question under study (Teddlie & Tashakkori, 2009). The use of both qualitative and quantitative data collection and analysis procedures also added rigor to the study by providing the researcher with additional perspectives that are beyond the scope of any single research method. Refer to *Chapter 3* for a description of this mixed-methods methodology.

The application of this methodology proved effective as it allowed the researcher to use both predetermined and emerging questions to guide the study. For instance, the inadequate state of the school-based hearing screening service in the Mitchell's Plain sub-district, as well as the school health teams' primary concerns were already known to the researcher and thus shaped the main research question. However, the specific underlying reasons for this state of affairs were not fully understood. The mixed methods approach thus gave the researcher the opportunity to ask both exploratory questions aimed at generating information about unknown aspects of the phenomenon and confirmatory questions for verifying existing theories and explanations (Teddlie & Tashakkori, 2009).

Furthermore, by combining qualitative and quantitative research methods the researcher was able to demonstrate the compatibility of these research tools as well as the subsequent benefits of such an exercise. For example, in determining the outcomes of the initial field test of the screening protocol under review, the researcher used a combination of quantitative outcome measures of the protocol's performance, i.e. sensitivity and specificity, and qualitative feedback from the school nurses regarding the protocol's performance in the field. When combining the two data sources, the researcher obtained information that revealed the outcome of the protocol, i.e. whether or not the protocol met certain standards of performance, whilst simultaneously giving insight into the process involved in implementing the protocol, i.e. how the protocol was implemented and how it should be implemented.

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Although the benefits of this mixed methods approach is undeniable, there is a limitation in the study's methodology. When considering the research focus area (as depicted in the Figure 21), the implementation of the present study's methodology allowed the researcher to address only certain aspects of the focus area. For instance, if one refers to Figure 21, the school nurses gave information pertaining to the shortcomings in their current screening program (Layer 2). Here, a number of shortcomings were listed, one of these being the lack of a suitable screening protocol. The study's methodology was thus devised to address this particular aspect (Layer 1), and in order to ensure that the resulting protocol was contextually-appropriate, factors from the broader context (Layer 3) were taken into account. However, there are still gaps that need to be addressed in this particular research area since the nurses' needs included more than their need for a screening protocol. Therefore the proposed methodological framework can be viewed as a starting point in addressing such complex research areas but should be further developed to fully address this and other multi-layered research questions.

Furthermore, the use of a novel methodological framework also called for the development of data collection and analysis tools to adequately address the research objectives. This included the development of rating scales for the data collection in objective (c), the rating system used to document observations in objective (d), and the rating system and model for data synthesis used in the analysis of objective (b). These tools are subject to further development and validation but serve as a starting point for the construction of such novel research instruments.

5.3. Limitations of the Present Study

With regard to the limitations of the present study, the researcher considered those limitations that emerged during the research process as a result of uncontrollable variables, those limitations related to the study's methodology, and the limitations related to the researcher's role in the study. Firstly, with regard to the impact of variables, the period between the screening and the diagnostic tests should be considered. Ideally, the period between the two tests should have been minimal but this was not practically feasible. Participant attendance for the diagnostic assessment was also poor thus resulting in a number of re-scheduled appointments, which further increased the period between the screening and diagnostic tests. As discussed in *Chapter 4*, this delay may have contributed to the poor agreement between the two tests' results.

Secondly, in terms of the study's methodology, the screening sample size (when field testing the protocol) was fairly small (i.e. 100 learners screened at school and 54 learners underwent diagnostic testing) when considering that one of the main intentions of the study was to determine the outcome measures of the screening protocol. Unfortunately due to constraining factors such as time and staff constraints, it was not possible to include a larger screening sample. Furthermore, due to the relatively small sample size, the prevalence of hearing loss in this sample was also lower than it may have been if the sample were larger (Whiting et al., 2004). Consequently, this low prevalence rate could have negatively affected the resulting sensitivity measure of the OAE test.

Furthermore, the fact that information such as the referral rates, rate of conductive hearing loss and the test performance for different types of hearing loss were not included in the analysis of the proposed protocol's performance can also be considered a limitation of the study. Such

information would have been useful to strengthen the discussion of the test performance results. Additionally, the discrepancy between the pass/fail criteria of the screening test versus the diagnostic test may be considered a limitation as it may have inadvertently increased the disagreement between the two sets of data.

Another limitation related to the study methodology is the fact that there was no established method of rating the suitability of the screening tests included in the systematic review in objective (b). For this reason a novel rating system was devised but since it was a new rating system, a number of limitations were noted. For instance, the actual rating of each test variable was dependent on the information in the available literature as well as the researcher's opinion regarding the suitability of the retrieved literature. Therefore, the evidence base may have been incomplete due to selective reporting or limited access to certain types of evidence. Furthermore, the reliability and validity of the rating system was not formally evaluated. Similarly, the rating scales used for data collection in objectives (c) and (d) were not formally validated.

The modification of the search criteria in the systematic review can also be considered a limitation in this study as it resulted in the inclusion of studies targeting infants and toddlers. Results could thus not be readily applied to the school-aged population and the school context. Another limitation to the study's methodology is that the sensitivity and specificity of tympanometry could not be determined.

Thirdly, the role of the researcher must be reviewed. The researcher acted as observer in objective (d) of the study and since no additional observer was included to corroborate the researcher's observations this could be considered a limitation of the study. However, in order to

minimize this potential bias, a structured observation schedule and corresponding rating scale was utilized. Similarly, due to a lack of suitable research assistants during the data collection period, the researcher acted as independent tester for the inter-tester reliability tests in objective (e) of the study and also acted as one of the testers who conducted the diagnostic assessments on the screening sample (objective *e*). This could be viewed as a limitation of the study. However, in order to reduce the impact of this variable the researcher was blinded to the screening results obtained by the nurses.

5.4. Future Implications

The future implications of this study can be divided into two broad categories which include: future clinical implications, and future research implications. When considering the clinical implications of the present study's findings one should bear in mind the existing service delivery shortcomings and challenges discussed earlier in this chapter. It is often assumed that such challenges are addressed by simply proposing new models and systems. However, if the existing problems are not properly recognized and dealt with it will merely be perpetuated into the new model or system. The following clinical actions are thus recommended to address the challenges that school health staff, related healthcare providers, health planners and the general public are faced with:

1. Increase specialist services forming part of the DHS to improve the referral pathway from the school to more accessible referral centers such as a CHC or district hospital, and ultimately to tertiary levels of service delivery if necessary. Such a referral pathway will improve the effectiveness of any school-based hearing screening program.

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2. Increase the understanding and awareness amongst decision-makers, health planners and the public of the importance of school health services including school-based hearing screening programs. In so doing, school health services may become more appropriately prioritized which in turn could positively affect resource allocation and community involvement.
3. Increase the number of school health personnel by not only creating more posts but also improving incentives to maintain staff and providing training of assistants where necessary. This includes the training of community health workers and other volunteers to enable them to assist in the provision of school-based health services such as hearing screening.
4. Improved communication and coordination between relevant sectors and departments such as the Department of Health and the Department of Education as this kind of collaboration will improve health planning. Furthermore, this kind of coordination and collaboration may initiate much-needed action in the area of school-based hearing screening.

With regard to the research implications it is recommended that more research be focused on increasing the interface between health service researchers and policy- or decision makers. This is important as researchers aim to translate their findings into policy making decisions that will ultimately improve the state of health services or the health of their target population (Akukwe, 2007). For this reason, the following health research studies are suggested:

1. A more comprehensive evaluation of the outcomes measures of the proposed hearing screening protocol in different school settings, covering a larger geographical area and including a larger screening sample.

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2. Examining the parents and educators role in the identification of hearing loss in the school-aged population, including their perceptions regarding the value of hearing screening.
3. More comprehensive epidemiological data is required in order to carry out economic analysis studies in developing countries, including studies that determine the cost of the burden of hearing impairment and the cost-effectiveness of different identification and intervention programs pertaining to hearing impairment. It is hoped that such data will improve the resource allocation for such identification and intervention services in developing countries.
4. Studies aimed at monitoring school-based screening programs at provincial and national levels to determine the effectiveness of such programs and possible ways to improve current programs. The information generated from such studies can provide policy makers with evidence based research to inform their decision-making.

It is essential that one adopts and maintains a research evidence-based approach to the planning for school health services. Although the present study's findings revealed useful information, unanswered question and gaps in service delivery still remain. For this reason, it is recommended that the information generated from this study be put to use whilst continuing to refine, field test and research the area of school-based screening protocols and services.

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Dissemination strategies:

- Presented initial findings to the National and Provincial Department of Health
- Will present findings including the proposed protocol to Western Cape Metropole District Health Services (MDHS) School Health Task Team at the end of February 2011
- Publication in international journal

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IDENTIFICATION OF A SCHOOL HEARING SCREENING PROTOCOL

Appendix A1

Consent letter to CHC facility manager

[On letterhead]

UNIVERSITY OF CAPE TOWN

DIVISION OF COMMUNICATION SCIENCES AND DISORDERS

DATE: 19 January 2008

TO: FACILITY MANAGER

.....Community Health Centre

I am a student registered for the Masters degree in Audiology at the University of Cape Town. As part of my degree requirements I am conducting a research project, under the supervision of Prof. Kathard and Ms Petersen.

The study is aimed at developing a contextually-relevant hearing screening tool for use in schools. This will contribute to the identification of hearing loss in school learners and subsequently the appropriate management of these cases. Based on personal interaction and related literature, it is evident that there is no standard method of hearing screening in schools in the Western Cape and as such, this form of screening is not routinely performed in many schools. Thus, the development of a screening tool that is effective and addresses the needs of the school health team can contribute significantly to appropriate and relevant service delivery for school learners.

In order to achieve these aims, I request permission to approach the district's school health team for participation in the study. Their task would involve taking part in a group discussion to identify context-specific needs, to help the researcher determine the current state of audiological services in schools as well as the perceived shortcomings in this regard. They will also be required to implement the selected hearing screening protocol in their respective schools and provide feedback (in a group discussion) regarding its effectiveness in addressing their needs. The two group discussions described here will each last for a maximum of 2 hrs and the implementation of the screening protocol should be completed in one screening session (the duration of the screening session to be confirmed once screening protocol is determined).

All participant responses will be treated with confidentiality and anonymity of the Facility and participants will be ensured at all times. All information obtained will be used for the purposes of this study only, including subsequent papers and conferences

IDENTIFICATION OF A SCHOOL HEARING SCREENING PROTOCOL

pertaining to this particular study. Furthermore, the study's activities will be conducted in such a way that it will have only minimal interference with the school health team's operational responsibilities. Thus, data collection activities will be structured around the nurses' work schedules.

Your assistance and feedback in this regard will be much appreciated. My contact information is listed below for your convenience.

Email:

Cell:

Hoping you take this request into kind consideration.

Yours sincerely,

Ms T Cupido

Student

University of Cape Town

IDENTIFICATION OF A SCHOOL HEARING SCREENING PROTOCOL

Appendix A2

Consent letter to participating school nurses

[On letterhead]

UNIVERSITY OF CAPE TOWN

DIVISION OF COMMUNICATION SCIENCES AND DISORDERS

DATE: 21 January 2008

Dear participant

I am a student registered for the Masters degree in Audiology at the University of Cape Town. As part of my degree requirements I am conducting a research project, under the supervision of Prof. Kathard and Ms Petersen, from the University of Cape Town's Division of Communication Sciences and Disorders.

The study is aimed at developing a contextually-relevant hearing screening protocol for use in schools. This will contribute to the identification of hearing loss in school learners and subsequently the appropriate management of these cases. Based on personal interaction and related literature, it is evident that there is no standard method of hearing screening in schools in the Western Cape and as such, this form of screening is not routinely performed in many schools. Thus, the development of a screening protocol that is effective and addresses the needs of the school health team can contribute significantly to appropriate and relevant service delivery for school learners.

In order to achieve these aims, I wish to request your participation in the proposed research study. As the primary health workers in the schools in this sub-district, your participation is of vital importance. If you agree to take part in this study, your task would involve taking part in a group discussion to identify your context-specific needs, to help the researcher determine the current state of audiological services in schools as well as the perceived shortcomings in this regard. You will also be required to implement the selected hearing screening protocol in your respective schools and provide feedback (in a group discussion) regarding its effectiveness in addressing your needs. The two group discussions described here will each last for a maximum of 2 hrs (including breaks) and the implementation of the screening protocol should be completed in one screening session (the duration of the screening session to be confirmed once screening protocol is determined). During this session research assistants will be present to observe and assist you where necessary. You will also receive brief training (one session) prior to using the screening protocol under investigation.

IDENTIFICATION OF A SCHOOL HEARING SCREENING PROTOCOL

All participant responses and interactions will be treated with confidentiality and anonymity of the Facility and participants will be ensured at all times. All information obtained will be used for the purposes of this study only, including academic papers and conferences pertaining to the study. Furthermore, the study's activities will be conducted in such a way that it interferes only minimally with the school health team's operational responsibilities. Thus, all activities will be structured around your work schedules and will be done in a manner that suits your team.

Furthermore, special measures will be taken to ensure your comfort at all times e.g. refreshments will be served at all group activities and assistance will be provided whenever necessary. You are furthermore under no obligation to participate in the study and may leave the study group at any time.

Your assistance in this regard will be much appreciated. Hoping you take this request into kind consideration.

Yours sincerely,

Ms T Cupido

Student

Prof. H Kathard

Supervisor

Ms L Petersen

Supervisor

Please sign below if you agree to participate in the study:

Sign

Date

Appendix A3

Consent letter to expert panel

UNIVERSITY OF CAPE TOWN



School of Health & Rehabilitation Sciences

Divisions of Communication Sciences & Disorders · Nursing & Midwifery ·

Nutrition & Dietetics · Occupational Therapy · Physiotherapy

Old Main Building · Groote Schuur Hospital · Observatory · 7925

Telephone: +27 21 40664 Fax: +27 21/4066323

1 April 2008

Re: Letter of consent for participation in expert panel

Dear Participant

I am a student registered for the Masters degree in Audiology at the University of Cape Town. As part of my degree requirements I am conducting a research project, under the supervision of Prof. Kathard and Ms Petersen, from the University of Cape Town's Division of Communication Sciences and Disorders.

The study is aimed at developing a contextually-relevant hearing screening protocol for use in schools. This will contribute to the identification of hearing loss in school learners and subsequently the appropriate management of these cases. Based on personal interaction and related literature, it is evident that there is no standard method of hearing screening in schools in the Western Cape and as such, this form of screening is not routinely performed in many schools. Thus, the development of a screening protocol that is effective and addresses the needs of the school health team can contribute significantly to appropriate and relevant service delivery for school learners.

IDENTIFICATION OF A SCHOOL HEARING SCREENING PROTOCOL

In order to achieve these aims, I wish to request your participation in this research study. As experts in the fields of school health and/or audiological screening methods, your participation is of vital importance. If you agree to take part in this study, you will form part of a consensus panel that will come together for one session of approximately 2 hours (including breaks), in which two selected screening protocols will be rated and critically compared. For this purpose, you will receive an instructional letter outlining your role in the selection process and all the relevant information that will enable you to complete the included rating scale with ease. A brief discussion session will follow completion of the rating scale in which the panel will reach consensus regarding the most suitable screening protocol to be implemented in the proposed study.

All participant responses and interactions will be treated with confidentiality and anonymity will be ensured at all times. All information obtained will be used for the purposes of this study only, including academic papers and conferences pertaining to this study. Furthermore, the study's activities will be conducted in such a way that it interferes only minimally with the panel member's other roles and responsibilities. Thus, the panel's meeting will be structured around the panel members' work schedules.

Special measures will also be taken to ensure your comfort at all times e.g. refreshments will be served at the panel meeting and assistance will be provided whenever necessary. You are furthermore under no obligation to participate in the study and may leave the study group at any time.

Your assistance in this regard will be much appreciated. Hoping you take this request into kind consideration.

Yours sincerely,

Ms T Cupido

Student

Prof. H Kathard

Supervisor

Ms L Petersen

Supervisor

IDENTIFICATION OF A SCHOOL HEARING SCREENING PROTOCOL

Please sign below if you agree to participate in the study

Sign

Date

University of Cape Town

IDENTIFICATION OF A SCHOOL HEARING SCREENING PROTOCOL

Appendix A4: Permission from Western Cape Education Department

Navrae
Enquiries
IMibuzo
Telefoon
Telephone
IFoni
Faks
Fax
IFeksi
Verwysing
Reference
ISalathiso

Dr RS Cornelissen

(021) 467-2286

(021) 425-7445

20080212-0034



Wes-Kaap Onderwysdepartement

Western Cape Education Department

ISEBE leMfundo leNtshona Koloni

Ms Tracey-Lee Cupido
Division of Communication Sciences and Disorders
University of Cape Town
Private Bag
RONDEBOSCH
7700

Dear Ms T. Cupido

RESEARCH PROPOSAL: DEVELOPING A CONTEXTUALLY-RELEVANT HEARING SCREENING TOOL FOR USE IN SCHOOLS.

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **21st April 2008 to 27th June 2008**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr R. Cornelissen at the contact numbers above quoting the reference number.
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

**The Director: Research Services
Western Cape Education Department
Private Bag X9114
CAPE TOWN
8000**

We wish you success in your research.

Kind regards.

Signed: Ronald S. Cornelissen
for: **HEAD: EDUCATION**
DATE: 21st April 2008

MELD ASSEBLIEF VERWYSINGSNOMMERS IN ALLE KORRESPONDENSIE / PLEASE QUOTE REFERENCE NUMBERS IN ALL CORRESPONDENCE /
NCEDA UBHALE INOMBOLO ZESALATHISO KUYO YONKE IMBALELWANO

GRAND CENTRAL TOWERS, LAER-PARLEMENTSTRAAT, PRIVAATSAK X9114, KAAPSTAD 8000
GRAND CENTRAL TOWERS, LOWER PARLIAMENT STREET, PRIVATE BAG X9114, CAPE TOWN 8000

WEB: <http://wced.wcape.gov.za>

INBELSENTRUM /CALL CENTRE

INDIENSNEMING- EN SALARISNAVRAE/EMPLOYMENT AND SALARY QUERIES ☎0861 92 33 22
VEILIGE SKOLE/SAFE SCHOOLS ☎ 0800 45 46 47

Appendix A5

Consent letter to principals of participating schools

UNIVERSITY OF CAPE TOWN



School of Health & Rehabilitation Sciences

Divisions of Communication Sciences & Disorders · Nursing & Midwifery ·

Nutrition & Dietetics · Occupational Therapy · Physiotherapy

Old Main Building · Groote Schuur Hospital · Observatory · 7925

Telephone: +27 21 40664 Fax: +27 21/4066323

1 April 2008

Re: Letter of consent for participation in audiological research

Dear Principal & educators

I am a student registered for the Masters degree in Audiology at the University of Cape Town. As part of my degree requirements I am conducting a research study, under the supervision of Prof. Kathard and Ms Petersen, from the University of Cape Town's Division of Communication Sciences and Disorders.

The study is aimed at developing a contextually-relevant hearing screening tool for use in schools. This will contribute to the identification of hearing loss in school learners and subsequently the appropriate management of these cases. Based on personal interaction and related literature, it is evident that there is no standard method of hearing screening in schools in the Western Cape and as such, this form of screening is not routinely performed in many

IDENTIFICATION OF A SCHOOL HEARING SCREENING PROTOCOL

schools. Thus, the development of a screening tool that is effective and addresses the needs of the school health team can contribute significantly to appropriate and relevant service delivery for school learners.

In order to achieve these aims, I request permission to approach 25 grade one learners from your school. These learners will be randomly selected and consent will also be sought from each learner's primary caregivers. Their participation would involve them undergoing three hearing tests. The first two tests will be brief screening tests lasting approximately 10 minutes each and with your permission these tests will be conducted at your schools, by the school nurses & an Audiologist based at the site. The third and final test will be conducted by an Audiologist in a more clinical environment and the test will last approximately 20 minutes. All testing procedures will involve basic, non-invasive methods to determine the effectiveness of the hearing screening tool under investigation in the study.

All participant responses will be treated with confidentiality and anonymity of the schools and participants will be ensured at all times. All information obtained will be used for the purposes of this study only, including academic papers and conferences pertaining to this study. Furthermore, the study's activities will be conducted in such a way that it interferes only minimally with the school operational responsibilities and learners class schedules. Class teachers will thus be consulted to determine test times and the appropriate staff members will be kept informed of all aspects of the learners' participation.

Your assistance in this regard will be much appreciated. Hoping you take this request into kind consideration.

Yours sincerely,

Ms T Cupido

Student

Prof. H Kathard

Supervisor

Ms L Petersen

Supervisor

Appendix A6

English consent letter to parents of participating learners

UNIVERSITY OF CAPE TOWN



School of Health & Rehabilitation Sciences

Divisions of Communication Sciences & Disorders · Nursing & Midwifery ·

Nutrition & Dietetics · Occupational Therapy · Physiotherapy

Old Main Building · Groote Schuur Hospital · Observatory · 7925

Telephone: +27 21 40664 Fax: +27 21/4066323

1 April 2008

Re: Letter of consent for learners to participate in hearing testing

Dear Parent/caregiver

I am an Audiology student at the University of Cape Town. As part of my degree requirements I am conducting a study, under the supervision of Prof. Kathard and Ms Petersen, from the University of Cape Town's Division of Communication Sciences and Disorders.

For my study, I would like to develop a hearing-screening tool for use in schools to help us identify hearing loss in school-aged children. In order to do this, I request your permission to have your child's hearing tested on three occasions. Two of the tests will take place at your child's school during the normal school day and will be done by the school nurse and a hearing specialist. The third test will take place at a Red Cross Children's Hospital and will be done by a hearing specialist. As caregiver, you will be asked to bring your child to Red Cross but will receive money to cover your transport costs. The hearing tests will not involve any harmful procedures. It involves placing earphones

IDENTIFICATION OF A SCHOOL HEARING SCREENING PROTOCOL

on your child's head and playing sounds to him/her through these earphones. S/he is then required to let us know whether or not s/he heard the sound. Their ears will also be examined by shining a special torch into their ears. The test is fairly quick, lasting for about 10 minutes.

Your child's test results will be treated with confidentiality and all the information will be used for this study only. If however a hearing problem is identified, the child's personal details will be given to the local clinic or hospital staff for treatment purposes. Class teachers will also be informed of everything so that the study does not interfere with your child's classes. You will be informed of your child's test results and treatment will be provided if an ear or hearing problem is identified. Your child's participation will be much appreciated but s/he does not have to participate if you do not want them to.

Yours sincerely,

Ms T Cupido

Student

Prof. H Kathard

Supervisor

Ms L Petersen

Supervisor

Please sign below if you allow your child to participate and return the form to school as soon as possible.

Parent/caregiver sign

Date

IDENTIFICATION OF A SCHOOL HEARING SCREENING PROTOCOL

Please allow the child to mark the appropriate box:

I would like to take part in the hearing tests.

Yes	No
-----	----

University of Cape Town

Appendix A7

Afrikaans consent letter to parents of participating learners

UNIVERSITY OF CAPE TOWN



School of Health & Rehabilitation Sciences

Divisions of Communication Sciences & Disorders · Nursing & Midwifery ·

Nutrition & Dietetics · Occupational Therapy · Physiotherapy

Old Main Building · Grootte Schuur Hospital · Observatory · 7925

Telefoon: +27 21 40664 Faks: +27 21/4066323

26 May 2008

Met betrekking tot: Toestemmingsbrief vir leerders se deelname in gehoortoetsing

Beste Ouer/voog

Ek is 'n Oudiologie student by die Universiteit van Kaapstad. As deel van my graad vereistes is ek tans besig om 'n studie aan te voer, onder toesig van Prof. Kathard en Mev. Petersen, van die Universiteit van Kaapstad se Division of Communication Sciences and Disorders.

Vir my studie, wil ek graag 'n gehoor-sifting instrument ontwikkel vir die gebruik in skole en om sodoende ons te help om gehoor verlies te identifiseer in skoliere. Om dit uit te voer verg ek u toestemming om u kind se gehoor op drie geleenthede te toets. Twee van die toetse sal plaasvind by u kind se skool gedurende 'n normale skool dag en sal uitgevoer word deur die skool verpleegster en gehoor spesialis. Die derde toets sal plaasvind by die Rooikruis Kinder Hospitaal en sal uitgevoer word deur 'n gehoor spesialis. As voog, sal u gevra word om u kind na die Rooikruis Kinder Hospitaal te neem, maar u sal vergoeding ontvang vir u vervoer onkostas. Die gehoor toetse sluit geen skadelike

IDENTIFICATION OF A SCHOOL HEARING SCREENING PROTOCOL

prosedures in nie. Dit behels die plasing van oorfone oor u kind se ore waardeur klanke vir hom/haar gespeel sal word. Hierna is van hom/haar verlang om ons in te lig of hy/sy die klank gehoor het. Hulle ore sal ook geondersoek word met 'n spesiale flits wat in die ore geskyn word. Die toets is redelik vinning om te doen en duur ongeveer 10 minute.

U kind se toets-uitslae sal behandel word as vertroulik en alle informasie sal slegs vir hierdie studie gebruik word. Indien 'n gehoor verlies wel vasgestel word, sal die kind se persoonlike besonderhede oorgehandig word aan die plaaslike kliniek of die betrokke hospitaal personeel vir behandeling doeleindes. Klas opvoeders sal ook ingelig word van alle verhandelings sodat die studie nie inmeng met u kind se klasse nie. U kind se deelname sal baie waardeer word, maar hy/sy hoef nie deel te neem indien u nie wil hê hy/sy moet nie.

Die uwe,

Mej. T Cupido

Student

Prof. H Kathard

Opsiener

Mev. L Petersen

Opsiener

Teken asseblief onder indien u toestemming gee dat u kind 'n gehoortoets ondergaan, en handig hierdie vorm so gou as moontlik in by die skool.

Handtekening van ouer/voog

Datum

IDENTIFICATION OF A SCHOOL HEARING SCREENING PROTOCOL

Laat u kind asseblief die gepaste blokkie merk:

Ek wil graag deelneem in die gehoortoetse.

Ja	Nee
----	-----

University of Cape Town

Appendix A8

Consent letter to Medical superintendent of participating tertiary hospital

UNIVERSITY OF CAPE TOWN



School of Health & Rehabilitation Sciences

Divisions of Communication Sciences & Disorders · Nursing & Midwifery ·

Nutrition & Dietetics · Occupational Therapy · Physiotherapy

Old Main Building · Groote Schuur Hospital · Observatory · 7925

Telephone: +27 21 40664 Fax: +27 21/4066323

15 April 2008

Re: -----Hospital, Audiology Dept as audiological research site

-----Hospital

Medical Superintendent

Dr

I am a student registered for the Masters degree in Audiology at the University of Cape Town. As part of my degree requirements I am conducting a research study, under the supervision of Prof. Kathard and Ms Petersen, from the University of Cape Town's Division of Communication Sciences and Disorders.

The study is aimed at developing a contextually-relevant hearing screening tool for use in schools. This will contribute to the identification of hearing loss in school learners and subsequently the appropriate management of these cases. Based on personal interaction and related literature, it is evident that there is no standard method of hearing screening in schools in the Western Cape and as such, this form of screening is not routinely performed in many

IDENTIFICATION OF A SCHOOL HEARING SCREENING PROTOCOL

schools. Thus, the development of a screening tool that is effective and addresses the needs of the school health team can contribute significantly to appropriate and relevant service delivery for school learners.

In order to evaluate the effectiveness of the developed screening tool, all participants will have to undergo diagnostic audiological assessments in a sound clinical environment. These findings will then serve as the reference standard against which the findings from the screening tool will be compared. As the Audiology Department at ----- Hospital constitutes an ideal clinical environment for testing, I would like to request permission to make use of these facilities for the purpose of verifying the effectiveness of the developed screening tool.

If permitted, I will schedule four visits to the Audiology Department and test a total of twenty five grade one learners per visit i.e. total of one hundred learners to be tested. All arrangements will be made in such a way that it interferes only minimally with the Audiologists' operational responsibilities and work schedules. They will thus be consulted to determine test times and dates, and will be kept informed of all aspects of the research activities conducted on the premises. As researcher, I will organise any supervision and transportation issues pertaining to the participants and their caregivers. I will also liaise with the relevant staff members should the need for additional audiological or otological services be identified.

Furthermore, all findings will be treated with confidentiality and anonymity of the hospital and participants will be ensured at all times. All information obtained will be used for the purposes of this study only, including academic papers and conferences pertaining to this study.

Your assistance in this regard will be much appreciated. Hoping you take this request into kind consideration.

Yours sincerely,

Ms T Cupido

Student

Prof. H Kathard

Supervisor

Ms L Petersen

Supervisor

Appendix A9

Consent letter to the Audiology Department of participating tertiary hospital

UNIVERSITY OF CAPE TOWN



School of Health & Rehabilitation Sciences

Divisions of Communication Sciences & Disorders · Nursing & Midwifery ·

Nutrition & Dietetics · Occupational Therapy · Physiotherapy

Old Main Building · Grootte Schuur Hospital · Observatory ·7925

Telephone: +27 21 40664 Fax: +27 21/4066323

15 April 2008

Re: ----- Hospital, Audiology Dept as audiological research site

----- Hospital

Audiology Department

Head of Department

I am a student registered for the Masters degree in Audiology at the University of Cape Town. As part of my degree requirements I am conducting a research study, under the supervision of Prof. Kathard and Ms Petersen, from the University of Cape Town's Division of Communication Sciences and Disorders.

The study is aimed at developing a contextually-relevant hearing screening tool for use in schools. This will contribute to the identification of hearing loss in school learners and subsequently the appropriate management of these cases. Based on personal interaction and related literature, it is evident that there is no standard method of hearing screening in schools in the Western Cape and as such, this form of screening is not routinely performed in many

IDENTIFICATION OF A SCHOOL HEARING SCREENING PROTOCOL

schools. Thus, the development of a screening tool that is effective and addresses the needs of the school health team can contribute significantly to appropriate and relevant service delivery for school learners.

In order to evaluate the effectiveness of the developed screening tool, all participants will have to undergo diagnostic audiological assessments in a sound clinical environment. These findings will then serve as the reference standard against which the findings from the screening tool will be compared. As the Audiology Department at ----- Hospital constitutes an ideal clinical environment for testing, I would like to request permission to make use of these facilities for the purpose of verifying the effectiveness of the developed screening tool.

If permitted, I will schedule four visits to the Audiology Department and test a total of twenty five grade one learners per visit i.e. total of one hundred learners to be tested. All arrangements will be made in such a way that it interferes only minimally with your operational responsibilities and work schedules. You will thus be consulted to determine test times and dates, and will be kept informed of all aspects of the research activities conducted on the premises. As researcher, I will organise any supervision and transportation issues pertaining to the participants and their caregivers. I will also liaise with the relevant staff members should the need for additional audiological or otological services be identified.

Furthermore, all findings will be treated with confidentiality and anonymity of the hospital and participants will be ensured at all times. All information obtained will be used for the purposes of this study only, including academic papers and conferences pertaining to this study.

Your assistance in this regard will be much appreciated. Hoping you take this request into kind consideration.

Yours sincerely,

Ms T Cupido

Student

Prof. H Kathard

Supervisor

Ms L Petersen

Supervisor

Appendix A10

Consent letter to research assistant

UNIVERSITY OF CAPE TOWN



School of Health & Rehabilitation Sciences

Divisions of Communication Sciences & Disorders · Nursing & Midwifery ·

Nutrition & Dietetics · Occupational Therapy · Physiotherapy

Old Main Building · Grootte Schuur Hospital · Observatory · 7925

Telephone: +27 21 40664

Fax: +27 21/4066323

June 2008

Dear Participant

I am a student registered for the Masters degree in Audiology at the University of Cape Town. As part of my degree requirements I am conducting a research project, under the supervision of Prof. Kathard and Ms Petersen, from the University of Cape Town's Division of Communication Sciences and Disorders.

The study is aimed at developing a contextually-relevant hearing screening protocol for use in schools. This will contribute to the identification of hearing loss in school learners and subsequently the appropriate management of these cases. Based on personal interaction and related literature, it is evident that there is no standard method of hearing screening in schools in the Western Cape and as such, this form of screening is not routinely performed in many schools. Thus, the development of a screening protocol that is effective and addresses the needs of the school health team can contribute significantly to appropriate and relevant service delivery for school learners.

IDENTIFICATION OF A SCHOOL HEARING SCREENING PROTOCOL

In order to achieve these aims, I wish to request your participation in this research study. As knowledgeable individuals in the field of audiological screening, your participation is of vital importance. If you agree to take part in this study, you will act as research assistant, observing and documenting the school nurses' implementation of a selected hearing screening protocol. You will be given an observation schedule to guide you in the observation process as well as an instructional session to provide you with all the relevant information. This observation process should last approximately 2 hours but precise duration will be confirmed once the screening protocol is determined.

Your participation will be treated with confidentiality and anonymity will be ensured at all times. Special measures will also be taken to ensure your comfort at all times e.g. refreshments will be served at the instructional session and assistance will be provided whenever necessary. You are furthermore under no obligation to participate in the study and may leave the study group at any time.

Your assistance in this regard will be much appreciated. Hoping you take this request into kind consideration.

Yours sincerely,

Ms T Cupido

Student

Prof. H Kathard

Supervisor

Ms L Petersen

Supervisor

Please sign below if you agree to participate in the study

Sign

Date

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Appendix A11

Permission from Research Ethics Committee

Handwritten notes in blue ink:
1. Tshabalala
Master's study



UNIVERSITY OF CAPE TOWN

**Health Sciences Faculty
Research Ethics Committee**
Room E52-24 Groote Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6492 • Facsimile [021] 406 6411
e-mail: Nosil.Tytwabi@uct.ac.za

13 December 2007

REC REF: 479/2007

Prof H Kathard
Communication Sciences & Disorders

Dear Prof Kathard

**PROJECT TITLE: TOWARDS THE DEVELOPMENT OF A CONTEXTUALLY-RELEVANT,
SCHOOL-BASED HEARING SCREENING PROTOCOL**

Thank you for submitting your study to the Research Ethics Committee for review.

Please could you indicate if the consent forms will be available in Afrikaans and Xhosa (if appropriate).

We have attached the reviewer's methodological comments which you might wish to consider in future versions of your study. Ethics Approval will not be dependent on your response to these comments.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the REC. REF in all your correspondence.

Yours sincerely

Handwritten signature of Prof M Blockman

PROF M BLOCKMAN
CHAIRPERSON, HSF HUMAN ETHICS

Handwritten initials: pp

lemjedi

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Appendix B

Discussion guide for the focus group in objective (a)

Initial interview guide

Purpose	Topics
<p>1. Establishing rapport</p>	<ul style="list-style-type: none"> -Introductions & complete consent letters -Further explanation of purpose of focus group -Description of the session structure & facilitator’s role in the session -Description of the school health services in the district, how it functions
<p>2. Determine current state of the service</p>	<ul style="list-style-type: none"> -What does the current hearing screening service include -How are learners managed with regards to ear & hearing problems -The nurses & CHW’s skills in the area -Their opinion regarding the adequacy of their skills & knowledge in the area -methods of hearing screening currently utilised -Support services available, forming part of the school-based screening program -Subjective opinions regarding the effectiveness of the hearing screening service at present
<p>3. Determine the problems experienced or any shortcomings of the school-based hearing screening service</p>	<ul style="list-style-type: none"> -What are the problems experienced with school-based hearing screening in the district -what are the context-specific needs -Suggestions to improve on the current state of the hearing screening service -Expectations: What constitutes an effective school-based hearing screening service??

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Recommended changes:

Rephrase items in section 3 and remove redundant items, as it yields many repetitive responses.

Revised interview guide

Purpose	Topics
<p>Establishing rapport</p>	<ul style="list-style-type: none"> -Introductions & complete consent letters -Further explanation of purpose of focus group -Description of the session structure & facilitator's role in the session -Description of the school health services in the district, how it functions
<p>Determine current state of the service</p>	<ul style="list-style-type: none"> -What does the current hearing screening service include (screening methods & management issues) -The nurses' skills attained in the area & subjective opinion regarding the adequacy of skills & knowledge in the area -methods of hearing screening currently utilised -Support services available, forming part of the school-based screening program -Subjective opinions regarding the effectiveness of the hearing screening service at present
<p>Determine the problems experienced or any shortcomings of the school-based hearing screening service</p>	<ul style="list-style-type: none"> -What are the problems experienced with school-based hearing screening in the district (& what nurses would need to overcome these problems) -Suggestions to improve on the current state of the hearing screening service & make it more effective

Appendix C

Summarised transcript of focus group data obtained in objective (a)

Discussion point 1: Description of the school health services in the district, how it functions

Nurse 1: Ok at the moment, normally we would be a team of 4 and we falling under the Mitchell's Plain Community Health Centre, we cover about plus minus 51 schools, primary schools uhm in the district and if we are full uh staff competency then we can manage to do that but if we not the we have some uncovered areas so and the teams, the 4 teams is uhm uhm 4 registered nurses. And 4 nurses. Alright so that means we have a registered nurse and a nurse in the team so that makes the 4 teams out in the district. At the moment we are uh 3 and half teams, 3 and a half teams cos 1 registered nurse just left, she accepted a position elsewhere. So we have got one area that is shared amongst us so for instance should there a child be needing something like screening for eye testing vision , vision is ja and eye testing maybe a speech referral or some hearing problems or whatever ... and then we will well the one that's closest to that school will go and attend to that uh need at the school.

Nurse 1: ...otherwise we work together and we try and share the work of the uncovered areas

Nurse 2: Ja and our duties uhm we mainly focus on the Grade R's and the Grade 1's uhm and we do a uhm how do you say it a superficial screening compared to the one that we did before. We just sort of do the head part uhm we test eyes we check their ears exclude wax uhm we do height and weight and....

Nurse 1:visual acuity

Nurse 2: We used to do a more complex screening where we do the whole gross motor and all of that but we don't do that now because government says there is too few of us to do all of that at one school we need to uhm do a less deep screening and do a sort of superficial one so that we can cover more grade R and 1 learners

Discussion point 2: What does the current hearing screening service include (screening methods & management issues)

Nurse 1: What I detect is the we have got a form that [CHC Audiologist previously employed in the sub-district] gave us initially and that is primarily for the teachers because they are there to they observe the children so obviously when they educate the kids they can detect which one has a hearing problem, you see and then they the ones who make a note in there for the teacher themselves they've got this uh each teacher is supposed to have a sheet that [CHC Audiologist] gave for them 2 years ago I think ja and uh so they have to fill it in and then once they detect it or they feel that this the problem the form comes to us we assess the child we look into the ears maybe the child is not deaf maybe there's a lot of wax in maybe he's got the impacted wax. So then we look at the child and then we refer the child so that is the way we are doing things at the moment and uh... the grade R/1's we all look into each single child's ears so that is makes their task easier and even now it's the beginning of the year they wouldn't know so we look into each and every child's ear and then we screen the ears

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Nurse 1: Ja...I used to use the one [hearing screening test] with the words. Then you have to stand a distance away from the child and then have to repeat it...2 metres away from the child and then he has to stand with his ear towards your mouth in other words he's got to stand to your side and you got to face the child buy he's standing 2 meters away...and then he has to repeat the words that you saying... and you have to use a normal voice tone like we talking now say shoe spoon and he has to repeat it

Nurse 2: I never used that because when I came into schools they were still using rattle
And that was not too long ago

So for Audiology we never really had anything concrete

Nurse 1: at the moment it's still because then they said to us because there's such a uhm people the old we are quite fairly new the whole Mitchell's Plain team is new and the others the school nurses in the district it appears as they don't do it the same that shoe spoon¹² [words test]was a very old thing but some of them it phased out there is no really actual

thing that we say look you have to do that it's not standard or whatever you see.It's not standard...

Nurse 1: ...so if we should be having a problem that needs referral to a audio audiologist which we don't have there in the area go to the clinic then they have to refer you have to just follow the system just go according to the system for instance if I refer someone to [tertiary hospital] to the audiologist it's not going to be accepted it must come via the channels...via clinic

Discussion point 3: The nurses' skills attained in the area & subjective opinion regarding the adequacy of skills & knowledge in the area

Nurse 1: I personally feel I'm not [equipped to conduct hearing screening]. I know how to work with the audiometer we've received the training but my concern is those children that

you've missed out that it's not detected you know uhm like I said need a standard protocol or something

Nurse 2: Just the normal examination, there's a lot of times I still struggle I'm sure that only comes through years and years of more training and more training this afternoon ag this morning I wondered what is a dull drum again that sort of thing and if you don't see it everyday so that would be my need is the examination the ear more training on that uhm the audiometer myself

Discussion point 4: Methods of hearing screening currently utilised

See Discussion point 2.

Discussion point 5: Support services available, forming part of the school-based screening program

Nurse 1: A support service? Uhm I don't feel I honestly no the only support that we had was [CHC Audiologist previously employed in the sub-district] but she left, the only support that we had that we could do something about... because when we entered school health we had the shoe spoon thing [words test]...you know we had a lot of fun at school and uh never the less . So when [CHC Audiologist] came along we uhm received training on how to use the audiometer with the community health workers at the clinic and we tried we

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gave our input at the deaf awareness week in September. But now I don't know how it's going to work now regarding our referrals cos we would like to refer the children the same way as we refer [for] speech [problems]..so but at the moment we have to hang in there but we don't [have support]

Discussion point 6: Subjective opinions regarding the effectiveness of the hearing screening service at present

Facilitator: Did you feel that that [current hearing screening protocol] was working?

Nurse 1: No not really. I would say we don't pick up all [children] with hearing problems we don't definitely I mean lets be honest because of this time limitations and to reach the target [meet certain monthly stats requirements]

Discussion point 7: What are the problems experienced with school-based hearing screening in the district (& what nurses would need to overcome these problems)

Nurse 1: Yes especially it's difficult sometimes to do the hearing test with the audiometer in school because the school is close to the main road you see there's trains

you see or Interval or what for it when it's very quiet because now the teacher they now having now a a um biblical¹³ whatever or they singing or they repeating the work or all they all where everyone has to speak or sing or whatever they doing and then you unable because you cannot do a hearing test when where there are other outside noise going to affect you're you're the result of

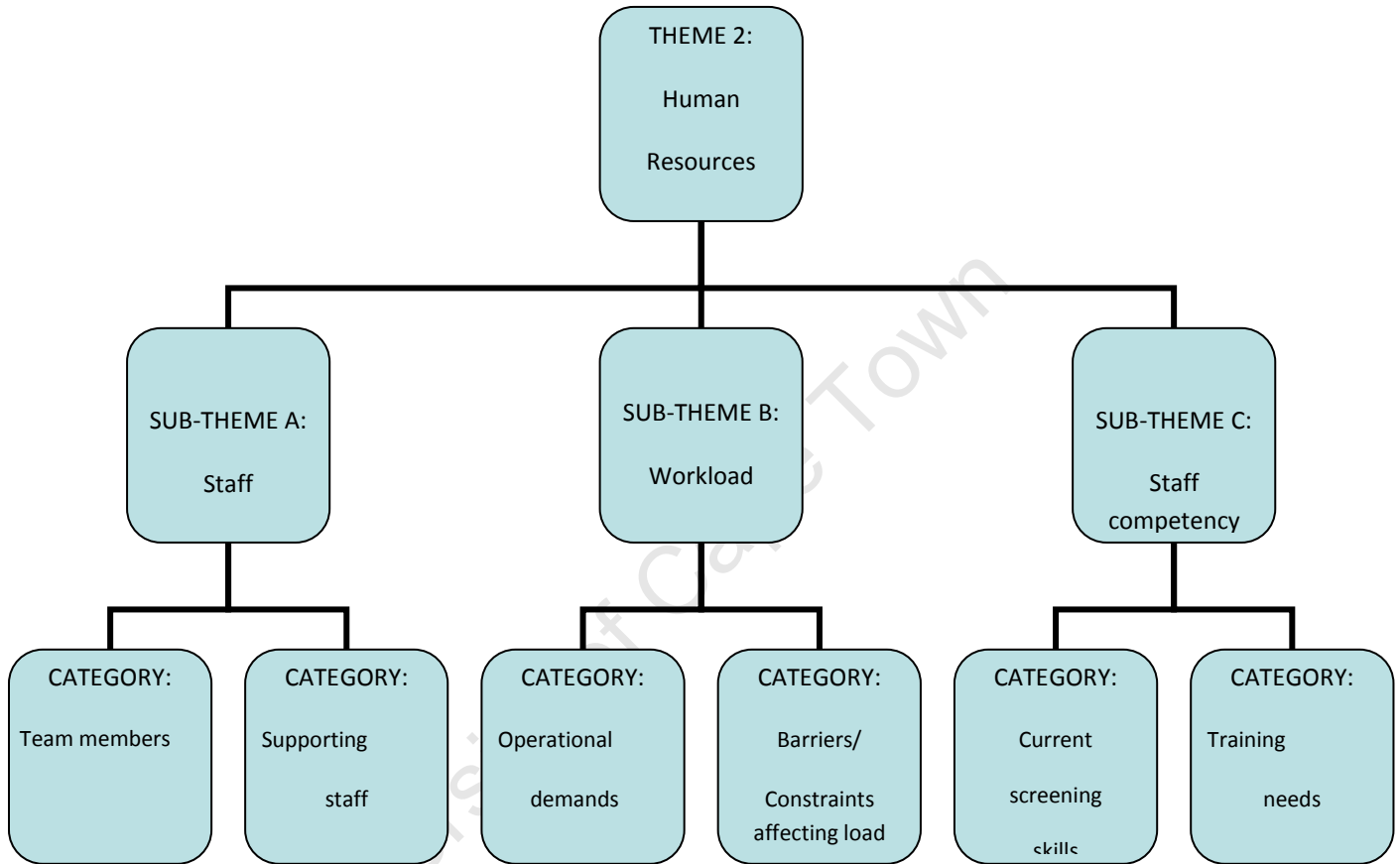
Nurse 1: I would say what we need is uhm, what would be significant if we can have another way of doing the hearing screening , an alternative way of doing the actual hearing screening besides the audiometer that is the problem at the moment that is a problem you know

Nurse 2: With these children, it's [pure-tone screening] too long a processes it's a long procedure

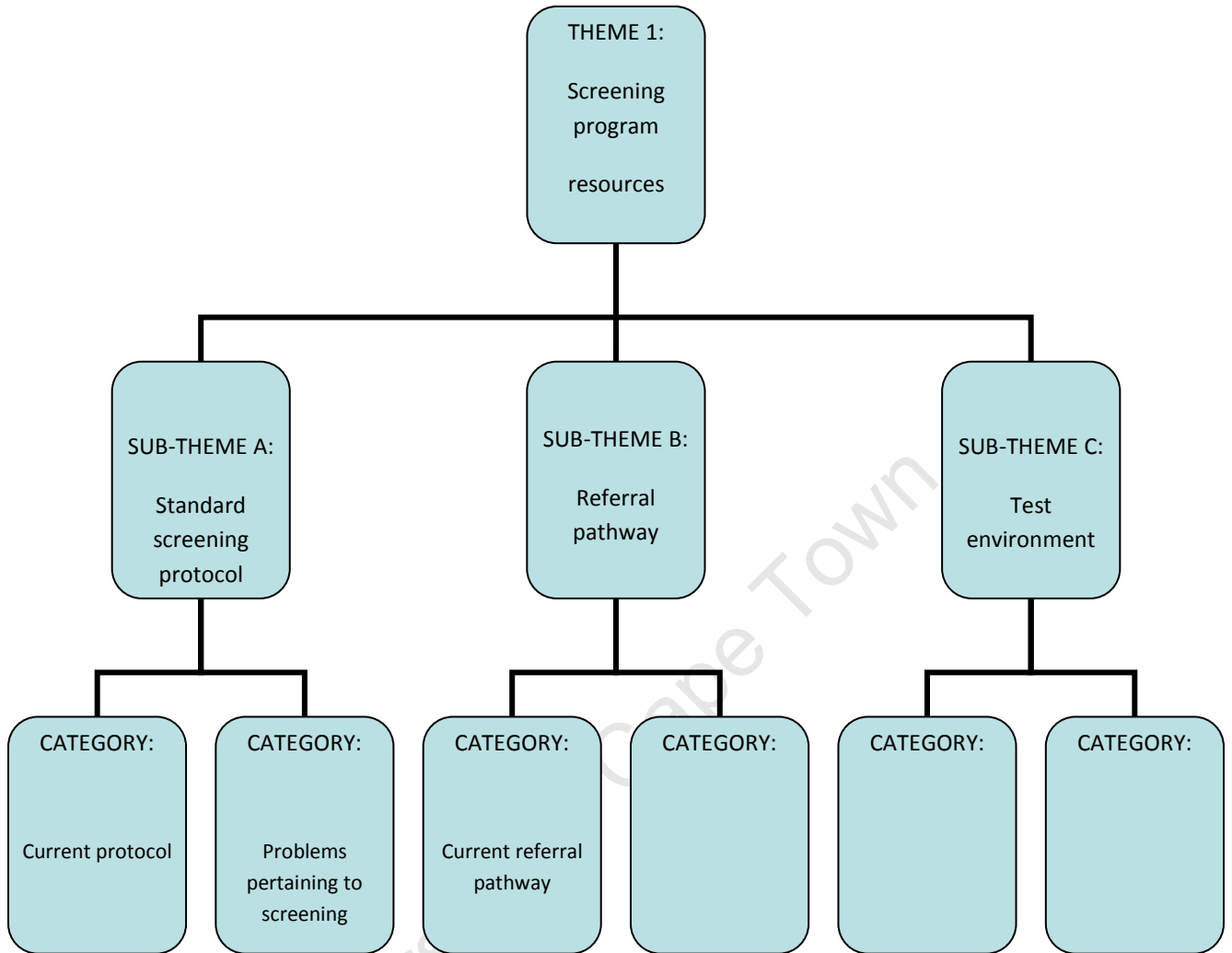
Also information from Discussion points 2, 3 & 5.

Appendix D

Data analysis flowchart-categories, sub-themes & themes for objective (a)



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Appendix E1:

Checklist for appraising the quality of research studies in objective (b) (modified from Cochrane Methods Working Group on Diagnostic and Screening Tests)

1) *Descriptive information about the study*

- a) Study identification (3)
- b) What is the study type? (3)
- c) What tests are being evaluated? (1)
- d) What are the characteristics of the population and the study setting? (1)
- e) Is the incremental value of the test being compared to other routine tests? (2)

2) *Have selection bias been minimised?*

- a) Were participants selected consecutively? (2)

3) *Have final outcomes been adequately ascertained?*

- a) Is the decision to perform the reference standard independent of the screening test results (i.e. avoidance of verification bias) (1)

4) *Have measurement biases been minimised?*

- a) Was there a valid reference standard? (1)
- b) Are the screening test and reference standards measured independently? (1)
- c) Are screening tests measured independently of other clinical and test information? (2)
- d) If screening tests are being compared, have they been assessed independently in the same participants or done in randomly allocated participants? (1)

Group 1= Crucial information

Group 2= Information that adds to the quality of the study but not crucial

Group 3= Extra information

Appendix E2

List of adaptations made to the checklist used for assessing the quality of studies in objective (b)

- The original checklist includes five sections with specific questions/items listed below it. In the adapted version of the checklist, the fifth section (i.e. relating to interventions) was omitted as it was not applicable to the present study.
- The 'tests' in the original checklist was revised to 'screening tests' in the adapted version
- Item 2 under section three of the original checklist was omitted as it was not applicable to the present study
- Sections and items were numbered in the adapted version
- In the adapted version, the specific items were graded in terms of how vital the information was in determining the quality of a study

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Appendix F

Data extraction tables for systematic review in objective (b)

F1 Study descriptors

Study	Tester	Tests evaluated	N	Population characteristics	Context
1. Beppu et al., 1997	Not specified	TEOAE vs CPA	93 ears	2-3 years old; 32 males & 15 females. Subjects had suspected HL, delayed speech	Japanese Health Centre soundproof rooms
2. Prescott et al., 1999	Hospital-Audiologist School- 4 th yr Audiology students	Voice test	177 in hospital 201 in schools	Hospital: 3-12yrs old, no confirmed HL; no delays & English is L1/L2 Schools: 3-7yrs old; English L1/L2	RXH in Western Cape sound-treated rooms; Classrooms of school in community (quiet room)
3. Omoding, 1999	Audiologists	Voice test	177 in hospital 201 in schools	Hospital: 3-12 yrs old, mean age of 5.8yrs; English is L1/L2 & no delays Schools: 3-7yrs; English is L1/L2 & familiar with test material	RXH hospital, sound-treated Rooms. Pre-primary school in Cape Town, classrooms with ambient noise ranging 30-40dB
4. Driscoll et al., 2001	Audiologist	TEOAE vs PT & tymps	940	6 yr old children	Developed country, school setting -non sound-treated rooms with ambient noise levels between 34-51dB
5. Dille et al., 2007	Audiologists Audiology graduate students	TEOAE & DPOAE & tymps	33	4months-4yrs4months; 18 boys & 15 girls	Quiet faculty room in pre-school & in alcove area in the nursery at pre-school in Tucson, Arizona
6. Krueger & Ferguson, 2002	Audiologist	DPOAE, tymps, PT's	599 ears	2 nd & 3 rd grade students; 163 girls & 137 boys (multi-racial)	Four schools in San Antonio, Texas
7. Driscoll et al., 20'02	Audiologist with specific training	TEOAE's (& tymps)	489	Children in special schools with mean age of 9.6yrs. 308 males	15 special schools in Brisbane, Australia, non sound-treated rooms

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				& 181 females. Conditions primarily CP, Down's syndrome & autism	with ambient noise levels= 31-61dB (if noise exceeded 50dB, test was paused)
8. Newton et al., 2001	Teachers, nurses or caregivers	Questionnaire (to detect HL greater than 40dB)	735 (some excl.)	372 males & 385 females. Ages: 2.21-7.5 yrs with mean age of 5.2yrs	Six districts in Kenya. Tests done in quietest rooms available with ambient noise levels 35-40dB
9. Eiserman et al., 2008	Lay screeners who attended 6hr training session	DPOAE	4519	Children 3 yrs old & younger	Children in Early Migrant & American Indian Head Start programs in Kansas, Oregon, Utah & Washington. Tested in natural environments
10. Hammond et al., 1997	Parents Audiometry by nurses	Parental questionnaire	657	Preschool children aged 4-5yrs	Metropolitan area in Adelaide, Australia, in preschool setting
11. Taylor & Brooks, 2000	2 Audiologists	TEOAE	297 ears	Preschool & school-aged children; 3-8 yrs of age	-Sound-treated room Alabama
12. Nozza et al., 1997	Pneumatic otoscopy- pediatrician validated for identification of MEE; OAEs by 2 audiologists; Audiometry by 3 audiology graduate students	TEOAE	61	School-aged children; 5-10yrs old	Under typical school hearing screening conditions in Pittsburgh -At elementary school
13. Dhooge et al., 2006	Not specified	DPOAE	34	Children & young adults, subjects treated for cancer (with platin derivatives). Mean age= 9.6yrs (2.3-26yrs)	Clinical context with sound-proof booths for testing at Ghent University Hospital (Belgium)
14. Engdahl et al., 2005	2 Audio technicians & 1 trained assistant	DPOAEs, TEOAEs	6415	Adults aged 20-97 yrs with mean age of 50yrs. General population-unscreened	Norway OAE test room not sound-Proof, audiometry tests conducted in sound-proof booths
15. Sabo, 2004	Author appraised articles but testers for specific articles not specified	Whispered voice test	8 studies 4 studies = 290 4 studies = 716	Adults = 290 aged 17-89yrs Children= 716 aged 3-12 yrs	Primary care context
16. Bento et al.,	Teachers	Video test	122	Children, aged 7-9yrs (incl boys &	Screener done in school in

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2003	Audiologists performed audiometry			girls) from the first grade of a public elementary school	Sao Paolo, Brazil. Audiometry conducted in acoustic cabin
17.Berg et al., 2006	Trained CHW's	CPA OAEs & tympanometry	4003 (CPA) & subset of 569 (OAEs & tymps)	Children aged 2-9yrs but subset for OAEs & tymps were aged 2-5yrs	Rural Bangladesh Audiometry was home-based OAE & tymps protocol test environment not specified— but noted that it was done under rural field conditions
18.Sideris & Glatke, 2006	Experienced, certified, paediatric audiologists	Pure-tones TEOAEs Immittance screening	200	Children aged 2yrs 1 mo-5 yrs 10mo. Children enrolled in the Head start program in the District of Columbia or in child care/academic facilities in the District of Columbia & surrounding metropolitan areas	-Children in the Head start program in the District of Columbia or in child care/academic facilities in the District of Columbia & surrounding metropolitan areas -Testing done in educational setting
19. Hof et al., 2005	Quantitative	OAEs	111	Children with hearing complaints, aged 1-7yrs	University hospital in The Netherlands. Tests conducted in sound-proof booth
20.Gomes & Lichtig, 2005	Trained non-professional	Parent report questionnaire	133	Pre-school children, 3-6years	Sao Poalo, Brazil
21.Sabo et al., 2000	Gold standard by Audiologist	TEOAE vs pure-tones	583	School-aged learners	Arizona, four schools
22.Richardson et al., 1995	Audiologist	TEOAE	52	Children, age not specified	Bath, Audiology clinic
23.Olusanya, 2001	ENT, Audiologist & author	Otoscopy, tymps & questionnaire	359	Mean age 6.7yrs	Lagos-high density inner-city area School- permissible ambient noise levels
24.Holtby et al., 1997	School nurses	Pure-tone screening & impedance test	610	School entry children (5-6yrs)	19 primary schools in Redcar & Cleveland local authority area in Northeast England Tested at school
25.Richardson et al., 1998	Audiologist	TEOAEs	110	Children with bacterial meningitis from 21 health centres (ages not specified)	Children recruited from hospitals in defined area of England & Wales Tested in hospital setting
26.Pröschel & Eysholdt, 1995	Not specified	TEOAEs	243	Children with known hearing Thresholds	Germany; test environment not specified

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27. Xu et al., 2003	Audiologist	DPOAEs vs ABR	198 ears	'At risk' neonates	China; test environment not specified
28. Saleem et al., 2007	Audiologist	OAEs vs Pure-tones	90 ears	Children listed for grommet insertion	Hospital setting in UK
29. Lo et al., 2006	Audiologist	Questionnaire; Otoscopy; Tympanometry; ART & Pure-tones	117 cases; 159 controls	6-7 yr old children	School setting in China
30. Savio et al., 2006	Audiologist	MSSR & ABR	508	High risk infants	Paediatric hospital and Maternity Institute in Habana, Cuba
31. Taylor et al., 2000	Audiologist	Tympanometry; TEOAEs & Pure-tones	152	Pre-school & school-aged children aged 3-8 years	Sound-treated room; USA
32. Lyons et al., 2004	Audiologist	Pure-tones; Tympanometry & DPOAEs	1003	Children with mean age of 6.2 years	Non sound-treated environments in schools in Australia
33. Olusanya et al., 2006	Audiologist	TEOAEs & AABR	1132	Babies	Immunisation Clinic in Lagos, Nigeria & RSA

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Appendix F2

Quality

Study	Consecutive attenders (selection bias avoided)	Verification bias avoided (ref std applied in uniform manner)	Valid reference standard	Test & reference standard measured independently	Tests being compared measured independently	Are tests assessed independently in same patients or randomly
1	Yes	Yes	Yes	Yes	N/A	Same
2	Yes, randomly selected	Yes	Yes	Yes	N/A	Same
3	Yes	Yes	Yes	Yes	N/A	Same
4	Random selection from 22 schools	Yes	Yes	Yes	N/A	Same
5	Learners based at testing site-convenience sampling	N/A	N/A	N/A	Yes	Same
6	Prospective sampling of school learners	N/A	No		Yes	Same
7	No selection criteria, all participants recruited on voluntary basis	Yes	Records	Yes	Yes	Same
8	Random allocation to 23 nursery schools & child health clinics in districts	Yes	Yes	Yes	N/A	Same
9	Yes	Yes	Yes	Yes	N/A	Same
10	Yes	Yes	Yes	Yes	N/A	Same
11	Yes	Yes	Yes	Yes	N/A	Same
12	Volunteers at schools	Yes	Yes	Yes	N/A	Same
13	Yes	Yes	Yes	Yes	N/A	Same
14	Yes	Yes	Yes	Yes	No (done together)	Same
15	Not specified	Not specified	Audiometry done in ≥ 80% of participants	Yes (in cases where audiometry done)	N/A	Same (in cases where audiometry done)
16	Learners randomly selected	Yes	Yes	Yes	N/A	Same
17	Randomly selected	No	Yes	Yes (in cases where	Yes	Same (in cases

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				both methods done)		where both methods done)
18	Convenience sampling of children enrolled in certain programs (refer to population characteristics)	Yes	Yes	Yes	Yes	Same
19	Yes (but children with suspected SNHL or TM perforations were excluded)	Yes	Yes	Yes	No	Same
20	Random	Yes	Yes	Yes	N/A	Same
21	Random	Yes	Yes	Yes	Yes	Same
22	Consecutive attenders at Audiology Clinic	Yes	? not specified	? probably	N/A	Same
23	Random selection	No	Yes	Yes	Yes	Same
24	Random	No	Yes	Yes	Yes	Same
25	Purposive sampling	Yes	Yes (ABR)	Yes	N/A	Same
26	Random	Yes	? subjective tests & AEPs	Yes	N/A	Same
27	Purposive sampling	No (only if failed screener they underwent diagnostics)	Yes	Yes	Yes	Same
28	All children in specific ENT program	Yes	Yes	Yes	Yes	Same
29	No	No	Yes	Yes	Independently	Done in test group & control group
30	Yes	Yes	Yes	Independently	Independently	Same
31	No	No	Yes	Yes	Compared	Same
32	Yes	No	No	N/A	Independently	Same
33	Yes	Yes	Yes	Yes	Independently	Same

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Appendix F3

Applicability

Study	How tests performed	Threshold or cut-off used	Clinical problem	Incremental value of the tests	Overall validity of study	Year of study
1	<p>CPA possible in 82 ears vs OAE's possible in 77 ears:</p> <p>-positive OAE result in 27 ears with NH & Type A tymp (hit)</p> <p>-negative OAE result in 48 ears with HL &/or abnormal tymps (true negative)</p> <p>-2ears present OAE but HL found with CPA</p> <p>- one case with borderline intelligence where CPA not possible but OAE was</p>	<p>OAEs:30dBnHL</p> <p>CPA mean PTT = 20DbHL or less</p>	<p>Hearing deficit or</p> <p>delayed speech</p>	<p>Test time-8sec per ear</p> <p>Less expertise required, easy to use & interpret</p> <p>?cost</p>	Informally validated procedures	1997
2	<p>Hospital: specificity-95.9%</p> <p>sensitivity- 80%</p> <p>School: specificity- 96.8%</p> <p>sensitivity-83.3%</p> <p>Mild HL may be missed as well as HFHL & unilateral losses</p>	<p>Whispered voice= Normal hearing</p> <p>i.e. 30-45dB (1m from ear)</p> <p>at least 50% correct at this level</p>	HL	<p>Less expertise required, less time, cost & easy to interpret</p> <p>Variability in noise</p>	Informally validated but not standardised	1999
3	<p>Hospital: specificity-95.9%</p> <p>Sensitivity-80%</p> <p>School: specificity-97.8%</p> <p>Sensitivity- 83.3%</p> <p>Mild HL, may be missed</p> <p>Unilateral HL may be missed (unless better ear masked using tragal pressure)</p>	<p>Whispered voice= Normal hearing</p> <p>i.e. 30-45dB (1m from ear)</p> <p>at least 50% correct at this level</p>	HL	<p>Less expertise required, less time, cost & easy to interpret</p> <p>Variability in noise & certain types of</p> <p>HL may be missed</p>	<p>Procedure validated & standardised material used.</p> <p>Sensitivity & specificity measures are comparable to similar studies</p>	1999
4	<p>Overall TEOAE pass/fail compared to overall PT screening (incl tymps) using 3dB SNR ration criterion for OAEs:</p> <p>-relatively low false alarm rate</p> <p>-high true negative rate 0.9</p> <p>-high test performance index</p>	<p>PT-25dB/less</p> <p>Tymps- Type C1/A</p> <p>OAEs-response recorded 3dB above noise floor</p>	HL & ME problems	<p>OAEs average test time = 1 minute</p> <p>High accuracy & efficiency scores</p> <p>(although not as high as PT & tymps)</p> <p>Could increase value</p>	Procedures valid & standardised measures used	2000

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	<p>0.87</p> <p>-high efficiency 0.89</p> <p>-strong NPV 0.98</p> <p>But</p> <p>-moderate hit rate 0.68</p> <p>-false negative rate 0.32</p> <p>-PPV 0.3</p> <p>TEOAE not highly sensitive to ME dysfunction.</p>			by changing criteria		
5	<p>DPOAE & TEOAE different in low frequencies but no significant differences in high frequencies</p> <p>Both methods nearly equivalent agreement with tympanometric gradient BUT overall correspondence between OAEs & tymps not perfect</p>	<p>TEOAE: band reproducibility $\geq 60\%$ & 3dB SNR</p> <p>DPOAE: 3dB above mean noise & 2 standard deviations</p> <p>3/5 frequencies must have response to pass the overall screen regardless of method used (for OAEs)</p> <p>Tymps: gradient of 160daPa or less= normal</p> <p>Pass= when both ears passed the measures</p>	HL (&ME problems)	-quick, well-tolerated	Standard procedures used with valid criteria	2007
6	<p>PT false positive rate: 1.2%</p> <p>DPOAEs false positive rate: 4.2%</p> <p>(in 7 cases DPOAE suggested normal hearing when PT's yielded abnormal results-all 7 had normal tymps.</p> <p>Tymps least reliable in detecting HL i.e. false positive rate: 6.4%</p>	<p>PT = 35dBHL & must respond to 3 out of 4 frequencies</p> <p>DPOAE absent if 3/more responses below normal window frame</p> <p>Tymps=Type A pass</p>	HL		No reference standard	2002
7	<p>Both tests:</p> <p>Failure rates were higher for those indicating positive history than those indicating negative history (66% & 53% respectively)</p> <p>Both tests:</p> <p>Higher failure rates in cases where parents expressed</p>	<p>TEOAE- pass if TEOAE spectrum was recorded at least 3dB above noise floor & halfway across frequency bands of 2-3 & 3-4kHz (modified Rhode Island Hearing assessment project pass/fail criteria)</p> <p>Tymps-pass= Type</p>	<p>Children with disability</p> <p>(incl intellectual disability)</p> <p>-testing for HL (& ME problems)</p>	<p>80% of children could be tested</p> <p>Test time per ear= 2mins</p> <p>74% could be tested with tymps</p> <p>(i.e. low CNE rates in a "difficult to</p>	Standard procedures & criteria used where possible	2001

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	concern i.e. 92% vs 50%; same effect if child had history of ear trauma or measles	A/C1		test ⁿ population)		
8	Sensitivity= 100% Specificity= 75% NPV= 100% PPV= low	Only questions where answers indicated normal hearing = pass	HI (& ME problems)	Low cost Quick & easy to administer May miss certain conditions if used on its own	In relevant language ? validity & reliability measures of questionnaire Standard verification measures used	2000
9	PPV = 67.3% Estimated NPV= 99.6% Other data not available	Minimum DP amplitude of -6 @ 5000; -5@4000; -8@3000 & -7@2000 with noise floor of 6dB. Number of frequencies for an overall screening pass = 3	HL (& ME problem)	Test time = 4 mins	Standardised procedures used to train All healthcare providers & Audiologists followed their own standard diagnostic procedures Follow up assessment not completed thus "gold standard" criteria to assess sensitivity cannot be applied	2007
10	Sensitivity = 56% Specificity = 52% PPV = 4% NPV = 97%	Audiometry: 30dB @ 1000Hz; 20dB @ 2000Hz & 25dB @ 4000Hz	HL	Quick, easy, low cost but poor accuracy	Factor analysis * reliability measures were done & is acceptable Audiometry- used standard screening procedures Questionnaire not validated	1997
11	Pure-tones: Sensitivity- 81% Specificity- 95% High positive correlation between the 2 tests = 0.70 Tymps: Sensitivity- 60% Specificity- 91% Moderate positive correlation = 0.42	Audiometry: 20dB @ 1.2 & 4kHz in both ears = pass Tymps: Type A = pass OAEs: Response 3dB above noise floor, at least 3 frequency bands = pass	HI (& ME problem)		Equipment & procedures standard	2000
12	Comparisons between OAEs & acoustic immittance variables were not statistically significant (in the "no referrals" group)	Otoscopy & tymps Pure-tones & OAEs (see study for details)	HL (& OE & ME problems)		Standard procedures are validated Specialist expertise employed	1995

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	<p>BUT</p> <p>High correlation between TEOAE & immittance in mod-severe scarring group ($r = -0.65$)</p> <p>No accurate estimate of sensitivity & specificity for hearing screening comparison</p>					
13	<p>High correlation between audiometric data & DPOAE amplitude i.e. 0.82 ($p < 0.01$) using Pearson correlation analysis</p>	<p>DPOAE:</p> <p>2f1-f2 level of 3dB above noise floor</p> <p>Audiometry:</p> <p>40dB for all 6 frequencies tested</p>	HL (ototoxicity)		Controlled conditions-study includes a control group in addition to study group	2006
14	<p>DPOAE better than TEOAE at frequencies ≥ 4kHz</p> <p>TEOAEs are superior with criteria of normal hearing threshold set to high thresholds but DPOAE better if normal hearing thresholds set to low thresholds.</p> <p>TEOAE & DPOAE combined:</p> <p>$R^2 = 0.41-0.66$ (i.e. correlation with PTT) correlation increases at higher frequencies.</p>	Not specified	HL		Standard procedures used & the recommended standards are met for audiometry testing	2003
15	<p>Adults: sensitivity= 90-100%</p> <p style="padding-left: 40px;">specificity= 70-87%</p> <p>Children: sensitivity= 80-96%</p> <p style="padding-left: 40px;">specificity= 90-99%</p> <p>i.e. less sensitive when used with children</p>	<p>Lack of standardisation for defining HL</p> <p>Adults: 30-40dB = Normal</p> <p>Children: 20-35dB = Normal</p>	HL	<p>Test is inexpensive; offers some objectivity relative to querying BUT</p> <p>is highly subjective method because of loudness of whisper, choice of stimuli & distance of speaker from the patient</p>	<p>-quality of reporting in majority of studies is low</p> <p>-heterogeneity in methods, reliability & reproducibility of the studies</p> <p>-only one study met all quality criteria</p> <p>-technique not standardised</p> <p>-studies had different methodology, prevalence data & small samples</p>	2003
16	<p>Sensitivity= 100%</p> <p>Specificity= 79.8%</p>	<p> Screener: children who answered to 5 or less of the tones in any frequency were considered a fail.</p>	HL	<p>-cheap</p> <p>-can be applied by teachers at schools</p>	-method was validated	2003

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	May fail to detect unilateral losses	Audiometry: 25dB cut-off used for all tested frequencies i.e. 500Hz, 1000Hz, 2000Hz & 4000Hz		-technically efficient		
17	<p>-CPA feasible for most children aged 6-9yrs but 66% of younger age group could not be tested with CPA</p> <p>-Of this younger group only 8.3% could not be tested with OAE/tymps protocol</p> <p>-Overall, 60% of children screened with CPA passed; 1.6% referred & 38.3% were untestable (89% uncooperative; 8.6% sore ears & 2% developmental delay)</p> <p>-569 children underwent OAE/tymps testing: 74% passed OAEs; 17% referred on both OAE & tymps; 0.4% referred on OAEs & passed tymps & 8.3% untestable (2/3 due to wax & 1/3 uncooperative)</p> <p>Test-retest reliability of OAE/tymps protocol: kappa coefficient = 0.95, confidence interval 0.89,1.00</p>	<p>-Audiometry: 20 & 30dB used as cut-offs</p> <p>-OAEs/tymps instruments automated for "pass" or "refer". OAEs first, if pass, no tymps done. If fail OAEs, tymps done</p>	HL & ME problems	<p>-Physiologic tests yield less untestable cases (in younger age group) – his leads to less over-referrals for diagnostic evaluation</p> <p>- like CPA, OAEs/tymps is now relatively low cost, portable & battery operated</p> <p>-CPA provides additional info, re perception, however tester could inadvertently cue child</p>	<p>-validity of all methods are well-established</p> <p>-training done by paediatric audiologist over 2wk period</p> <p>-ASHA guidelines used for procedures & test parameters</p> <p>-Due to time constraints-all tests not conducted on same day. This time delay could have affected findings.</p>	2005
18	<p>-21.5% failed pure-tones; 21% failed OAEs. No significant differences in referral rates</p> <p>-40/43 subjects who failed pure-tones also failed TEOAEs and/or Immittance. 36/42 subjects who failed TEOAEs also failed either pure-tones and/or Immittance.</p> <p>-44.2% of pure-tone failures also failed Immittance whereas 62% of OAE failures also failed immittance</p> <p>-mean testing time for pure-tones 137.6s S.D. ± 71.1s vs OAE test time = 113.4s S.D. ± 68.4s</p> <p>-10/43 subjects who failed pure-tones passed further assessments whereas 6/42 subjects referred by TEOAEs passed all other screenings</p>	<p>-Pure-tones: failure was a response at any frequency between 1-4kHz in either ear at a level greater than 20dBHL; or inability to condition child</p> <p>-TEOAEs: SNR must be at least 3dB at 3 distinct frequencies between 1-4kHz. Classification of a failing response was made after the second OAE screening</p> <p>Immittance: symmetric tympanometry had acoustic admittance equal to an equivalent volume of at least 0.3ml H₂O located at a pressure between -200 and +50dPa</p>	HL & ME problems	<p>-TEOAEs less affected by non-compliance</p> <p>-more children may fail TEOAE due to ME problems</p> <p>-TEOAEs are easier to administer by non-audiologist</p> <p>-TEOAE test time is much less</p>	<p>-Standard test procedures, cut-off & test parameters used</p> <p>-all tests conducted by qualified professional</p> <p>-seems methodologically sound</p>	2004
19	Not specified	12 different pass definitions were used	HL (& ME)	Less time-consuming than standard	Not specified	2004

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		for OAE results For pure-tones, cut-off of 20dB used		audiometric testing & less costly in long run		
20	Minimal Inter-rater concordance was 77% Poor sensitivity	Not specified	HL	Cost Non-professional can conduct it	??	2005
21	Pure-tones: Sensitivity-87% Specificity-80% TEOAE's: Sensitivity- 65% Specificity- 91% i.e. Pure-tones are statistically better	Not specified	HL	Same as other OAE studies	Standard & valid measures & procedures used	2000
22	Sensitivity- 100% Specificity-0.46-0.58 & 0.76-0.82, depending on criteria used	Not specified	HL	Same as above	?	1995
23	Questionnaire: Sensitivity-10% Specificity-94% PPV-21.7% NPV-86% Otoscopy: Sensitivity- 56% Specificity -62.4% PPV-19.4% NPV-89% Tymps: Sensitivity-52% Specificity – 84% PPV-34.6% NPV-91.5% Questionnaire & Otoscopy:	Norm	HL (& ME's)	?	Valid criteria & procedures Gold standard	2000

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	<p>Sensitivity- 60%</p> <p>Specificity- 58%</p> <p>PPV-18.9%</p> <p>NPV-90%</p> <p>Questionnaire, Otoscopy & tymps:</p> <p>Sensitivity- 76%</p> <p>Specificity-54.6%</p> <p>PPV- 21.3%</p> <p>NPV-23.3%</p>					
24	<p>PTA:</p> <p>Sensitivity- 86%</p> <p>Specificity- 70.2%</p> <p>Impedance:</p> <p>Sensitivity-83.7%</p> <p>Specificity- 73.6%</p>	<p>Impedance:</p> <p>Abnormal pressure, compliance or ART = fail</p> <p>Pure-tones:</p> <p>20dB either ear for 250-4000Hz</p>	HL	?	?	1997
25	<p>TEOAEs:</p> <p>Sensitivity = 1.00 (95% CI, 0.59-1.00)</p> <p>Specificity= 0.91 (0.85-0.97)</p> <p>PPV= 0.44 (0.2-0.7)</p> <p>NPV= 1.00 (0.96-1.00)</p>	<p>Fail= ABR V threshold was ≥ 30dBnHL</p> <p>OAEs:</p> <p>SNR ≥ 3dB for one or more bandwidths</p>	HL	?	?	1998
26	<p>Sensitivity= 93%</p> <p>Specificity= 67%</p>	<p>Cut-off for normal hearing = 30dB</p>	HL	N/A	All info not specified	1995
27	<p>ABR sensitivity= 99%</p> <p>DPOAE sensitivity = 97%</p>	<p>Not specified</p>	HL	N/A	All info not specified	2003
28	<p>Sensitivity for CHL = 94%</p> <p>Specificity = 100%</p> <p>PPV = 100%</p>	<p>Not specified</p>	HL & MEE	N/A	All info not specified	2007
29	<p>Method: parent suspecting HL to detect OME</p> <p>Sensitivity= 19.7%</p>	<p>Otoscopy-appearance of bubble or effusion</p> <p>Tympanometry-Type B/C</p>	OME & HL			2006

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	Specificity= 96.9%	Reflexes-none PTA-25dB (part of reference std)				
30	Sensitivity = 100% Specificity = 92-95%	Pass/fail criteria were set at 40dBnHL	HL	MSSR may have potential advantage to identify low frequency HL		2006
31	TEOAEs vs Pure-tones: Sensitivity- 81% Specificity- 95% TEOAE vs Tymp: Sensitivity- 60% Specificity- 91%	Pure-tones: 20dB @ all frequencies bilaterally Tymps: ASHA standards OAE: 3dB above noise floor	HL & ME			2000
32	Not specified?	Pure-tones: Thresholds exceeding 25dB Tympanometry: Type B/C2 (Jerger classification)	HL & ME			2004
33	2-stage screening protocol has sensitivity & specificity of more than 90%	OAEs ABR	HL			2006

Appendix G

Representation of the impact of test variables used in objective (b)

In the table the criteria for the rating of each test variable is specified in italics. The impact of the test variables is recorded (in red) for each hearing screening test, and the number of times similar findings are reported in the reviewed literature is indicated next to each test e.g. In the first cell, the test time for AABR is considered to be more than 30 minutes (i.e. high impact). Since it's marked as "AABRX1" it means that this finding was only reported in one of the reviewed studies. OAEs on the other hand is reported to have a test time of approximately 5 minutes (i.e. low impact) and since it's marked as "OAEs X4", this finding was reported in four of the reviewed studies, making it a more consistent finding.

If a test has a high impact rating on a specific test variable (indicated by the "impact of test variable" column), it means that the test performs poorly with respect to that variable, which is in turn considered a weakness of the test (resulting in a low score) Conversely, if a test has a low impact rating on a test variable, the test performance with respect to that particular test variable is considered to be a strength of the test under investigation (resulting in a high score). A score of 0 is the least desirable score and a score of 3 was the most desirable score.

Impact of test variables on the hearing screening tests included in the review

Impact of test variable	Test time	Ease of administration	Ease of interpretation	Sensitivity to noise
High impact Score=0	<i>More than 30mins</i> AABRX1	<i>Expert tester required</i>	<i>Expert tester required</i>	<i>Can only conduct in noise levels ≤30dBSPL</i>
Fairly high impact Score=1	<i>15-20mins</i>	<i>Moderate degree of expertise</i>	<i>Moderate degree of expertise</i>	<i>Can only conduct in noise levels ≤40dBSPL</i>
Moderate impact Score=2	<i>10-15mins</i>	<i>Minimal amount of expertise required</i>	<i>Minimal amount of expertise required</i>	<i>Can only conduct in noise levels ≤50dBSPL</i>

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<p>Low impact</p> <p>Score=3</p>	<p><i>±5mins or less</i></p> <p>OAEs x4</p>	<p><i>Can reliably be performed by non-specialist</i></p>	<p><i>Can reliably be interpreted by non-specialist</i></p>	<p><i>Can conduct test in noise levels up to 55dBSPL</i></p>

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Appendix H

Rating scale used for the expert panel in objective (c)

Rating scale for identifying one hearing screening protocol for use by school health nurses

INSTRUCTIONS: Please read each statement carefully. Choose the option that best fits the statement by circling the chosen number that represents the answer. The two protocols can be seen on page one of this document.

Response options:
 0 = Strongly disagree
 1 = Disagree
 2 = Neutral
 3 = Agree
 4 = Strongly agree

Example:

Screening for hearing loss in the school-aged population is important.	0	1	2	3	4
--	---	---	---	---	---

COST						
1	Audiologic equipment is expensive; however more children can be screened in a day (cost-benefit).	0	1	2	3	4
2	The protocol is cost-effective to maintain within a school setting.	0	1	2	3	4
TIME						
3	The protocol is efficient to set up each day.	0	1	2	3	4
4	The protocol is efficient to set up between each child.	0	1	2	3	4
5	The protocol can be administered in a short space of time.	0	1	2	3	4
6	The protocol can accurately be fitted into the current hearing screening program in the schools.	0	1	2	3	4
EASE OF ADMINISTRATION						
7	The protocol can accurately be performed by school health nurses.	0	1	2	3	4
8	No response is required from the participant (child) during testing.	0	1	2	3	4
9	The protocol is suitable to be administered in school environmental conditions e.g. classroom noise, traffic noise and break time.	0	1	2	3	4
10	It is easy to train the nurses to administer and interpret the test results.	0	1	2	3	4
RELIABILITY						
11	The protocol can accurately identify those children with a suspected hearing loss.	0	1	2	3	4
12	The protocol is able to screen large numbers of children in a day.	0	1	2	3	4
13	The results obtained from the protocol are reliable (if the test is repeated, the same results should be yielded).	0	1	2	3	4
14	The protocol cannot correctly identify those at risk for hearing impairment.	0	1	2	3	4

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SAFETY						
15	The protocol adheres to ethical guidelines, such as not inflicting harm on the participant (child).	0	1	2	3	4
16	The protocol is safe to administer on participants (children).	0	1	2	3	4
17	The protocol provides no discomfort to the participants (children).	0	1	2	3	4
OTHER						
18	Room acoustics need to be taken into account when administering this protocol.	0	1	2	3	4
19	The protocol meets the prescribed needs of the community	0	1	2	3	4
20	The equipment for this protocol is portable i.e. can be easily moved/transported between testing sites.	0	1	2	3	4

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Appendix I

Cover page of the rating scale used in objective (c)

[On letterhead]

Dear Participant

Thank you for participating in this study. Your role as part of this consensus panel is to critically compare findings on two hearing screening protocols to determine which protocol should be implemented in the present study. In addition, your choice of protocol should address the needs highlighted by the school health team. This will ensure that the chosen screening protocol is not only audiological effective but also contextually relevant. For this purpose, this document includes all relevant issues to consider, including:

- Technical aspects of each screening protocol i.e. sensitivity and specificity measures
- Context-specific needs of the school health nurses that should be met

The screening protocols include Protocol A (Otoscopy-OAEs & Tympanometry) and Protocol B (Otoscopy-Tympanometry & Pure-tones).

Technical and general aspects of protocol

Protocol A	Protocol B
Good sensitivity and specificity	Good sensitivity and specificity
Objective-can use on very young and difficult-to-test children; doesn't rely on child's understanding or active cooperation	Behavioural-need to condition the child, relies on child's understanding and active cooperation. Good indication of child's hearing ability
Test time usually less than two minutes	Test time usually 5-10minutes
No subjective interpretation required	Some degree of subjectivity in interpreting child's responses

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Sensitive to noise	Sensitive to noise
Equipment generally more expensive than screening audiometer	Equipment generally less expensive than OAE machine

Context-specific needs (pertaining to protocol)

- Screening protocol that is quick,
- Easy to administer
- Easy to interpret
- Not too sensitive to noise
- Reliable measure of hearing status with good sensitivity and specificity values

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Appendix J

The steps of the Delphi method

Steps	Included in present study
1. Selection of one or more expert panels	Yes
2. Development of first round questionnaire	Yes
3. Testing the questionnaire	Yes
4. Transmission of the first questionnaire to the panelist	Yes
5. Analysis of the first round responses	Yes
6. Preparation of the second round questionnaire	No
7. Transmission of the second questionnaire to the panelist	No
8. Analysis of the second round responses (steps 6 to 8 are repeated as long as necessary to achieve stability in results)	No
9. Completion of a report (by analysis team) to present the conclusions of the exercise	Yes

Appendix K

Instructional letter for consensus panel

UNIVERSITY OF CAPE TOWN



School of Health & Rehabilitation Sciences

Divisions of Communication Sciences & Disorders · Nursing & Midwifery ·

Nutrition & Dietetics · Occupational Therapy · Physiotherapy

Old Main Building · Grootte Schuur Hospital · Observatory · 7925

Telephone: +27 21 40664

Fax: +27 21/4066323

15 April 2008

Dear Participant

Thank you for participating in this study. Your role as part of this consensus panel is to critically compare findings on two hearing screening protocols to determine which protocol should be implemented in the present study. In addition, your choice of protocol should address the needs highlighted by the school health team. This will ensure that the chosen screening protocol is not only audiological effective but also contextually relevant.

For this purpose, Part 1 of this document includes all relevant issues to consider, including: measures to evaluate the effectiveness of each screening protocol i.e. sensitivity and specificity measures context-specific needs that should be met by the screening protocol. Part 2 of the document includes the rating scale to be completed by each member of the expert panel. This scale is presented in the form of multiple choice questions, which merely requires you to select the response option that best describes your opinion of each statement. These scales must be completed independently but the researcher will be present throughout to assist where necessary. After completion of the scale, the panel will engage in a group discussion in which all relevant issues (raised in the rating scale) are

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considered and critically discussed in an attempt to collectively decide on the most effective and contextually relevant hearing screening protocol.

Thank you for your time and valued assistance in this study.

Yours sincerely,

Ms T Cupido

Student

Prof. H Kathard

Supervisor

Ms L Petersen

Supervisor

University of Cape Town

Appendix L1

Settings of the Sound level meter used in objective (d)

- Mode of operation: Sound Pressure Level (SPL)
- Frequency weighting: “A” weighting which emulates the human ear
- Response time: a fast response time weighting was used
- Measurement range: 30 to 100dB

(Brüel & Kjær Integrating Sound Level Meter Type 2239A operation manual)

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Appendix L2

Abnormalities of the outer ear and tympanic membrane

Pinna	External auditory meatus (EAM)	Tympanic membrane
Pre-auricular sinus ¹⁴	Impacted wax	Dull colour
Malformations	Ear discharge	Perforations
Inflammation	Foreign body	Inflammation
	Swelling	

¹⁴ Pre-auricular sinus refers to a pit-like depression occurring in a triangular area just anterior to the auricle (Hughes & Pensak, 2007).

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Appendix L3

Collection parameters for DPOAE system

Test frequency	Test tone (L1)	Test tone (L2)	F2/F1	Artifact level
5000Hz	65dB	55dB	1.22	30
4000Hz	65dB	55dB	1.22	30
3000Hz	65dB	55dB	1.22	30
2000Hz	65dB	55dB	1.22	30

(AuDX DPOAE system operation manual, 2005)

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Appendix L4

Tympanometry test specifications

Probe tone- 226Hz, +/- 3%

Pressure range- +200daPa to -400daPa

Rate of sweep- 600daPa/sec except near tympanogram peak where sweep rate slows to 200daPa/sec to provide better definition of peak compliance.

Direction of sweep- Positive to negative

Gradient- tympanogram pressure width at 50% of peak compliance

(GSI 38 Auto Tympanometry Instruction Manual, 2006).

Normative data for tympanometry

- Normal ear canal volume ranged from 0.2 to 2.0cm³
- Normal compliance ranged from 0.2 to 1.8 cm³
- Normal middle ear pressure ranged from -100 to +50daPa

(GSI 38 Auto Tympanometry Instruction Manual, 2006).

Thereafter the tympanograms were classified according to type A, A_S, A_D, B or C definitions as per Jerger's (1970) classification system.

Jerger's (1970) classification system for tympanometry

Tympanogram type	Interpretation
Type A tympanogram	<ul style="list-style-type: none">- Normal pressure, compliance and ear canal volume- Clear peak at or around 0daPa on tympanogram- Indicates normal or sensori-neural hearing loss
Type A _S tympanogram	<ul style="list-style-type: none">- Peak compliance +/- 0daPa on tympanogram- Base peak compliance low (<0,3cm³)- Clear peak- Indicates that the middle ear mechanism is stiff

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Type A _D tympanogram	<ul style="list-style-type: none">- High compliance in 0daPa area on the tympanogram- Indicates discontinuity of ossicular chain or a hyperflaccid tympanic membrane
Type B tympanogram	<ul style="list-style-type: none">- No peak, i.e. straight line on tympanograms- Associated with OME, impacted cerumen, foreign bodies, canal wall probe placement, occluding ventilating tubes
Type C tympanogram	<ul style="list-style-type: none">- Peak compliance in negative pressure range compared with normal- Associated with recovery of fluid in ME, sign of ET dysfunction

For a tympanogram to be considered normal, the result must fall within the normal range as specified in the manual's normative data. This would then correspond with a Type A tympanogram.

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Appendix M

Observation Schedule for School-based hearing screening in objective (d)

Participant: _____

School: _____

Date: _____

Tester factors	Score	Comment
Handling of screening equipment		
Appropriate implementation of screening protocol		
Aware of variables that could influence results		
Able to troubleshoot independently		
Ease with which results are interpreted e.g. tympanograms		
Ease with which admin completed		
Average test time appropriate		
Knows when to refer		

Testee factors	Score	Comment
Compliance		
Behavioural issues		

Environmental factors	Score	Comment
Background noise		

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Test room set up		
Distractions (visual, interruptions, etc.)		
Room size		

General observations related to the implementation of the screening protocol:

Descriptors for evaluation rating scale:

Score	Descriptor
1	Unsatisfactory use of screening equipment; poor implementation of screening protocol ; lack of knowledge pertaining to results & referral criteria; unable to troubleshoot; average test time exceeds 15 minutes per learner, poor testee compliance, background noise levels unacceptably high at all times, inadequate test environment
2	Demonstrates difficulty handling equipment ; incomplete understanding of screening protocol; knowledge pertaining to results & referral criteria is below minimum competence; average test time between 10-15 minutes per learner, poor testee compliance; background noise levels high intermittently; inadequate test environment
3	Starting to demonstrate competency when handling equipment; adequate understanding of & implementation of screening protocol but still relies on some guidance; adequate knowledge of results & referral criteria; average test time 5-10 minutes per learner; good testee compliance; background noise levels intermittently exceeds 60dB; adequate test environment but not ideal
4	Starting to demonstrate above minimum competence when handling equipment; good understanding of & implementation of screening protocol; can troubleshoot effectively; good knowledge of meaning of results & referral criteria; average test time 5 minutes per learner; good testee compliance; background noise levels 40-50dB constantly; good test environment with minimal variables
5	Able to carry out all aspects of the screening independently; effective troubleshooting; average test time 2-5 minutes; background noise levels below 40dB constantly; good test environment with no significant variables

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Appendix N

Outline of the school nurses' training program

Trainer	Duration	Content	Staff numbers	Nurses' evaluation of training program
<p>Qualified Audiologist with background knowledge of the tests used in the protocol as well as staff training experience</p>	<p>6 hours</p>	<ul style="list-style-type: none"> -Purpose of hearing screening -Anatomy & physiology of the ear -Introduction to the screening protocol -Theory related to OAEs & tympanometry -Demonstration & practice session -Case discussions related to the clinical implementation of the protocol -Q & A session -Evaluation (in which the nurses completed feedback forms) -Each nurse also received a handout containing all the relevant information and screening procedures. 	<p>All the participating members of the district's school health team attended the training program including three professional nurses and one enrolled nursing assistant.</p>	<p>Based on the nurses' feedback:</p> <ul style="list-style-type: none"> -They understood the information presented -They were comfortable using the equipment and conducting the procedures demonstrated -They felt adequately equipped to screen a school-aged child's hearing using the proposed tests. <p>However the nurses felt that they would benefit from more exposure and practice with the equipment.</p>

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Appendix O1

Screening record sheet

Child name: _____

Date: _____

Grade: _____

Age: _____

Participant number: _____

Teacher/contact nr: _____

Relevant case history info:

Screener 1: conducted by school nurse

Simply indicate whether the learner passes/fails in appropriate box. If learner fails a test, specify the reason for failing.

Tests	Right ear	Left ear
Otoscopy		
OAE's		
Tympanometry (if necessary)		

Tick the appropriate box for the following items.

Estimated test time:

2-5 minutes	5-10 minutes	more than 10 minutes
-------------	--------------	----------------------

Test conditions:

Acceptable noise levels	Moderate noise levels	Very noisy environment
-------------------------	-----------------------	------------------------

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Testee compliance:

Child compliant for all tests	Child not compliant for at least 1 test	Child not compliant for all tests
-------------------------------	---	-----------------------------------

Screener 2: conducted by independent tester

Tests	Right ear	Left ear
Otoscopy		
OAE's		
Tympanometry (if necessary)		

Tick the appropriate box for the following items.

Estimated test time:

2-5 minutes	5-10 minutes	more than 10 minutes
-------------	--------------	----------------------

Test conditions:

Acceptable noise levels	Moderate noise levels	Very noisy environment
-------------------------	-----------------------	------------------------

Testee compliance:

Child compliant for all tests	Child not compliant for at least 1 test	Child not compliant for all tests
-------------------------------	---	-----------------------------------

Diagnostic date:

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Appendix O2

Letter with reminder to parents

[On letterhead]

Dear Parent/Caregiver

I wish to thank you for agreeing to have your child participate in this research project. Your contribution to this study is appreciated and will hopefully help us to improve the hearing services at your child's school.

Now that the hearing screening has been completed, your child will have to attend ----- Hospital for another more detailed hearing test. Your child's appointment is for _____ at 1pm. S/he will not need a folder and will not need to pay for anything. Upon your arrival at the hospital come to the Outpatients Building, First Floor, Room S24, Audiology Department. Ask for Ms Cupido and you will be helped there.

I do realise that this may be an expensive trip for you and will thus give a sum of _____ as a contribution towards your travelling costs.

Thank you once again for your participation.

Kind regards,

T. Cupido

UCT Master's student

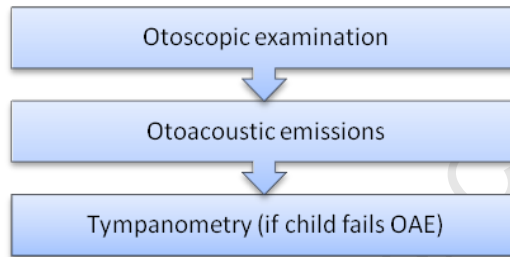
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Appendix P

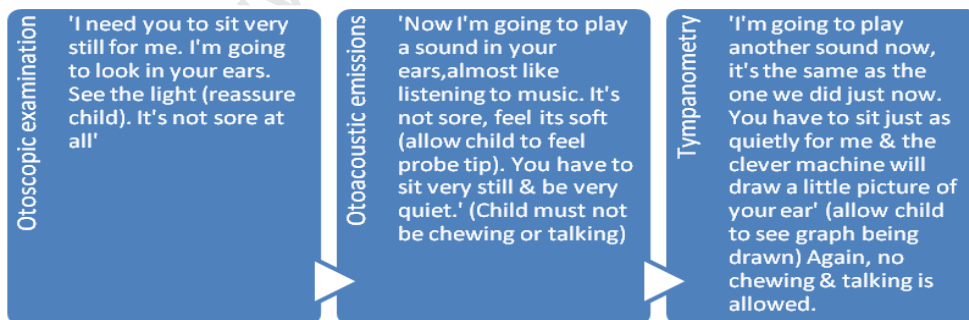
Summary of screening procedure given to school nurses

Setting up the test environment:

- Quietest room available
- Have assistant help with children- 1 in the room at a time
- Record relevant information on record sheet
- Screening protocol includes:



- Give specific instructions:



- Record all results obtained on record sheet provided as well as reasons for failures

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- Remember normative data for tympanometry:

Compliance (y-axis)	0.2-1.8ml
Middle ear pressure (x-axis)	-100+50daPa
Ear canal volume	0.2-2.0

Type A= Normal graph

Type B= Flat graph (no compliance; indicative of middle ear pathology, tympanic membrane perforation, blocked ear canal)

Type C= Negative middle ear pressure (compliance relatively normal; indicative of start/end of otitis media, eustachian tube dysfunction)

Criteria for fail/referral: refer to training handout!

- After testing is completed, child to receive letter for parent & date for follow up testing (failures to be given earliest date)
- For any basic outer or middle ear problems the child will receive management at school/local clinic following the diagnostic test.
- For any possible hearing loss or middle ear problem (requiring ENT specialist) following diagnostic test—researcher to arrange referral & further investigation/management at tertiary hospital

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Appendix Q

Focus group pilot study for objective (d)

Factors considered	Pilot study set-up	Findings
Duration	Two hours were set aside for the session.	The session lasted for approximately 60 minutes
Participants	A group of two health professionals were recruited. Their work experiences include service provision in school settings and it was thus assumed that they have sufficient knowledge of the general school health services & challenges faced when working in this environment.	Although both participants were very forthcoming, the session may have been more effective if more participants were present. Valuable information was still obtained & all discussion topics were covered.
Facilitation	The researcher was responsible for facilitating the discussion & managing the audio-visual recording equipment used for data collection.	The researcher was initially more involved in the discussion than desired. This may be due to the fact that the pilot study participants were not fully informed about every aspect of the study, thus more guidance was required. In addition, the discussion schedule was not very clear with regards to the relevant areas for discussion—which further

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		increased the need for researcher input.
Context	The room in which the discussion took place was fairly spacious, allowing for participants & facilitator to sit in a semi-circle. This facilitated good interaction.	The room set-up was ideal for a focus group session.
Data collection	A voice-recorder was placed in the centre of the circle to capture the discussion in auditory mode. A video-recorder was set up in an unobtrusive position and manual note-taking was also included when it was deemed necessary.	The data collection strategies were suitable.
Discussion schedule	A structured discussion schedule was used, clearly outlining the topics to be covered by the group.	Various items on the schedule required clarification in order to yield appropriate responses. The discussion schedule also yielded some repetitive responses, thus requiring some revision.

Appendix R

Revised interview guide for objective (d)

A) Re-establishing rapport

- Explanation of purpose of group discussion
- Description of the session structure

B) Feedback

Perceptions re implemented test

- How well did training equip nurses for implementation- Skills attained & adequacy of skills & knowledge; any comments or suggestions in this regard
- How well was protocol understood prior to implementation (incl. admin & use of machine)
- Effect of my presence during the implementation phase [additional guidance; bias; Hawthorne effect]
- How was it implemented: steps followed; site management; testing; admin, assistance required, etc.
- How well did test address each of the needs highlighted in the needs analysis (noise; time; staff constraints; user-friendly tool; competence [need for training/further input]; referral pathway [support services]; cost issues)
- Subjective opinions regarding the audiological effectiveness & feasibility (applicability) of hearing screening protocol & its implementation as part of school health package

Shortcomings

- Problems experienced
- Suggestions to improve on the proposed screening protocol

C) Additional comments

D) Closing & thanks

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Appendix S

Audiological assessment form

Child name: _____

Date: _____

D.O.B/Age: _____

Tester: _____

Participant number: _____

Contact nr: _____

Contact person: _____

Relevant case history info:

Results:

Tests	Right ear	Left ear
Otoscopy		
Tympanometry		
Reflexes		

Audiogram:

0db					
5					
10					
15					
20					
25					
30					
35					

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40					
45					
50					
55					
60					
65					
70					
75					
80					
85					
90					

250Hz 500Hz 1000Hz 2000Hz 4000Hz 8000Hz

Audiometer: _____ Test reliability: _____

Comments:

Tester sign: _____

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Appendix T 1

Spreadsheet for inter-tester reliability measure

INTER-TESTER RELIABILITY TABLE:OAE's TEST

Participant	NURSES' SCREENING		INDEPENDENT TESTER'S SCREENING	
	R	L	R	L
H1	P	P	P	P
H2	P	P	P	P
H3	P	P	P	P
H4	P	P	P	P
H5	P	P	P	P
H6	P	P	P	P
H7	P	P	P	P
Hy1	P	P	P	P
Hy2	P	P	P	P
Hy3	F	F	P	F
Hy4	P	P	P	P
Hy5	P	P	P	P
Hy6	P	P	P	P
Hy7	P	F	F	F
Hy8	P	P	P	P
Hy9	P	P	P	P
Hy22	F	F	P	F
T1	P	P	P	P

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T2	P	P	P	P
T3	P	P	P	P
T4	P	P	P	P
T5	P	P	P	P
T6	P	P	P	P
T7	P	P	P	P
T8	P	P	P	P
T9	P	P	P	P
M1	P	P	P	P
M2	P	P	P	P
M3	P	P	P	P
M4	P	P	P	P
M6	F	P	F	F
M7	P	P	P	F
M8	P	P	P	P
M9	P	P	P	P
M10	P	P	P	P
M11	F	P	F	P
M12	P	P	P	P
M13	P	P	P	P
M14	P	P	P	P
M15	P	P	P	P
M16	P	P	P	P
M17	P	P	P	P
M18	P	P	P	P

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M20	P	P	P	P
M21	P	P	P	P

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Appendix T2

Spreadsheet for sensitivity and specificity measures

Comparison of diagnostic & screening test results

Participant Info	OAE Screener		Diagnostic test: Pure- tones	
	R	L	R	L
1	P	P	P	P
2	P	P	P	P
3	P	P	P	P
4	P	P	P	P
5	P	P	P	P
6	P	P	F	F
7	P	P	P	P
8	P	P	P	P
9	F	F	F	F
10	P	P	P	P
11	P	P	P	P
12	P	P	P	P
13	P	P	P	P
14	P	P	P	P
15	P	P	F	P
16	P	P	P	P
17	P	P	P	P
18	P	P	P	P
19	P	P	P	P

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20	P	P	P	P
21	P	P	P	P
22	P	P	P	P
23	F	P	P	P
24	F	F	F	F
25	P	P	P	P
26	P	P	P	P
27	P	P	P	P
28	P	P	P	P
29	P	P	P	P
30	F	P	P	P
31	P	P	P	P
32	P	P	P	P
33	P	P	P	P
34	P	P	P	P
35	P	P	P	P
36	P	F	P	P
37	P	P	P	P
38	P	P	P	P
39	P	P	P	P
40	P	P	P	P
41	P	P	P	P
42	P	P	P	P
43	P	P	P	P
44	P	P	P	P

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45	P	P	P	P
46	P	P	P	P
47	P	P	P	P
48	P	P	P	P
49	P	P	P	P
50	P	P	P	P
51	P	P	P	P
52	P	P	P	P
53	P	P	P	P
54	P	P	P	P

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Appendix U

Formulae for predictive values

The predictive value of a positive test (PV+) is the likelihood that the testee with a positive result actually has a hearing loss (Johnson & Danhauer, 2002) and is obtained with the formula below:

$$PV+ = \frac{\text{Sensitivity} \times \text{Prior probability}^{15}}{(\text{Sensitivity} \times \text{Prior probability}) + (1 - \text{Specificity} \times 1 - \text{Prior probability})}$$

The predictive value of a negative test (PV-) is the likelihood that the testee with a negative test result does not have a hearing loss (Johnson & Danhauer, 2002) and is obtained with the formula below:

$$PV- = \frac{\text{Specificity} \times (1 - \text{Prior probability})}{(\text{Specificity} \times [1 - \text{Prior probability}]) + ([1 - \text{Sensitivity}] \times \text{Prior probability})}$$

*Prior probability is the prevalence of a disease for a particular individual based on the demographic and clinical features estimated before performing a test (Johnson & Danhauer, 2002).

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Appendix V

Results for the representation of the impact of test variables in objective (b)

Impact of test variable	Test time	Ease of administration	Ease of interpretation	Sensitivity to noise
High impact Score=0	<i>More than 30mins</i> AABR ¹⁶ X1	<i>Expert tester required</i>	<i>Expert tester required</i>	<i>Can only conduct in noise levels ≤30dBSPL</i>
Fairly high impact Score=1	<i>15-20mins</i>	<i>Moderate degree of expertise</i> Pure-tones ¹⁷ X2 AABR ¹⁸ X4	<i>Moderate degree of expertise</i> Pure-tones ¹⁹ X2 Voice test ²⁰ X2	<i>Can only conduct in noise levels ≤40dBSPL</i> OAEs ²¹ X2 Voice test ²² X2
Moderate impact Score=2	<i>10-15mins</i> AABR ²³ X1	<i>Minimal amount of expertise required</i> OAEs ²⁴ X1 Voice testX2 ²⁵ Pure-tones X1 ²⁶	<i>Minimal amount of expertise required</i> Pure-tonesX1 ²⁷	<i>Can only conduct in noise levels ≤50dBSPL</i> Pure-tones ²⁸ X2 AABR ²⁹ X1
Low impact Score=3	<i>±5mins or less</i> Voice testX1 ³⁰ OAEs ³¹ x4	<i>Can reliably be performed by non-specialist</i> OAEs ³⁴ X2	<i>Can reliably be interpreted by non-specialist</i> OAEs ³⁵ X2 AABR ³⁶ X2	<i>Can conduct test in noise levels up to 55dBSPL</i> Pure-tones ³⁷ X1

¹⁶ Watson, McClelland & Adams, 1996

¹⁷ Beppu, Hattori & Yanagita, 1997; Berg, Papri, Ferdous, Khan & Durkin, 2006

¹⁸ Martin & Clarke, 1996; Olusanya et al., 2006; Savio et al., 2006; Watson, McClelland & Adams, 1996

¹⁹ Beppu et al., 1997; Martin & Clarke, 1996

²⁰ J.Davis, personal communication, February 2007; Eekhof, de Bock, de Laat, Dap, Schaapveld & Springer, 1996

²¹ Dhange et al., 2006; Jacobson & Jacobson, 1994

²² Prescott et al., 1999 & Omoding, 1999

²³ Van Straaten, 1999

²⁴ Olusanya, Wilrz & Luxon, 2008

²⁵ Prescott, Omoding, Fermor & Ogilvy, 1999; Omoding, 1999

²⁶ Roush, 2001

²⁷ Roush, 2001

²⁸ ASHA, 2005; Martin & Clarke, 1996

²⁹ Van Straaten, 1999

³⁰ Omoding, 1999

³¹ Dille et al., 2007; Driscoll et al., 2001; Eiserman et al., 2008; Beppu, Hattori & Yanagita, 1997

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	AABR ³² X1			
	Pure-tones ³³ X2			

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³⁴ Eiserman et al., 2008; Sideris & Glatke, 2006

³⁵ Eiserman et al., 2008; Sideris & Glatke, 2006

³⁶ Van Straaten, 1999; Watson, McClelland & Adams, 1996

³⁷ ANSI S3.1-1991 in Katz, 2002

³² Van Straaten, 1999

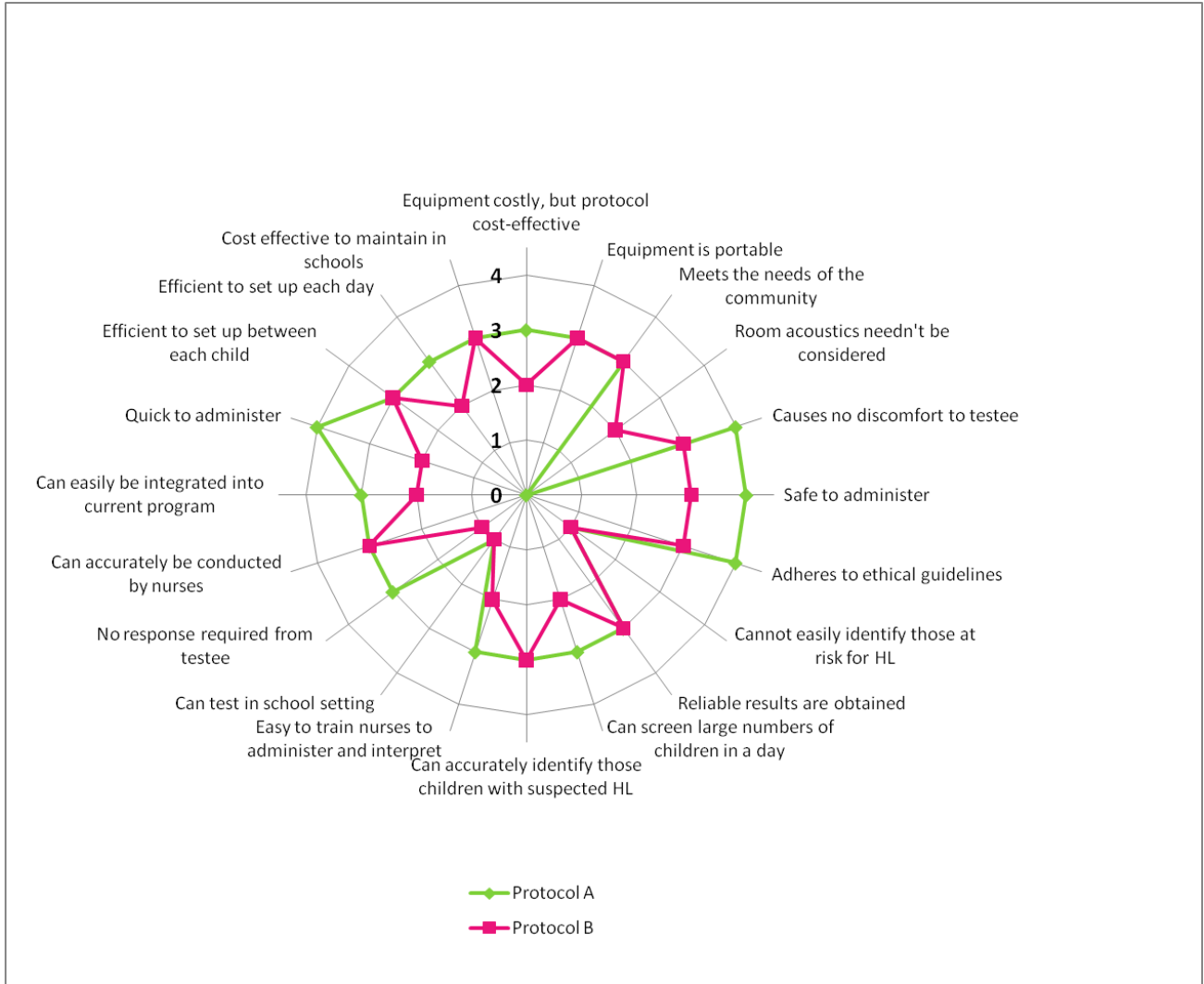
³³ Eekhof, de Bock, de Laat, Dap, Schaapveld & Springer, 1996; Sideris & Glatke, 2005

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Appendix W1

Radar charts depicting responses for raters in objective (c)

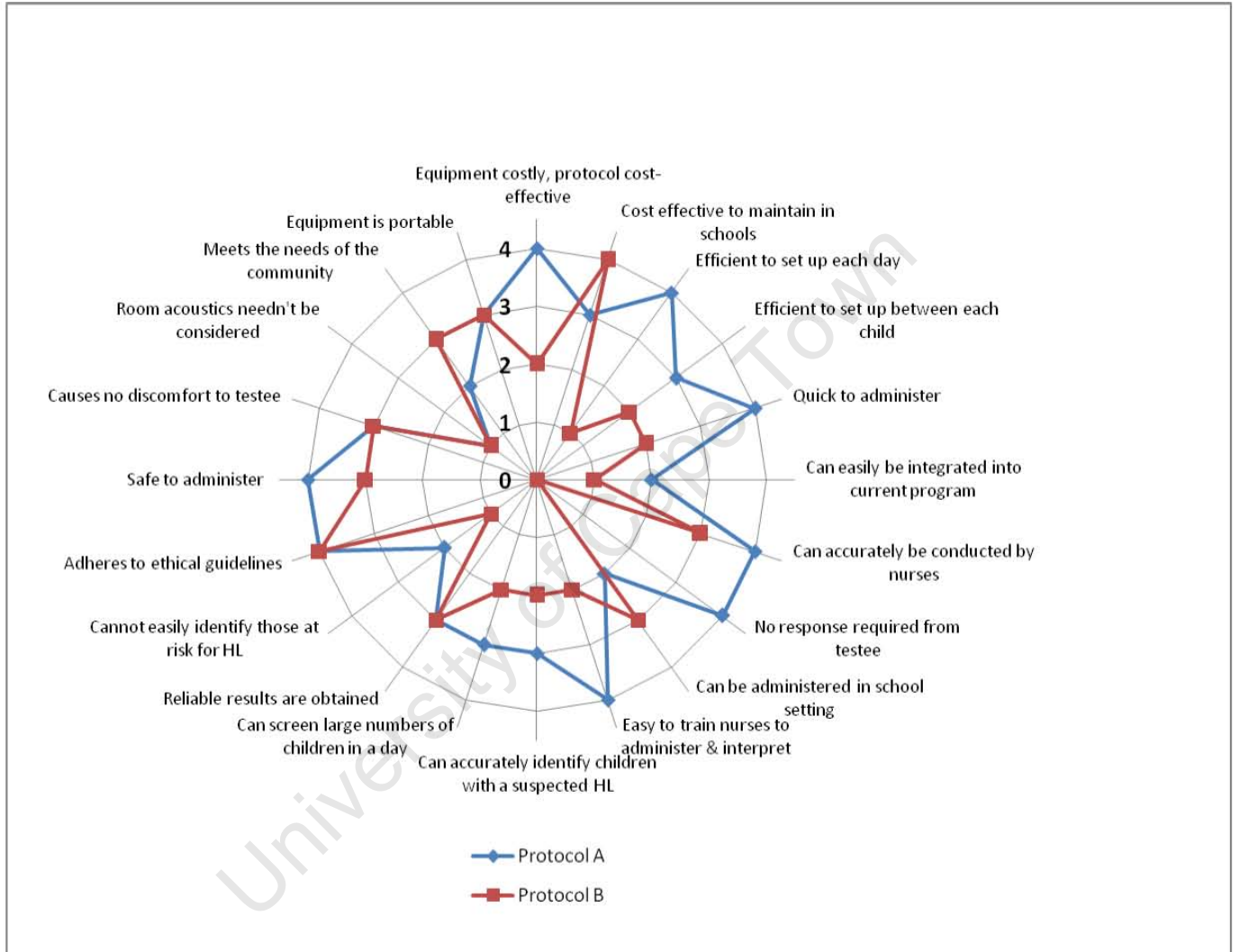
Rating scale responses obtained for Rater 1



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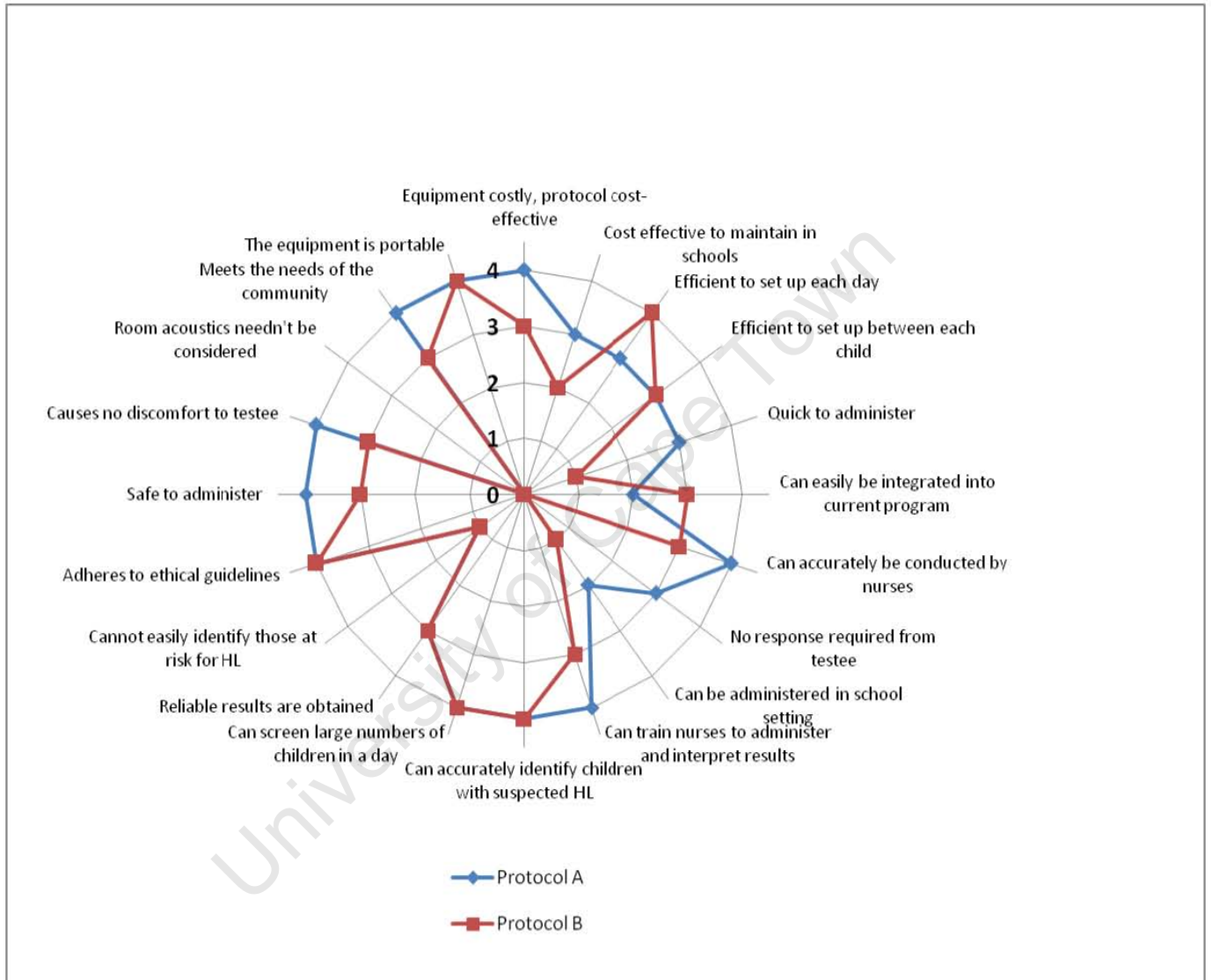
Appendix W2

Rating scale responses obtained for Rater 2



Appendix W4

Rating scale responses obtained for Rater 4



Appendix X

Completed observation scales for objective (d)

Observation Schedule

Tester factors	Observation
Ease with which testing conducted (handling of equipment)	needed tt support initially but able to work independently after
Ease with which results are interpreted	✓ (types still need support).
Ease with which results are recorded	✓
Average amount of time taken to perform test	5 mins.

Testee factors	Observation
Learner's understanding of test requirements	✓
Compliance	✓

Environmental factors	Observation
Background noise	Mild - moderate levels
Visual distractions	✓
Other distractions	Children in test room
Size of room	✓
Room set up	Comfortable; (C) + (N) seated * Room situated amongst classrooms tt noise interference.

General

comments: "test env too noisy" showed tt. ? if machines set up too close to E/other → electrical interference. or too close to window.
 ? size of OAE probe tips too big.
 Later in morn → workmen came to school → drilling; knocking etc. a contributed to big noise. Also intervals
 * noise interference affecting test time significantly.
 * OAE's repeatable but tester not happy w its effect on test time.
 Total number of learners tested: $\frac{22}{7}$: 16.

Some learners absent today.

Total pass/fails: $\frac{22}{7}$; Pass = 12 ; Fail = 4

Majority of failures at which level of protocol (which test): OAE's

Majority of failures due to: ? ME involvement
 ? noise factors.

T.C.A for 9 learners.
 23/7/08.

✓ = acceptable.

4/5 (numbers correspond to clinics rating scale).

Observation Schedule

Tester factors	Observation
Ease with which testing conducted (handling of equipment)	4-5 ✓ (some initial support).
Ease with which results are interpreted	5 ✓
Ease with which results are recorded	✓
Average amount of time taken to perform test	2-5 mins.

Testee factors	Observation
Learner's understanding of test requirements	✓
Compliance	✓

Environmental factors	Observation
Background noise	✓ Room has good conditions for testing.
Visual distractions	✓
Other distractions	none ✓
Size of room	✓
Room set up	✓ (issues w plug switches - power).

General

comments: Otoscopy already done before my arrival at school - results recorded (as separate to rest of protocol).
✓ lots of multi-tasking possible while test is running.
* some noise later in morning.
✓ understanding of variables w can affect results e.g. noise; child moving.

Total number of learners tested: _____

Total pass/fails: _____

Majority of failures at which level of protocol (which test): _____

Majority of failures due to: _____

Observation Schedule

(2, 3 + 5
3, 4 + 5) kHz.
- not as sensitive to noise
- much quicker test time.

Tester factors	Observation
Ease with which testing conducted (handling of equipment)	New machine (Bio-logic; Audx) -> not used for training. Initial support - then 4-5.
Ease with which results are interpreted	✓ 5
Ease with which results are recorded	✓ 5
Average amount of time taken to perform test	2-5 minutes.

Testee factors	Observation
Learner's understanding of test requirements	✓
Compliance	✓ (one learner crying but still able to test).

Environmental factors	Observation
Background noise	✓ (mild-mad levels intermittently)
Visual distractions	✓
Other distractions	✓
Size of room	✓
Room set up	✓

General comments: _____

Total number of learners tested: _____
 Total pass/fails: _____
 Majority of failures at which level of protocol (which test): _____
 Majority of failures due to: _____



Observation Schedule

Tester factors	Observation
Ease with which testing conducted (handling of equipment)	✓ (Tymps = 3 ; needs some support) 4-5
Ease with which results are interpreted	✓ (Tymps = 3) 5
Ease with which results are recorded	✓
Average amount of time taken to perform test	

Testee factors	Observation
Learner's understanding of test requirements	✓
Compliance	✓

Environmental factors	Observation
Background noise	✓ (intermittent mild-mod)
Visual distractions	✓
Other distractions	✓ (none)
Size of room	✓
Room set up	✓ (? machine too close to window - noise)

General

comments: Room situated by offices → less b/g noise than in classroom / around classrooms. (like in Hazeldene). Does have ++ noise inter-mittently!!
 May need more input / practise 2 tymps.
 * OAE's not repeated in most cases; *

Total number of learners tested: _____

Total pass/fails: _____

Majority of failures at which level of protocol (which test): _____

Majority of failures due to: _____

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Appendix Y1

Contingency table showing the agreements and disagreements between Nurse 1 and independent tester's results

		Nurse tester		Total
		Positive	Negative	
Independent tester	Positive	0	0	0
	Negative	0	14	14
		0	14	14

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Appendix Y2

Contingency table showing the agreements and disagreements between Nurse 2 and independent tester's

OAE results

		Nurse tester		Total
		Positive	Negative	
Independent tester	Positive	3	1	4
	Negative	2	14	16
		5	15	20

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Appendix Y3

Contingency table showing the agreements and disagreements between Nurse 2 and independent tester's

Tympanometry results

		Nurse tester		Total
		Positive	Negative	
Independent tester	Positive	2	0	2
	Negative	0	1	1
		2	1	3

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Appendix Y4

Contingency table showing the agreements and disagreements between Nurse 3 and independent tester's results

		Nurse tester		Total
		Positive	Negative	
Independent tester	Positive	0	0	0
	Negative	0	18	18
		0	18	18

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Appendix Y5

Contingency table showing the agreements and disagreements between Nurse 4 and independent tester's

OAE results

		Nurse tester		Total
		Positive	Negative	
Independent tester	Positive	2	2	4
	Negative	0	34	34
		2	36	38

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Appendix Y6

Contingency table showing the agreements and disagreements between Nurse 4 and independent tester's

Tympanometry results

		Nurse tester		Total
		Positive	Negative	
Independent tester	Positive	2	0	2
	Negative	0	0	0
		2	0	2

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