

The Feasibility of a Computer-Based Hearing-Screening Programme among school learners in the Western Cape Province.

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Table of Contents

<i>Acknowledgements</i>	i
<i>List of Tables</i>	ii
<i>Lists of Figures</i>	iii
<i>List of Abbreviations</i>	iv
<i>Glossary of Terms</i>	v
<i>Abstract</i>	vi
Introduction	1
Literature review	2
Health Care System in South Africa	2
Audiology Services in Developing Countries	3
Need for Hearing-screening	6
Prevalence of Hearing Loss	7
Effect of a Mild Hearing Loss	9
Impact of an Unidentified Hearing Loss	9
Principle of Hearing-screening	12
Hearing-screening Platform	13
Hearing-screening Instrumentation	14
Pure-tone Hearing-screening Protocol	19
Sensitivity and Specificity of Screening Tools	19
Stand-alone versus a Computer-based Screening Audiometer	20
Location of Hearing-screening Programme	21
Background Noise	24
Personnel	25
Attitudes of Screening Personnel	26
Computers	28
Methodology	30
Purpose	30
Aim	30
Main Aim	30
Sub-aim	30
UCT hearing screening Review	31
Research Design	31
Selection Criteria	31
Selection Criteria for Schools	31
Participant Hearing-screening Record Selection Criteria	31
Sampling	31
School Sampling	31
Participant Sampling	32
Description	32
School Description	32
Participant Description	32
Data Collection	33
Data Analysis	33
Quantitative Analysis	33
Reliability and Validity	34
Attitudes	34
Research Design	34
Participants	35
Selection Criteria	35
Recruitment	35
Sample Size	36
Sampling	36

Description of Participants	36
Questionnaire	38
Questionnaire Format	38
Questionnaire Development	38
Pilot Study	44
Data Collection	45
Data Analysis	45
Quantitative Analysis	45
Qualitative Analysis	46
Reliability and Validity	46
Noise Level Survey	46
Research Design	46
School Selection Criteria, School Selection Procedure and School Description	47
Instrumentation	47
Data Collection	47
Data Analysis	48
Reliability and Validity	48
Ethical Considerations	48
Confidentiality	48
Autonomy	49
Beneficence and Non-maleficence	49
Professional Competence	49
Dissemination	49
Results	50
Referral rates of Hearing loss in School aged children	50
Hearing screening referral excluding 500 Hz	51
Hearing-screening Performance as a Function of Frequency	52
Laterality	53
Unilateral versus Bilateral Hearing-screening Failures	53
Gender Differences in Hearing-screening Performance	54
Gender Differences when 500 Hz was excluded	55
School and Geographical Differences	56
Results obtained from the Questionnaire	56
Gender	56
Computer Literacy Exposure	56
The Effects of an Unidentified Hearing Loss on a Learner's Development and School Performance	59
Rationale and Need for Hearing-screening	60
Knowledge of Causes of Hearing loss and Hearing-screening	61
Information obtained from a Hearing-screening Test	63
Resources	64
Time Requirements for Hearing-screening	64
Personnel to conduct Hearing-screening	65
Location/ site of Hearing-screening Programme	65
Understanding of Equipment required for Hearing-screening	66
Value of Computers	67
Computer Training	68
Participants' Attitudes towards the Acquisition of New Skills	69
Noise Level Survey	71
Computer Site	72
UCT Hearing-screening Site	72
Other Site	73
Discussion	75
Referral rates for Hearing loss in School-aged Children	75
Resources	82

Knowledge about Hearing-screening and Resources required for Hearing-screening	87
Value of Computers, Computer training and Skills Development	95
Noise Survey	96
Conclusion	98
References	99
Appendices	
Appendix A: Cost analysis of a computer-based versus a stand-alone hearing-Screening audiometer	108
Appendix B: Review of the UCT's School-based Hearing-screening Programme	109
Appendix C: Participants in the Prevalence Review as a Function of School, Gender and Grade	110
Appendix D: Questionnaire	111
Appendix E: Informed Consent Form	121
Appendix F: Approval Letter from the UCT FHS Ethics Committee	122
Appendix G: Permission Letter from the Department of Education	123
Appendix H: Detailed Analysis of Failed Frequencies	124
Appendix I: Laterality Differences for Hearing-screening Test	125
Appendix J: Performance of Pupils on the Hearing-screening Test as a Function of School	126
Appendix K: Percentage Agreement Information from the Questionnaire	127
Appendix L: Verbatim Comments regarding Hearing losses	129
Appendix M: Verbatim Comments regarding Hearing-screening	131
Appendix N: Verbatim Comments regarding Computers	132
Appendix O: Verbatim Comments regarding Learning New Skills, such as Hearing-screening	133
Appendix P: Detailed Noise Level Measurements at the UCT's Hearing-Screening Schools per Site	134
Appendix Q: Measurements at School's 1-11 as a Function of Time	135
Appendix R: Comparison of Prevalence Results, including and excluding 500 Hz	141

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Lists of Tables

Table 1	Maximum allowable ambient noise for a 20 dB HL screening level	24
Table 2	Gender and Grade of participants in the review	32
Table 3	Number of ear failures as a function of frequency	52
Table 4	Number of failures, as a function of gender, with and without 500 Hz	55
Table 5	Hearing-screening failures as a function of geographical area	56
Table 6	Exposure to computers in the workplace	57
Table 7	Areas of development impacted by a hearing loss	59
Table 8	Need and rationale for hearing-screening in the school environment	61
Table 9	Possible common causes of hearing losses in children	62
Table 10	Statistical results for the correctness of perception of commons causes of hearing loss in children	62
Table 11	Prevalence of hearing loss amongst school children	63
Table 12	Information obtained from a hearing-screening test	64
Table 13	Effect of time on hearing-screening	65
Table 14	Personnel to conduct hearing-screening	65
Table 15	Possible locations for conducting hearing-screening programmes	66
Table 16	Statistical results for a suitable location for conducting hearing-screening programmes	66
Table 17	Statistical results for the understanding of the equipment used in hearing-screening	67
Table 18	Statistical results for the value of computers	68
Table 19	Statistical results for computer training	69
Table 20	Desire to learn new skills	69
Table 21	Advantages of acquiring new skills	70

List of Figures

Figure 1	Years of experience of participants at school sites	37
Figure 2	Qualifications of participants	37
Figure 3	Performance of learners on the pure-tone hearing-screening test (including 500 Hz)	51
Figure 4	Performance of learners on the pure-tone hearing-screening test (excluding 500 Hz)	52
Figure 5	Percentage of ear failures as a function of frequency	53
Figure 6	Learners who had unilateral versus bilateral hearing-screening failures	54
Figure 7	Performance of learners on the hearing-screening test as a function of gender	54
Figure 8	Performance of learners on the hearing-screening test as a function of gender, excluding 500 Hz	55
Figure 9	Average sound level meter measurements at three sites at 1 kHz per school	71
Figure 10	Average noise level measurements of computer site relative to ANSI standards at 1 kHz	72
Figure 11	Average noise level measurements of present UCT hearing-screening site relative to ANSI standards	73
Figure 12	Average noise level measurements of 'other' site relative to ANSI standards at 1 kHz	73
Figure 13	Suggested hearing-screening programme protocol at primary level (school site)	81
Figure 14	Suggested knowledge, skills and attitude domains that could be incorporated in a hearing-screening training programme	90
Figure 15	Service delivery structure for a school-based hearing-screening programme	94

List of Abbreviations

ABR	-	Auditory Brainstem Response
AIDS	-	Acquired Immune Deficiency Syndrome
ANSI	-	American National Standards Institute
ART	-	Antiretroviral Therapy
ASHA	-	American Speech-Language-Hearing Association
B. Ed	-	Bachelor of Education
CBD	-	City Bowl District
CD	-	Compact Disc
dB HL	-	Decibel Hearing level
dB SPL	-	Decibel Sound Pressure Level
EMDC	-	Education Management District Centre
ENT	-	Ear, Nose and Throat Specialist
HIV	-	Human Immunodeficiency Virus
HL	-	Hearing Loss
HPCSA	-	Health Professions Council of South Africa
JCIH	-	Joint Committee on Infant Hearing
kHz	-	Kilo Hertz
MS	-	MicroSoft
NIH	-	National Institute of Health
OAE	-	Otoacoustic Emissions
PTHS	-	Pure-tone Hearing-screening
SLM	-	Sound Level Meter
SNHL	-	Sensorineural Hearing Loss
UCT	-	University of Cape Town
UCT FHS	-	University of Cape Town Faculty of Health Sciences
UNICEF	-	United Nations International Children's Emergency Fund
WHO	-	World Health Organisation

Glossary of Terms

<i>Centrality</i>	The subjective importance by the participant of the question item (Schuman & Presser, 1996).
<i>Certainty</i>	The extent to which the participant agreed or disagrees with the response item.
<i>Feasibility</i>	Practicality, possibility (Allen, 1989).
<i>Importance</i>	The subjective significance of the question item in the participant's life (Schuman & Presser, 1996).
<i>Intensity</i>	The subjective strength of feeling as reported by the respondent (Schuman and Presser, 1996).
<i>Salience</i>	The salience hypothesis is that a particular response is made more attractive through a kind of consciousness-raising awareness process created by preceding questions (Schuman & Presser, 1996).
<i>School Clinic</i>	In the Western Cape there were 22 School clinics, which have been re-organised into seven Early Management District Centres (EMDC). Multiple schools fall under a single school clinic in a specific area. The school clinic is responsible for the management of learners in a specific region and provides specialized services (social work, psychology, remedial support) to the schools under its auspices (Lewis, F, Personnel communication, June, 2003).
<i>School Site</i>	In this study, school site refers to the actual school location where teaching occurs. At the school site there are no specialized services. Therefore each school could be classified as a school site. Many schools (or school sites) would fall under one school clinic/EMDC.
<i>Viability</i>	Feasible from an economic view (Allen, 1989).

Abstract

The need for a school-based hearing-screening programme in the Western Cape was investigated by auditing a current school-based hearing-screening programme, the attitudes and knowledge of school clinic personnel towards hearing, hearing losses, change and technology and the environmental noise levels at school sites. The University of Cape Town's hearing-screening programme at eleven primary schools (N = 1101/ age mean seven years) was audited which revealed a 14% referral rate for hearing loss amongst school-aged children. The effects of environmental noise on hearing-screening performance at 500 Hz was investigated. When the hearing-screening results at 500 Hz were excluded from the audit, the referral rate was reduced from 14 % to 8%. The attitudes of school clinic personnel (N =88) towards hearing, hearing losses, hearing-screening, change and technology were obtained by a self-administered questionnaire and were favourable towards the implementation of a hearing-screening programme. The quantitative results were substantiated by the qualitative data. The noise level measurements at the eleven primary schools fell within the acceptable limits for ambient noise during the hearing-screening. The high referral rate from the hearing screener amongst this population, positive beliefs of school clinic personnel and the acceptable noise levels at probable hearing-screening sites all augur well for the implementation of a school-based hearing-screening programme. The implications suggested that a hearing-screening programme at Western Cape schools is feasible and should be implemented to minimize the adverse effects of an unidentified hearing loss on a learner's language and psychosocial development as well as educational performance. A service delivery structure for a school-based hearing-screening programme was proposed which included a hearing-screening protocol as well as suggested knowledge, skills and attitude domains that could be incorporated into a hearing-screening training programme. The shortcomings of the study included: incomplete data being available for the UCT hearing-screening programme review; the review being retrospective; and the limitations of using a non-standardized and novel questionnaire in data collection.

Keywords: Hearing-screening, Hearing loss, Attitudes, Noise levels.

Introduction

The health care systems and audiological services in developing countries, like South Africa, have certain common problems such as competing health demands, lack of information regarding the prevalence and epidemiology of hearing losses, lack of specialist audiological personnel and limited technological services (Gopal, Hugo & Louw, 2000). Deafness and hearing impairment are often invisible and forgotten problems in developing countries, especially among children (Jauhiainen, 2001). However the burden of hearing impairment is thought to be twice as large in developing countries than developed nations (Smith, 2001) and yet services in these countries are non-existent or limited. Thus, there is a need to improve the identification of children who have a hearing impairment.

A minimal hearing loss can have adverse affects on a child's language and psychosocial development as well as educational performance and thus needs to be identified as early as possible to minimise these affects. The current research attempts to determine the feasibility of a computer-based hearing-screening programme at school sites to help in the identification of milder hearing losses. Computer-based hearing-screening may be seen as an innovative way to try and meet the challenges of a developing country's limited resources.

In the current study, the University of Cape Town's hearing screening programme was reviewed. The attitudes and knowledge of school clinic personnel towards hearing, hearing losses, hearing-screening, change and technology as well as their willingness to be trained and involved in a hearing-screening programme were investigated to determine how these attitudes would impact on the feasibility of such a programme. To gather this information, a self-administered questionnaire was distributed to school clinic personnel at relevant school sites.

The economic, environmental (noise levels at school sites) and technological considerations for a hearing-screening programme were determined by a survey of the school sites. These factors were then used to determine the feasibility of a computer-based hearing-screening programme, under the auspices of the Department of Education, in the Western Cape Province.

Literature Review

Health Care System in South Africa

In South Africa, the system of apartheid, or the total separation of people on the basis of their skin colour, had officially been in place since 1948 and came to an end on the tenth of May 1994 (Bradley, 1996). Prior to the 1994 elections, South Africa had 15 parallel Departments of Education and 15 Departments of Health under the guise of separating responsibility for each group according to their own needs while systematically depriving all but one racial minority of adequate resources (Van Ameringen, 1995). The enormous problems that this inherited system posed and continues to pose in the education and health sector cannot be taken lightly. Good progress has however been made in attempting to overcome this legacy. One of these has been establishment of a unitary health and unitary educational system with a single National Department and nine Provincial Departments (Buch, 2000).

Many years into the democratic rule, the post-apartheid South African state continues to face challenges of a great magnitude. Due to the legacy of apartheid there is a huge discrepancy in the health care system along geographical lines, race and access to health care services. Firstly, regarding geographical lines, the United Nations International Children's Emergency fund [UNICEF] (1996) noted that a vast difference exists between health care services along rural and urban lines. Bradley (1996) and Kubba, MacAndie, Ritchie and MacFarlane (2004) supported the view of UNICEF as they suggested that preventable diseases, such as those arising from unclean water and poverty are rife in rural areas, but not in urban areas. Secondly, regarding the huge discrepancy in health care services due to race, Oldfield (2002) remarked that the majority of South Africa's population are deprived of quality health care and thirdly, regarding access to health care services, UNICEF states that health care services are divided along private versus public lines. This huge discrepancy has specifically led to minimal or no services existing in these previously disadvantaged areas for the diagnosis and subsequent rehabilitation of hearing-impairment. An undiagnosed hearing loss may have a negative impact on a child's language development (Tharpe & Bess, 1991), psychosocial development (Elango, Purohit, Hashim, & Hilmi, 1991) and academic performance (Olusanya, 2000; Smith, 2001;). The effects of an

undiagnosed hearing loss shall be discussed in detail later. A great urgency exists to extend audiological services to this previously disadvantaged population. The challenge lies in creating services which are efficient and relevant to the South African context. Novel thinking is needed to address these needs in light of the limited resources. A change in the mechanism for the delivery of audiological services in attempting to screen the hearing of those previously disadvantaged could be seen as a small step in the right direction. One particular group in such need is the school-aged population.

Audiology Services in Developing Countries

While South Africa's health care system and audiological services may have been shaped by the apartheid system, it also shares many similarities with other developing countries. Deafness and hearing impairment are often invisible and forgotten problems in these countries, especially among children (Smith, 2001). Smith reported that the burden of deafness/hearing impairment is thought to be twice as large in developing countries than developed nations and yet services in the former are non-existent or limited. Thus, one needs to consider alternative service delivery models to improve the identification of these children who have a hearing impairment in developing countries.

The health care systems and audiological services in developing countries like South Africa have certain common problems such as competing health demands, lack of information regarding the prevalence and epidemiology of hearing losses, limited technological resources and equipment and lack of specialist audiology personnel (Gopal et al., 2000). These common problems are individually discussed.

The first common problem in developing countries is competing health demands such as Human immunodeficiency virus (HIV) and Tuberculosis, and malnutrition (Jaihiainen, 2001; Wilson, Naidoo, Bekker, Cotton & Maartens, 2003). Prescott, Omoding, Fermor, and Ogilvy (1999) argued that developing countries are confronted daily by an overwhelming burden of deadly diseases and as a result it is not uncommon for these countries to prioritise their health care needs due to limited funding and lack of resources. Olusanya (2000), Olusanya (2001), and Swanepoel

(2004) support the argument by Prescott et al. and further argued that conditions which are perceived as non-life threatening and thus low on the priority list such as hearing impairment are often neglected due to poor socio-economic conditions. Olusanya (2001) felt that these competing demands need to be taken into account when considering the provision of audiological services in developing countries.

The second problem highlighted by Gopal et al. (2000) is a lack of information regarding the prevalence and epidemiology of hearing losses in developing countries. Smith (2001) supports Gopal et al. and further added that there was a severe scarcity of accurate, standardised, population-based data on the prevalence and causes of hearing losses in developing countries. The World Health Organisation (WHO, in Smith) programme for the prevention of deafness estimates that at least 120 million people worldwide have a disabling hearing-impairment with the majority (78 million) being in developing countries and a large percentage of these being children. Such a position is supported by Jauhiainen (2001) who found that the majority of children with hearing impairment live in developing countries with limited or no access to audiological services for appropriate diagnosis and rehabilitation. Moreover Prescott et al. (1999) remarked that in developing countries, there was a higher incidence of conditions contributing to hearing impairment relative to developed countries and one could assume that the prevalence of hearing losses in developing countries would be higher.

The third common problem with audiological services in developing countries is the limited available technical resources and equipment (Gell, White, Newel, Mackenzie, Smith, Thompson & et al. 1992; Gopal et al. 2000; Prescott et al., 1999). Swanepoel (2004) also supports the view of Gell et al., Gopal et al., and Prescott et al. as he felt that there was a lack of resources for diagnosis of hearing impairment in developing countries. Where audiometers were present (usually in urban areas), they tend to be non-portable and are not regularly calibrated as many of them are donated from industrialised countries resulting in a lack of spare parts required for repairs (Gell et al.). Prescott et al. and Jauhiainen (2001) argued that due to the lack of resources, ideally a method should be devised which requires minimal and cost effective equipment. This study proposes a service delivery model for school-based hearing-screening, which in the light of the South African context could be seen as a viable alternative to a lack of services.

The fourth constraint outlined by Gopal et al. (2000) was a lack of specialised audiology personnel trained in the provision of audiological services. Prescott et al. (1999) argued that a hearing-screening method should be simple and able to be taught to primary health care workers. Jauhiainen (2001) supported Prescott et al. and felt that audiological services based on highly trained and qualified personnel are a luxury of well-developed health, social and educational frameworks that seldom exist in developing countries. Swanepoel (2004) further suggested that the problems of hearing losses in developing countries are worsened by a lack of awareness and the absence of regular hearing-screening programmes.

Competing health demands, the undetermined prevalence rate of hearing losses, limited equipment and shortage of adequately trained personnel are challenges in the provision of audiological services in developing countries but should not prohibit attempts to provide a service. Jauhiainen (2001) felt that the effective use of a country's limited resources in terms of equipment and audiological personnel should be taken into account when tailoring programmes for each country in the developing world. One should look to identify methods, which do not require expensive, non-portable equipment, and are simple (thus minimising personnel training) and are able to be implemented despite competing health demands. The constraints of a developing country have been considered when discussing the feasibility of the study's hearing-screening service delivery model.

The challenges facing the provision of audiological services in developing countries are vast but steps still need to be taken to improve the situation. This position is supported by Prasansuk (2000) who felt that despite the hindrances present in the developing world, development and implementation of hearing-screening programmes were necessary. Universal neonatal hearing-screening and screening at later ages (preschool and school age level) is not always feasible due to lack of resources and other constraints as highlighted above but some intervention needs to be considered.

Need for Hearing-screening

In the United States of America, the Joint Committee on Infant Hearing [JCIH] (2000) and National Institute on Health [NIH] (1993) position statements concluded that all infants admitted to the neonatal intensive care unit should have their hearing screened before leaving the hospital and that universal hearing-screening should be implemented for all infants within the first three months of life. The American Academy of Paediatrics (1999) and the Health Profession Council of South Africa: Professional Board for Speech, Language and Hearing Professions (2002) fully endorsed the implementation of universal hearing-screening. The advantages of universal hearing-screening include: the majority of the neonatal population is screened; and that hearing losses are identified within three months of a child's birth (JCIH; NIH; Spivak, 1998). Universal screening has not yet been implemented in South Africa due to limited economic and human resources, expensive equipment and competing health demands.

Support exists (American Speech-Language-Hearing Association [ASHA], 1997; Elango et al., 1999; Gell et al., 1992; Olusanya, 2001; Parving, 1999; Rao, Subramanyam & Rajashekhar, 2002) for the adoption of a hearing screener at a later stage (perhaps at school entry level) when a universal hearing-screening programme is not present or to detect acquired hearing losses. Since no universal hearing-screening programme has been implemented in South Africa at present, it is even more important to screen for hearing losses at a later stage.

Regarding hearing-screening after the neonatal period, the ASHA guidelines (1997) aimed to identify hearing losses greater than 20 dBHL, which were considered to adversely affect a child's communication ability. The ASHA guidelines recommended annual hearing-screening for all children at a school age entry level. This ASHA recommendation supports the need for hearing-screening at a school entry level (Gelfand, 1996). The rationale for hearing-screening at a later stage (perhaps at school entry level) is supported by an NIH (1993) consensus statement, which reported that 20 to 30% of hearing-impaired children acquired hearing loss during early childhood. Elango et al. (1991) and Parving (1999) recommended that screening school children may help to identify cases of hearing impairment and middle ear pathologies earlier and thus minimise the negative impact on the learning processes during the school years. The JCIH (2000)

and Olusanya (2001) support the argument of Elango et al. and Parving and also proposed the ongoing monitoring of children who are at risk for acquiring a hearing loss where existing infrastructure may be utilised to make the hearing-screening programme more cost-effective. Gell et al. (1992) and Rao et al. (2002) advised routine screening of all children at school entry level since many causes of hearing impairment are preventable. However, Smith (2001) reiterated the need for accurate prevalence data, which is needed when planning hearing-screening programmes. Hearing-screening should be an integral component of audiological services in developing countries, whether it is universal or at a later stage. Due to the problems of the current hearing-screening service provision system, an innovative service delivery protocol should be devised to meet the demands of a developing country like South Africa. This service delivery protocol could be provided at a school age level to increase the access to audiological services (in addition to neonatal hearing screening) and provide identification of children with hearing losses acquired in early childhood.

As stated earlier the majority of the hearing-impaired population in developing countries are children. However such statistics only reflect disabling hearing impairment. According to Prescott et al. (1999) many more children may have less severe hearing losses related to middle ear pathologies, whose consequences may not be as disabling. The current research study explores the health care issues of those school age children who present with less severe hearing losses and suggest possible strategies for the detection of hearing losses within a developing nation context such as South Africa.

Prevalence of Hearing Loss

Before initiating screening services for a pathology, its prevalence must be sufficiently great to warrant setting up such a service. Few studies determining the prevalence of hearing losses in South Africa have been conducted, and these studies have had limited sample sizes that are not very representative. Bhoola and Hugo (1995), in Kwa-Zulu Natal, established a prevalence rate for hearing losses of 13% for Black subjects and 14.3% for Indian subjects. This prevalence rate finding for hearing losses is similar to the studies by Meyer and Van den Berg (1985) and Meyer, Hurter and Van Rensburg (1987) which reported a prevalence rate of 15.2% among children in

Venda and 15.7% among children in Eersterust respectively. Hugo, Louw and Meyer (1991, in Swanepoel, 2004) surmised that there was a higher prevalence rate of middle ear infections in South Africa than in developed countries. The Community Agency for Social Enquiry report (1997) suggested that 1% of the South African population have a hearing impairment. However the same Community Agency for Social Enquiry report remarked that this number may be a gross underestimation due to the definitions used in the data collection and the stigma associated with a hearing loss. The finding by the Community Agency for Social Enquiry report was supported by the population census (Statistics S.A., 2003) which reported that 0.7% of the South African population had a hearing loss.

When considering the prevalence of hearing loss among school children in South Africa, it is advantageous to consult studies from other developing countries which are similar to South Africa. Elango et al. (1991) and Swart, Lemmer, Parbhoo and Prescott (1995) reported that the prevalence of hearing impairment was 5.8% and 3.3% in Malaysia and Swaziland respectively. Olusanya, Okolo and Ijaluola (2000) and Rao et al. (2002) reported that the prevalence of hearing impairment of school-aged children in rural Nigeria and rural South India was 13.9% and 11.9% respectively. Thus, they concluded that hearing impairment and preventable ear diseases were important health concerns among school-aged children in rural areas. Hatcher, Smith, Mackenzie, Thompson, Bal, Macharia et al. (1995) reported that the prevalence rate of mild hearing impairment was 5.6% in Kenya. Hatcher et al. suggested that these prevalence rates merely represented mild hearing loss and that the prevalence rates increased when more severe forms of hearing losses were included. It thus becomes clear, that in developing nations like South Africa, the prevalence rates (Bholla & Hugo, 1995; Olusanya, 2000; Rao et al., 2002.) are higher than in developed nations (Smith, 2001), and that rural populations are at greater risk relative to urban individuals (Prescott et al, 1999). Jacob, Rupa, Job and Joseph (1997) suggested a few reasons for the difference in prevalence rates between developed and developing nations which included the absence of regular screening programmes, poverty, malnutrition, ignorance and paucity of accessible health care in developing countries.

Prevalence reviews have their own set of limitations and need to be examined with caution (Gell et al., 1992). Factors which cause differences in the prevalence data relate to the population

screened, protocols used and the pass/ refer criteria used (Bluestone, 1998). While no large scale studies have been done in the Western Cape Province of South Africa (Shung-King, Abrahams, Giese, Guthrie, Hendricks, Hussey et al., 2000), given that there are many individuals living in constrained economic circumstances both in urban and rural areas (Buch, 2000) it could be expected that hearing problems will be present at elevated rates relative to developed nations.

The above statistics begin to provide support for the need for hearing-screening at stages other than newborn perhaps at a school entry level. There seems to be a high prevalence of these milder hearing losses at this age. However what effect do these mild losses have on a child's development and school performance?

Effects of a Mild Hearing Loss

A 'minimal' hearing impairment is a term commonly used to describe the following types of hearing losses: mild bilateral sensorineural hearing losses (SNHL); bilateral conductive hearing loss secondary to middle ear effusion; high frequency hearing losses; and unilateral SNHL (Tharpe & Bess, 1999). Tharpe and Bess suggested that reference to specific types of hearing losses as minimal or mild seems to contribute to the thinking that their effects are mild or negligible. Even mild bilateral or unilateral hearing losses may contribute to various problems in areas of educational achievement, language learning, social and emotional function, and attention and behaviour in a young child. Elango et al. (1991) are in agreement with Tharpe and Bess and suggest that the identification of hearing losses in children is of great importance as it often goes unrecognised and may create the serious problems described. It would be assumed that by school-going age more severe hearing losses would have been detected by parental suspicion due to delayed language milestones, inattentiveness or poor performance. The possible effects of an undiagnosed mild hearing loss in the school age population shall be discussed below.

Impact of an Unidentified Hearing Loss

What impact does a mild hearing loss have on a child's academic performance? Elango et al. (1991) and Smith (2001) argued that a mild hearing impairment can impair a child's academic

performance as it adversely affects their acquisition of linguistic skills needed in the classroom situation. Tharpe and Bess (1991) and Olusanya, Luxon, and Wirz (2004) are in agreement with Elango et al. and Smith in their view that a minimal hearing impairment can negatively influence a learner's educational performance as it affects a child's communicative ability under certain listening conditions and may contribute to a learning delay. Hicks and Tharpe (2002) reported that children with hearing losses had poorer reaction times to phonetically balanced-kindergarten word lists than normal hearing children in educational tasks. They deduced that children with hearing losses expended more effort in performing tasks such as note-taking while listening, than normal hearing children resulting in poorer academic performance. Davis, Elfenbein, Schum and Bentler (1986) in their study of 40 hearing-impaired children found that there were marginally significant differences in reading ability between the sample and normative data on the Reading Comprehension Subtest of the Peabody Individual Assessment Test. Children with unilateral hearing losses may demonstrate poor school performance as they may have difficulty with speech recognition when background noise is present, and localization difficulties, which may lead to poor academic progress (Tharpe & Bess, 1991). Davis et al. argued that educational deficits experienced by the average hearing-impaired child are directly related to delays in the development of language and verbal skills. Thus, a mild hearing loss can have an adverse effect on a child's academic performance.

How does a mild hearing loss impact a child's language development? Tharpe and Bess (1991) argued that mild bilateral hearing losses put children at risk for language delays because of their poor speech recognition abilities. Smith (2001) supported this view as he remarked that children with chronic otitis media seemed to fare worse than hearing peers on expressive language tasks as the resulting hearing loss disrupted their language development. Davis et al. (1986) in their study on the effects of mild hearing losses on language found that the performance of the sample as a whole revealed significant deviations from the norms for the test (Peabody Picture Vocabulary test- revised) indicating that even the mildest hearing losses are likely to result in delays in vocabulary development. Therefore, as highlighted above, even a mild hearing loss can negatively impact on a learner's language development.

Does an undiagnosed hearing loss impact on a child's psychosocial development? Smith (2001) and Elango et al. (1991) both argued that mild hearing losses can affect a child's psychosocial development and growth resulting in isolation and stigmatisation. Davis et al. (1986) further argued that hearing impaired children experience behavioural problems, especially in social settings resulting in isolation and poor adjustment to school. Bess, Dodd-Murphy and Parker (1998, in Hicks & Tharpe 2002) reported that children with minimal hearing losses report having more stress than normal hearing children possibly as a result of their social isolation. Thus an undiagnosed hearing loss can have an impact on a child's psychosocial development.

How does a mild hearing loss affect the behaviour of a school-aged child? Davis et al. (1986) argued that children with hearing impairment show a similar interest in routine play, sports and hobby activities as normal hearing children but are perceived (by their teachers and parents) as having more problems interacting with others and establishing friendships. They further felt that hearing-impaired children were often described by their parents as having externalising behaviour problems that were characterized by aggression, impulsivity, immaturity, and resistance to discipline and structure. Brookhouser, Worthington, and Kelly (2001) support Davis et al. (1986) and further argued that 31% of hearing impaired children have behavioural problems. Olusanya (2000) further remarked that any hearing loss, if undetected and unmanaged could affect an individual's behaviour and quality of life. Therefore a mild hearing loss can affect the behaviour of a school-aged child.

The effects of an unidentified milder form of hearing loss have been described above, which provides support for the establishment of a hearing-screening programme for the school-aged population to improve the identification of these hearing losses and facilitate the necessary subsequent remediation. The high prevalence of hearing losses in the school age population and the adverse effect these losses may have, provide support for hearing-screening at a school entry level. In summary this researcher concludes that an undiagnosed hearing loss can lead to language delays which can affect a child's academic achievement which can be compounded by behavioural problems resulting in additional psychosocial problems such as isolation. One could hypothesize that earlier identification of hearing losses at a school age level, through a hearing-screening programme could minimise language delays and reduce the adverse effects on

educational achievement, as well as minimize behaviour and psychosocial problems. But what does hearing-screening entail and what methods could be used for the school age population?

Principles of Hearing-screening

Davies (1996) described hearing-screening as a rapid process that identified, in a defined population, a sub-group with a high probability of having a hearing impairment. This sub-group is then referred for further assessment. Hearing-screening is not designed to produce an accurate, detailed quantitative measurement. Roush (2001) and Tweedie (1987) remarked that the goal of a screening programme is to identify asymptomatic individuals with a greater likelihood of presenting with the target disorder, in this case a hearing loss, so that diagnostic testing can be performed on this selected group. It should merely work on a pass/ refer criteria. Screening programme designs, procedures, protocols and equipment will vary with the target population and goals (Johnson, 2002). Thus, universal newborn screening versus screening at a later stage differ significantly in the methods utilised and in the goals.

The three most important preconditions for establishing a screening programme according to Davies (1996) and Parving (1999) are: The condition to be screened should have important health, social and educational consequences if left untreated; Secondly good referral services need to be available for assessment and diagnosis; and thirdly appropriate rehabilitation services need to exist. Davies further felt that screening programmes need suitable support services at the secondary and tertiary level.

The prevalence of hearing losses in the school age population (Hatcher et al., 1995; Olusanya et al., 2000; Rao et al., 2002) and the adverse affects that an unidentified hearing loss may pose (Davis et al., 1986; Elango et al., 1991; Smith, 2001; Tharpe & Bess, 1991) would meet Davies's (1996) first precondition. Swanepoel (2004) also felt that the prevalence of hearing loss is adequately high to justify hearing-screening. In South Africa however, a large void exists in terms of providing diagnostic audiology and rehabilitation services, making it difficult to meet the second and third preconditions.

When devising a hearing-screening programme various tenets should be included in its development. These tenets are that a large percentage, if not all of the target population should be tested; the methods utilised should be cost-effective and simple; and the test procedure must be reliable and quick (Spivak, 1998). Swanepoel (2004) also agreed with Spivak that an important tenet of a hearing-screening programme is the coverage (number of learners screened). Furthermore, the test used must be suitable for the target population and finally the test should fail all those with a hearing loss or defect (Tweedie, 1987). In addition, Olusanya (2001) felt that the ideal mass screener should be inexpensive, quick to administer and should entail simple equipment. It should also be highly specific, highly sensitive, reliable and acceptable (Spivak). Screening programmes must strive to be efficient and should be properly evaluated to demonstrate acceptable performance (Spivak). Swanepoel also agreed that an important measure of a hearing-screening programme was the referral rate. Parameters that are used to evaluate screening programmes are: sensitivity, which is the ability of the screening procedure to identify the target population; and specificity, which is the ability of the procedure to not identify those who truly do not have the disorder (Johnson, 2002). The sensitivity and specificity of various screening methods shall be discussed later. The training of personnel, methods used and population screened might be wide ranging and shall depend on the screening protocol and goals utilised (Davies, 1996). Thus, many factors need to be considered when developing a hearing-screening programme.

Hearing-screening Platform

One needs to consider the platform on which a school-based hearing-screening programme could be based. Uys and Hugo (1997) remarked that in South Africa there is a trend towards a community based service delivery model in all professions, including that of audiology. Olusanya (2001) remarked that it is more practical and easier to use existing services. Swanepoel (2004) proposed a service delivery model for infant hearing-screening in South Africa. This model, with modifications, is also appropriate when considering a school based hearing-screening programme. It is a three tier system namely; Service delivery structure; role players and responsibilities and Screening protocol. This service delivery model is discussed in detail in the discussion.

Hearing-screening Instrumentation

From the above discussion, the importance of hearing-screening at a school-age level can be seen. One debate in hearing-screening surrounds the instrumentation that should be utilised in such a hearing-screening programme (Gell et al., 1992). The instruments for conducting a hearing-screening with a school age population shall be discussed here. There are many different approaches which include the voice test (Prescott et al., 1999), parental questionnaires (Newton, Macharia, Mugwe, Ototo & Kan, 2001), otoacoustic emissions [OAE's] screening (Hall, 2000), auditory brainstem response [ABR] screening (Hood, 1998), immitance screening (Holtby, Forster, & Kumar, 1997), otoscopic screening (Olusanya, 2001), pure-tone screening audiometry with a stand alone audiometer (Gell et al., 1992; Johnson, 2002; Karlsmose, Pedersen, Lauritzen & Parving, 1998; Sabo, Winston, & Macais, 2000) and pure-tone screening audiometry using a computer-based screening programme (Harell, 2002).

The first method to be discussed for conducting hearing-screening with the school-aged population is the 'voice' test. Browning, Swan and Chew (1989) refined the 'voice' test into a six-point scale test. This test was however further simplified for the South African context into a three-point scale test (Whisper level, conversational level, loud level) by Prescott et al. (1999). This procedure involves the tester familiarising the child with the test procedure by informing the child that they shall be required to repeat words/ phrases that will be said by the tester at an arm's length behind the child. A trial run is conducted at a conversational level to ensure the child understands the test procedure. The test begins by the tester delivering words at a whisper level, if the child fails to respond, the tester increases the loudness of their voice to a conversational level and then in turn to loud (if the child still does not respond). If the child is able to repeat words at whisper level, they pass the 'voice test'. If the child needs a conversational level in order to repeat words then the child would be referred for further investigation.

The World Health Organisation (WHO) report on the international workshop on primary ear and hearing care (1998) recommended the use of the 'voice' test when screening young children. Prescott et al. (1999) felt that the modified 'voice test' was a simple (doesn't require masking), rapid, easily applicable and cost effective hearing-screener, which could be used in a variety of

settings. They measured the specificity and sensitivity of the 'voice test' compared to pure-tone audiometry. The study showed a sensitivity of 83.3% and specificity of 96.8% of the voice test when compared to pure-tone hearing-screening. Despite the low cost of the 'voice test', various limitations exist. The 'voice test', when a whisper level was used, had an intensity level in the 30-45 dB HL range as measured by a sound level meter (SLM). Thus, children who pass the voice test may in all likelihood still have a mild hearing loss, which could adversely affect school performance. Dempster and Mackenzie (1992) are in agreement with this view that the 'voice' test misses 25% of children with mild hearing losses and felt that it could not be recommended where other audiological services are available. 'Voice tests' are not frequency specific, and as Prescott et al. (1999) remarked, two areas of concern are high frequency hearing losses or unilateral losses, which the voice test may miss. Thus, the 'voice test' was not able to yield ear-specific results as the stimulus was produced in the free field. Although basic masking can be conducted by rubbing the tragus of the opposite ear, the reliability of this fundamental masking has not been established. Secondly, although the 'voice test' requires no equipment, it is unlikely that the venue where the test will be administered will have a SLM to ensure the test-re-test validity. Thus the level of the whisper may be unknown and may result in a large number of false-negative referrals. Thirdly, frequency specific information could not be gathered by the 'voice test'. Thus, high frequency hearing losses may be missed. There are no standardised words lists that are utilised and this may pose a problem. The problem of culturally and linguistically appropriate word lists in a multi-lingual society like South Africa could also pose a problem even if a standardised word list was created. Ambient background noise may interfere with the stimulus presentation as words are presented in the free field. Although there are benefits in using the 'voice test', its applications should be limited to when there is no other audiological alternative. Its widespread application to the school entry level population has not yet been investigated.

A second method used for hearing-screening with the school age population is the questionnaire (filled in by both the teacher and the parent). Questionnaire-based surveys are routinely employed by primary health care workers for the reporting of disease conditions and risk factors for hearing impairment (Olusanya, 2001). The parental questionnaire showed a high specificity of 94.0% but a low sensitivity of 10% for hearing losses (Olusanya). Hammond, Gold, Wigg and Volkmer

(1997) remarked that a hearing questionnaire, when compared to audiometry, had a sensitivity of 56% and a specificity of 52%. Olusanya and Hammond et al. highlighted the ineffectiveness of questionnaires in detecting mild or unilateral hearing losses in children and suggested that a questionnaire was a poor predictor of hearing impairment. Olusanya et al. (2000) found that the majority of ear abnormalities and hearing impairments were not detected or reported by parents or teachers and further remarked that parental interviews would not be suitable for the detection of hearing losses in the absence of other means. Thus, due to the low specificity of questionnaires and its low-hit rate in the detection of mild or unilateral hearing losses, which may affect school performance, the use of questionnaires in isolation is not recommended. It should further be noted that a questionnaire would need to be validated and customised for each specific community for which it may be used. Despite the limitations of a questionnaire in school age screening it should not be discounted and could be used in association with another hearing-screening method.

A third method which could be used at a school entry level is immittance screening. Northern and Downs (2002) reported that acoustic immittance screening was well suited for use with children because it requires minimal co-operation, is an objective test, and is quick and easy to administer. Opponents to immittance screening raise concern about the high false referral rates. Olusanya (2001) and Elango et al. (1991) reported that tympanometry was not used as a test of hearing acuity due to its low sensitivity yield and high false positive rate, which have adversely affected its widespread application. Northern and Downs felt that the low specificity rates of immittance screeners were due to over-rigid failure criterion and not necessarily related to actual test instrumentation. It appears that more research needs to be conducted on utilising tympanometry for school entry level screening before its wider scale application.

A fourth method for hearing-screening is otoscopic examination. Olusanya (2001) reported that referring based on otoscopic abnormality yielded a large number of false positive referrals. The implications of false referrals shall be discussed later. Eighty point five percent of all otoscopically abnormal children had hearing sensitivity within the normal range supporting the view that otoscopic examination is not an appropriate test for hearing acuity. Northern and Downs (2002) felt that if otoscopy was used as a criterion, it would produce a higher sensitivity

agreement indicating hearing losses incorrectly as fewer children would fail. The high false positive yield of otoscopic screening could affect its widespread applications.

A fifth method that could be considered for hearing-screening at a school entry level is auditory brainstem responses (ABR). The ABR is a complex response to particular types of external stimuli that represent neural activity generated at several anatomical sites, from the eighth cranial nerve to the auditory cortex (Hood, 1998). Screening ABR's are obtained by presenting click stimuli at one or two intensities to each ear individually. The automated ABR method minimises the decision-making process and it can be administered with minimal training (Hood, 1998). Abramovich (1990) indicated that the following groups of older children may require an objective hearing assessment namely; children with the following conditions such as mental retardation, cerebral palsy with disordered gross motor development, neurological handicap, autistic like state, and severe visual disability. Thus the ABR may be utilised in the difficult to test older child. Meyer, Witte, Hildemann, Hennecke, Schunck, Maul and et al. (1999) reported that the sensitivity of the ABR's was <98% and specificity was 96%. Despite the high sensitivity and specificity of ABRs, it has been recommended that ABR tests not be used on school age population because they are: time consuming and costly (Jauhainen, 2001); merely indicate hearing sensitivity in the high frequencies (Abramovich, 1996); and thus miss low frequency hearing losses (Hood, 1998). ABR screening should not be discarded in the neonatal population where subjective results can not be obtained. Not much research has been done on the use of ABR screening on school children.

Otoacoustic emissions (OAE's) are yet another procedure that could be utilised in school based hearing-screening. OAE's are a sensitive, clinically feasible measure of cochlear function [outer hair cell] (Hall, 2000). Spivak (1998) remarked that the advantages of OAE's include its sensitivity to middle ear and cochlear auditory dysfunction, quick test time, safe, reliable, relevant simple test procedure, and objective measure. Hall (2000) remarked that OAE screening could meet even the most stringent requirements for sensitivity (close to 100%) and specificity (greater than 95%). Disadvantages include being adversely affected by background noise, unlikely to be obtained in the presence of middle ear pathology, limited research on OAE's screening in the pre-school and school population, and expensive instrumentation which may be not viable in the South African context (Hall). Driscoll, Kei and McPherson (2000) reported that

there were significant sex and ear asymmetry effects on signal to noise ratio, response characteristics, whole wave reproducibility, band reproducibility, and noise level with transient evoked OAE's. As a result normative data must be determined before OAE screening in the school age population is commenced. Since no large-scale hearing loss prevalence studies have been conducted in the Western Cape, it is unlikely that a large-scale study to develop normative data for OAE's is feasible at this time.

Pure-tone hearing-screening is the seventh measure, which may be utilised for school based hearing-screening. Children with mental ages of two and a half years and above should be capable of undertaking a simple pre-audiometry conditioning procedure (Johnson, 2002). Most normally developing children of three and a half years and above should be able to co-operate successfully with audiometric testing if the tester is sufficiently skilled (McCormick 1996). With children between the age of three and a half and five years it is a matter for the tester's discretion whether to start with headphones. Thus, all school age children should be able to respond to pure tone audiometry with headphones.

Johnson (2002) felt that pure-tone hearing-screening identified children who required further assessment, was quick and easy to administer, inexpensive, and the results were generally reliable. However the disadvantages included it not being useful for children with developmental problems, some training was required to conduct the procedure and a very quiet environment was required (Johnson, 2002). Jacob et al. (1997) felt that despite these limitations, pure-tone hearing-screening was relatively inexpensive, required limited resources and minimal time. Manual pure-tone audiometry is still the most common technique for hearing-screening among school-aged learners (Gell et al. 1992; Karlsmose et al., 1997).

The audiometer is an electronic device that is either stand-alone or is integrated into a computer system. The stand-alone system audiometer is the most commonly used although the number of computer-integrated devices is growing rapidly (Harell, 2002) due to the advantages of the reduced cost and infrequent calibration. The current research concentrated on pure-tone hearing-screening using a computer-based programme, which shall be discussed later. Firstly, pure-tone hearing-screening shall be discussed.

Pure-tone Hearing-screening Protocol

The ASHA guidelines (1997) are based on an identification audiometry protocol presenting 1 kHz, 2 kHz and 4 kHz via air conduction at a 20-dBHL level for each ear individually. If a screening protocol is intended to identify middle ear pathologies, the protocol may include 500Hz providing ambient noise is limited. A pass on the protocol requires the child to respond to all frequencies at the 20-dBHL level. The 3 kHz and 6 kHz frequencies should not be included in the screener (Northern & Downs, 2002). If a child is unable to hear even one frequency at 20-dBHL level it will constitute a fail. Those children who fail screening should ideally be screened again on the same day before a referral is made. The ASHA (1997) guidelines recommended the addition of tympanometry in the screening protocol. If immittance screening is not incorporated, then 500Hz should be included as long as noise levels permit the identification of middle ear pathologies (Gell et al., 1992). The effects of noise on pure-tone hearing-screening shall be discussed in more detail later.

Sensitivity and Specificity of Screening Tools

Holtby et al. (1997) compared pure-tone screening and impedance screening of school entrant children by nurses. They found both measures produced similar validation indices after two stages of screening namely 74.4% sensitivity for both methods and a specificity of 92.1% for pure-tone and 90% for impedance. When single stage screeners were employed it resulted in higher sensitivity but lower specificity. They concluded that impedance screening is more technically efficient but required more time than pure-tone screening with the school age population. Silman et al. (1994 in Gelfand 1996) found that screening protocols using frequencies from 500 to 4000 kHz had a correct identification rate of 85%. Gell et al. (1992) felt that false referrals have dire financial implications in any health care system but especially in developing countries which already are over-burdened and have competing health demands. The negative effect of false referrals is supported by Olusanya (2001) who felt that false positives may cause unnecessary parental concern, and could dampen enthusiasm for a screening programme. Rao et al. (2002) found that of the 102 children who failed the hearing-screening at school, 13 were later found to have normal hearing. Sabo et al. (2000) compared pure-tone screening and transient

evoked OAE's screening in the grade school population. They found that the sensitivity and specificity of pure-tone screening was 87% and 80% compared with 65% and 91% for transient evoked OAE's. They concluded that pure-tone screening was a statistically better screening test for detecting hearing losses at the school entry level.

The literature seems to provide support for the use of pure-tone audiometry over all the other methods described above (Sabo et al., 2000; Holtby et al., 1997). The reason seems to be based on its superior sensitivity and specificity as well as ease of administration. However it is advisable to use a combination of screening instruments to insure maximum sensitivity and specificity. A combination of screening methods shall be explored in the discussion.

Stand-alone versus a Computer-based Screening Audiometer

What one needs to consider are the benefits of a stand-alone audiometer versus a computer-based audiometer. As mentioned above, most pure-tone screening audiometers are stand-alone but a few are being integrated into computer software (Harrell, 2002). A stand-alone portable audiometer although commonly used for school screening, has its disadvantages such as the high cost of equipment, calibration costs and the constant threat of damage to equipment during transportation from site to site (Gell et al., 1992). A computer-based hearing-screening programme utilises a computer already at the screening site where the screening programme is loaded onto the computer and saved. The only additional equipment (computer already at site) required for computer-based screening is a disk containing the hearing-screening programme, sound card and headphones. The cost for this type of computer-based audiometer would probably be significantly lower than the cost of the stand-alone portable audiometer. Considering the lowest cost for a Stand-alone audiometer is over R25 000, the computer-based option would in all likelihood be significantly less. See Appendix A for a cost analysis comparing a stand alone versus computer-based hearing-screening audiometer. Since the computer at the site is used, damage to the equipment during transportation is eliminated and reduces the threat to calibration as all software is contained on a disk. The cost of equipment calibration needs to be taken into account when considering a hearing-screening programme. It is usually advised that objective checks of performance should be undertaken at least annually, preferably bi-annually (HPCSA,

2002). Wood (1996) recommended that equipment be calibrated whenever there is a threat to calibration, such as equipment being moved. Calibration is necessary to ensure that audiometers produce the specified loudness level and frequency, that the frequency is only present in the headphone to which it is directed and that the presented tone is free from distortion or unwanted noise interference. Since the error of measurement produced by the client cannot be controlled, efforts must be put into electronic calibration and personnel calibration (Wilber, 2002a). A computer-based screening programme would calibrate itself and thus it would not need to be calibrated annually as it will be constantly adhering to the strictest standards. Such self-calibration implies a high standard of signal delivery. In addition, calibration costs will be significantly reduced/eliminated and the inconvenience of annual calibrations which may have left the screening site without an audiometer for a time period during calibration, will be minimized.

A pure-tone computer-based hearing-screening programme is currently being developed at the Cape Peninsula University of Technology and should be nearing completion at the end of 2005 (Kierman, S, personnel communication, March 11, 2005). A further example of an online pure-tone hearing-screening test can be viewed at www.onlinehearing.org. Computer-based hearing-screening would incorporate existing computer with software specifically designed to simulate an audiometer. Using computer-based pure-tone screening could be seen as an innovative way to try to meet the challenges of a developing countries' limited resources.

Location of Hearing-screening Programme

When considering hearing-screening of children at a school entry level, the environment in which hearing-screening shall take place needs to be considered. For this research two environments were considered namely; the primary health care centre and the school site environment.

Firstly, hearing-screening at a primary health care centre was considered. Smith (2001) remarked that there were multiple opportunities for prevention at all levels of health services, but particularly in the community and at primary levels of health care. The primary health care worker could be incorporated into a screening programme (Smith). Researching the feasibility of

a hearing-screening programme at primary health care centres was originally considered but discounted for a variety of reasons including: unacceptably high noise levels in the clinic setting; a general lack of computers at clinics (with the consequent implication of staffs' lack of knowledge on how to use computers and huge costs in acquiring computers for primary level care clinics); and competition with other more highly prioritised health demands. Swanepoel (2004) supported Smith's view in that there were high levels of noise in the clinic setting which could be seen as a barrier to hearing-screening. However Swanepoel in his review of two clinics remarked that the assets of using a clinic as a screening platform were sufficient chairs, tables, appropriate hygiene levels, electricity and plug points, bathroom facilities and sufficient space. However Swanepoel found that in practice this proved not to always be the case.

A preliminary survey was conducted at 13 primary health care centres in the Western Cape Province to determine the feasibility of a computer-based hearing-screening programme at primary health care clinics. The following clinics were included in the preliminary survey: Barrydale; Botrivier; Bredasdorp; Ceres; Elim; Grabouw; Hawston; Hermanus; Kleinmond; Napier Riviersonderend; Swellendam; and Villiersdorp. These clinics were not randomly chosen from Primary health care centres in the Western Cape but co-incided with the University of Cape Town Otorhinolaryngology (ENT) outreach programmes to the above mentioned centres where pure-tone hearing-screening was conducted. The SLM measurements of ambient noise in all the clinics exceeded at least 55- 75 dB SPL for all frequencies. Thus the noise levels at the primary health care centres exceeded the maximum allowable ambient noise for a 20 dB HL screening level as outlined by the American National Standards Institute [ANSI] (1977). Pure-tone hearing-screening was conducted at the above-mentioned clinics but testing at 500Hz was often abandoned due to there being excessive background noise making pure-tone screening at this frequency at 20-dBHL level impossible. Only two clinics, namely Grabouw and Hermanus had a computer (i.e. 1 computer in the main reception area). The attitudes towards personnel at primary health care clinics regarding hearing losses, hearing-screening, computers and change were not determined. Jauhiainen (2001) noted that developing countries were battling with the basic requirements of health in terms of malnutrition, HIV, tropical and epidemic diseases which have a higher priority due to their life threatening consequences. For this reason determining the feasibility of a hearing-screening programme using a computer-based audiometer at primary

health care clinics was discounted and an alternative hearing-screening environment was investigated namely the school clinics and the school sites. Furthermore the primary health care centres were also discounted due to lack of available computers as well as unacceptably high ambient noise levels.

School clinics and school sites were investigated as another possible site for a hearing-screening programme. Under the old education system there were 22 school clinics in the Western Cape Province. These 22 clinics have been amalgamated into 7 Education management district centres (EMDC). Each EMDC has three branches namely; mainstream schools, special education and psychological services (Lewis, F, personnel communication, June, 2003). The advantages of these sites over primary health care clinic sites included less ambient noise levels, increased availability of computers and personnel. These sites also had the above stated resources namely, chairs, tables, electricity, water, bathroom facilities. However, one of the most important determining factors was that hearing impairment impacts on educational performance of children and could be assessed as a greater priority in an educational rather than in a health setting. Milder forms of hearing impairment could be considered health risks in primary health care clinics but are presently overshadowed by more pressing concerns. The school clinics and school sites in the Western Cape could be seen as a viable environment for a computer-based hearing-screening programme.

The WHO report on South Africa described a health promoting school as one that aimed at achieving healthy lifestyles for the whole population affected by developing supportive environments, which are conducive to the promotion of health. The establishment of health promoting schools in the Western Cape has been the widest in comparison to the other provinces; the process has been driven by school health nurses in partnership with educators. Shung-King et al. (2000) remarked that school health programmes could reduce common problems in the school environment. These health-promoting schools would be an ideal environment for encouraging hearing-screening using a computer-based audiometer.

Background Noise

Pure-tone screening requires a very quiet environment. See Table 1 for the ANSI S3.1-1991 from Katz (2002) which suggests the maximum allowable ambient noise for a 20 dB HL screening level.

Table 1
Maximum allowable ambient noise for a 20 dB HL screening level

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

When discussing the feasibility of a hearing-screening programme the effects of background noise should to be examined. Even when the quietest room is used in hearing-screening it would be unrealistic to expect no background noise to be present. (Gelfand, 1996). Background noise may exert a masking effect and cause elevated hearing thresholds to be recorded. The effect of ambient noise on hearing-screening is dependent on the type of background that is present in terms of its frequency and intensity characteristics, the frequency of tones used, the lowest threshold that is desired to be measured and the mode of presentation (Wood, 1996).

Rao et al. (2002) during their research into hearing impairment among children at school entry level recommended that hearing assessment be done in the quietest room in the school with windows and door closed. Ideally, sound level meter (SLM) measurements should be taken at the screening site and compared to the ANSI normative data to ensure compliance. All steps should be taken to minimise the effects of noise on the reliability of the test results. Hatcher et al. (1995) while studying the prevalence of ear problems in Kenyan school children abandoned testing at 500 Hz and 1 kHz due to background noise. They used only 2 and 4 kHz. It should be noted however that in this study the Liverpool field audiometer was used. The Liverpool field audiometer is a modified stand-alone audiometer. This portable hand-held field audiometer was designed specifically for hearing-screening (Hatcher et al.) It emits tones at the following frequencies: 500Hz, 1 kHz, 2 kHz and 4 kHz at intensity levels of 30 dB HL, 50 dB HL and 80

dB HL. The limitations of this audiometer include missing milder hearing losses (< 30 dB HL) and the inability to mask the non-test ear as it comprises only one earphone. Ambient noise may also interfere with test results as the non-test ear is uncovered.

One way to reduce the effects of environmental noise levels in the test environment is through the correct selection of earphone types used to deliver the stimulus. Insert earphones are recommended over supra-aural headphones for a variety of reasons including: prevention of collapsing canals, increased interaural attenuation of test signal thus reducing the need for masking, and greater reliability (Harell, 2002). Problems with interaural earphones include narrow frequency response, leakage of sound, possibility of collapsing ear canal, inability to produce signals of extremely short duration, reduced interaural attenuation, and creation of occlusion effect (Wilbur, 2002b). Karlsmose et al. (1997) is in agreement with Harrell and further felt that insert earphones would reduce the effects of ambient noise when compared to supra-aural headphones. The current research investigated the noise levels at school sites to determine how this may affect feasibility. More specifically the ambient sound levels in the rooms where the computers are present shall be measured to determine the level of adherence to the noise level requirements.

Personnel

A further consideration for hearing-screening involves the personnel involved in the screening procedure. Northern and Downs (2002) felt that although audiologists play an essential role in hearing-screening programmes, it is generally not cost-effective for audiologists to be involved in the actual screening procedure but should rather have an oversight of the screening programme. Instead of training special professionals to carry out hearing-screening programmes, a need exists to train existing health care workers (Jauhiainen, 2001). Other researchers (Orlando & Sokol, 1998; Olusanya, 2001) agree with Jauhiainen as they believe that nurses are one group of highly trained professionals who may be used for hearing-screening programmes to make hearing-screening more cost-effective. Olusanya (2001) felt that hearing-screening could be conducted by non-audiologist professionals who are at the right place at the right time such as school clinic personnel. The use of non-audiologist professionals for hearing-screening is supported by

Swanepoel (2004) who suggested that the trainability and attitude of nurses and lay volunteers should be assessed.

School clinic personnel may be trained to conduct pure-tone hearing-screening programmes. Individuals who conduct hearing-screening need to be trained in pure-tone hearing-screening and the hearing-screening programme needs to be supervised and co-ordinated by an audiologist. The training to perform pure-tone audiometry should cover various aspects including the rationale for hearing-screening, basic ear anatomy and basic pathology, equipment use, troubleshooting, techniques and protocols used, and their role and responsibilities regarding referrals and follow-up (Johnson, 2002). Proper training of personnel is essential to the success and efficient and smooth operation of any screening programme. The training should be didactic as well as practically based (Orlando & Sokol, 1998). Please see discussion section for the suggested knowledge, skills and attitude domains that could be incorporated in a hearing-screening training programme.

Attitudes of Screening Personnel

Olusanya (2000) remarked that in many cases, various health care workers and lay volunteers are enlisted in screening programmes on the basis on their interest or perceived knowledge rather than their conviction and commitment to the required actions. In his study, he divided possible personnel for screening programmes into four groups. Group A had very little knowledge about the nature and significance about the planned programmes. Group B had a good understanding of the required tasks but were in some way constrained either personally or by other factors. Those who fell into these groups (Group A and Group B) were those workers who did not feel that the benefits of a programme outweighed the sacrifice. The third group [such as teachers/ parents] (C) had some experience with disability and were concerned but were unaware of what needed to be done. The last group (D) were those appreciative of the significance of hearing disability and were committed to actions that would promote its detection, prevention and management. They were not put off by change. All personnel for screening would ideally fall into group D, but this may not be practical. Personnel, who fell into group A, if involved in the screening programme, would require training to acquire new skills and counselling about the benefits of the programme. Personnel who fell into group B would need to be assisted to change their mindset through

awareness. Group C individuals would need to be informed about their role, while personnel in group D should be the core of the programme, and could be used as team leaders. Clemens, Doolittle and Hoyle (2002) reviewed records of kindergarten health assessment reports to determine how accurate and complete the records were. They found that only 20% were fully completed, and only 32% had recorded results for all six screening tests. Screening tests most applicable to school readiness such as vision, hearing and developmental screening were recorded only 55% of the time. They suggested that the incomplete record keeping may reflect attitudes of nurses towards screening measures (Clemens et al., 2002). This result highlighted the importance of selecting personnel who view screening in a positive light. In the current study the attitudes of school clinic personnel towards screening, hearing-screening, hearing loss, computers and change screening was investigated to determine how this would affect the feasibility of a computer-based hearing-screening programme at school sites.

Olusanya (2000) felt that any programme deployed without taking into account the attitudinal status of personnel or their reactions to the proposed change may be counter-productive. Spivak and Jupiter (1998) remarked that personnel support for the programme would be essential. It was not unusual for individuals to initially be reluctant, sceptical or suspicious of a programme. They further warned that an individual who was coerced against his or her will to add another job to their busy schedule was not likely to perform satisfactorily. Thus the selection criteria and training needs of those personnel who may perform hearing-screening should be involved during the planning phase of a hearing-screening programme. This study investigated the opinions of the potential school hearing-screening personnel to determine their role and responsibilities in the feasibility of such a programme. Gopal et al. (2000) felt that there was a need for the education of nurses, community health workers and social workers in order to allow them to participate in the identification of hearing losses. Hatcher et al. (1995) cautioned that there was some variation among results obtained by individuals doing audiometry, which may have been due to real differences or to their differing abilities. However Karlsrose et al. (1997) found that there were only minor differences between results obtained by audiologists in a sound-proof setting and by informally trained personnel in a clinic setting. Karlsrose et al. stressed that discrepancies in results between audiologists and other personnel could be minimised by adequate training and supervision.

Computers

In considering hearing-screening involving the use of computers, the school clinic personnels' computer awareness and literacy would also need to be investigated. Mikuleky and Ledford (1987) felt that individuals needed to be actively involved in the training in the use of a computer system. To be able to participate in the decision making process, individuals need to be knowledgeable about computers and should be computer literate. Basic computer training could be included when informing selected personnel about hearing-screening and the methods utilised. School personnel have the same needs as any other group when change in their environment occurs and there are five basic reasons why people resist change (New & Couillard, 1981 in Mikuleky & Ledford, 1987). These included threatened self interest, inaccurate perception of the intended change, and objective disagreement with the change, psychological reactance, and low tolerance for change. Thus any programme which aimed to introduce computer technology with school personnel, should address these basic issues. In the current study these five areas were explored with likely hearing-screening personnel.

Mills and O'Keefe (1991) noted that as computer systems are further developed they shall be applied in more diversified healthcare settings. Marr (1991) further remarked that continued training in computer software was essential to keep individuals abreast of ever-changing dynamic computer applications. The attitudes of clinic personnel towards computers and their computer literacy levels were investigated in the current research to determine how this would affect the feasibility of a computer-based hearing-screening programme.

McClaren (1988 in Sinclair & Place, 1991) remarked that the majority of research has been in the context of developing appropriate primary health care rehabilitation programmes. He felt there was a fundamental need for research which focussed more on intervention programmes, which made better use of existing resources. The current research attempted to analyse a programme, which would utilise available resources to try to minimise the gap in healthcare services, created by the apartheid regime and compounded by factors inherited by developing countries. Using our existing resources, whether it be computers and personnel for a school based hearing-screening programme may be one way of minimizing the costs and ensuring the cost-effectiveness of a

programme. It is imperative that access to audiological services be extended to a larger portion of the South African population.

Milder forms of hearing losses are prevalent in the school going population and have many adverse effects on a child's development and school performance. Identification and subsequent intervention is essential to maximise an individual's potential. An innovative service delivery structure that utilises available resources and is efficient and effective needs to be developed. A computer-based hearing-screening audiometer may be seen as one option for hearing-screening at school clinics. Before the hearing-screening programme implementation, the attitudes of school site personnel towards screening, hearing-screening, hearing losses, change and technology, computers and willingness to learn new skills needs to be investigated to determine how their attitudes would impact the viability of a hearing-screening programme. This current research further attempted to determine the economic (personnel) and technological (computers, noise level) factors which may affect the feasibility of a computer-based hearing-screening programme.

Methodology

Purpose:

To facilitate the improved detection of hearing loss in the school-aged population and there by minimise the negative speech, language and education sequalae.

Aim

Main aim:

To determine the feasibility of introducing a computer-based hearing-screening programme at school sites in the Western Cape Province.

Sub-aim:

i. To audit the University of Cape Town's (UCT) hearing-screening programme. Specifically to document:

- The number of learners screened
- Pass/ refer rate of learners on a hearing-screening test
- Laterality differences
- Frequency differences
- Gender differences

ii. To determine the suitability of school personnel to conduct hearing-screening. Specifically, to determine their attitudes and knowledge with regard to:

- Milder forms of hearing loss
- The impact of a mild hearing loss on a child's school performance
- Screening in general
- Hearing-screening in particular
- Computer-based technology
- Computer literacy levels
- Change in general and in the workplace in particular

iii. To determine the environmental noise levels at school sites.

UCT Hearing screening review

Research Design

The UCT hearing screening review was a retrospective non-experimental audit design (Trochim, 2001). Thus, hearing screening referral information was obtained via a review of existing data. As this study documented the results of the UCT's hearing-screening programme, this design best facilitated the process. See Appendix B for a review of the UCT's hearing-screening programme (a response by the learner at 25 dB HL at all frequencies for both ears was required to pass the hearing-screening).

Selection Criteria

Selection Criteria for Schools

- All primary schools that participated in the UCT hearing-screening programme during 2003 and 2004.

Participant Hearing-Screening Record Selection Criterion

The following participants' hearing-screening records were included in the review:

- All learners whose hearing was screened during the UCT hearing-screening programme.
- Learners who completed the pure-tone hearing-screening test.
- Results from the hearing-screening must have been deemed reliable by the qualified audiologist supervising the hearing-screening programme at the school.

Sampling

School Sampling

Blanket sampling was used to include schools in the review. Blanket sampling refers to when all available schools are included in the study (Trochim, 2001). As all eleven primary schools

involved in the UCT hearing-screening programme were included in the review, this sampling method best facilitated the process.

Participant Sampling

Once again, blanket sampling (Trochim, 2001) was used to include participants in the review. As all participants in the UCT hearing-screening programme, who met the study criteria, were included in the review, this sampling method best facilitated the process.

Description

School Description

Eleven primary schools were included in the hearing screening audit for 2003 and 2004 namely: two schools in Athlone [School 2 and 4], one school in Observatory [School 5], one school in Rondebosch [School 6], two schools in Salt River [School 1 and 8], two schools in Seapoint [School 3 and 7], one school in Tamboerskloof [School 10], one school in Welcome Estate [School 9] and one school in Zonnebloem [School 11].

Participant Description

There were 1101 learners (515 males and 586 females) who were included in the UCT hearing-screening programme at the eleven schools. See Table 2 for a detailed description of the participants. Appendix C describes the participants as a function of school, gender and grade. Race and ethnicity were not documented during the UCT hearing-screening programme.

Table 2
Gender and Grade of participants in the review

Grade 0		Grade 1		Grade 2		Grade 3		Grade 4		Grade 5		Grade 6		Grade 7		Total
M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
12	12	242	281	124	131	28	47	28	32	22	19	21	24	38	40	1101

Data Collection

The purpose and nature of the study was described to the relevant stakeholders in order to obtain their permission to conduct the review. The clinical coordinator of the UCT hearing-screening programme gave permission for the review to be conducted. Each school's principal gave verbal permission to the researcher to use their school's hearing-screening records for the review. Both were assured that the names of the children and the schools would not be recorded thus ensuring their confidentiality and privacy. The UCT clinical supervisor at each school was contacted telephonically to gain access to the hearing-screening records. The hearing-screening records of all the schools for 2003 and 2004 were then reviewed to describe the nature of the hearing-screening results (number of learners screened, pass/ refer rate of learners on a hearing-screening test, laterality, frequency and gender differences) amongst this sample.

Data Analysis

Quantitative Analysis

To determine the performance of the learners on the hearing-screening test the number of hearing-screening passes and referrals in the school population were analysed via frequency counts since all the information was categorical data (Howell, 1999). With categorical data or count data, the data consists of totals or frequencies for each category and thus frequency counts were the best statistical method to extrapolate information (Howell). Pure-tone hearing-screening thresholds for the left and right ear were statistically compared to determine laterality effects using the Mann-Whitney test (Howell). This analysis was done in order to determine whether the results of individual ears could be presented without regard for laterality. Hearing-screening performance as a function of frequency (500 Hz, 1 kHz, 2 kHz and 4 kHz) were compared via a frequency count. Hearing-screening performance of learners who had unilateral versus bilateral failures were compared using a frequency count. The performance of learners on the hearing-screening test including and excluding 500Hz were compared using a frequency count. Since hearing-screening results at this frequency are commonly affected by background noise, the researcher compared the pass and referral rates with and without 500 Hz in the test battery. The

effect of gender and geographical location on the pupil's hearing-screening performance were analysed using frequency counts.

Reliability and Validity

Data from specific schools for 2003 and/or 2004 [two in Salt River, one in Seapoint, and one in Zonnebloem] were not available for analysis. The hearing-screening records from these schools had been misplaced and despite a thorough search could not be obtained. The omission of these four schools' data may have affected the validity of the prevalence review but the extent of the impact could not be determined. Additionally the hearing-screening results from one school in Observatory (2004) were a fraction of the previous year due to logistical problems during the hearing-screening and this may have affected the validity of the prevalence data.

Only hearing-screening results deemed reliable by the audiologist supervising the hearing-screening at the school were included in prevalence review. In order for the results to have been deemed reliable, the learner had to respond to the same intensity level at 1 kHz at the beginning and at the end of the hearing-screening test (test-retest reliability).

Ten percent of the hearing-screening audit results were analysed by an independent external observer and there was 100% agreement between the results obtained by the independent external observer and the results of the researcher. The independent external observer was a post graduate student (Economics) at the UCT who had experience with data analysis and statistical procedures and who was blinded to the results of the original analysis by the researcher.

Attitudes

Research Design

A descriptive survey research design that involves describing the characteristics of a group by means of instruments such as questionnaires (Gopal et al., 2001) was selected. As this study attempted to document the attitudes of school personnel on issues such as computer literacy and hearing-screening, among others, this design best facilitated this process. Within this descriptive

survey research design a combination of quantitative and qualitative methods were implemented, with quantitative data being the dominant model and qualitative data (less dominant) being used for verification and clarification purposes.

Participants

Selection Criterion

In order to be included in the study, the participants had to meet the following requirements:

- Be a staff member at a school site but need not be permanently based at a school clinic. This criteria was selected as a small number of staff members are permanently based at a school clinic and as a result the pool of participants would have been limited. Furthermore, including many different categories of school personnel would yield a better understanding of the range of individuals who would be willing to engage in a hearing-screening programme.
- Have a tertiary diploma/degree ideally in a health/ education related field. This field was non-exclusionary and included nursing (all pathways), psychology, social work, teaching, diploma in child health, and community health and so forth. A tertiary qualification was used as a selection criterion to represent the typical personnel in the education and school environment.
- Be literate in English, but need not necessarily be a first language English speaker. Since the questionnaire was in English it was an essential requirement that the participants be literate in English to ensure that the results obtained were reliable and valid.
- Regularly be in contact with school-aged learners to ensure that the participants had sufficient exposure to learners to complete all the sections of the questionnaire.

Recruitment

The researcher met with groups (10 members or less) of school clinic staff members at their weekly regional meetings where he addressed them on the nature of the study and its implications

for 5 minutes. After the group had been addressed, members who were willing to participate in the study were requested to read the informed consent form and either consent or decline to participate in study. Upon giving consent, participants were handed the questionnaires in the meeting. Personnel who gave informed consent were required to complete the questionnaire at the meeting. All questionnaires deemed reliable (with no similar answers to the reversed items in two or more sections) were included in the study. The researcher met with eleven such groups of school clinic staff members until a sufficiently large number of participants had been recruited, after which recruitment was discontinued.

Sample size

A minimal sample size of 71 participants was required to correspond to the necessary power value of 0.80 (Howell, 1999). Once the researcher had reached this number he held one last group meeting and thereafter discontinued recruitment (88 participants).

Sampling

Non probability purposive sampling (Trochim, 2001) was used in the attitude scale data collection. Non probability purposive sampling refers to seeking one or more predefined groups until a predetermined number of respondents are obtained (Trochim). Since recruitment was discontinued when a sufficiently large number of participants had been recruited, this sampling method best facilitated the process.

Description of Participants

Eighty eight individuals (80 female and 8 male) participated in the study. The participants represented a varied age range, years of work experience, qualifications and exposure to computers as illustrated below. Ethnicity was not determined by the questionnaire as this information was not required in the biographical information section.

The participants' mean age was 34 years with a range of 24 years to 56 years. The participants had a mean of 6 years 6 months work experience at school sites with a range of 6 months to 25 years. The majority of participants (62%) had between 1 and 5 years experience. See Figure 1 for the years of experience of participants at school sites.

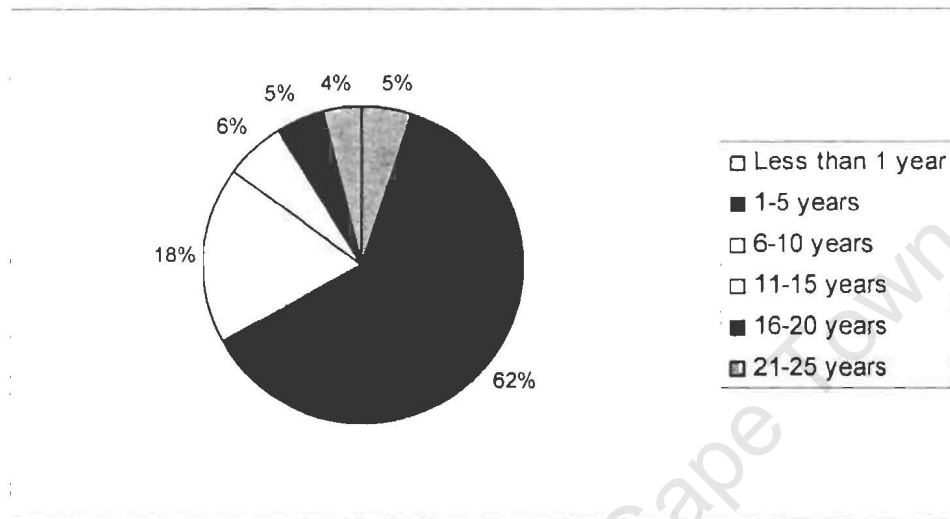


Figure 1. Years of experience of participants at school sites.

With regard to the participant's tertiary qualifications, 24 participants had a Diploma in Education, 14 had a Specialised Education Diploma, 17 had a Diploma (unspecified), 13 had a Bachelor of Education (B.Ed.), 5 had a B.Ed. with Psychology Honours, and 15 participants had qualifications that were unspecified. See Figure 2 for the qualifications of the participants.

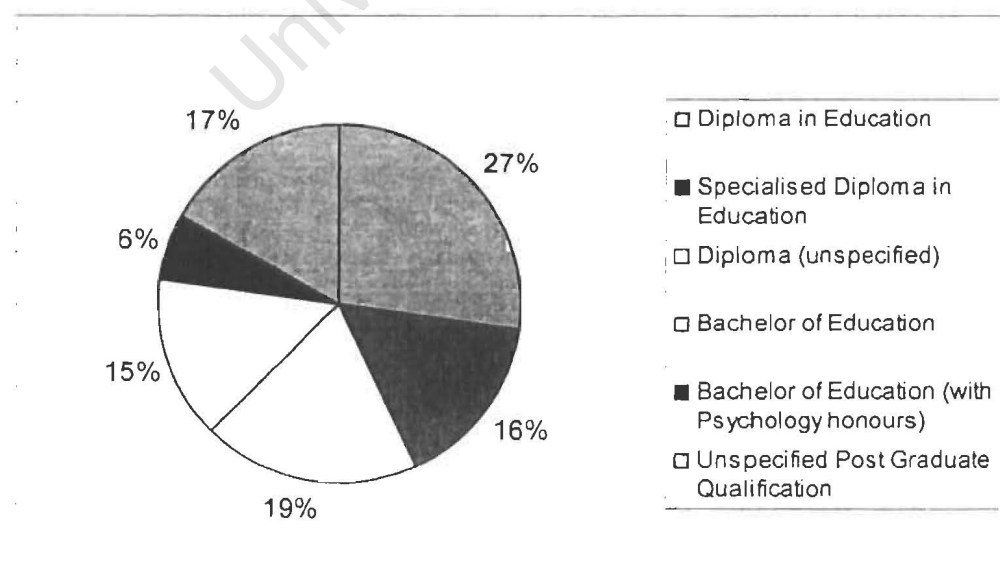


Figure 2. Qualifications of participants.

The participants had a wide range of computer experience and exposure to computers in the workplace. This aspect will be described under the results section.

Questionnaire

A questionnaire was designed by the researcher to elicit information from the school personnel.

Questionnaire Format

The questionnaire was divided into five smaller sections. The first section elicited Biographical/ personal details (including information about literacy skills, participant details and prevalence of hearing loss). The participants' estimation regarding the prevalence of hearing loss of school children was included in order to be compared with the prevalence review results from the UCT hearing-screening review. The other sections included attitudes towards: Screening, hearing-screening, hearing losses, and change in the workplace and computers. The rationale for each section has been provided in the literature review.

The devising of attitude statements requires that they should be meaningful and interesting, even exciting to participants (Oppenheim, 2001). Salant and Dillman (1994) describe good questions as those that are specific, use simple words, are not vague, and are short. A large pool of questions was developed initially for each section and then further reduced following consultation with other academics. Each section had a limited number, between 10 and 13 close-ended questions followed by up to three open-ended questions to increase the likelihood of the questionnaire being completed. Likert scaling was used for the close-ended question section, as discussed below, whereby the participants were required to circle the most appropriate answer to each response statement.

Questionnaire Development

An attitude scale was developed, by the researcher, for use in this study. Attitudes are reinforced by beliefs [cognitive component], and often attract strong feelings [emotional component], which may lead to particular behavioural intents [the action tendency component] (Oppenheim, 2001).

Schuman and Presser (1996) felt there were a large number of concepts related to attitude such as intensity, centrality, salience, certainty, importance and confidence. They felt that attitudes vary in strength and thus an attitude scale based on agree /disagree is not as useful as a more descriptive scale, such as the Likert scale. Firstly the close-ended question format shall be discussed (Likert scaling) followed by a discussion about the open-ended question format.

Likert scaling was incorporated in this study as an attitude measurement scale. Likert scaling has been widely used in instruments measuring opinions, beliefs and attitudes (DeVellis, 1991). When Likert scaling is used, the item is presented as a declarative sentence, followed by response options that indicate varying degrees of agreement with, or endorsement of the statement (DeVellis). Likert scaling has its disadvantages (such as limited choice and minimal qualitative data obtained) but is less laborious than Thurstone scales and is the most popular scaling procedure in use today (Oppenheim, 2001).

How does the order of Likert scaling affect research results? Should 'strongly agree' or 'strongly disagree' come first? Quinn and Belson (1969 in Schuman & Presser, 1996) found that primary effects received more responses. The role of primary effects would thus play a role as to 'strongly agree' being first or last. However, Quinn and Belson (1969 in Schuman & Presser) felt that this primary effect could be minimised by the participant having sufficient time to look over the alternatives as opposed to an interview. Thus, self-administered questionnaires minimize the primary effect as compared with the interview format. The current study set up the Likert scale so that favourable first (strongly agree) was used, as it's the traditional order and most commonly used (Schuman & Presser). The primary effects were minimised, as the attitude scale was self-administered.

Does the inclusion of a 'no choice' column such as 'uncertain' affect the study results? Schuman and Presser (1996) found that the 'uncertain' option significantly increased the proportion of participants who gave 'uncertain' responses. Participants may have given a more substantial response if not given the 'uncertain' option column. They found that the tendency towards the 'uncertain' option could not be minimised by the question content. However, they felt that people who tend towards the middle view were not an important source of instability within the

questionnaire, but could add random error into the correlations. Schuman and Presser (1996) further reported that adding the 'uncertain' option increased choice in that area to about 10-20% of responses, or larger. However, this change to the mid-line also seemed to affect other margins proportionately. It was thus decided to include the 'uncertain' option to allow participants this choice.

The close-ended questions (Likert scaling) have been discussed above. however open-ended questions were also utilised in the questionnaire. Open-ended questions give a more valid representation of the respondent's attitude as the respondent is required to produce an answer themselves (Schuman & Presser, 1996). Furthermore open-ended questions may minimise social desirability effects, prevent mechanical choice or mere guessing (Schuman & Presser). However in the current questionnaire open-ended questions were selected at the end of each section to allow respondents the opportunity to provide additional information and express themselves freely on the issue. Furthermore these open-ended questions followed close-ended questions which allowed the respondent the opportunity to explain their selected choice (Salant & Dillman, 1994). A limited number of open-ended questions (3) were included at the end of each section in order to minimise the disadvantages of exclusively using open-ended questions. The disadvantages of using open-ended questions include that they can be time-consuming, rarely provide accurate measurements or consistent information and lastly data analysis with open-ended questions can be highly time-consuming (Salant & Dillman). Therefore, a combination of both open and close-ended questions were incorporated in the questionnaire development in an attempt to balance the advantages and disadvantages of using these types of question format.

The traditional scales of attitude measurement (such as a Likert scale) have the following requirements; uni-dimensionality, linearity, validity, reliability, and reproducibility (Oppenheim, 2001). Firstly, uni-dimensionality refers to the homogeneity of the scale and should be about one thing at one time making the scale as uniform as possible. This means that the items should be cohesive and fit together to measure the same dimension with minimal extraneous variance (Oppenheim, 2001). To attempt uni-dimensionality in this study's attitude scale, the questionnaire was divided into four smaller sections, each of which measured one aspect at a time thus creating coherence within each section. Secondly, linearity refers to equal or equal appearing intervals to

make quantitative scoring possible. Linearity was achieved by using the Likert scale format throughout the questionnaire. Each section had the same Likert scaling system, font, and spacing.

The third measurement of a tool is validity. There are four main types of validity namely: face validity; content validity; criterion validity; and construct validity (Litwin, 1995). Face validity is based on a cursory review of items by untrained judges. To assess face validity you may simply show the questionnaire to a few untrained individuals to see whether they think items appear to be fine (Litwin). It is the least scientific assessment of all validity measures. To establish face validity, the questionnaire was shown to five individuals all engaged in postgraduate research at the UCT who were unbiased, to gain their opinion. The five respondents all remarked that the questionnaire appeared to test what it was meant to and thus the face validity could be assumed to be good.

Content validity concerns item sampling adequacy, that is the extent to which a specific set of items reflect a content domain (DeVellis, 1991). Content validity is a subjective measure of how appropriate the items seem to a set of reviewers who have some knowledge of the participant matter (Litwin, 1995). Content validity is not quantified by statistics but rather it is presented as an overall opinion of a group of trained judges. Content validity was gauged by allowing five individuals to judge content. These five individuals all have had experience with hearing-screening. However, content validity is subtler when measuring attitudes and beliefs, as it is difficult to determine exactly what the range of potential items are and when a sample is representative (DeVellis). Regarding content validity, the same five respondents all felt that the item sampling was adequate and three minor changes were made based on their recommendations in the final questionnaire.

Criterion validity is a measure of how well one instrument compares with another similar instrument. Criterion validity may be broken down into concurrent and predictive criterion validity. Concurrent validity could not be established with this tool, as no existing survey instrument existed with which to compare the current tool. Predictive validity could not be established with this tool as it refers to the ability of the survey instrument to forecast behaviours, attitudes, or outcomes. There are two forms of construct validity namely convergent and

divergent validity. These were not established with the tool as these types of validity can only be determined after many years experience with the tool (Litwin, 1995).

The fourth requirement of a traditional scale is reliability. Litwin (1995) outlines the four types of reliability as test-retest reliability, alternate form reliability, internal consistency reliability and inter-observer reliability. Test-retest reliability is the most commonly used indicator of survey instrument reliability. It is measured by having the same set of participants complete a survey at two different points in time to determine the stability of their responses (Litwin). The test-retest reliability of the questionnaire was determined by randomly selecting five participants who were required to complete the same questionnaire for a second time, a month after the first administration and then determining the percentage agreement values to compare the two sets of responses with regard to their test-retest reliability. These five participants were randomly chosen from the entire pool of participants. There was an 80% agreement between the two sets of responses at different times which can be considered good test-retest reliability (Litwin).

Internal consistency reliability is used to measure different aspects of the same concept or the homogeneity of the items comprising the scale (Devellis, 1991). Co-efficient alpha measures internal consistency reliability among groups of items combined to form a single scale. Internal consistency reliability was not determined for the questionnaire utilised in the current research. Since internal consistency reliability was not assessed the researcher was unable to determine if the different items complemented each other in their measurement of different aspects of the same variable or quality.

Alternate form and inter-observer reliability was not required as this survey instrument was self-completed by the participants. Inter-observer reliability was not an issue (Litwin, 1995).

Two factors that may affect the results of the questionnaire completion are social desirability bias and acquiescence. Social desirability bias refers to the tendency for participants to reply 'agree' to items that they believe represent socially desirable attitudes (Oppenheim, 2001). Oppenheim described acquiescence as a general tendency toward assent rather than dissent (such as ticking 'strongly agree' to all options). Social desirability bias is very difficult to control but may be

minimised by a statement at the beginning of the questionnaire urging participants to reflect how they truly feel and that all results shall be confidential. Schuman and Presser (1996) felt that there were various explanations for acquiescence or the agreeing response bias. These included acquiescence as a personality trait; a low level of education, strength of feeling, as well as the race of interviewer and race of participant may lead to acquiescence. Each of these probable causes of acquiescence shall be individually discussed as well as how the researcher attempted to minimise these factors.

Firstly, acquiescence as a result of low education has been minimised by setting the participant selection criteria requiring further education degree/diploma. The second factor influencing acquiescence was the race of participant and the race of interviewer, which could have posed problems but was minimised by self-completion of the questionnaire. Thirdly, strength of feeling refers to those claiming greater intensity who would be immune to acquiescence. To reduce acquiescence, Schuman and Presser (1996) suggested reversal of certain items and comparison of responses to these reversed items. Arguments have been made as to the actual presence of acquiescence and whether one can truly reverse items that mean the opposite. These debates are too large to be discussed in this forum. For simplicity, within each section of the questionnaire, one question was reversed. If contradictions arose (same response e.g. 'strongly agree' and 'strongly agree' to reversed questions), the interviewer followed the following steps namely: The participant was informed about the discrepancy and allowed time to re-read the question/s and modify their response if they saw fit. Any terms which the participant found unclear were addressed and thereafter if contradiction still existed in two or more sections, the questionnaire was discounted as the possibility of acquiescence was high.

The following factors, which were used in this study, have been shown to increase response rates: Advance notice of the forthcoming study; explanation of participant selection; assurance of confidentiality; standard appearance and limited length of questionnaire; the topic and its degree of interest; and lastly rapport (Oppenheim, 2001). These factors shall be individually discussed to demonstrate how the researcher attempted to increase response rates. Beginning with advance warning, a letter to the school clinic was sent/faxed to the school clinic and a suitable time for the questionnaire completion was negotiated between the interviewer and the school clinic director.

Secondly, each participant was informed of how they were selected for the study; and an explicit statement regarding confidentiality was prominent on the front page of the questionnaire to allay possible apprehensions and no names were collected. The length and appearance of the questionnaire was modified following the pilot study to make the format easily accessible. The topic and its degree of interest have been shown to also affect response rates. If the topic is of intrinsic interest to participants or they believe that their responses may have an affect on policy their response rates improve (Oppenheim, 2001). The researcher explained how their questionnaire could hopefully lead to a change in the service provision of audiological services to school children in the Western Cape region. Lastly rapport, refers to the researcher's ability to establish and maintain rapport. Rapport was established by the researcher introducing himself, talking with potential participants at their meetings and dressing casually.

In summary, a self-administered questionnaire with a Likert scale, with 'strongly agree' first and including an 'uncertain' option was used followed by open-ended questions at the end of each section.

Pilot Study

A pilot study was executed to try out the questionnaire tool with a small group of individuals. The intention was to streamline the questionnaire, attend to the reliability and validity issues of the questionnaire, address any items that may not be clear, and minimise errors in the form and typing of the final questionnaire. A pilot study was done at one school clinic using five volunteers who had similar characteristics to the participants. They were required to complete the draft questionnaire and then gave feedback about problem areas that they encountered, which could be avoided in the final version of the questionnaire (Litwin, 1995).

The results from the pilot study led to minor changes in the length of questionnaire (the questionnaire was shortened), format (font was enlarged and changed to Times New Roman), and clarity (three terms were replaced with more colloquial terms namely wax replaced cerumen, middle ear infection replaced otitis media and rewarding replaced the term enriching). No changes were made with regard to the question format (Likert scaling with 'uncertain' option) or

consent form. See Appendix D for the final version of the questionnaire used in the study and Appendix E for the study's consent form.

Data Collection

Permission was obtained from the University of Cape Town's Faculty of Health Sciences (UCT FHS) Research Ethics Committee (Appendix F) and Department of Education (Appendix G) to conduct the study. Written informed consent was obtained from those individuals willing to participate in the study. The questionnaire was presented to the study participants by the researcher who explained the purpose of the study. Participants were allowed time to ask any questions and to seek clarification (but there was no interpretation of the questions). The benefit of personal contact was thus provided. The participant was left alone to complete the questionnaire by himself or herself. Once the questionnaire was completed it was reviewed by the researcher, for reversed items and if discrepancies arose, these were discussed with the participant and an opportunity was provided for the participant to make any modifications.

Data Analysis

Quantitative Analysis

Wilcoxon's matched-pairs signed ranks test was utilised to determine whether participant responses deviated significantly from the neutral value. Percentage agreement was performed initially on all measures to determine what the level of agreement was amongst participants.

The sections regarding the participants' attitudes towards hearing, hearing-screening, computers and new skills could not be collapsed however each statement has been analyzed in isolation to determine whether the mean of the participants differed from the neutral value (3). However certain statements (both open and close ended) were discussed under a single heading depending if they were related.

Qualitative Analysis

Responses to the open-ended questions were qualitatively analysed by categorizing them into common trends. The qualitative analysis process occurred in three stages: data reduction, data display, and conclusion drawing, as outlined by Miles and Huberman (1994). The first stage was data reduction which referred to the process of selecting, focussing and simplifying the data (Miles & Huberman). The second major flow of analysis activity was the data display stage which was an organised and compressed assembly of the information that permitted conclusions to be drawn. The third and last phase of qualitative data analysis was the conclusion drawing and verification stage (Miles & Huberman).

Reliability and Validity

Ten percent of the questionnaire data was analysed by an independent external observer and these correlated (94%) with the results of the researcher. The independent external observer was a post graduate student (Economics) at the UCT who has experience with data analysis and statistical procedures. Reliability and validity of the questionnaire has been discussed under the questionnaire development section earlier.

Noise Level Survey

Research Design

The method selected for data collection was a descriptive quantitative survey design (Trochim, 2001). As the study attempted to measure the noise levels at various sites at the eleven Primary schools to determine the feasibility of conducting hearing-screening, this design best facilitated the process.

School Selection Criteria, School Selection Procedure and School Description

The eleven Primary schools that were already part of the prevalence review were included in the noise level survey. Please refer to the prevalence review for comprehensive school selection criteria, school selection procedure and school description.

Instrumentation

A Quest Technologies 2700 Sound level meter (SLM) was used for the noise level measurements to determine the level of background noise present at each site. The SLM was last calibrated in July 2003 (ten months prior to the commencement of this study).

The SLM was set as follows:

Mode of Operation: Sound Pressure Level (SPL)

Frequency weighting networks: A. The 'A' weighting setting emulates the response of the human ear at low levels and is used for most industrial and community noise measurements (Quest Technologies 2700 SLM user manual).

Response: Slow (1 second time constraint).

Reference frequency of SLM: 1 kHz

Frequency range of SLM: 4 Hz to 50 kHz

Accuracy: Within 0.7 dB

Data Collection

Prior to the noise level measurements being taken at each site, internal calibration was done on the SLM (as per the Quest 2700 SLM user manual). The noise levels at 3 sites per school were determined by taking SLM measurements using the above stated settings. Site 1 was a location where computers were situated (such as a computer room, library or computer work station) designated as the computer site. Site 2 was a location where the present UCT hearing-screening was conducted [hearing-screening site] and site 3 was a randomly selected classroom location [other]. SLM measurements were taken at 10 second intervals for a 5 minute time period at each site. These SLM measurements were manually recorded by the researcher.

Data Analysis

The SLM measurements for each school (at three sites) were graphically represented as noise intensity in dB SPL as a function of time. Thereafter the SLM measurements were calculated for each school (at three sites) and then averaged out and graphically represented as an average SLM measurement in dB SPL as a function of each school. The average SLM measurements at each site, at each school, were then compared to the ANSI standards for the maximum allowable ambient noise levels.

Reliability and Validity

A post graduate Audiology student made independent SLM readings at one school [i.e. School 4]. These readings were then compared to readings obtained by the researcher. The sites chosen for the SLM measurements and the time of day that measurements were taken were identical to those by researcher. The average SLM measurements differed by less than 2 dB SPL at the computer site, less than 3 dB SPL at the hearing-screening site and 3.5 dB SPL at the 'other' site.

Ethical Considerations

Prior to beginning the study permission was obtained from the UCT FHS Research Ethics committee, Department of Education and affected primary school principals.

Confidentiality

Sub-aim I: For the purpose of the audit, no names of learners or schools were included in the prevalence review. All information obtained from the UCT hearing-screening programme was kept confidential and no participants were identified in any way. Sub-aim II and III: All personal information obtained from the questionnaires was kept confidential as all participants were assigned a research number and all data was analysed using this number and not their names. This information was also conveyed to the participants in the consent form. See Appendix D. Sub-aim IV: The schools were informed that the results of the noise level audit included in the study were categorised under an assigned number [i.e. School 4] and not under the school's

name. All schools and participants were informed that they would not be identified in any way in any publications arising from the study.

Autonomy

Sub-aim I: Parents of the learners signed consent forms prior to their child participating in the UCT hearing-screening programme. Sub-aim II and III: Participants were informed both verbally and in writing about the aims and nature of the study and what was expected of them. They were given the opportunity to ask questions and seek clarification prior to signing the informed consent form. Informed consent (written) was obtained from each participant by the researcher prior to including them in the study. Sub-aim IV: The noise level survey was described (including its implications) to each primary school principal. The principal was then able to give informed consent (verbal) to conduct the noise survey. All participants were verbally informed of their rights to not participate in the study and to withdraw their participation at any time once the study had begun. This information was also conveyed in the consent form.

Beneficence and Non-Maleficance

Sub-aim I and IV: No learners were harmed in the study as no contact with the learners was required as no testing was performed. Sub-aim II and III: The participants were verbally informed about the benefits and risks of the study to themselves by the researcher. This information was also conveyed in the consent form. The study was designed so that there were none/minimal risks involved in participation.

Professional competence

The necessary skills and knowledge were acquired by the researcher to conduct the study.

Dissemination

The results of the study shall be made available to all relevant stakeholders such as the Department of Education, affected school principals and all other interested parties on completion of the study.

Results

The results will be described in accordance with the aims of the study. Firstly the pass/ referral rate of learners during the UCT hearing-screening programme will be presented. Next the attitudes of school site personnel towards hearing, hearing losses, change and technology will be examined. Lastly the noise level measurements at eleven screening schools shall be presented. All these factors shall be presented to determine the feasibility of introducing a computer-based hearing-screening programme at schools in the Western Cape Province.

Referral rates of Hearing Loss in School-aged Children

Due to the limited available data regarding immittance measures (less than 10% of schools had immittance measures documented) during the UCT hearing-screening programme, only pure-tone hearing-screening results of the learners shall be presented. The limited and incomplete immittance information was attributed to the lack of immittance equipment, equipment not working optimally, time constraints, human error, and incomprehensive documentation of results. The otoscopic examination results were not compared to the pure-tone hearing-screening results. The reason was that in the UCT hearing-screening protocol, if the tympanic membrane was not visible, due to impacted cerumen, on otoscopic examination (which was the first test evaluation), the child was referred to their General Practitioner and pure-tone hearing-screening was not conducted.

Of the 1101 learners whose hearing was screened during the UCT hearing-screening programme, 152 learners failed the screening at one or more frequencies. See Figure 3 for the performance of learners on the pure-tone hearing-screening test, including 500 Hz.

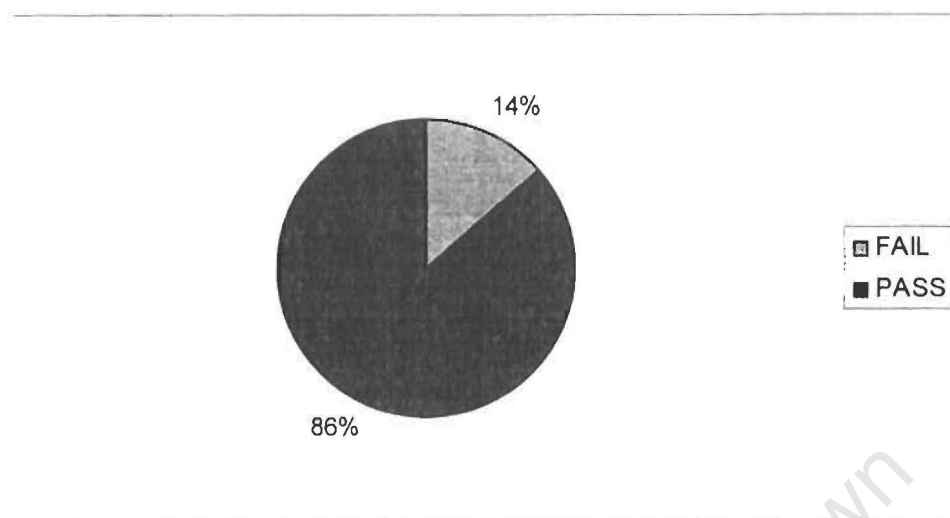


Figure 3. Performance of learners on the pure-tone hearing-screening test (including 500Hz).

Hearing screening referrals excluding 500Hz

Background noise in the hearing-screening environment can raise the learners' hearing thresholds, especially at 500 Hz (Hatcher et al., 1995; Rao et al., 2002). As a result, more learners may fail the hearing-screening test, not as a result of a hearing loss, but due to environmental noise. Therefore the hearing-screening results were re-analyzed, and all failures at 500 Hz in the left and/or right ear/s were eliminated i.e. were not counted as failures.

Thus, of the 1101 learners whose hearing was screened during the UCT hearing-screening programme, 152 learners (14%) failed the hearing-screening test when all frequencies were included. The number of learners who failed the hearing-screening test when all frequencies were included (152 learners/ 14%) was compared to the number of learners who failed the hearing-screening test when 500 Hz was excluded (87 learners/ 8%). See Figure 4 for the performance of learners on the hearing-screening test, excluding 500 Hz. There were significantly less hearing-screening failures when 500 Hz was excluded ($t = 3.448$, $\alpha = .05$). As mentioned earlier, due to the lack of comprehensive immittance results, information on the tympanometric results of those learners who failed at 500 Hz could not be investigated.

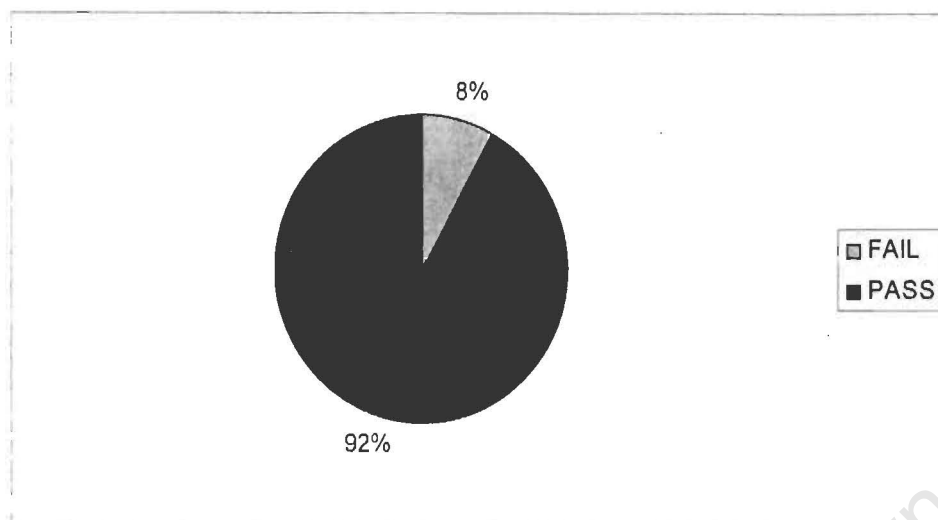


Figure 4. Performance of learners on the pure-tone hearing-screening test (excluding 500 Hz).

Hearing-screening Performance as a Function of Frequency

If a learner failed the hearing-screening test at 500 Hz and 2 kHz Left, and 1 kHz Right this was considered to be three ear failures (as failures per frequency were calculated). Of the 152 learners who failed the pure-tone hearing-screening test, there were 387 ear failures at one of the following four frequencies 500 Hz, 1 kHz, 2 kHz and 4 kHz. See Table 3 for the number of ear failures as a function of frequency. See Figure 5 for percentage information regarding ear failure as a function of frequency. See Appendix H for a detailed analysis of frequencies failed.

Table 3
Number of ear failures as a function of frequency

Frequency failed	Number of ears
500 Hz	168
1 kHz	90
2 kHz	59
4 kHz	70

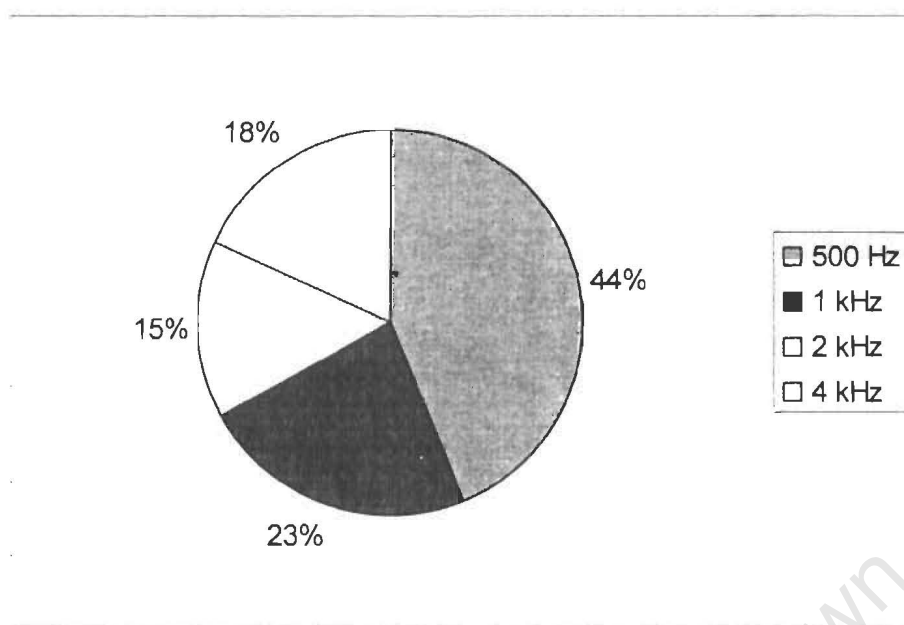


Figure 5. Percentage of ear failures as a function of frequency.

Laterality

The Mann-Whitney test (Howell, 1999) showed that the pass and referral rates for the left and right ear of the learners were not significantly different for pure-tone hearing-screening thresholds. [For a difference between the left and right ear to be significant ($W_s \leq 11$; $\alpha = .05$; two tailed) however in current study this was not the case ($W_s = 14$; $\alpha = .05$; two tailed). Thus the null hypothesis of no difference could not be rejected and therefore the two sets of ears (right and left) were not significantly different from each other]. Therefore these results have been presented without reference to laterality of the ear. See Appendix I for detailed analysis of laterality, as a function of frequency.

Unilateral versus Bilateral Hearing-screening Failures

Of the 152 learners who failed the hearing-screening test when all frequencies were included, 106 learners had unilateral ear failures while 46 learners had bilateral ear failures. See Figure 6 for learners who had unilateral versus bilateral hearing-screening ear failures.

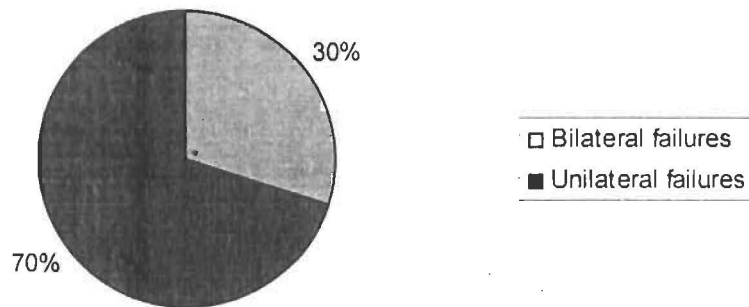


Figure 6. Learners who had unilateral versus bilateral hearing-screening failures.

Gender Differences in Hearing-screening Performance

There were 515 males and 586 females included in the hearing-screening audit. Of these learners, 82 males (16%) failed the hearing-screening test compared to 70 females (12%) who failed. There were significantly more male failures than female failures, when 500 Hz was included ($t = 2.2$, $\alpha = .05$). See Figure 7 for performance of learners on the hearing-screening test, as a function of gender.

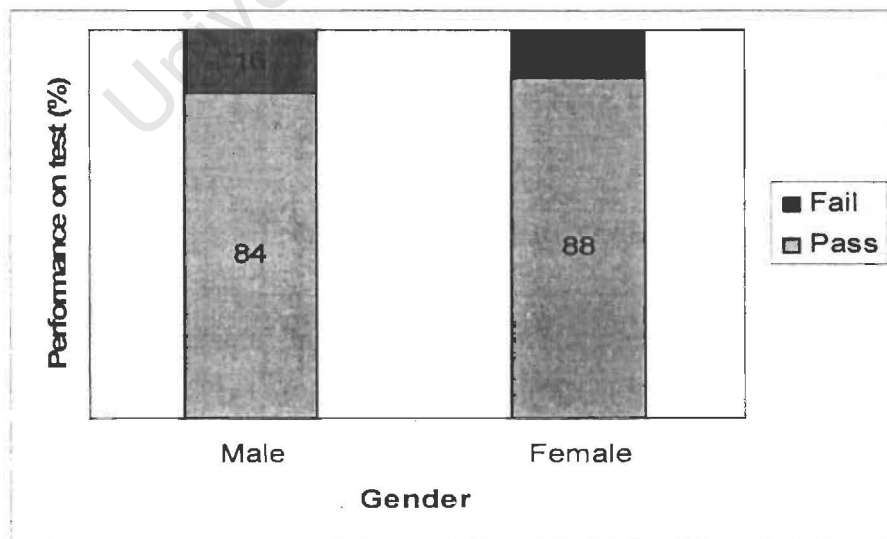


Figure 7. Performance of learners on the hearing-screening test as a function of gender.

Gender Differences when 500 Hz was excluded

Gender differences were compared again once the failures at 500 Hz were removed. This comparison was done to determine the effect of environmental noise on the hearing performance at 500Hz [i.e. to determine if one gender was more adversely affected by noise in the low frequencies]. The comparison between genders (excluding those who failed at 500 Hz) revealed that 9% of male learners ($n = 47$) failed the hearing-screening compared to 7% of female learners ($n = 40$). See Figure 8 for performance of learners as a function of gender on the hearing-screening, excluding 500 Hz.

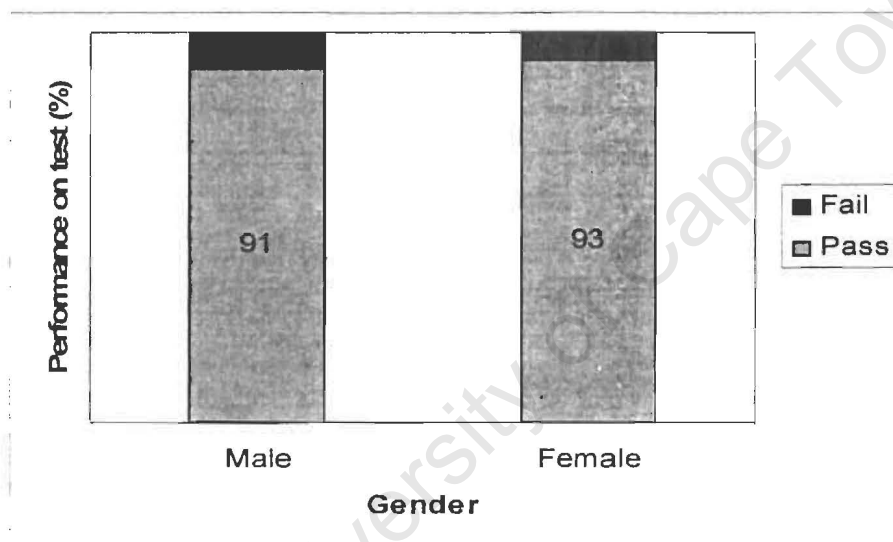


Figure 8. Performance of learners on the hearing-screening as a function of gender, excluding 500Hz.

Both genders were affected by background noise at 500 Hz during the hearing-screening test. See Table 4 for the number of failures as a function of gender with and without 500 Hz. When 500 Hz was excluded there were not significantly more male failures than female failures ($t = 1.13, \alpha = .05$).

Table 4
Number of failures, as a function of gender, with and without 500 Hz

	Males N = 515		Females N = 586	
	+ 500 Hz	- 500 Hz	+ 500 Hz	- 500 Hz
N	82	47	70	40
%	16	9	12	7

School and Geographical Differences

Since the number of learners who were screened at the respective school sites varied considerably (number of learners screened ranged from 0 learners to 513 learners at a single site) as did the failure rates (failure rates ranged from 2% to 33%) it was not possible to compare hearing-screening failures as a function of school. See Table 5 for failure rates on hearing-screening as a function of geographical area. Even after collapsing data into regions, no geographical inferences could be made. See Appendix J for comprehensive information regarding number of learners who passed/failed at each school site.

Table 5
Hearing-screening failures as a function of geographical area

Area	Number of schools	Failures %			
		0-10%	11-20%	21-30%	31-40%
City Bowl	4	1	1	0	2
Rondebosch	1	1	0	0	0
Athlone	4	2	1	0	1
Observatory	2	1	1	0	0

Results obtained from the Questionnaire

The results described below are those of the participants in response to the questionnaire. Gender differences shall be described followed by computer literacy exposure.

Gender

Due to the limited number of male participants ($n = 8$) relative to female participants ($n = 80$), no attempt was made to determine gender differences in attitudes towards various topics. Attitudes were analyzed as the sum of all responses by male and female participants ($N = 88$).

Computer Literacy Exposure

The participants were asked a variety of questions to determine their computer literacy exposure. The results suggested that most participants (95%) had used a computer with a slightly smaller number (68%) having attended a computer course. Microsoft Word was the most frequently used programme (41%), with Email and Microsoft Excel ranking a

distant second and third. Other computer programmes appeared not to be used as frequently ($\leq 2\%$). Nonetheless, 64% of the participants reported being comfortable using a computer. A large percentage of participants (37%) did not spend any time while at work on a computer closely followed by those who used it for one hour per workday (32%) with two hours and four hours ranking a more distant third and fourth. The results further suggested that most participants used a computer for: administration (45%); followed by developing worksheets (30%); mark sheets (20%); and least of all for developing training material (5%). See Table 6 below for the participants' exposure to computers in the workplace.

Table 6
Exposure to computers in the workplace

Computer Literacy	No. of Responses	Percentage
Ever used a computer		
• Yes	84	95
• No	4	5
Attended a computer course		
• Yes	60	68
• No	28	32
Familiarity with software programmes		
• MS Word	65	41
• MS Excel	41	26
• Email	44	28
• Powerpoint	4	2
• Corel Draw	1	1
• None	4	2
• Other	0	0
Comfort in using a computer		
• Yes	56	64
• No	32	36
Number of hours per workday spent using a computer		
• 0	33	37
• 1	28	32
• 2	12	14
• 3	4	5
• 4	9	10
• 4-6	1	1
• 6-8	1	1
• More than 8	0	0
Range of computer activities at work		
• Administration	36	45
• Developing worksheets	24	30
• Mark sheets	16	20
• Developing training material	4	5

Note: The number of responses in certain categories ('Software programmes' and 'Reasons for computer usage') were above or below the number of participants (N= 88) which was due to participants not responding or choosing more than one option.

The various sections in the questionnaire that measured attitudes towards hearing loss, hearing-screening, change and technology, could not be collapsed across sections since the attitudes within each section did not share a single theoretical basis (Personal Communication, S. Isaacs, January, 2005). Therefore each attitude as per the section in the questionnaire were statistically analyzed in isolation. However the results of certain measures were grouped together for ease of understanding.

To recapitulate, in order to determine whether a particular attitude was significant, the mean of the attitude was compared to the neutral value (mean = 3). If the attitude mean deviated significantly from the neutral value, it indicated that for that particular statement, the participants were not uncertain or neutral but had a tendency, either in a positive or negative manner, away from the neutral value.

Percentage agreement was performed initially on all measures to determine what was the level of agreement amongst participants. If there was a very high percentage of agreement, such as 100%, one would need to consider the effect of social desirability bias (Oppenheim, 2001). Limited percentage agreement data has been included in the results. Detailed results of the responses to each attitudinal statement in terms of the level of agreement or disagreement can be found in Appendix K.

The participants' attitudes towards hearing losses and hearing-screening shall be described under the following headings: Effects of an unidentified hearing loss; Rationale and need for hearing-screening; Knowledge of hearing loss and hearing-screening; Resources required for hearing-screening (including time, personnel and site); and Value of computers and Training.

The Effects of an Unidentified Hearing Loss on a Learner's Development and School Performance

The majority of participants believed that an unidentified hearing loss would affect on a learners' language, social, psychosocial development, behaviour and school performance. The participants' perceptions of the effects of a hearing loss on a learners' language, social, and psychosocial development, behaviour and school performance did deviate significantly from the neutral value indicating that participants believed that a hearing loss could affect a learner's development in all these areas. See Table 7 for the statistical analysis in this regard.

The results suggested that all the participants (100%) felt that a hearing loss, even when mild, could affect a child's school performance ($t = 19.48, p = <.0001$). In addition they also felt that a mild hearing loss could affect a child's language development ($t = 14.17, p = <.0001$). The majority of participants (96%) held the view that a mild hearing loss could affect a child's social development ($t = 10.88, p = <.0001$) while 78% of participants felt that a mild hearing loss could affect a child's psychosocial development ($t = 5.72, p = <.0001$). In addition 91% of the participants felt that mild forms of hearing loss could affect a child's behaviour ($t = 9.55, p = <.0001$).

Table 7
Areas of development impacted by a hearing loss

Areas of development	Mean	SD	<i>t</i> value	N	<i>p</i> value
Language	4.50	0.50	14.17	88	<.0001
Social	4.27	0.55	10.88	88	<.0001
Psychosocial	3.95	0.78	5.72	88	<.0001
Behaviour	4.30	0.56	9.55	88	<.0001
School performance	4.77	0.43	19.48	88	<.0001

Note: Significance level with Bonferroni correction, $\alpha = .0045, df = 87$.

The responses of the participants on the open-ended questions relating to hearing losses were categorized according to emergent themes namely: Early identification of hearing losses is of key importance; Urgent need to address children with hearing losses; and Knowledge of hearing losses. Regarding early identification of hearing losses amongst school learners, the participants ($n = 7$) re-iterated the importance of early detection and subsequent management of a learner's hearing loss. Furthermore, one participant felt that

there was an urgent need to address children with hearing losses in the school environment. The knowledge of hearing losses theme comprised of: Need for further awareness of temporary hearing losses and their effects on a learner's development ($n = 12$); Effects of temporary hearing losses on a child's development ($n = 2$), and a general lack of knowledge regarding hearing losses ($n = 6$). The qualitative data further highlighted the need for greater parental involvement in the hearing-screening process. Verbatim comments have been recorded in Appendix L.

In summary the results suggested that the participants felt that an unidentified hearing loss could have an affect on a learners' language, social, psychosocial development, behaviour, and school performance. Despite their good knowledge the participants still felt that further work still needed to be done to highlight the adverse effects of a hearing loss.

Rationale and Need for Hearing-screening

This section described the participants' opinions of/ attitudes towards/ understanding of the rationale and need for hearing-screening with regard to: Importance of identifying hearing losses; Priority of identifying hearing losses; Attainability of hearing-screening of all Grade one learners in schools; and poor detection rate of hearing losses amongst learners.

The participants' attitudes to the need and rationale for hearing-screening in the school environment all deviated significantly from the neutral value. See Table 8 for the statistical analysis in this regard. The results suggested that the majority of participants (91%) considered hearing losses to be an important health risk in children ($t = 6.90$, $p < .0001$). Detection of hearing losses in the school environment were considered to be of a high priority by all the participants ($t = 24.85$, $p < .0001$). Furthermore 95% of the participants were of the opinion that hearing losses often go undetected in the school setting ($t = 11.18$, $p < .0001$), and that every child entering Grade 1 should have their hearing screened ($t = 8.40$, $p < .0001$). A significantly greater number of participants

(55%) considered hearing-screening of all school children to be attainable within the South-African context ($t = 6.47, p = <.0001$). Furthermore the majority of participants (92%) were strongly of the opinion that hearing-screening was not a waste of time ($t = 6.12, p = <.0001$), which is consistent with the view that it is of high priority.

Table 8
Need and rationale for hearing-screening in the school environment

Scale item	Mean	SD	<i>t</i> value	N	<i>p</i> value
Importance	4.30	0.89	6.90	88	<.0001
High Priority	4.86	0.34	24.85	88	<.0001
Universal screening	4.23	0.67	8.40	88	<.0001
Detection rate	4.40	0.59	11.18	88	<.0001
Attainable	3.45	0.66	6.47	88	<.0001
Waste of time	4.18	0.91	6.12	88	<.0001

Note: Significance level with Bonferroni correction, $\alpha = .0045, df = 87$.

In summary the results suggested that the participants felt that hearing losses were an important health risk that often went undetected, hearing-screening should receive a high priority in schools, all Grade one learners should have their hearing screened, hearing-screening was attainable in South Africa, and that hearing-screening was not a waste of time.

Knowledge of the Causes of Hearing Loss and Hearing-screening

This section describes the participants' knowledge of the causes of hearing losses and hearing-screening with regard to the common causes of hearing losses, the prevalence of hearing losses, as well as the information obtained from hearing-screening.

Participants' responses suggested that they had a variable knowledge about the common causes of hearing losses among learners and these results are reflected in Table 9. There was a greater awareness that middle ear infections caused a hearing loss (68%) relative to the impact of wax (59%).

Table 9
Possible common causes of hearing losses in children

Common causes	Strongly Agreed	Agreed	Uncertain
Middle ear infections	18%	50%	32%
Wax	18%	41%	41%

Despite the large number of 'uncertain' responses regarding the participants' perceptions of the common causes of hearing losses, most participants (more than 60%) were correct in their perceptions of the common causes of hearing losses in children. See Table 10 for the statistical results regard the correctness of the perceptions of common causes of hearing loss.

In summary the above results suggest that the participants had variable knowledge regarding the common causes of hearing losses in the school-aged population.

Table 10
Statistical results for the correctness of perception of common causes of hearing loss in children

Causes of hearing loss	Mean	SD	<i>t</i> value	N	<i>p</i> value
Middle Ear Infection	3.86	0.71	5.72	88	<.0001
Wax	3.77	0.75	4.83	88	<.0001

Note: Significance level with Bonferroni correction, $\alpha = .0045$, $df = 87$.

The majority of participants (73%) were uncertain about the prevalence rate of hearing losses in the school-aged population ($t = 2.80$, $p = <.0052$) and were thus unable to either agree or disagree with the prevalence rate suggested by the researcher with the mean of their responses not deviating significantly from the neutral value (mean = 3). See Table 11 for the statistical results with regard to the prevalence of hearing loss amongst school children.

The participants estimated that the prevalence of children with a hearing loss ranged from 1 in 100 to 40 in 100 learners, with a mean prevalence of 7 in every 100 learners and a mode and median of 3 in every 100 learners. This prevalence information was determined from the participants' responses to an open ended question regarding the number of children per hundred (with whom they have contact) that they think have a hearing loss.

In summary, the results suggested that the participants were uncertain regarding the prevalence rate of hearing losses among the school-aged population.

Table 11
Prevalence of hearing loss amongst school children

	Mean	SD	<i>t</i> value	N	<i>p</i> value
Prevalence	3.27	0.45	2.80	88	.0052

Note: Significance level with Bonferroni correction, $\alpha = .0045$, $df = 87$.

Information obtained from a Hearing-screening Test

A significant majority (59%) of the participants felt that a hearing-screening test yielded information regarding the intensity and frequency characteristics of sounds that a child can and cannot hear. In addition only 14% of the participants felt that the results of hearing-screening provided information on how well a child would perform at school, while 50% disagreed with this position. The means of the participants' attitudes regarding the information obtained from a hearing-screening test (what a child can and cannot hear as well as how well a child will do at school) deviated significantly from the neutral value. These results suggested that participants felt that hearing-screening test yielded information regarding the intensity and frequency characteristics of sounds that a child can and cannot hear ($t = 4.89$, $p = <.0001$) while not necessarily given information about a child's school performance ($t = 2.40$, $p = <.0001$). See Table 12 for the statistical results with regard to the information that is obtained from a hearing-screening test.

The responses of the participants on the open-ended questions relating to hearing-screening were categorized according to emergent themes namely: The purpose of hearing-screening, and the importance of follow-up after hearing-screening. Regarding the purpose of hearing screening, participants ($n = 2$) felt that hearing-screening indicated what barriers may be present to hamper learning while two participants suggested that hearing-screening was not a test of a learner's cognitive ability. Regarding the theme of follow-up after hearing-screening, participants ($n = 2$) indicated that further diagnostic testing should be performed as soon as the learner fails the hearing-screener. Verbatim comments have been recorded in Appendix M.

In summary, the results suggested that the participants felt that a hearing-screening test revealed what a child can and cannot hear, as well as that a hearing-screening test does not give an indication regarding how well a child will perform at school. The quantitative results are supported by the qualitative data whereby participants indicated that hearing-screening is not a test of a learner's cognitive ability. Furthermore, from the qualitative data the participants felt that hearing-screening indicated what barriers may hamper learning and the importance of follow up after a hearing-screening programme.

Table 12
Information obtained from a hearing-screening test

Information obtained from screening	Mean	SD	t value	N	p value
What a learner can/cannot hear	3.73	0.70	4.89	88	<.0001
How well a learner will do at school	3.40	0.79	2.40	88	<.0001

Note: Significance level with Bonferroni correction, $\alpha = .0035$, $df = 87$.

Resources

The participants' understanding of the resources required for hearing-screening shall be described under Time and Personnel resources, Location of hearing-screening programme, and Equipment required.

Time Requirements for Hearing-screening

The participants' knowledge regarding the time requirements for hearing-screening were investigated namely: Hearing-screening as a quick procedure; and Hearing-screening would increase the participants' workload. See Table 13 for the statistical results in this regard. The mean of the participants' attitudes as to whether hearing-screening was a quick procedure ($t = 0.57$, $p = .093$) as well as whether hearing-screening would increase workload ($t = 0.75$, $p = 0.57$) did not deviate significantly from the neutral value. The results suggested that most participants (72%) were uncertain whether hearing-screening was a quick procedure (less than 5 minutes). In addition 50% of participants felt that hearing-screening would increase their workload while 27% 'disagreed' that hearing-screening would increase their workload, and 23% were 'uncertain' about the impact

hearing-screening would have on their workload. Thus at least half of the participants felt that their workload would increase if they engaged in hearing-screening.

In summary most participants were uncertain how long it would take to screen a child's hearing and at least half of the participants felt that hearing-screening would increase their workload.

Table 13
Effect of time on hearing-screening

	Mean	SD	<i>t</i> value	N	<i>p</i> value
Increase workload	3.27	0.93	1.37	88	.093
Hearing-screening is quick	3.09	0.75	0.57	88	.288

Note: Significance level with Bonferroni correction, $\alpha = .0035$, $df = 87$.

Personnel to Conduct Hearing-screening

The participants (54%) considered that hearing-screening could be done by school personnel with adequate training ($t = 3.65$, $p = .00074$). See Table 14 for the results of the participants' responses to school personnel conducting hearing-screening at school locations. At least 45% of participants were uncertain whether hearing-screening should only be done by audiologists ($t = 0.77$, $p = .22000$). These results suggested that over half of the participants felt that hearing-screening could be done by school personnel with adequate training while there was some uncertainty as to whether hearing-screening should only be done by audiologists.

Table 14
Personnel to conduct hearing-screening

	Mean	SD	<i>t</i> value	N	<i>p</i> value
Personnel to conduct screening					
School personnel with training	3.82	1.03	3.65	88	.00074
Audiologist	3.13	0.82	0.77	88	.22000

Note: Significance level with Bonferroni correction, $\alpha = .0035$, $df = 87$.

Location/Site of Hearing-screening Programme

The third factor which shall be described under resources required for hearing-screening is the possible location of the hearing-screening programme. The participants' responses

suggested that they had variable views about where a hearing-screening programme ought to be physically located. See Table 15 for responses regarding possible locations for hearing-screening programmes.

Table 15
Possible locations for conducting hearing-screening programmes

Location of screening	Strongly Agreed	Agreed	Uncertain	Disagree / Strongly Disagree
School clinic	8%	40%	22%	31%
Health care clinic	5%	55%	20%	20%

The participants did not consider the school clinic setting as a suitable location for pure-tone hearing-screening ($t = 0.72$, $p = <.239$). In addition, the majority of participants (60%) felt that a health care clinic could be a location for a hearing-screening programme ($t = 2.48$, $p = <.0107$). See Table 16 for the statistical results with regard to a suitable location of hearing-screening programmes.

In summary the results suggested that the participants felt that a health care centre would be a suitable location for conducting hearing-screening while they were uncertain about situating a hearing-screening programme at a school clinic.

Table 16
Statistical results for a suitable location for conducting hearing-screening programmes

Location of screening	Mean	SD	t value	N	p value
School Clinic	3.18	1.18	0.72	88	0.239
Health care clinic	3.45	0.86	2.48	88	<.0107

Note: Significance level with Bonferroni correction, $\alpha = .0035$, $df = 87$.

Understanding of the Equipment required for Hearing-screening

A large percentage of participants (68%) were uncertain as to whether hearing-screening was a complex procedure ($t = 0$, $p = 1.0$). The participants (59%) were also uncertain about whether hearing-screening was expensive ($t = 1.9$, $p = <.03$). See Table 17 for the statistical results in this regard.

In summary the results suggested that the participants were uncertain as to whether hearing-screening was a complex and expensive procedure.

Table 17

Statistical results for the understanding of the equipment used in hearing-screening

Hearing-screening equipment is	Mean	SD	<i>t</i> value	N	<i>p</i> value
Complex	3.00	0.68	0.00	88	1.0
Expensive	3.32	0.77	1.90	88	.03

Note: Significance level with Bonferroni correction, $\alpha = .0035$, $df = 87$.

Value of Computers

The participants' attitudes towards the value of computers were determined by specifically addressing whether computers: Improved productivity; Were considered an asset in the workplace; Made life easier; Made one afraid of using them; and had a place in a school clinic environment.

All the participants (100%) were of the opinion that computers improved productivity in the workplace ($t = 12.9$, $p = <.0001$). In addition they all considered computers to be an asset in the workplace ($t = 12.9$, $p = <.0001$). The participants (90%) felt that computers made life easier ($t = 9.74$, $p = <.0001$), and the majority (59%) did not feel afraid using computers ($t = 3.30$, $p = <.0001$). However, an interesting result to note was that 27% of participants were 'uncertain' as to whether they felt afraid of using computers. The majority of participants (86%) felt that computers had a place in a school clinic environment ($t = 8.50$, $p = <.0001$). See Table 18 for the statistical results with regard to the value of computers.

Qualitative data which arose from the open-ended questions regarding the value of computers supported the quantitative results above. The emerging themes which arose from the qualitative data regarding computers were: Advantages of computers; and Availability of computers. Participants elaborated on the advantages of computers namely: They made tasks less time consuming ($n = 2$), as well as they are very useful ($n = 2$). Participants ($n = 2$) further urged authorities to increase access and availability of computers. Verbatim comments have been recorded in Appendix N.

In summary, the results suggested that the participants felt that computers improved productivity, were an asset in the workplace, made life easier, and that computers had a place in a school clinic environment. Most of the participants did not feel afraid of using computers and desired a greater availability of computers in schools and the workplace.

Table 18
Statistical results for the value of computers

Attitude scale	Mean	SD	<i>t</i> value	N	<i>p</i> value
Computers improve productivity	4.31	0.47	12.9	88	<.0001
Computers are an asset	4.31	0.47	12.9	88	<.0001
Computers make life more easy	4.36	0.66	9.74	88	<.0001
Use of computers make me scared	3.73	1.03	3.30	88	<.0001
Computer belong in a school clinic	4.04	0.57	8.50	88	<.0001

Note: Significance level with Bonferroni correction, $\alpha = .005$, $df = 87$.

Computer Training

The following results/ attitudes regarding computer training are described namely computer usage with or without training. See Table 19 for the statistical results with regard to computer training.

The majority of participants (72%) considered computers to be easy to use ($t = 4.46$, $p = <.0001$). In addition, a significant majority of the participants (95%) also felt that computers were easy to use once a person had been trained ($t = 11.18$, $p = <.0001$), while 72% felt that computers were easy to use without training. The remaining participants were 'uncertain' whether computers were easy to use (with or without training). All the participants (100%) felt that computer training was essential for today's workplace ($t = 14.87$, $p = <.0001$). In addition, they all (100%) agreed that one was never too old to learn how to use a computer ($t = 13.34$, $p = <.0001$).

The participants' responses on the open-ended questions regarding computer training revealed that two participants felt that every educator should be trained in computer usage. Furthermore two participants ($n = 2$) felt that computer training should be made available for all learners. Verbatim comments have been recorded in Appendix N.

In summary, the results suggested that the participants felt that computers were easy to use (with or without training), computer training was essential in today's workplace and should be more widespread, as well as that one was never too old to learn how to use a computer. The quantitative results were supported by the qualitative data.

Table 19
Statistical results for computer training

Attitude scale	Mean	SD	t value	N	p value
Computers are easy to use	3.77	0.81	4.46	88	<.0001
Computers are easy to use (with training)	4.41	0.59	11.18	88	<.0001
Computer training is essential	4.59	0.50	14.87	88	<.0001
Never too old to learn to use computer	4.45	0.50	13.34	88	<.0001

Note: Significance level with Bonferroni correction, $\alpha = .005$, $df = 87$.

Participants' Attitudes towards the Acquisition of New Skills

The acquisition of new skills shall be described with respect to the desire to acquire new skills and the advantages of acquiring new skills.

All the participants (100%) felt that they would like to acquire new skills ($t = 30.10$, $p = <.0001$), and in particular they all indicated that they would like to acquire skills in being able to conduct hearing-screening ($t = 30.10$, $p = <.0001$). In addition, the participants (96%) reported that they would like to learn new computer programmes, such as a hearing-screening computer programme. See Table 20 for the statistical results with regard to the desire to learn new skills.

In summary the results suggested that the participants were favourably inclined towards acquiring new skills as well as those associated with hearing-screening, and learning new computer programmes such as one facilitating computer based hearing-screening.

Table 20
Desire to learn new skills

Attitude	Mean	SD	T value	N	p value
I like learning new skills	4.59	0.49	30.10	88	<.0001
I like learning new skills, like Hearing-screening	4.59	0.49	30.10	88	<.0001
Skill acquisition	4.68	0.56	28.27	88	<.0001

Note: Significance level with Bonferroni correction, $\alpha = .0045$, $df = 87$.

Most of the participants (above 50%) considered the learning of new skills to be beneficial ($t = 31.72$, $p = <.0001$), a challenge ($t = 27.95$, $p = <.0001$) and interesting ($t = 27.95$, $p = <.0001$). The response scores of these attitudes all deviated significantly from the neutral value. See Table 21 for the statistical results with regard to the advantages of acquisition of new skills.

The qualitative data that emerged from the participants' responses regarding the acquisition of new skills supported the quantitative results. The themes that emerged from the qualitative analysis regarding learning new skills were: The importance of learning new skills; and Advantages of learning new skills. Participants ($n = 3$) felt that it was imperative for educators to learn new skills especially with inclusive education. Regarding the advantages of learning new skills, participants ($n = 4$) felt that learning new skills was interesting, beneficial, and interesting. See verbatim comments in Appendix O.

In summary the results suggested that the participants felt very positive about learning new skills, the importance of learning new skills, and the subsequent advantages learning new skills could have. These results could highlight the participants' willingness to engage with change namely being trained in a hearing-screening training programme.

Table 21
Advantages of acquiring new skills

Advantages	Mean	SD	<i>t</i> value	N	<i>p</i> value
Beneficial	4.63	0.49	31.72	88	<.0001
Rewarding	4.61	0.46	33.00	88	<.0001
Challenge	4.59	0.50	27.95	88	<.0001
Asset	4.59	0.49	30.10	88	<.0001
Interesting	4.59	0.50	27.95	88	<.0001

Note: Significance level with Bonferroni correction, $\alpha = .0045$, $df = 87$.

All 88 participants indicated that they would be willing to attend a 12 hour training programme on how to conduct hearing-screening. Thus there was a very high percentage of interest in the hearing-screening training programme and a large perceived willingness to acquire new skills and engage with this change process.

Noise Level Survey

Noise level measurements were recorded at three sites at each school respectively. Site 1 was the Library/ computer room, Site 2 was the present site of the UCT's hearing-screening programme and Site 3 was a randomly selected site. See Figure 9 for the average noise levels at these three sites at each school. See Appendix P for the detailed noise level measurements for each school. See Appendix Q for the noise level measurements at each school as a function of the time of day.

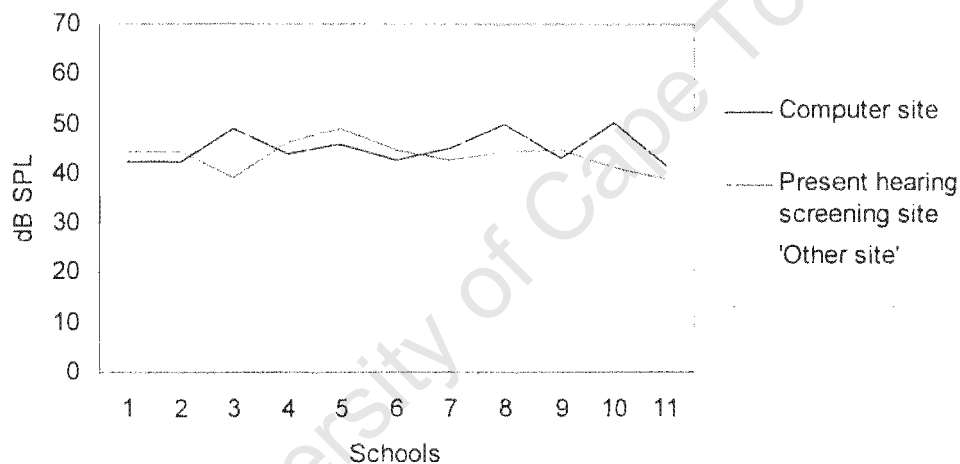


Figure 9. Average sound level meter measurements at 1 kHz at three sites per school.

Pure-tone screening requires a very quiet environment. The maximum allowable ambient noise for a 20 dB HL screening level, which was the case in the data audited, as per ANSI S3.1-1991 (in Katz 2002) is 49.5 dB SPL (using 1 kHz as the reference frequency). The reference frequency of the Quest technologies SLM used in the study was 1 kHz and thus all SLM comparisons were made using the ANSI standard at 1 kHz. The current SLM only measured environmental noise at 1 kHz and thus no comparisons could be made at other frequencies since this information was not available. Comparisons were made between the ANSI maximum allowable ambient noise for a 20 dB HL screening level and the three sites namely: the Computer site; UCT hearing-screening site; and 'Other' site.

Computer Site

The SLM measurements at the computer sites at the schools were all below the maximum allowable ambient noise at 1 kHz, except at two schools, School 8 (which had an average SLM reading of 49.7 dB SPL) and School 10 (which had an average SLM reading of 50.4 dB SPL). See Figure 10 for the average noise level measurements of the computer site relative to the ANSI standards at 1 kHz.

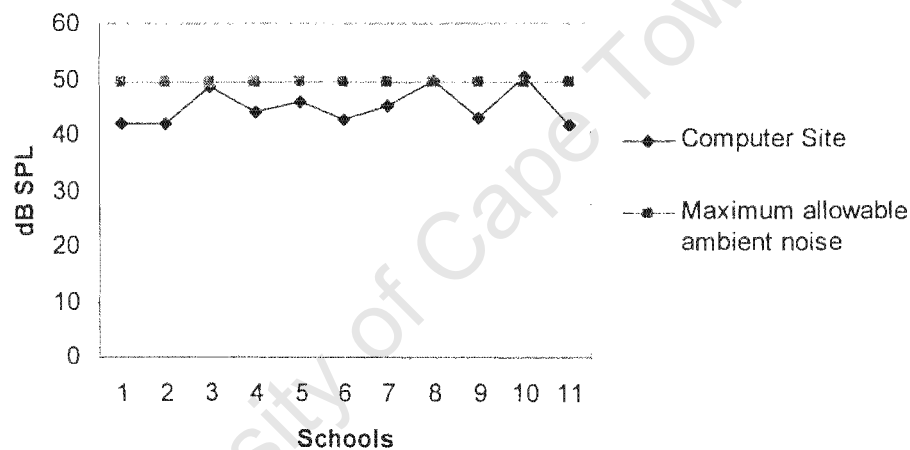


Figure 10. Average noise level measurements of computer site relative to ANSI standards at 1 kHz.

UCT Hearing-screening Site

At the hearing-screening sites currently used by the UCT at the schools, the SLM measurements were all below the maximum allowable ambient noise. See Figure 11 for the average noise level measurements of the UCT hearing-screening site relative to ANSI standard.

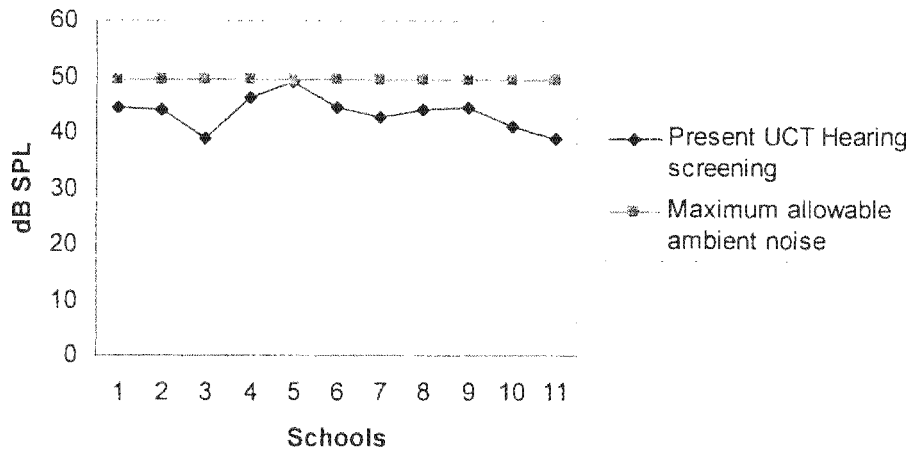


Figure 11. Average noise level measurements of the present UCT hearing-screening site relative to ANSI standards.

Other Site

At the 'other' site, seven out of the eleven schools had ambient noise levels below the maximum allowable ambient noise for a 20 dB HL screening test. Four schools were above the maximum allowable ambient noise- School 3 (50.97 dB SPL), School 5 (55.1 dB SPL), School 6 (59.3 dB SPL) and School 9 (51.24 dB SPL). See Figure 12 for average noise level measurements of the 'other' site relative to the ANSI standards at 1 kHz.

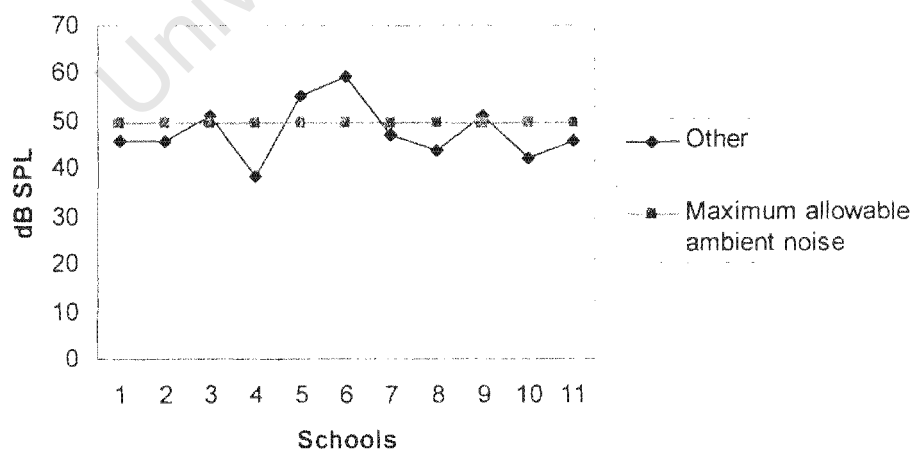


Figure 12. Average noise level measurements of 'other' site relative to ANSI standards at 1 kHz.

In summary, the noise level measurements at all the UCT hearing-screening sites as well as the majority of the computer sites at the eleven schools were below the maximum allowable ambient noise for hearing-screening to occur. Furthermore, the majority of the noise level measurements at the 'other' site (seven out of eleven) were below the maximum allowable ambient noise for hearing-screening to occur.

University of Cape Town

Discussion

The results of the current study will be discussed in accordance with the aims. Firstly the pass/refer rate of learners during the UCT hearing-screening programme will be discussed. Next the attitudes of school site personnel towards hearing, hearing losses, change and technology will be discussed. Lastly, the noise level measurements at eleven screening schools shall be discussed. All these factors shall be discussed with reference to minimizing the impact of a hearing loss and facilitating the optimal educational achievement and quality of life for these school-aged children via the introduction of a computer-based hearing-screening programme in the Western Cape.

Referral rates for hearing Loss in School-aged Children

Comparisons of suggested prevalence rates among studies pose difficulties relating to differing methodologies (retrospective versus prospective audits), including differing ages of the participants, and different countries, being more prevalent in the developing world (Bluestone, 1998). Despite these difficulties, comparisons may be made with caution, and the results of the current study were compared to those of developing countries. In this study the term referral rate has been used to describe the percentage of children who failed the hearing-screening. The term prevalence has been used by certain other authors when referring to hearing screening failures. However the author felt that the term referral rate is more reflective. Therefore the referral rate of this study has been compared to other studies which may refer to prevalence when in fact they are highlighting hearing screening results and not full diagnostic results.

The referral rate of hearing losses, in school-aged children arising from the audit of the UCT hearing-screening programme, was 14 %. Hence 14% of the learners at the eleven schools were referred (for further audiological test procedures/ medical follow-up) when 500Hz, 1 kHz, 2 kHz and 4 kHz were included. For the sake of the discussion the referral rate from the Audit shall be compared to the prevalence rates from a variety of studies. The referral rate of 14% is in agreement with the prospective study by Olusanya et al. (2000) in Nigeria which reported that the prevalence rates of hearing impairment of school-aged children in Nigeria could be as high as 13.9%. The hearing-screening procedure in the study by Olusanya et al. was similar to that of the UCT hearing-screening programme, but in the Olusanya et al. study, the sample size was smaller (N = 359) in that there were nearly two thirds fewer learners relative to the 1101 learners in the current study. Jacob et al. (1997) reported a hearing impairment prevalence rate in children of

11.9% in South India. However they had a smaller sample size ($N = 284$) and a more lenient pass/ refer criteria namely 40 dB HL. The current study's referral rate of 14% is much higher than that of the Swart et al. (1995) study in Swaziland which reported a prevalence rate of 3.3% amongst school children. A major difference between the two studies was that a pass/refer criteria level of 30 dB HL (and 35 dB HL in some cases) was used in the Swart et al. (1995) study versus a 25 dB HL level used in the UCT hearing-screening programme. Swart et al. remarked that more learners may have failed the hearing-screening test if a more stringent pass/refer criteria (such as 20 dB HL) was used. Thus internationally, the prevalence of hearing loss/ hearing-screening referrals among developing countries ranged from 3.3% to 11.9%, with the current findings falling above this range, which is most probably due to the more stringent criteria used in the UCT hearing-screening programme.

When the ear failures at 500 Hz were excluded from the UCT hearing-screening programme analysis, to address the potential impact of environmental noise on hearing performance, the number of referrals were reduced from 14% to 8%. This referral rate, excluding 500 Hz, more closely approximates the Hatcher et al. (1995) results in Kenya, with a prevalence rate of 5.6%. Hatcher et al. excluded 500 Hz and 1 kHz due to ambient noise [See Appendix R for a comparison of prevalence results between studies, including and excluding 500 Hz]. The sample size of the Hatcher et al. study was five times larger ($N = 5368$) than the current study. The pass/ refer criteria was set at 30 dB HL versus 25 dB HL in current study. A further difference between the two studies was that Hatcher et al. used a Liverpool Field audiometer, which emitted tones via free field, while the UCT hearing-screening programme used stand-alone audiometers with intra aural headphones. Lastly the majority of learners in the Hatcher et al. study were in the 10 to 14 year age range relative to the majority of learners in the current study being in the 6 to 8 year age range. Due to the limited frequencies included in the Hatcher et al. prevalence review, it is possible that the prevalence rate could have been much higher had 1 kHz been included and a pass/ refer criteria of 25 dB HL been used.

The current referral rate of 8% (excluding 500 Hz) more closely approximates the results of the Elango et al. (1991) study in Malaysia which reported that 5.8% of learners failed the hearing-screening test. The current study ($N = 1101$) and the Elango et al. study ($N = 1307$) had a similar sample size. The pass/ refer criteria in the Malaysian study was more stringent in that 20 dB HL.

was selected relative to the 25 dB HL level used in the UCT programme. Similarly, the study by Rao et al. (2002) in South India found a prevalence rate of 11.9% among school learners (when 500 Hz was excluded). The sample size of the Rao et al. study (N = 855) was similar to the current study (N = 1101). Thus, when failures at 500 Hz were excluded, the referral rates of the current study were lower and in the range reported by other developing nations.

Clinically, the implications are that environmental noise may affect a learner's performance at 500 Hz during hearing-screening which does not occur in a sound-proof booth. Thus a failure on the hearing-screening test at only 500 Hz should not be considered sufficient criteria for a referral. Rather 500 Hz should only be included in a hearing-screening protocol when immittance measures are not available (Gell et al., 1992). Such a position is in accordance with the American Speech and Hearing Association (ASHA) guidelines (1997) for an identification audiometry protocol (presenting 1 kHz, 2 kHz and 4 kHz via air conduction at a 20 dB HL level for each ear) and including 500 Hz if a screening protocol is intended to identify middle ear pathologies.

Karlslose et al. (1998) suggested that conducting audiometry without a sound attenuating booth, induced the risk of uncontrolled ambient noise masking accurate hearing thresholds. However they also reported that for frequencies from 500 Hz to 3 kHz there was an overestimation of hearing thresholds by only 1-2 dB HL in a non-sound-proof-booth versus a sound attenuating booth. Thus hearing-screening in a quiet environment, without a sound-proof booth, may still yield reliable and valid results. Martin and Champlin (2000) have proposed that the upper limit for normal hearing should be 15 dB HL instead of 25 dB HL, which if accepted could have ramifications for the pass/refer criteria in future hearing-screening programmes, impacting on the specificity and sensitivity which would need to be researched. The theoretical implications question the validity and reliability of hearing-screening at 500 Hz due to it being easily affected by environmental noise, despite the Karlslose et al. (1998) findings.

More children with HIV are surviving past early childhood due to being placed on anti-retroviral therapy [ART] (Wilson et al., 2003). As the ARV programme continues to roll out, more and more survivors may enter schools. It is known that children with HIV/ Aids (Wilson et al.) and even those on ARV's still have middle ear infections (Europa, M, personal communication, March, 2005). Thus the prevalence of hearing loss in the school-aged population may increase related to the longer lifespan of those with HIV. The impact of this factor in partially accounting

for the slightly higher prevalence figures reported in the current study (in sub Saharan Africa) than those reported by Hatcher et al. (1995) and Elango et al. (1992), needs to be researched.

Prior to initiating a screening service for a pathology, its prevalence must be sufficiently great to warrant such a screening service (Lundeen, 1991 in Gelfand, 1996). The World Health Organisation (1998) describes a disease's prevalence of more than 4% as a massive public health problem. The current review referrals rates (14% [+500 Hz] or 8% [-500 Hz]) strongly suggests that hearing losses among school-aged children are an important health problem and is sufficiently great to warrant the provision of services, i.e. hearing-screening programmes at education/ school institutions. The nature and causes of hearing loss contributing to a relatively high prevalence rate need to be researched to ameliorate the high prevalence rates of hearing loss in this population.

In the current study, 70% of learners had unilateral failures and 30% had bilateral hearing failures. These results are similar to those of Hatcher et al. (1995) where 61% of learners had a unilateral hearing loss and 39% had a bilateral hearing loss. The reasons for the minor differences between the two studies could be related to the methodological issues, such as sample size as highlighted above. Thus, the hearing-screening results suggested that more children are likely to have unilateral than bilateral hearing losses. The impact of this would be that the majority (70%) of those referred would still have acceptable hearing sensitivity and may not be as negatively impacted in terms of learning as those with bilateral hearing losses. However, as Brookhouser et al. (1991) reported, a unilateral hearing loss in children may be associated with significant deficits in auditory and psycholinguistic skills and school performance. Tarpe and Bess (1991) further highlighted the advantages of hearing via two ears rather than one, as binaural summation, localization, squelch effects and head shadow effects. As a result, children with a unilateral hearing loss would thus have greater difficulty with communication and in school settings than previously suggested (Tarpe & Bess).

However, a fairly substantial number of children (30% of those with a hearing loss) are disadvantaged in the classroom where learning and communication occur via aural/ oral medium due to a bilateral hearing loss. A bilateral hearing loss could have a wide range of effects in many areas of a child's development such as in their language, social, psychosocial and behavioural development (Davis et al., 1986; Elango et al., 1991; Gopal et al., 2001). Therefore, it is

imperative that all hearing losses, whether unilateral or bilateral be identified at the earliest possible opportunity via screening and referred for appropriate ENT and audiological follow-up.

Laterality differences between the left and the right ear were not significant. While 51% of unilateral failures occurred in the right ear, Hatcher et al. (1995) reported that 62% of their learners had a unilateral loss in the left ear. The laterality findings of the current study are similar to those of Karlsmose et al. (1998) who reported no ear differences. Since the current results are based on a hearing-screening programme with a pass/ refer criteria, thresholds were not established. These findings indicate that hearing-screening programmes should test both ears as is the protocol, as both ears are equally susceptible to a hearing loss. If only one ear is screened, one may miss a high percentage of children with a unilateral hearing loss in the other ear. Perhaps this issue could be researched to determine what percentage of children would be missed if only one ear was screened and the subsequent cost and time saving implications for service delivery.

The current results suggested that there were minimal gender differences with hearing impairment being slightly higher in boys (15.9% [+ 500Hz] or 9.1% [-500Hz]) than girls (11.9% [+500Hz] or 6.8% [-500Hz]). These results agree with those of Rao et al. (2002) in which minimal differences between the sexes regarding hearing losses were present (12.1% in girls relative to 11.8% in boys). Both these studies had similar methodologies and sample sizes (N = 1101 versus N = 855). Hatcher et al. (1995) are in agreement with the findings of Rao et al. and the current study as they also reported that there were no real differences between the sexes regarding hearing losses. The present results and previous studies suggest that one gender is not significantly different from the other with regard to the prevalence of hearing losses and therefore in need of more services and resources. Rather, both groups need to receive and have equal access to hearing-screening programmes and subsequent referral resources.

Analyses of results suggested that the prevalence did not appear to vary as a function of geographical area. One explanation could be that all eleven schools were within a 50 km radius of the UCT and that the true impact of geographical differences would have been revealed if a more diverse area had been sampled. Olusanya et al. (2004) remarked that within each country, there were many different geographical regions with different levels of development. From this we may assume that due to the limited sampling radius, a fairly homogenous sample was selected and thus geographical differences were not evident.

The current study was conducted on a fairly small sample ($N = 1101$) in a limited geographical area within 50 km area around the UCT in the Western Cape. It is recommended that future prevalence reviews be conducted, with a larger sample over a greater geographical area to obtain more representative information. The data for such a prevalence review study, preferably at a provincial or national level, could be obtained on an ongoing basis with all hearing-screening programmes being required to submit standardized information. The comprehensiveness of this information would thus avoid the need for a retrospective review, which has its own limitations. These hearing-screening programmes could screen school children's hearing using pure-tone audiometry as well as tympanometry and Otoacoustic emissions as discussed later. Utilizing pure-tone screening results, in isolation without tympanometry, has its drawbacks and future hearing-screening programmes should use a combination of methods to ensure maximum sensitivity and specificity of the programme.

Any prevalence review conducted in urban settings within the South African context must consider the fluidity of people's movements. Many children in the schools that were screened within the 50 km radius of the UCT, live beyond these borders and merely commute to the schools everyday. Therefore the area and socio economic background of a child's school are not always indicative of their home environment or socio- economic status. The socio-economic status and fluidity of movements of the children screened during the UCT hearing-screening programme may have also contributed to the higher prevalence rate relative to other studies. Rao et al. (2002) found that the prevalence of hearing impairment decreased with improved socio-economic status. This finding was supported by Kubba et al. (2004) who also reported that hearing impairment was closely associated with socio-economic deprivation. They felt that poverty had a two-fold effect namely: increasing the incidence of hearing loss and, enhancing the negative impact due to poorer access to health care. Certain research needs are highlighted by the current study namely that standardized methodologies with uniform protocols for hearing-screening, especially when conducting prevalence reviews need to be selected. Such uniformity would facilitate meaningful comparisons between studies. See Figure 13 for a suggested hearing-screening programme protocol. A 'refer' result in one ear determines an overall refer status for the learner. Otoacoustic emissions have not been included in this suggested protocol due to time and resource limitations but could be included if desired.

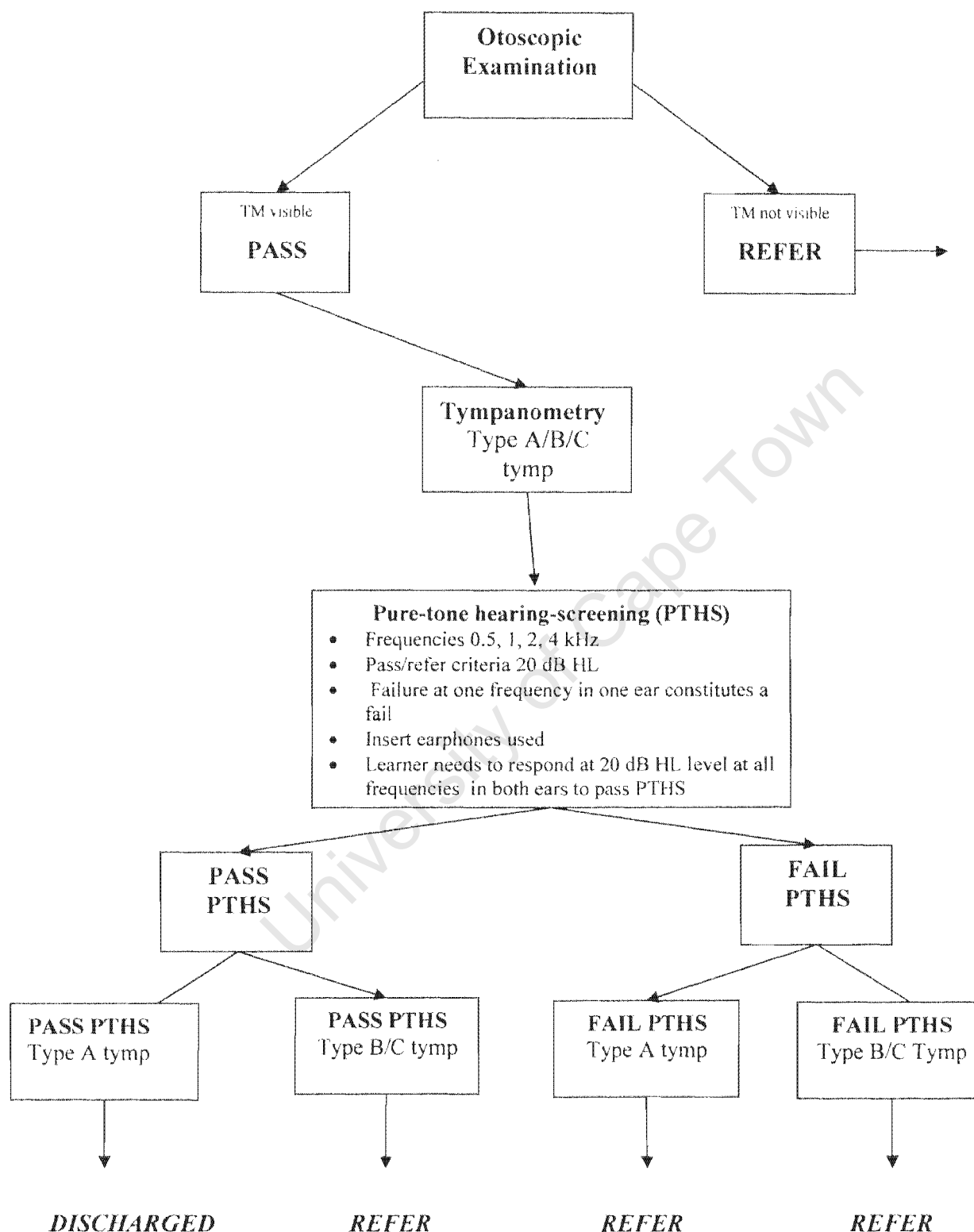


Figure 13. Suggested hearing-screening programme protocol at primary level (school site).

Walch, Anderhuber, Kole, and Berghold (2000) suggested that all hearing-screening results should be classified according to Boothroyd's system, which is similar to that proposed by Gell et al. (1992). In essence, it is suggested by the current researcher that a uniform classification system could include a standardized pass/ refer criteria, a standardized screening method and even a minimal sample size, in order to make meaningful and valid inferences about the prevalence results. The World Health Organisation Ear and Hearing Disorders Survey: Protocol and Software Package, has been developed for those planning to conduct a population- based survey in a developing country (World Health Organization, 1999). This software package (similar to proposed study's hearing-screening protocol) outlines a standardized process for conducting hearing-screening programmes, which would facilitate comparisons among developing nations in the future and contribute to a valid data base of prevalence reviews.

To conclude, the prevalence of hearing loss amongst the learners of the sample was within the international range for developing countries. However it could be speculated that the low socio-economic status, HIV and other demographic variables not explored in this study may have been contributing factors to this prevalence rate. Within this sample, more learners had unilateral than bilateral hearing losses while laterality, gender and geographical differences were minimal. Furthermore, the potential impact of environmental noise on a learner's hearing-screening performance was highlighted. The prevalence rate is sufficiently high to warrant the implementation of a school-based hearing-screening programme using a standardized protocol.

Resources

The knowledge regarding hearing losses, the effects of an unidentified hearing loss, knowledge of hearing-screening, need for hearing-screening, resources required for hearing-screening (including time, personnel and site), value of computers and training shall be discussed relative to the impact they have on the introduction of a computer-based hearing-screening programme at school sites.

The participants were aware that hearing losses often went undetected in the school setting. Such awareness is in accordance with Smith (2001) and Newton et al. (2001) findings that hearing

losses were often invisible and forgotten problems in developing countries. In addition, Smith reported that hearing losses were detected in only a few children soon after the causative event.

There was an awareness by the participants' that an unidentified hearing loss could affect many areas of a child's development such as their language, social, psychosocial and behavioural development. The impact of an unidentified hearing loss was reported by Davis et al. (1986) and Smith (2001) who confirmed that hearing losses of any degree affected the behaviour, social and psycho-educational development of a child adversely. The current study's results also supported Davis et al. (1986), Elango et al. (1991), Gell et al. (1992); Gopal et al. (2001) and Tharpe and Bess (1991) as they further concluded that even mild hearing losses placed a child at a greater risk for language and learning difficulties. The present study's quantitative results were supported by the qualitative findings suggesting that participants seem to have a good idea of the effect of a hearing loss on a child's development.

The participants considered hearing losses to be an important health risk in children. This awareness was justified in light of Rao et al. (2002) who reported that hearing impairment in children was a substantial health problem in developing countries. Furthermore, the participants felt that hearing-screening should have a high priority in the school situation. Quantitative results were supported by the qualitative findings suggesting that the early identification of hearing losses was of paramount importance and therefore hearing-screening should have a high priority in schools. These viewpoints are in agreement with Smith (2001) who recommended that hearing losses in children should be targeted for intervention in order to minimise problems with their language development and school progress. Further, Rao et al. and Smith also suggested that there was a need for regular hearing-screening programs, as the majority of the causes of hearing impairment are preventable. Despite the evidence that hearing-screening should be a high priority, the opposite may be true in reality. Gell et al. (1992) reported that the demands on the health care systems in developing countries made the detection of hearing losses in children a low priority. Olusanya (2000) further substantiated that hearing losses were generally neglected in developing nations and had a low priority since they were viewed as non life-threatening. The positive belief of participants that hearing-screening should have a high priority augurs well for initiating discussions regarding the implementation of a hearing-screening programme.

Reaffirming their view that hearing-screening should have a high priority, the participants also felt that hearing-screening was not a waste of time, that every child entering Grade 1 should have their hearing screened, and that such hearing-screening was attainable in the South African context. These positions differ from the view of Jaihiainen (2001) who felt that audiology was the luxury of well-built-up health systems. Jaihiainen was further skeptical about the attainability of universal hearing-screening services in developing countries due to more basic requirements still needing to be met, such as access to water, housing, and unemployment which have a greater priority. Despite the note of caution raised by Jaihiainen, the participants' positive attitudes towards hearing-screening provide a good foundation on which a hearing-screening programme could be based. The South African National government reported that positive attitudes were a prerequisite for the success of any programme (Department of Education, 2000) and in an Education Department's study, only 2% of participants felt that there was little value to learning a new concept (Department of Education). The challenge remains to educate, through a training programme, groups similar to these participants about the benefits of such a hearing-screening programme.

Since there was such a high agreement regarding the attainability of hearing-screening in South Africa, and the benefits of hearing-screening, there is a need to consider the validity of the participants' attitudes and determine if they did not perhaps respond in the manner they felt was expected of them, i.e. social desirability bias (Oppenheim, 2001).

The participants were uncertain regarding the prevalence of hearing losses among school-aged children. This uncertainty, regarding the true prevalence of hearing losses among school children correlates with many studies (Olusanya et al., 2004; Smith, 2001; Swanepoel, 2004). These studies suggested that the prevalence of hearing loss was higher in developing than in developed countries. However, prevalence data varied and as a result, accurate prevalence data is often lacking in developing countries. Therefore it is not unexpected that the participants were 'uncertain' regarding the prevalence of hearing losses in school children. The level of uncertainty also suggested that the scope of the problem may not be fully appreciated, which could have negative implications for service delivery and the willingness to provide services at an Education Department and National Government level.

There was also uncertainty regarding the causes of hearing losses, i.e. whether impacted cerumen/ and or middle ear infections were common causes of hearing loss amongst school children. The quantitative results were supported by qualitative findings suggesting a need for knowledge regarding hearing losses, which provides a fertile ground for learning and possibly bodes well for implementing a hearing-screening programme with these personnel. While participants were unaware of the causes of hearing losses in children, research (Elango et al., 1991; Hatcher et al., 1995; Rao et al., 2002) has shown that the most frequently occurring cause of hearing loss in children was impacted cerumen. These research findings were also true of the South African context in that 38.4% of the Black and 49% of the Indian pre-school learners in Kwa-Zulu Natal had impacted cerumen (Bhoola & Hugo, 1995). Impacted cerumen can be removed and when it was, a large percentage (42.3%) of children no longer presented with a hearing impairment (Jacob et al., 1997). It must be remembered that in the UCT hearing-screening protocol, all learners with impacted cerumen were referred following otoscopic identification, prior to screening and thus do not account for the prevalence figures in the study.

Given that the cerumen problem may be relatively easy to address with suitable referral and management, it is important that teachers be educated about the great likelihood that a number of learners will have impacted wax, which can affect hearing and school performance. Since the participants felt that middle ear infections were a more common cause of hearing loss than impacted wax, this highlighted the need for raising awareness regarding the effect of impacted wax on a child's hearing. Furthermore, the less than optimal awareness regarding the prevalence of hearing loss in school-aged children should provide a platform on which an awareness campaign could be based. Thus health promotion and disease prevention interventions within the primary health care model, need to be undertaken by the audiology profession to prevent a person acquiring a disease or condition, in this case a hearing loss. Consistent with such a recommendation are Gopal et al. (2001) who strongly support community involvement to facilitate and improve the early identification of hearing losses.

A future study could determine the number of referrals, during a hearing-screening programme, which were due to impacted wax and otitis media. This information could be used to highlight the extent of these problems, which can be easily treated/ remedied at a primary health care level. Allowing resources to be channeled at prevention rather than habilitation may avoid the

secondary level complications of a hearing loss caused by these conditions. The participants' view that otitis media was a common cause of hearing impairment is confirmed by research (Alberti, 1999; Smith, 2001; Swart et al., 1995) which indicated that otitis media is a major public and community health problem requiring a public health approach to its management.

Staff at the school sites expressed a need for greater parental involvement in the hearing-screening process. Such a need reflects the participants' awareness of the need for parents to be autonomous and be actively involved in the decision-making process. The need for parental involvement also suggested that there must be an active programme of information dissemination to parents which is supported by the health promotion aspects of primary health care. Ideally, school personnel would hold workshops with parents where the effects of early identification and the impact of an unidentified hearing loss could be discussed. These health promotion workshops could be coordinated by an audiologist at a regional level. Swanepoel (2004) also highlighted the need for community participation through awareness of the effects of hearing losses and the importance of early intervention.

Most of the participants appeared to be uncertain regarding the causes of hearing losses, and it is possible that the response options on the questionnaire could have influenced the results, which could then be viewed as a limitation of the questionnaire. As it is known that individuals respond better when they have to choose from a list (recognition) than if they have to recall items from memory (Tourangeau, Rips & Rasinski, 2000), it may be advisable for future studies to consider these factors in the design of a questionnaire.

To conclude, the participants were aware of the adverse effects that an unidentified hearing loss could have on a child's development. They believed hearing-screening should have a high priority in the school situation and was not a waste of time. Despite the participants' uncertainty regarding the causes and the prevalence of hearing losses, their positive beliefs regarding the importance of hearing and hearing-screening augurs well for the successful implementation of a hearing-screening programme. A hearing-screening training programme as outlined later would consolidate this awareness and lay a strong foundation for the implementation of a school-based hearing-screening programme in the Western Cape and thereafter the rest of the country.

Knowledge about Hearing-screening and Resources required for Hearing-screening

Selection of personnel to be included in a hearing-screening training programme deserves special attention. In order to maximize human resources and be fiscally responsible in a developing country, training would need to focus on key individuals who are willing, keen, and able to engage with change and can benefit from the transfer of knowledge and skills. Olusanya (2000) has proposed a categorization system that could prove helpful in this process. In Olusanya's "Category C" are those individuals who have some experience with the effects of hearing impairment and are concerned that a solution be found. However, these participants have in the past, been limited by their knowledge of what needs to be done. Ninety- two percent of the current study's participants fall into this category as they agreed that hearing-screening was not a waste of time. Thus it would be advantageous to select trainees from this group. The other 8% of participants fall in "Category A", and according to Olusanya these participants are not ready or willing to actively promote a programme or are relatively negative towards such a programme. Thus it would not be expedient to include these individuals in training.

More than half of the participants felt that hearing-screening would increase their workload. In order for a hearing-screening programme to be successful, this issue would need to be addressed, by an audiologist, possibly at a systems level (e.g. Department of Education). However, this fairly negative impression is similar to that reported by Spivak and Jupiter (1998) who found that at the beginning of a hearing-screening programme, personnel may be reluctant, skeptical or suspicious. However these negative views normally change over time (Spivak & Jupiter). Olusanya (2000) remarked that implementing any change would face some degree of resistance. Clemens et al. (2002) found that when hearing-screening was mandated, as in a test battery, the screening forms were often incomplete which could be attributed to a perceived increase in workload. This finding highlighted the importance of education and actively involving relevant staff members in the development of a hearing-screening programme, in order to facilitate its success. A training programme would include personnel who could potentially be involved in a hearing-screening programme. The attitude scale used in this study regarding hearing losses could be administered to determine who would be suitable candidates to train. Furthermore, once training had begun with the key personnel who had been identified as keen and willing to engage

in such an activity, ways to redistribute their workload need to be addressed to allow them to accommodate their additional responsibilities.

The results regarding the location of a hearing-screening site between a school site versus a health clinic site resulted in much uncertainty. Swanepoel (2004) initially proposed that despite the high levels of noise at primary health care clinics in South Africa, the perceived advantages would include sufficient chairs, tables, appropriate hygiene levels, electricity and plug points, bathroom facilities and sufficient space. However Swanepoel reported that these perceived advantages were often replaced by overcrowding, electricity failures, and safety concerns. It should be noted that the advantages as outlined by Swanepoel are also relevant to a school site setting. If addressing the feasibility of implementing a hearing-screening programme for school-aged children, then it would be advisable to locate the hearing-screening programme at the school. A hearing-screening programme at a school versus a primary health care clinic would minimize logistics and transportation costs, time spent traveling and waiting at health care facility. Furthermore it would reduce the risks associated with transporting the children to the health care clinic and minimise the amount of time lost on educational activities, as children could return to the classroom once their hearing has been screened. Additionally, as outlined in the literature review, the availability of computers and quiet spaces at primary health care clinics was very limited. Furthermore, once a child has been placed in an educational setting, the onus for hearing-screening may be seen as a responsibility of the Department of Education and not that of the Department of Health. The Health Department's role may begin once the child has been referred after failing the second hearing-screening at the school. Furthermore the Department of Health and Education may need to develop new policies and legislation regarding school-based hearing-screening prior to the implementation of such a programme in order for each Department's role to be clearly defined.

The resources required for hearing-screening include personnel resources, time resources as well as money resources. The participants lacked knowledge on the nature of the resources required, which is only to be expected given that hearing-screening is outside their area of expertise. Since the participants felt that hearing-screening could be done by school personnel with adequate training, this provides a good foundation for a hearing-screening training programme.

Furthermore all the participants were willing to be involved in a twelve hour training session which highlighted their initial willingness to be part of/ participant in a hearing-screening training programme. Once again, education of relevant school personnel, including those in the Department of Education on the resources needed would have to be addressed.

A hearing-screening training module, for school personnel, could be designed and managed by a qualified audiologist. Such a recommendation is in accordance with the World Health Organization (2001) guidelines for hearing in developing countries. The audiologist would be responsible for the training of appropriate staff and oversee the project within the primary health care approach. As the World Health Organization (1998) requires that all training materials and modules be culturally appropriate, the development of a hearing-screening training programme must reflect diverse cultural factors. The HPCSA / South African Qualifications authority should be consulted regarding an accredited hearing-screening training module which should be utilized, (following consultation with the board), in a hearing-screening training module. A hearing-screening training programme (managed by a qualified audiologist), as illustrated in Figure 14, ought to include the following content areas: Information on the nature of hearing losses (Olusanya et al. 2004); Need for hearing-screening (Spivak, 1998; Gelfand, 1996); Resources required for hearing-screening (Gell et al, 1992); Protocol used for school-aged hearing-screening (Davies, 1996; Northern & Downs, 2002); Skills required to cope with a hearing loss in the classroom situation and to conduct hearing-screening; and attitudes towards hearing and hearing-screening (Olusanya, 2000).

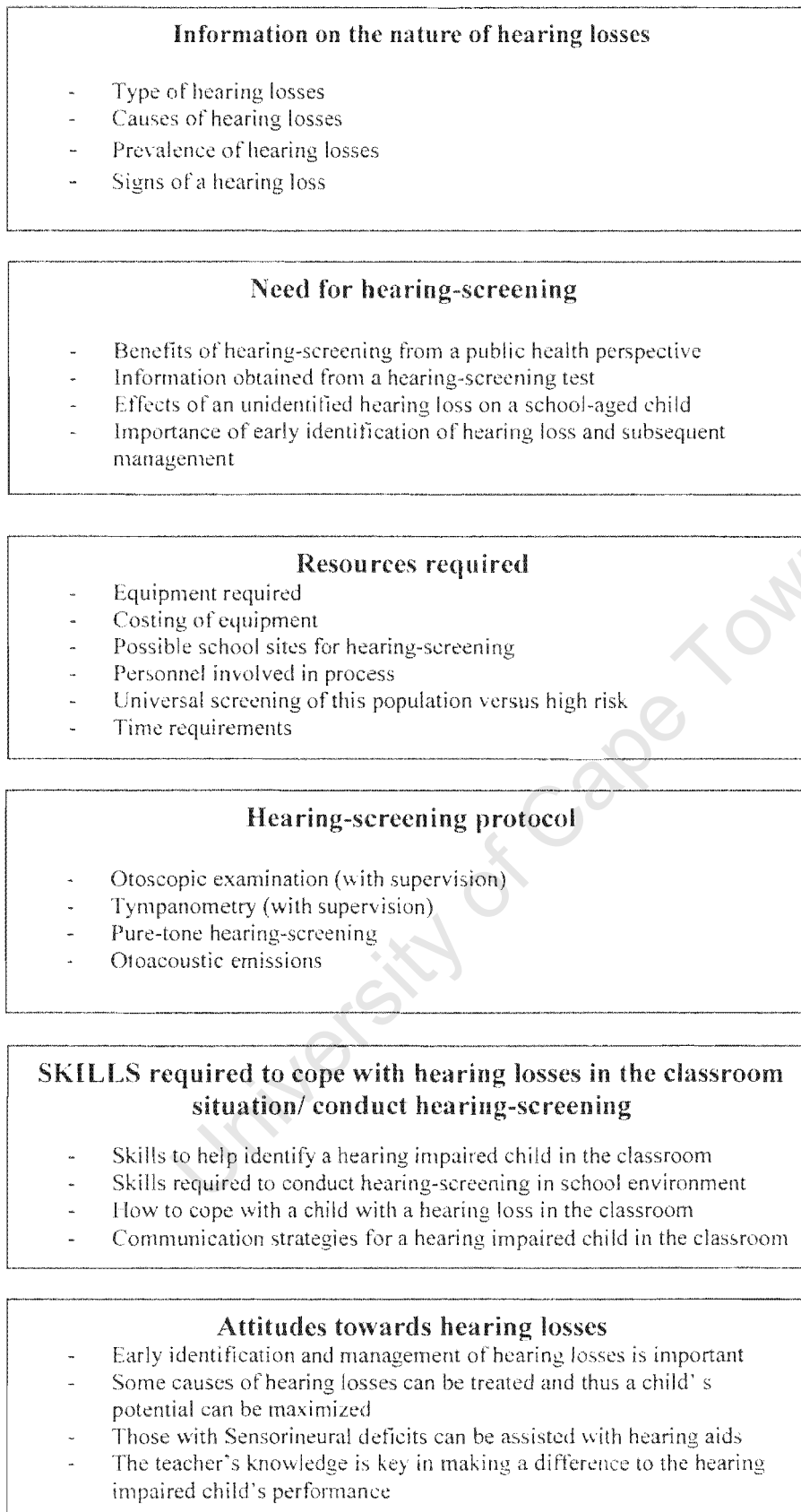


Figure 14. Suggested knowledge, skills and attitude domains that could be incorporated in a hearing-screening training programme.

It is likely that hearing-screening will be perceived as expensive, as Jaihiainen (2001) reported that audiology has a profile of advanced technology and expensive equipment. Therefore Gell et al. (1992) and Jacob et al. (1997) recommendations regarding children in developing countries were that hearing-screening should utilize a simple audiometer and otoscopic examination protocol to minimize costing. Alternatively following these recommendations, children in developing countries could be screened using an existing computer with a hearing-screening programme on a CD disc which would limit the cost involved as only the CD and headphones would need to be purchased. To minimize expenses, strategies on how to share and maximize the use of available equipment need to be discussed in planning sessions prior to the implementation of the training and the implementation of the hearing-screening programme.

Beckham (2002) reported that the range of cultures in South Africa needs to be investigated to determine how this would affect participants' attitudes towards and/or perceptions of screening. It would thus be recommended that future studies could incorporate a larger sample thus allowing for a more diverse range of cultural beliefs.

Service delivery issues for a hearing-screening programme would need to be addressed. Newton et al. (2001) remarked that the establishment of any screening programme should be part of a well planned service delivery structure, which would incorporate treatment options as well as habilitation for any child detected through screening. The World Health Organisation, in Smith (2001), proposed three levels of prevention for hearing impairment in children. Level one has been discussed earlier under health promotion activity (preventing person acquiring disease or hearing impairment). Secondary prevention describes a level of care where although an impairment is present (such as a hearing loss), it is prevented from producing a disability i.e. a child with a hearing loss (impairment) is screened to reduce the negative effects of an unidentified hearing loss (which could result in a disability). Tertiary prevention describes the level of care where the aim is to minimise the long term effects of an illness/ impairment through rehabilitation, such as the fitting of hearing aids and subsequent management (Smith, 2001).

Based on these three levels of prevention, a computer-based hearing-screening programme would be based at a secondary level of prevention. However it should be noted that programmes aimed

at highlighting the importance and treatment of middle ear infections and wax could be placed at the first level of prevention. By screening all Grade one learners, the negative effects of a hearing loss could be prevented through the early detection and subsequent referral to the appropriate services. Gell et al. (1992) stated that a screening programme should not begin unless appropriate follow-up services had been established. Gopal et al. (2001) support Gell et al. in that they felt that screening programs should only be implemented when all components are available to provide appropriate follow-up services. No single service can meet these demands and as a result a partnership between the Department of Health and Education would be required to make hearing-screening viable. Such a partnership to address hearing loss and screening would be highly advantageous and needs to be lobbied for. The Departments of Education, both at a Provincial and National level, have an essential role to play in co-coordinating services for policy development, awareness campaign implementation, intervention services and follow-up.

Following a viable service delivery model that allows for all components of a hearing-screening programme to be implemented, a measure of the programmes' efficacy would need to be determined. The efficacy of an initial programme would need to be determined prior to a roll-out on a larger scale. If the efficacy of a pilot hearing-screening training programme proved to be beneficial then the model could be implemented more widely. If not, amendments could be made (in light of reason for failure) and the model retested.

Gopal et al. (2001) highlighted the need to consider local constraints and limitations with regard to the available personnel, equipment and finances. This position is supported by Swanepoel, Delpont and Swart (2004) who urged that the Health Professional Council of South Africa Professional Board position statement on hearing-screening be critically revised within the South-African context, concentrating on the existing available audiological and otological health services (required for follow-up), prior to implementing a programme. Jaihiainen (2001) remarked that developing countries needed to develop programmes which effectively utilized the available resources for the training of personnel.

Swanepoel (2004) proposed a service delivery model for infant hearing-screening in South Africa. This model can be applied, with modifications, to school-based-hearing-screening. It is a

three tier system namely: Service delivery structure; Role players and responsibilities and Screening protocol.

In this modified model, there are three levels in the service delivery structure. See Figure 15 for the service delivery structure. The primary level is the school site where hearing-screening tests could be conducted. If the learner failed the initial screening, they would need to be referred to the second level. The second level could be a Special needs school with an audiologist with diagnostic audiology equipment (as well as access to a school nurse for management of wax and middle ear pathologies). Such schools already exist in the Western Cape and include those that cater for children are hearing impaired. Thereafter, if the child failed the comprehensive hearing test or if no further medical intervention was required they would be referred to the tertiary level for management and fitting of hearing aids if appropriate. This level could be based at a centralized school clinic site where the appropriate resources could be pooled. Therefore the hearing-screening programme would fall under the auspices of the Department of Education while maintaining a working relationship with the Department of Health should medical intervention be required, at either level two or three. This model is supported by World Health Organisation (1998) in that they propose that early identification and treatment of hearing impairment is most appropriate and cost effective when undertaken as part of primary health care. The role players at level one, in the hearing-screening context, would be teachers, teacher support staff, principal, audiologists and parents. The suggested screening protocol for this model could be a combination of pure-tone hearing-screening, otoscopic examination and tympanometry (Refer to Figure 13 earlier for suggested pure-tone hearing-screening programme protocol). Otoacoustic emissions could also be added to the protocol. The equipment would ideally be a computer-based hearing-screening programme due to resources (cost, availability). Once again specific reference would need to be made regarding the sensitivity and specificity of the protocol selected for programme.

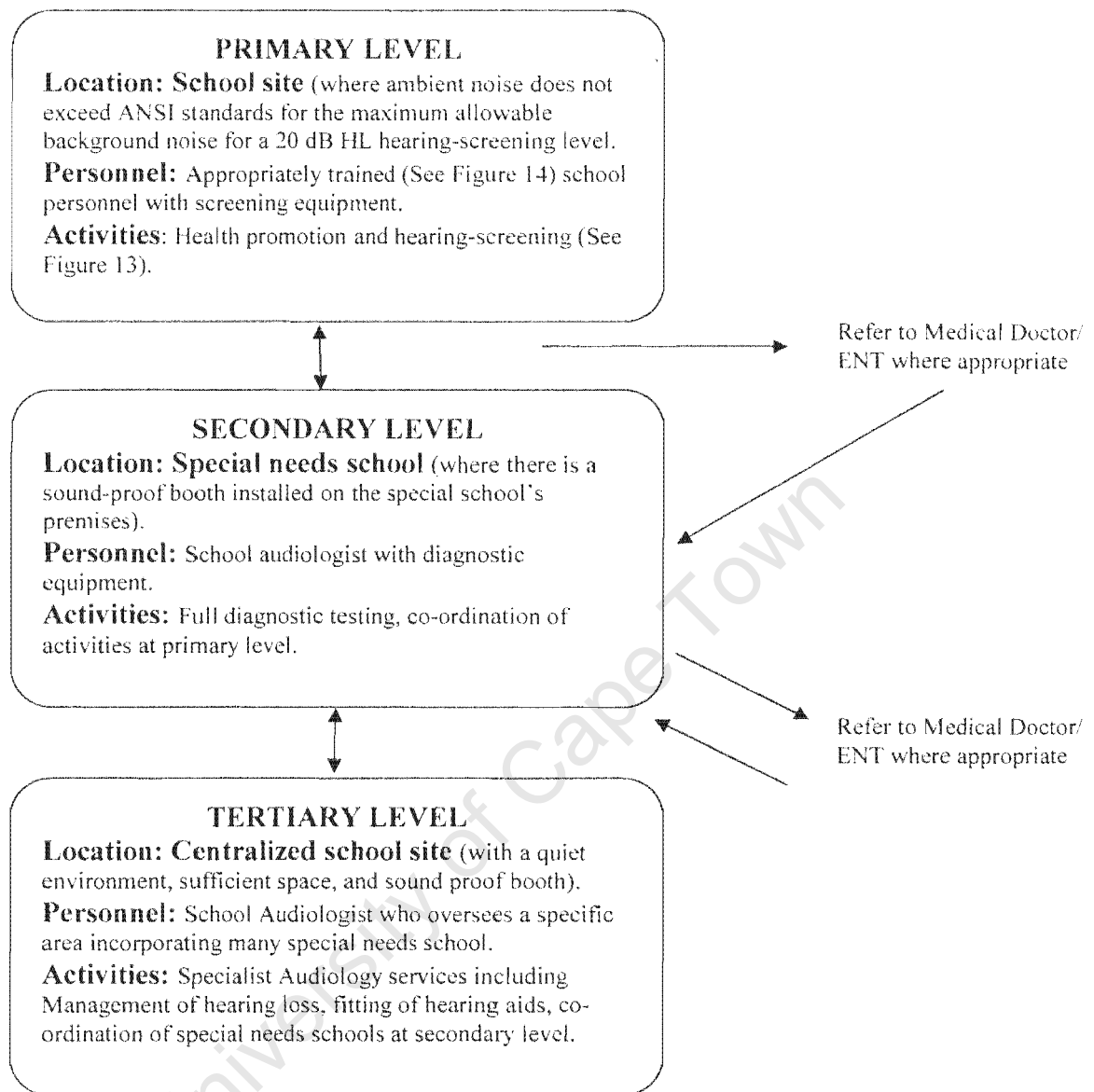


Figure 15. Service delivery structure for a school-based hearing-screening programme.

A school-based hearing-screening programme, would need the support of the Department of Education and Department of Health at both a National and Provincial level as well as the public as outlined above. Furthermore, existing resources could be incorporated into the programme to minimize the costs involved and maximize the use of existing resources.

To conclude, despite the uncertainty of the participants regarding the resources required for hearing-screening and the possible location of a hearing-screening programme, a school-based

hearing-screening model is still very feasible in the Western Cape. The model proposed by the researcher offers an initial framework on which this programme could be based.

Value of Computers, Computer Training and Skills Development

A computer-based hearing-screening programme seems feasible. Such a position is supported by the participants' overall positive attitudes towards the use and value of computers, eagerness regarding learning/ training to use computers and learning to conduct hearing-screening, previous computer experience and learning new skills. While the computer exposure levels of the participants could not be compared to any pre-existing studies there is some evidence (Department of Education, 2000) that previous exposure and experience provides a foundation upon which new knowledge is more easily built/ acquired and learned. Additionally there is less "fear of the unknown" which also facilitates learning and acceptance of technology. The participants' view that computer training was essential, is supported by Marr (1991) who highlighted the importance of computer training to keep professionals abreast of changes. The participants' eagerness in regard to learning to use computers supported is by Mukti (2000) who found that in rural Malaysia, secondary school teachers showed low computer anxiety levels and a very favourable attitude towards computers despite having limited exposure to computers. Mukti remarked that there was a moderate relationship between computer experience and positive attitude towards computers, and that computer experience was a poor indicator of a participant's attitude towards a computer training programme. The National Government suggested that the success of a computer programme is based on positive attitudes towards computer use, sufficient knowledge and lastly an intrinsic appreciation of computers (Department of Education, 2000). Thus considering the participants' positive view, a computer-based programme should be fairly readily accepted as a hearing-screening tool.

The education of relevant school personnel including those in the Department of Education on the change that is required would need to be addressed. It is likely that this need for change may at first be challenged, as New and Couillard (1981; in Mikuleky & Ledford, 1987) reported that people initially are resistant to change due to an inaccurate perception of the intended change. The personnels' attitudes towards the perceived change ought to be shared in the strategic planning sessions prior to the implementation of training and the hearing-screening programme.

The participants' positive belief regarding computers and previous computer exposure augurs well for the implementation of a computer-based hearing-screening programme in the Western Cape. Such a computer-based hearing-screening programme has the advantage of requiring only a minimal outlay in terms of costs. See appendix A for cost analysis. Instead of an audiometer being purchased, a computer-based hearing-screening programme on a CD and headphones (both of which are portable) could be used at various educational institutions most of which already have computers.

Noise Survey

The average noise level measurements at the current computer site in the schools and the current UCT hearing-screening site were similar to those of Hatcher et al. (1995) study. During their pilot study they found that the average background noise level was 45 dB SPL (range 30 to 60 dB SPL). However, specific stimulus parameters (frequency and intensity) at which the measurements were done were not stated. It should be noted that during the Hatcher et al. study no SLM measurements were taken at the time of the hearing-screening programme due a lack of equipment being available. Rao et al. (2002) felt that the number of learners referred following hearing-screening may have been inflated as the ambient noise levels were in the range of 32 to 56 dB SPL with 18.2% of the children being examined in noise levels of 50 to 56 dB SPL. Swart et al. (1995) during their prevalence study in Swaziland found that the noise level at 1 kHz to be 49 dB SPL which is similar to the SLM measurements obtained at 1 kHz in the current study.

Although the background noise levels for the UCT hearing-screening programme was below the ANSI requirements at 1 kHz, the background noise may still have had a masking effect as suggested by Karlsmose et al. (1998). As discussed earlier conducting audiometry without a sound attenuating booth increased the risk of accurate hearing thresholds being masked due to uncontrolled ambient noise (Karlsmose et al). However for frequencies from 500 Hz to 3 kHz there was an overestimation of thresholds by only 1-2 dB HL in non-sound-proof booth versus sound-proof booth which probably has a negligible impact on hearing performance. The adverse effects of environmental noise on hearing-screening thresholds at 500 Hz has been highlighted earlier by Hatcher et al. (1995); Rao et al. (2002); and Swart et al. (1995). However it should be noted that it is difficult to make comparisons as no information is given in the Hatcher et al. and Rao et al. (2002) studies regarding the type of SLM used, filter sets used and weighting used.

Prior to any hearing-screening programme (including the UCT hearing-screening programme) being implemented, it is essential that SLM measurements at all frequencies be conducted at the sites. This should be done to ensure that the background noise is within the acceptable limits (ANSI limits) and also to select the most appropriate hearing-screening site, which by its very nature may not occur in a sound-proof booth. These SLM measurements should be conducted annually to ensure the reliability and validity of the hearing-screening results. Even if the background noise levels are below the acceptable limits, it is beneficial to combine pure-tone screening with tympanometry and even OAE's to minimize the false positives. Furthermore at each school, a situational analysis should be conducted prior to the implementation of any hearing-screening programme to determine the most suitable screening location (such as school hall, classroom, and computer room). This analysis would need to ascertain the environmental constraints of each location (in the form of space and access to plug points), noise levels and the availability of computer equipment in order to determine the best location for a hearing-screening programme at each school.

It would be advisable that the SLM measurements be repeated at the same sites using a SLM which covers the entire frequency range (particularly 500 Hz), rather than only 1 kHz as was the case in the current study. These results should then be compared to the requirements of ANSI to ensure that they fall within the acceptable limits. The noise level measurements at each frequency could be compared to the failure rate at each frequency to determine if there is a correlation. All research on the prevalence of hearing loss should include the noise levels at testing sites to ensure the reliability and validity of the study results.

The environmental noise at the eleven screening sites was within the accepted standards as outlined by ANSI. However the potential impact of environmental noise on a learner's hearing-screening performance should be noted and at all times a hearing-screening site should be selected after a situational analysis (measuring the ambient noise) has been conducted.

The researcher recommends that a further study could investigate the actual costing of such a computer-based hearing-screening programme and the options available for financing such a project. Furthermore it is recommended that a pilot project could initially be implemented in one district and then in time be extended to other regions once modifications had been made.

Conclusion

The study attempted to determine the feasibility of a computer-based hearing-screening programme in the Western Cape Province. Prior to initiating a screening for a pathology its prevalence needs to be sufficient to warrant such a screener. Following an audit of the UCT hearing screening programme a referral rate of 14% for hearing loss was determined which meets this precondition for the introduction of a hearing-screening programme and constitutes a health need which needs to be addressed .

The positive beliefs and knowledge of the school clinic personnel towards hearing, hearing losses, screening, knowledge and technology augurs well for the introduction of a computer-based hearing-screening programme. The attitudes of these respondents towards a probable hearing-screening training programme was also favourable.

The environmental noise levels at 11 school sites were found to be within the acceptable levels and thus, despite perhaps affecting the hearing screening performance of the learners, would not act as an insurmountable barrier to a hearing screening programme at school sites.

The results of the study provide strong support for the feasibility of a computer-based hearing screening programme in the Western Cape and further studies could conduct a pilot project based on this service delivery model.

The shortcomings of the study included: incomplete data being available for the UCT hearing-screening programme review; the review being retrospective; and the limitations of using a non-standardized and novel questionnaire in data collection.

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Appendix A

Cost analysis of a computer- based versus a stand-alone hearing screening audiometer

The table below only represents the cost for one audiometer. However in a hearing screening programme multiple audiometers would need to be purchased exponentially increasing the cost. A value has not been assigned to the headphones as both methods requires these.

Stand-alone audiometer	Computer-based audiometer
Screening Audiometer R25 000.00	Computer with sound card(already present at school site): R0.00
Headphones X value	Headphones X value
Annual calibration: R 1000.00	Annual calibration R 0.00 (done internally by software)
Continued cost to ensure audiometer operates optimally	Computers are maintained as part of school duties at no cost to programme
OVER R 26 000	R 0.00

Appendix B

Review of the University of Cape Town's School-based Hearing-screening Programme

Second year Speech, Language Pathology and Audiology students at the University of Cape Town (UCT) conducted a hearing-screening programme at eleven Western Cape primary schools that were already receiving speech and language services, within a 50 km radius of the university throughout February-May, 2003 and February-June 2004. Since the purpose was to identify those with a hearing loss, all pupils/ learners who had consent from their parents/ legal guardians participated in the programme. Saturation sampling was used to select participants for the UCT hearing-screening programme. Hearing-screening began with the pupils in the lowest grade and continued for a predetermined time period at each school.

Equipment

Otoscopic examinations were conducted first, followed by tympanometry (using two portable Madsen Accuscreen tympanometers). Pure tone testing was done at 1, 2, 4 and .5 kHz using calibrated MA41 audiometers with supra aural earphones. A response at 25 dB HL at all frequencies for both ears was required to pass the screening. This screening protocol was the same as that used in other prevalence studies (Gell et al. 1992; Hatcher et al. 1992; Karlsmose et. al, 1998). All children who failed to respond to the minimal level [25 dB HL] at one frequency failed the screener and were referred for further diagnosis and management.

Noise Levels during Hearing-screening

All screening was conducted on the school premises, and while not in a sound-proof booth, it was done in a quiet environment. No sound level metre measurements were obtained on the same day as screening to determine the ambient noise.

Appendix C

Participants in the hearing-screening audit, as a Function of School, Gender and Grade

School	Year	Grade 0		Grade 1		Grade 2		Grade 3		Grade 4		Grade 5		Grade 6		Grade 7		Total
		M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
1	2004	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	2004	-	-	-	-	-	-	-	-	27	29	19	17	20	23	34	38	207
2	2003	-	-	64	69	57	63	21	40	-	-	-	-	-	-	-	-	314
3	2004	2	2	20	21	-	-	-	-	-	-	-	-	-	-	-	-	45
3	2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	2004	2	2	6	7	3	3	-	-	-	-	-	-	-	-	-	-	23
5	2004	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	3
5	2003	-	-	18	17	7	4	1	1	-	-	3	2	1	1	4	2	61
6	2004	-	-	12	22	-	-	-	-	-	-	-	-	-	-	-	-	34
6	2003	-	-	14	15	6	4	-	1	-	2	-	-	-	-	-	-	42
7	2004	-	-	8	7	2	3	-	1	1	1	-	-	-	-	-	-	23
8	2004	7	8	6	9	-	-	-	-	-	-	-	-	-	-	-	-	30
8	2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	2004	-	-	27	30	34	37	6	4	-	-	-	-	-	-	-	-	138
9	2003	1	-	38	46	4	5	-	-	-	-	-	-	-	-	-	-	94
10	2004	-	-	28	36	11	12	-	-	-	-	-	-	-	-	-	-	87
11	2004	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		12	12	242	281	124	131	28	47	28	32	22	19	21	24	38	40	1101

Appendix D

Questionnaire

**ALL INFORMATION CONTAINED IN THIS QUESTIONNAIRE SHALL BE
CONFIDENTIAL.**

SECTION A:

BIOGRAPHICAL INFORMATION

School clinic/ site: _____

Area	that	you	service:
Number	of	schools	that you service:
Number	of	years	working at School clinic/ site:
Degree/	Diploma/	Training	certificates:
Experience	with	screening	(if any):
Training	with	screening	(if any):

1. How many children per hundred that you see do you THINK have a hearing loss?
Eg. 1 in every 100.

2. Have you ever used a computer?

YES NO

3a. Have you attended any computer courses?

YES NO

3b. If YES, please specify.

4a. With which of the following software programs are you familiar/ worked with?

Instructions: Please circle all that are relevant

NONE MS WORD MS EXCEL EMAIL
OTHER

4b. If OTHER, what other programs are you familiar/ worked with?

5. Are you comfortable using a computer?

YES NO

6. How many hours per workday do you use a computer?

7. If you use a computer at work for what reasons do you use it?

SECTION B

ALL RESPONSES ARE CONFIDENTIAL. PLEASE REFLECT YOUR TRUE FEELING AS THERE ARE NO RIGHT OR WRONG ANSWERS.

Instructions: Please circle the most appropriate response to the following statements.

1. Hearing losses are an important health risk in children.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

2. Hearing losses, even when mild, can affect a child's school performance.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

3. Mild hearing losses can affect a child's language development.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

4. Mild hearing losses can affect a child's social development.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

5. Identification of hearing losses should have a high priority in the school situation.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

6. Hearing losses often go undetected in the school setting.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

7. Hearing losses occur in at least 3-5% of school age children.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

8. Identification of hearing losses should have a low priority in school situation.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

9. Impacted wax is a common cause of hearing losses in school age children.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

10. Middle ear infections are a common cause of hearing losses in school age children.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

11. Mild forms of hearing loss can affect a child's psychosocial development.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

12. Mild forms of hearing loss can affect a child's behaviour.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

13. Do you have any comments/ information about hearing losses you would like to add?

SECTION C

Instructions: Please circle the most appropriate answer to the following statements.

1. A hearing-screening programme would increase workload.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

2. Hearing-screening is a waste of time.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

3. Hearing-screening should be done at school clinics/school sites.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

4. Hearing-screening should be done at primary health care clinics.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

5. Hearing-screening is a complex procedure.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

6. Hearing-screening is a time-intensive procedure.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

7. Hearing-screening should only be done by audiologists.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

8. Hearing-screening is expensive.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

9. Hearing-screening could be done by school clinic/school site personnel with adequate training.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

10. Hearing-screening is a quick (less than 5 minutes) procedure.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

11. Hearing-screening is attainable within the South African school system.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

12. Hearing-screening should be done on every child entering grade 1.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

13. Hearing-screening tells us what sounds a child can and can't hear.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

14. Hearing-screening tells us how well a child will do at school.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

15. Do you have any comments/ information about hearing-screening you would like to add?

SECTION D

Instructions: Please circle the most appropriate answer to the following statements.

1. Computers can improve productivity.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

2. Computers are an asset in the workplace.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

3. Computers can make your life more easy.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

4. Computer training is essential in today's workplace.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

5. Computers are easy to use.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

6. Computers are easy to use once you have been trained in their use.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

7. Computers make me feel scared.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

8. Computers are difficult to use even after you have been trained in their use.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

9. You are never too old to learn how to use a computer.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

10. Computers have a place in a school clinic/school site.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

11. I am too old to learn how to use a computer.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

12. Do you have any comments about computers you would like to add?

13. Do you have any information about computers you would like to add?

SECTION E

Instructions: Please circle the answer most appropriate to the following statements.

1. Learning new skills is beneficial to you.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

2. Improving yourself is an asset.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

3. I like learning new skills.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

4. Learning new skills is rewarding.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

5. I would like to learn new skills, like hearing-screening.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

6. Learning new skills is a challenge.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

7. I dislike learning new skills.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

8. Learning new skills, like hearing-screening, would be interesting.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

9. I would like to learn to use new computer programs, such as computer based hearing-screening.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

10. Learning new skills is a waste of time.

Strongly Agree Agree Uncertain Disagree Strongly Disagree

11. Would you be prepared to undergo a hearing-screening training programme lasting about 12 hours?

YES

NO

12. If NO, please specify your reason/s for not being prepared (such as time etc)?

13. Please give any comments/ information about learning new skills, like hearing-screening?

Appendix E

Informed consent form

PURPOSE OF THE STUDY:

The present study attempts to determine the viability of a computer-based hearing screening programme at school clinics/sites. Specifically, the feelings and knowledge of school clinic staff towards hearing screening and hearing losses will be investigated

REQUIREMENTS:

If you agree to participate in this study, you will be required to complete a questionnaire, which should take about ten minutes. No long written answers are required. I will be available while you complete the questionnaire to answer any questions you may have.

RISKS AND BENEFITS:

There are no benefits or risks for you personally, however the results of the study will hopefully lead to a change in the service provision of Audiological services to school children in the Western Cape region.

VOLUNTARY PARTICIPATION:

You have the right to decide whether you will participate in this study. It is a voluntary choice. You also have the right to withdraw at any time during the study or even after it has begun and there will be no penalties attached to your withdrawal.

CONFIDENTIALITY

All information shall be confidential, your name will not be recorded, and you will not be identified in any publication of this study. On the questionnaire you will be identified by a code that only I will know, this is for recheck purposes. Your responses will not be shared with your boss/ supervisor (and will not be used in any prejudicial manner).

If you wish to contact me at any stage, my name is Craig North-Matthiassen, my contact number is 0823329565 and my email address is cnorthm@webmail.co.za

I have read the above information and am aware that I can withdraw at any point. I have been given a chance to ask questions and have had the questions answered.

I agree to participate in the study.

Name

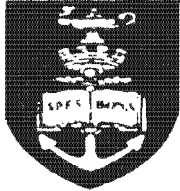
Signature

Date

Appendix F

Approval letter from University of Cape Town's Faculty of Health Sciences Research Ethics Committee

UNIVERSITY OF CAPE TOWN



Research Ethics Committee
Faculty of Health Sciences
OMB E53 Room 44.1, GSH
Queries : Xolile Fula
Tel : (021) 406-6492 Fax: 406-6411
E-mail : Xfula@curie.uct.ac.za

07 November 2003

REC REF: 325/2003

Mr C North-Matthiassen
17 Liberty Court
1 Military Road
Tamboerskloof
Cape Town
8001

Dear Mr North-Matthiassen

THE VIABILITY OF INTRODUCING A NOVEL COMPUTER- BASED HEARING SCREENING PROGRAMME IN THE WESTERN CAPE PROVINCE

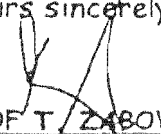
Thank you for submitting your study to the Research Ethics Committee for review.

Date Considered: 31 October 2003

Decision: Approved

Please find attached the list of members who attended the meeting.
Please quote the above Reference number in all correspondence.

Yours sincerely


PROF T. ZIBOW
CHAIRPERSON

Approval letter from Western Cape's Provincial Department of Education

enquiries: Dr Ronald Cornelissen
 Dikhoza
 Telephone: (021) 467 2250
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 Faks: (021) 425 7445
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 Isidathiso: 20030510 0928



Western Cape Education Department

ISebe leMfundo leNtshona Koloni

Mr Craig Nort-Matthiassen
 17 Liberty Court
 1 Military Road
 Tamboerskloof
 CAPE TOWN
 8001

RESEARCH PROPOSAL: THE VIABILITY OF INTRODUCING A NOVEL COMPUTER-BASED HEARING SCREENING PROGRAMME IN THE WESTERN CAPE PROVINCE.

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 **19th January 2004 to 30th June 2004.**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December 2004)
7. Should you wish to extend the period of your survey at the school(s), 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 of the school where the intended research is to be conducted.
9. Your research will be limited to the list of schools submitted to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director, Education Research.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

**The Director: Education Research
 Western Cape Education Department
 Private Bag 9114
 CAPE TOWN
 8000**

We wish you success in your research

Kind regards

Signed: Ronald S. Cornelissen

123

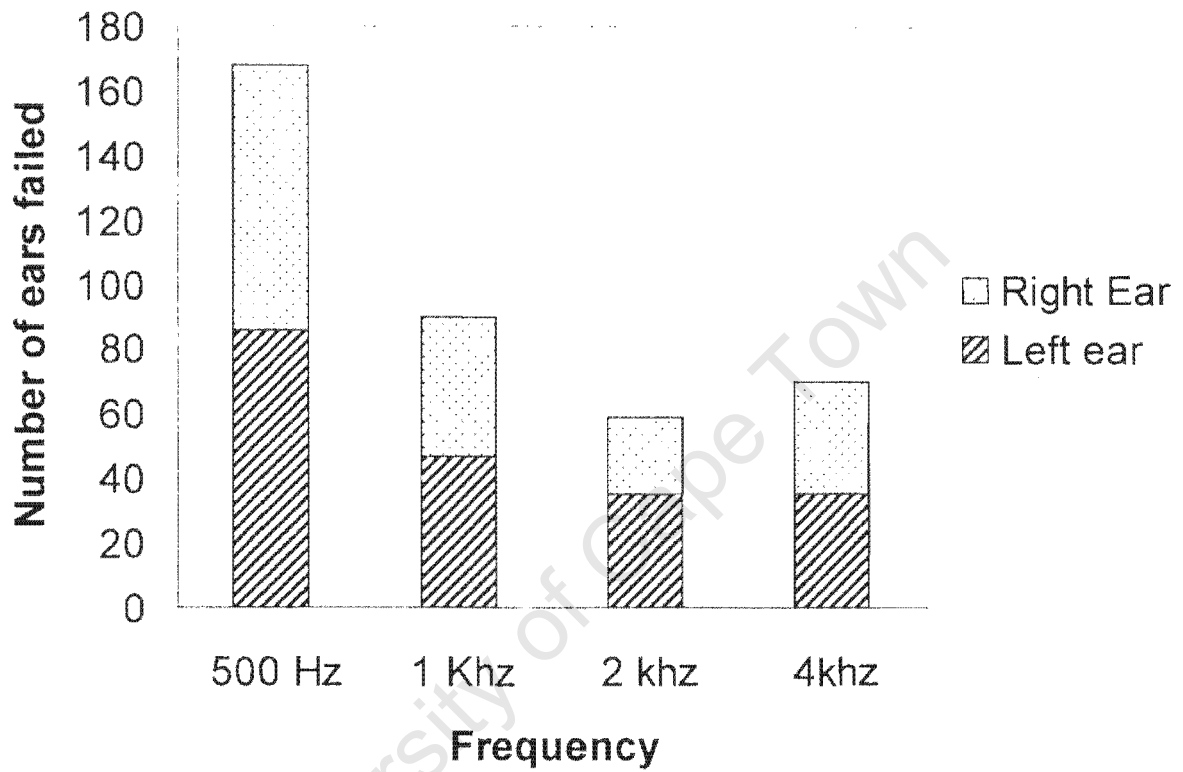
Appendix H

Detailed Analysis of Failed Frequencies

Description of failed frequency	Number of Learners
500 Hz Left	24
500 Hz Right	33
1 kHz Left	3
1 kHz Right	3
2 kHz Left	3
2 kHz Right	3
4 kHz Left	1
4 kHz Right	7
All frequencies (0.5, 1, 2, 4 kHz)	14
500 Hz Left and Right	8
4 kHz Left and Right	2
500 Hz Left or Right and 1 kHz Right	7
All frequencies Left and 4 kHz Right	5
All Frequencies Left	3
500 Hz and 4 kHz left	4
All frequencies Right	4
500 Hz and 1 kHz Left	10
500 Hz and 1 kHz Right	5
500 Hz Left and Right, 1 kHz Left and Right and 4 kHz Right	1
500 Hz Left and Right, 1 kHz Left and Right and 4 kHz Left	1
500 Hz Left and Right, 1 kHz Left and Right and 2 kHz Left	3
2 kHz and 4 kHz Left	1
500 Hz and 4 kHz Left	1
500 Hz Left and Right, 1 and 4 kHz Left	1
All frequencies Left (Excl 4 kHz) and 1 kHz and 4 kHz Right	1
500 Hz, 1 kHz and 2 kHz Left	1
500 Hz, 1 kHz and 2 kHz Right	2
500 Hz, 1 kHz and 2 kHz Left and 500 Hz Right	1

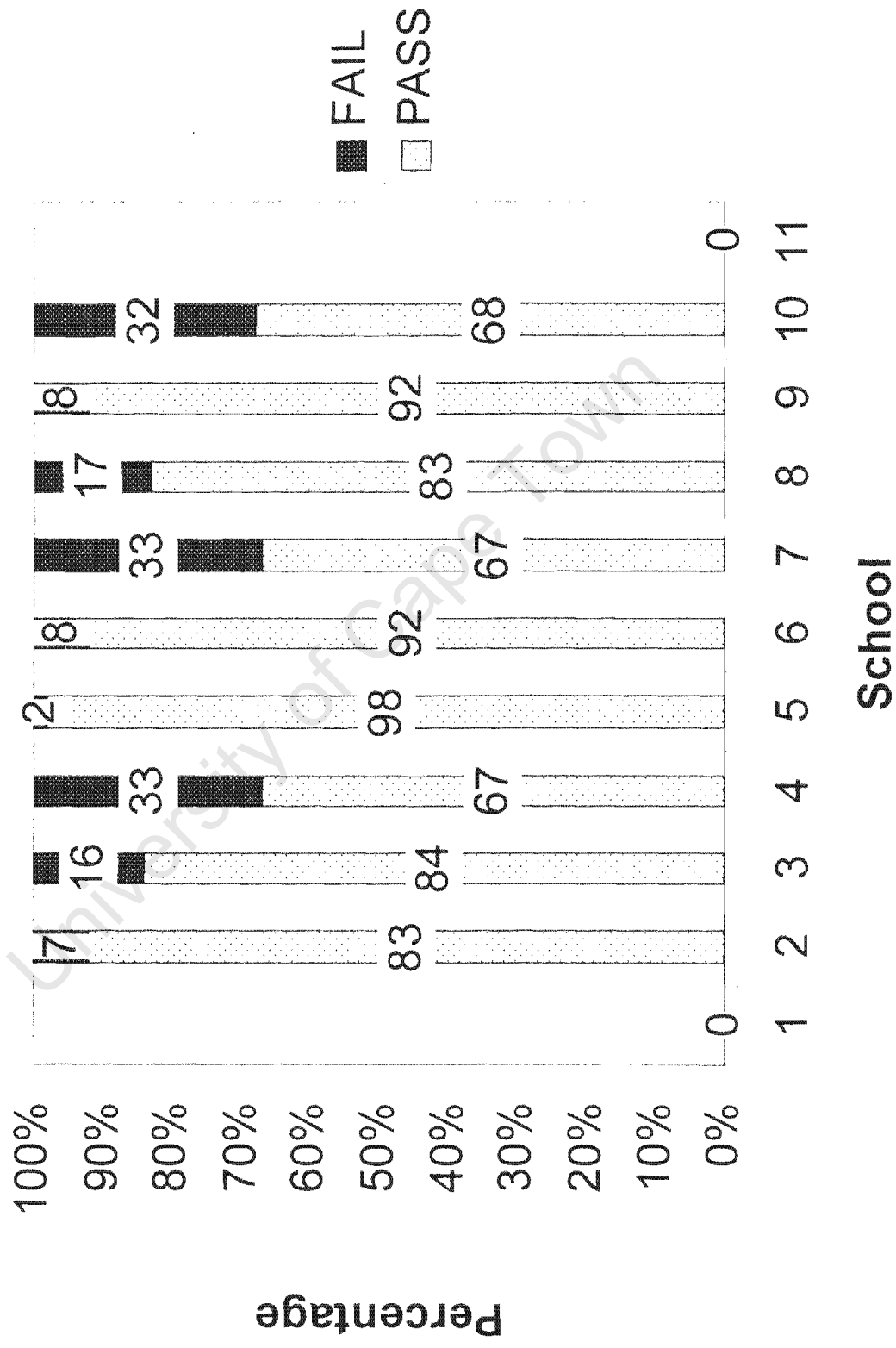
Appendix I

Laterality Differences for Hearing-screening Test



Appendix J

Performance of Pupils on the Hearing-screening Test as a Function of School



Appendix K

Percentage Agreement Information from the Questionnaire (Section B- Section E)

Section B

Question	'Strongly Agree'	'Agree'	'Uncertain'	'Disagree'	'Strongly Disagree'
1	50%	41%	0%	9%	0%
2	77%	23%	0%	0%	0%
3	55%	45%	0%	0%	0%
4	37%	59%	4%	0%	0%
5	86%	14%	0%	0%	0%
6	50%	45%	5%	0%	0%
7	0%	27%	73%	0%	0%
8	0%	0%	14%	55%	31%
9	18%	41%	41%	0%	0%
10	18%	50%	32%	0%	0%
11	23%	55%	18%	4%	0%
12	27%	64%	9%	0%	0%

Section C

Question	'Strongly Agree'	'Agree'	'Uncertain'	'Disagree'	'Strongly Disagree'
1	5%	45%	23%	27%	0%
2	0%	4%	4%	55%	37%
3	8%	40%	21%	22%	9%
4	5%	55%	20%	20%	0%
5	5%	9%	63%	23%	0%
6	5%	25%	47%	23%	0%
7	5%	32%	45%	18%	0%
8	9%	23%	59%	9%	0%
9	23%	55%	9%	9%	4%
10	9%	5%	72%	14%	0%
12	36%	50%	14%	0%	0%
13	14%	45%	41%	0%	0%
14	0%	14%	36%	45%	5%

Section D

Question	'Strongly Agree'	'Agree'	'Uncertain'	'Disagree'	'Strongly Disagree'
1	32%	68%	0%	0%	0%
2	32%	68%	0%	0%	0%
3	45%	41%	10%	0%	0%
4	59%	41%	0%	0%	0%
5	14%	58%	19%	9%	0%
6	45%	50%	5%	0%	0%
7	0%	14%	27%	32%	27%
8	0%	9%	14%	63%	14%
9	45%	55%	0%	0%	0%
10	18%	68%	14%	0%	0%
11	50%	50%	0%	0%	0%

Section E

Question	'Strongly Agree'	'Agree'	'Uncertain'	'Disagree'	'Strongly Disagree'
1	64%	36%	0%	0%	0%
2	59%	41%	0%	0%	0%
3	59%	41%	0%	0%	0%
4	68%	32%	0%	0%	0%
5	59%	41%	0%	0%	0%
6	50%	50%	0%	0%	0%
7	0%	0%	55%	45%	0%
8	59%	41%	0%	0%	0%
9	73%	23%	4%	0%	0%
10	4%	0%	0%	32%	64%

Appendix L

Verbatim Comments regarding Hearing Losses

Early identification of hearing losses is of key importance ($n = 7$).

- The earlier the better.
- Hearing losses must be picked up soon.
- Children must be identified at a young age.
- Children must be identified young.
- Pupils with loss must be seen to when it occurs and not wait.
- Early identification of hearing losses is essential.
- It is important to identify child while they are still young.

Urgent need to address children with hearing losses ($n = 1$).

- There is an urgent need to identify children with hearing losses ...

Knowledge of hearing losses and hearing-screening ($n = 12$).

Need for further awareness of temporary hearing losses and their effects on a child's development ($n = 4$).

- Parents and teachers should be made aware about temporary hearing loss caused by ear infection thus learners performance fluctuates.
- We need to be taught how a hearing loss affects a child's development.
- I need to know how a child with a hearing loss differs from other kids.
- I am unsure what special needs a child with a hearing loss needs to help them cope.

Effect of temporary hearing losses on a child's development (n = 2).

- Children with temporary hearing losses lag behind their peers.
- Children with hearing losses that come and go still have problems in many areas.

General lack of knowledge regarding hearing losses (n = 6).

- I think there is a problem with our clinics because when you identify a learner with a hearing problem and send him/her to the clinic, they don't do a thorough checking. He/She's given painkillers only.
- I need more information about hearing losses.
- I want to be taught all there is to know about hearing and hearing losses.
- People out there do not know about hearing losses.
- Our community does not know about hearing losses.

General lack of exposure to hearing-screening (n = 2).

- When I studied there were no modules on hearing-screening or what affects a hearing loss could have.
- I have only heard about hearing-screening from other teachers but have had very little exposure to it in my school.

Parental involvement in process (n = 3).

Parents need to play a larger role in process (n = 2).

- Parents should inform school whenever they suspect a hearing problem with their child.
- Parents must not sit back and wait for us to do everything.

Parents are aware of problem (n = 1).

- Most of the parents are aware of this problem.

Appendix M

Verbatim Comments regarding Hearing-screening

Purpose ($n = 4$).

Indicates what barriers may be present to hamper learning ($n = 2$).

- If a child fails a hearing test it shows us that this might be a problem in his learning path. We can then look at ways to overcome this barrier.
- It shows us what barriers may be present to hinder the child's learning process and gives us an indication of what problems he may incur.

Not a test of cognitive ability ($n = 2$).

- If a child fails a hearing test it does not mean they are dumb or anything as the test is not a test of how clever a child is.
- A hearing-screening test does not test a child's cognitive ability or intelligence but merely what they can hear and can't.

Follow-up ($n = 2$).

Further diagnostic testing should be performed as soon as child fails screener ($n = 2$).

- When a child fails the hearing-screening test it is important that they go a place where they can do further tests.
- There must not be a long wait between the screener and more tests at a hospital when a child fails as time is very important.

Appendix N

Verbatim Comments regarding Computers

Computer Training is Essential ($n = 4$).

Every educator should be trained in computer usage ($n = 2$).

- Every person should be taught how to use a computer. It is very important in today's world.
- Learning how to use a computer is very important.

Computer training should be made available to all pupils ($n = 2$).

- Computer skills should be taught to every pupil that enters grade 1.
- Children should be trained how to use a computer to help them with their work.

Advantages of computers ($n = 4$).

Computers are very useful ($n = 2$).

- It (Computers) is a really useful tool in the workplace. Programs on our computers at school are very useful for the learners.
- Computers are very helpful in my day to day work.

Less time consuming ($n = 2$).

- Computers help me save time at work and at home.
- Computers make a big difference with my work. I can save time and spend it then with the pupils.

Availability of computers ($n = 2$).

Should be more widespread ($n = 2$).

- Computers should be placed in every class in the country.
- Computers are great but we need many more in our schools.

Appendix O

Verbatim comments regarding learning new skills, such as hearing-screening

Importance of learning new skills ($n = 3$).

- As an educator/ individual it is imperative to learn new skills especially with inclusive education.
- It would be an advantage, especially in schools with a low socio-economic area. I think a lot of children with learning difficulties is a result of hearing loss.
- Being in a LSEN post it would be good to have these skills to test these learners (it would save a lot of time).

Advantages of learning new skills ($n = 4$).

- It will be interesting, will help me educationally, working with learners with special needs.
- It would definitely benefit me to do such a hearing training program. To analyze, diagnose barriers in learning.
- Being a learning support teacher you meet many children with a mild hearing loss and if you are trained you could assist the learner and sort out this problem.
- It is important that we who works with learners know what the problems are and how to address it.

Appendix P

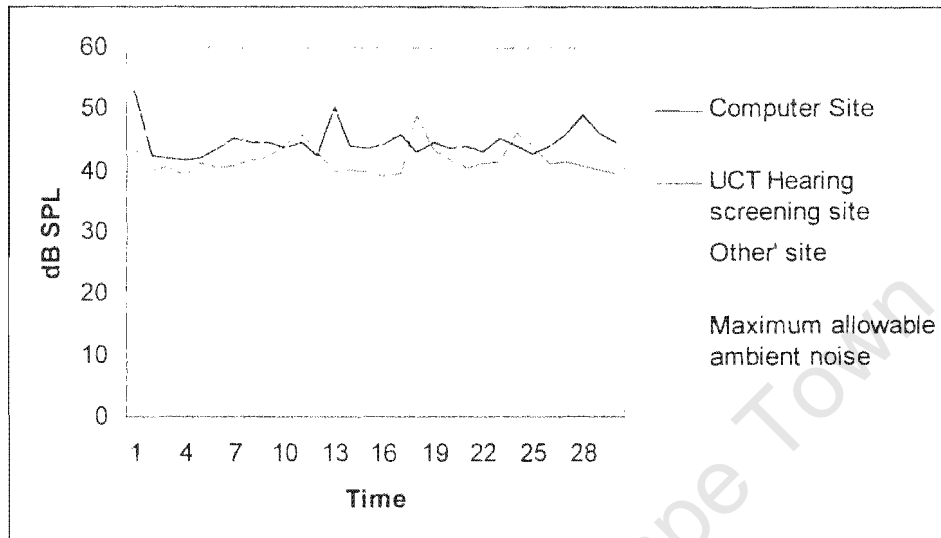
Detailed Noise Level Measurements at the UCT Hearing-screening Schools per Site

School	Computer Site	Hearing-screening site	'Other' site
1	44.7	41.78	45.15
2	42.24	44.41	45.97
3	48.93	39.11	50.97
4	44.06	46.41	38.55
5	45.86	49.2	55.1
6	42.7	44.7	59.3
7	45.2	42.89	47.05
8	49.7	44.3	44
9	43.05	44.65	51.4
10	50.4	41.6	42.13
11	41.7	38.81	46.01

Appendix Q

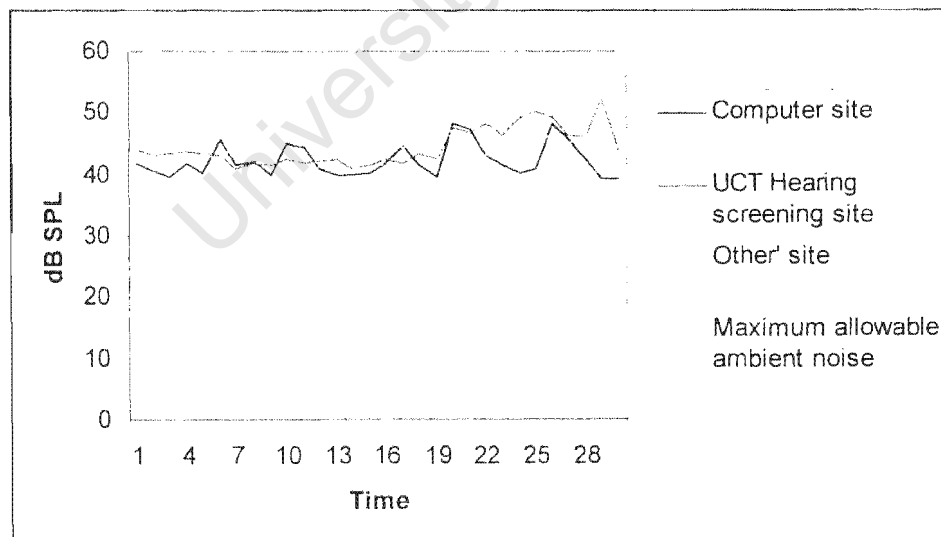
Noise level measurements at School's 1-11 as a function of time

Noise level measurements at **School 1** as a function of time



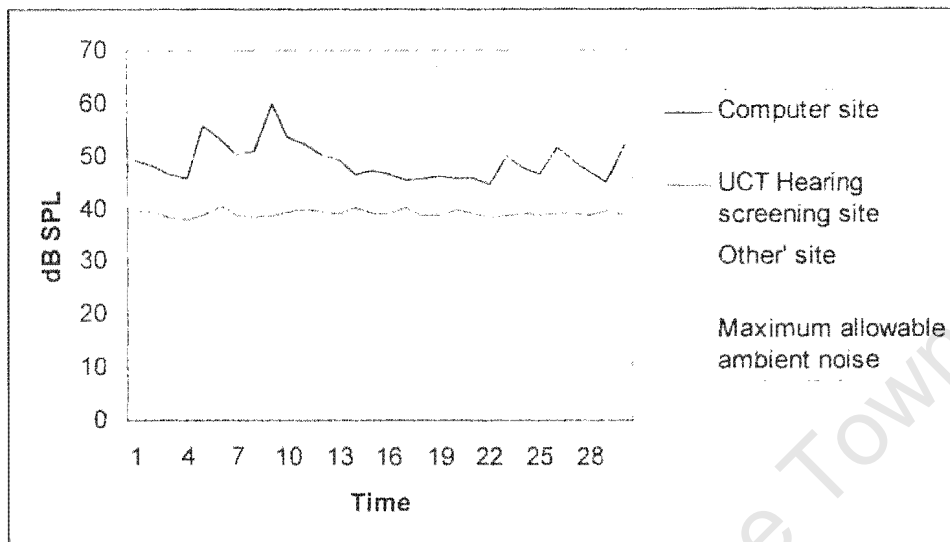
Note: Each time unit represents 10 seconds

Noise level measurements at **School 2** as a function of time



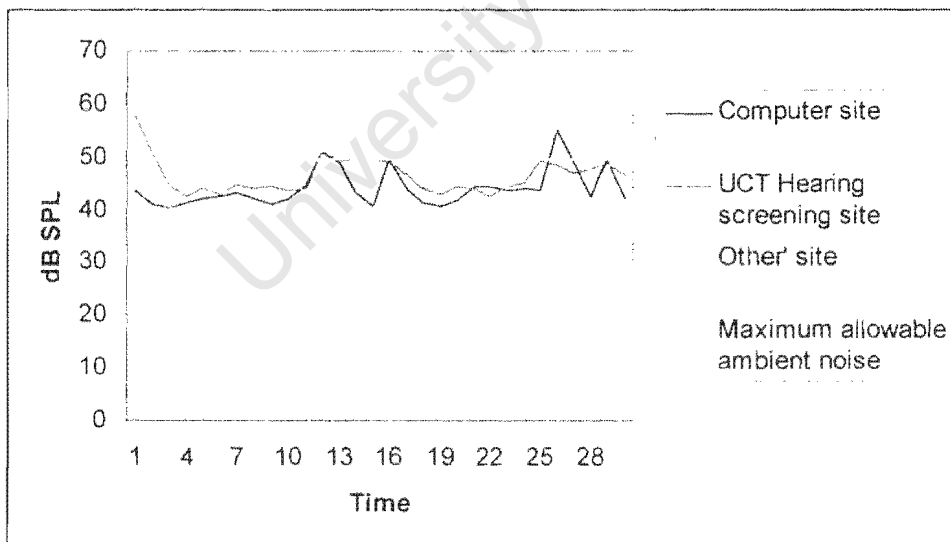
Note: Each time unit represents 10 seconds

Noise level measurements at **School 3** as a function of time



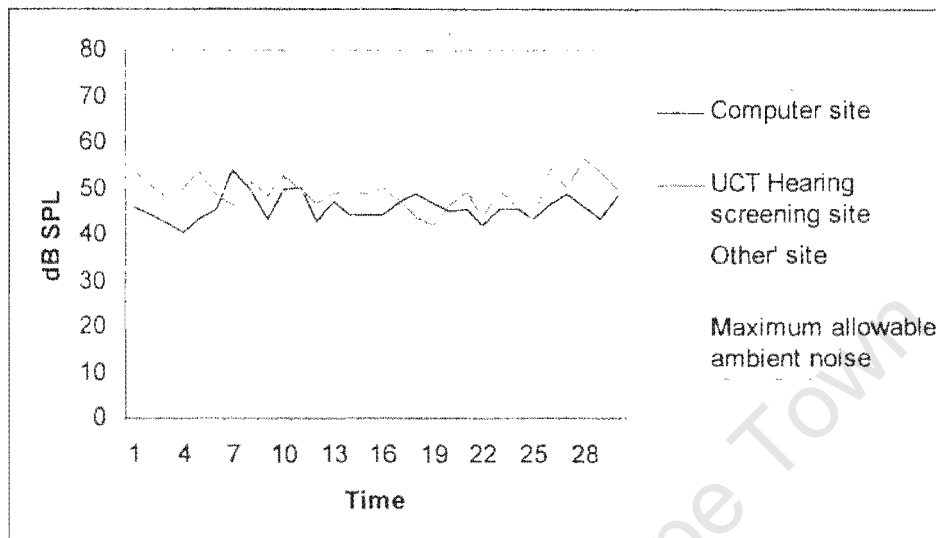
Note: Each time unit represents 10 seconds

Noise level measurements at **School 4** as a function of time



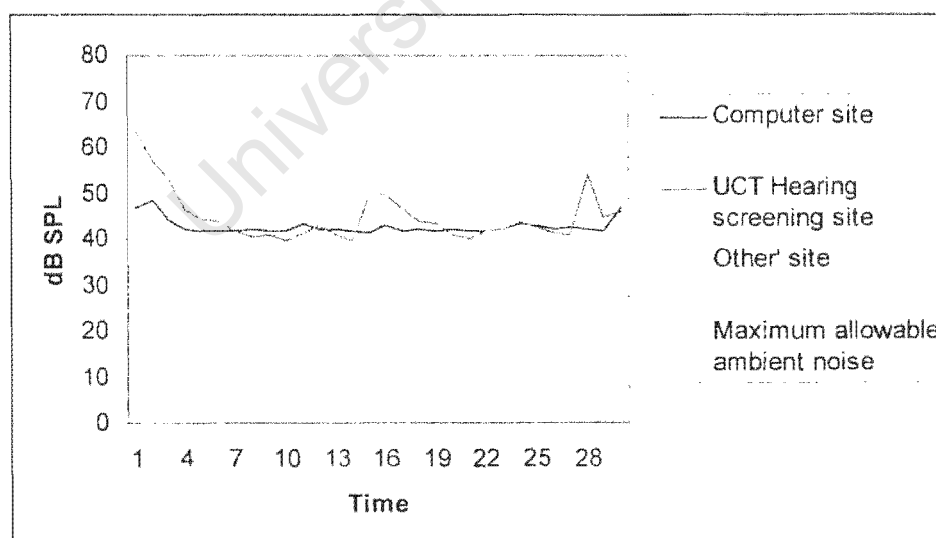
Note: Each time unit represents 10 seconds

Noise level measurements at **School 5** as a function of time



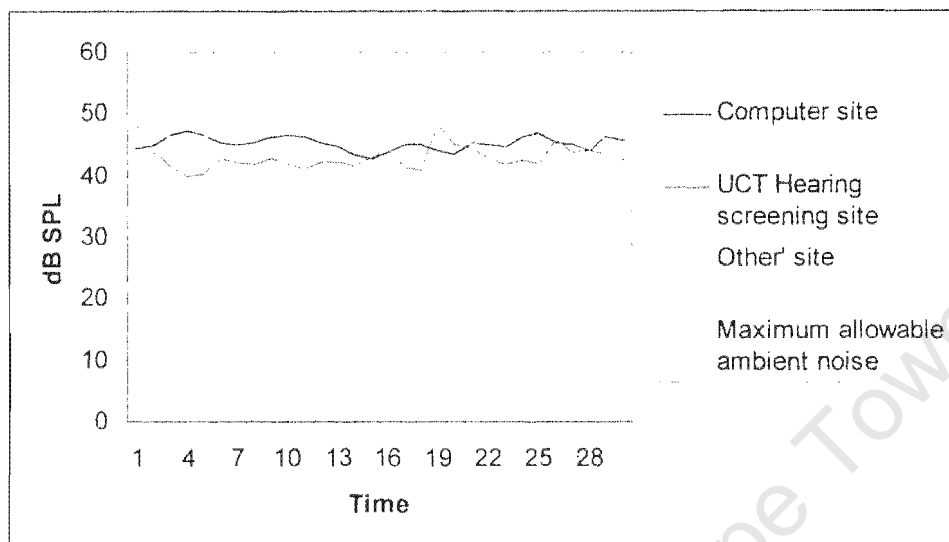
Note: Each time unit represents 10 seconds

Noise level measurements at **School 6** as a function of time



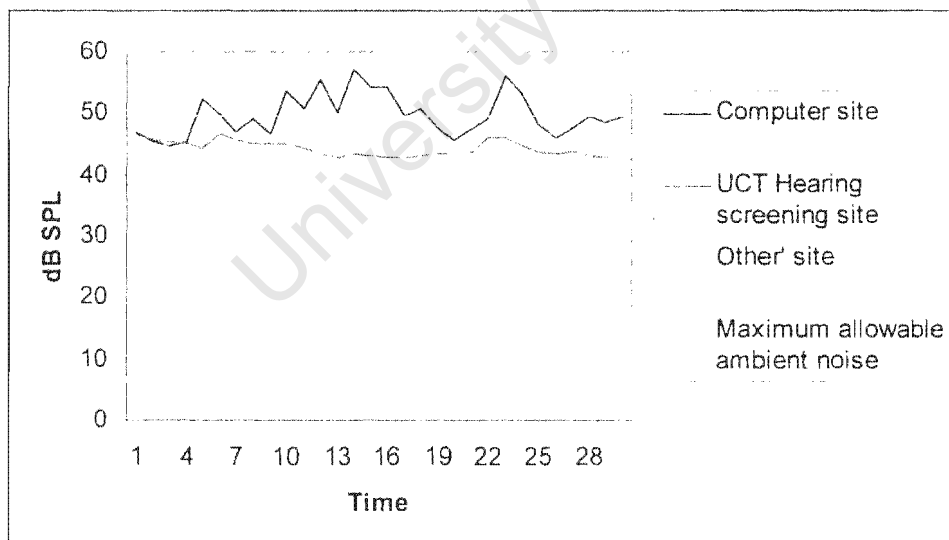
Note: Each time unit represents 10 seconds

Noise level measurements at **School 7** as a function of time



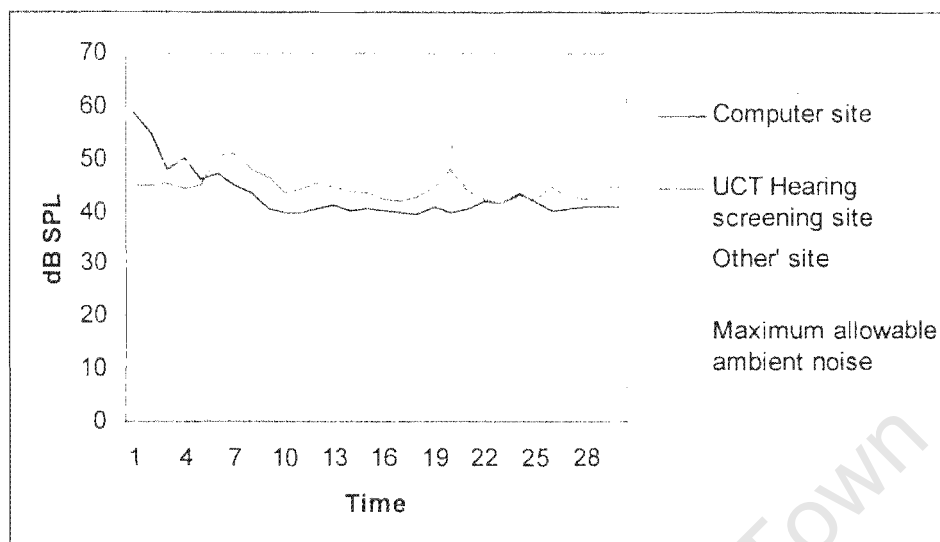
Note: Each time unit represents 10 seconds

Noise level measurements at **School 8** as a function of time



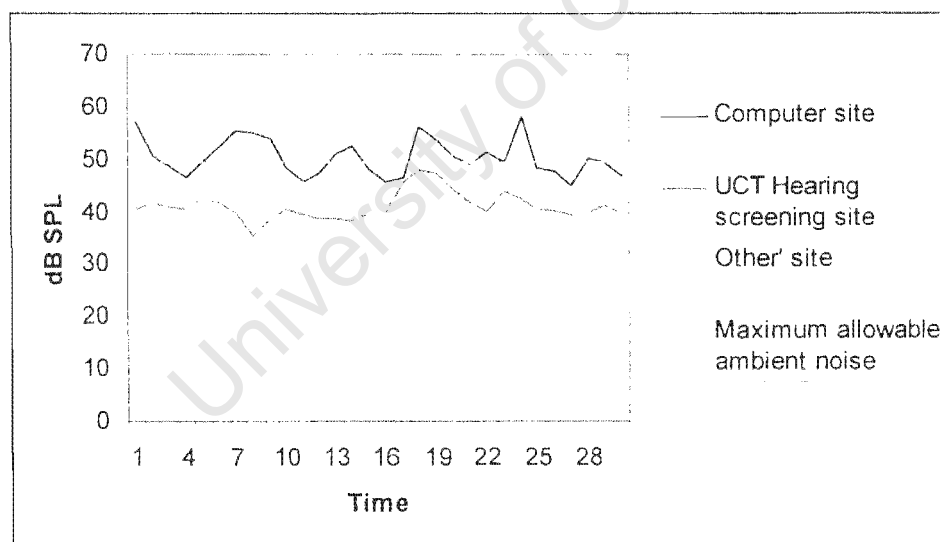
Note: Each time unit represents 10 seconds

Noise level measurements at **School 9** as a function of time



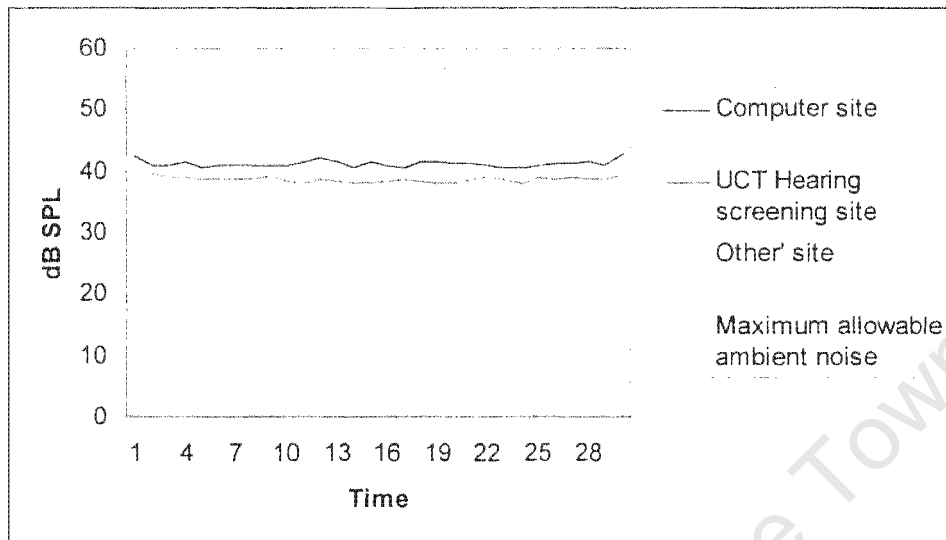
Note: Each time unit represents 10 seconds

Noise level measurements at **School 10** as a function of time



Note: Each time unit represents 10 seconds

Noise level measurements at **School 11** as a function of time



Note: Each unit of time represents 10 seconds

Appendix R

Comparison of hearing screening programs, including 500 Hz

Author	Year	Country	Referral	Frequencies tested	Referral criteria	Sample Size
Current study	2005	South Africa	14.0%	500 Hz, 1,2,4 kHz	25 dB HL	1101
Olusanya et al.	2000	Nigeria	13.9%	500 Hz, 1,2,4 kHz	25 dB HL	359
Jacob et al.	1997	South India	11.9%	500 Hz, 1,2,4 kHz	40 dB HL	284
Swart et al.	1995	Swaziland	3.3%	500 Hz, 1,2,4 kHz	30 dB HL	2430

Comparison of hearing-screening programmes, excluding 500 Hz

Author	Year	Country	Referral	Frequencies tested	Referral criteria	Sample Size
Current study	2005	South Africa	8.0%	1,2,4 kHz	25 dB HL	1101
Rao et al.	2002	South India	11.9%	1,2,4 kHz	25 dB HL	855
Hatcher et al.	1995	Kenya	5.6%	2,4 kHz	30 dB HL	5368
Elango et al.	1991	Malaysia	5.8%	1,2,4 kHz	20 dB HL	1307