

CHAPTER 6

RESULTS AND DISCUSSION

Aim: To present the results of the empirical research and to elucidate the meaning and significance thereof

6.1. INTRODUCTION

The move toward newborn and infant hearing screening at Maternal and Child Health (MCH) 6-week immunisation clinics, as recommended by the Professional Board for Speech, Language and Hearing Professions year 2002 HSPS (HPCSA, 2002:2), has created new challenges for audiological practice in the national healthcare system of South Africa. It has produced an obligation to conduct Essential National Health Research (ENHR), as recommended by the Department of Health (1997:15), to establish the feasibility of using these clinics as platforms for widespread infant hearing screening. This type of research is essential to the planning and implementation of widespread screening programmes that constitute the first step in establishing a South African Early Hearing Detection and Intervention (EHDI) system.

A theoretical underpinning for the implementation of newborn and infant hearing screening programmes including the justification for, current practice of, challenges in developing contexts and the status of EHDI internationally and in South Africa was provided in Chapters 2 to 4. Chapter 5 presented the methodological approach that supplied the operational framework for extracting the necessary data for addressing the main aim of this study. **The aim of this chapter is to describe an early hearing detection programme at two MCH**

clinics in a developing South African context and to discuss it in terms of relevant and comparable literature. Figure 6.1 provides a presentation of the sub-aims investigated to attain the main goal of the study.

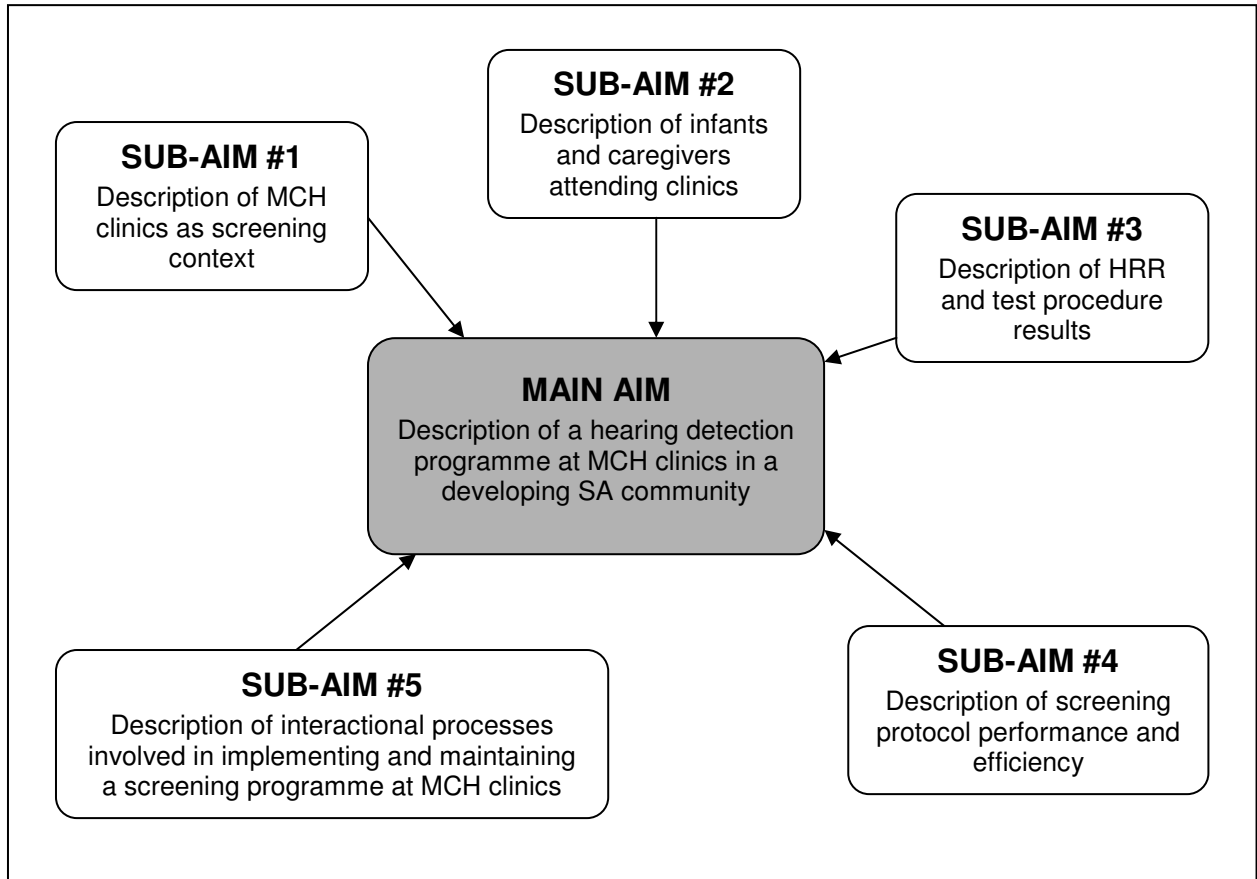


FIGURE 6.1 Sub-aims constituting the main aim of the current study

The descriptive results for all sub-aims will address the research question and attain the goal of the current study. According to Neuman (1997:367), comparison is the key to all research and the meaning and significance of results depend upon appropriate interpretation, relevant conclusions, and generalisations based on the analysed data (Smit, 1983:22). The results of the current study are presented and discussed according to the sub-aims as specified in Figure 6.1.

6.2. RESULTS AND DISCUSSION OF SUB-AIM #1: MCH CLINICS AS HEARING SCREENING CONTEXT

The first sub-aim of the study was to describe the two MCH clinics in the Hammanskraal community in terms of their suitability as a platform for conducting newborn and infant hearing screening. The descriptions were part of the less-dominant research method being qualitative in nature. All descriptions were recorded and analysed from field notes and critical reflections by the fieldworkers involved.

6.2.1. Presentation and discussion of results for sub-aim #1

A summary of the fieldworkers' descriptions classified in terms of assets and barriers posed by the MCH clinics as a context for hearing screening is presented in Table 6.1.

TABLE 6.1 Summary of qualitative results describing the clinics as screening platforms

CLINICS AS HEARING SCREENING CONTEXT

ASSETS:

- A room with enough space was made available at each clinic. At one clinic the testing room was separate from the rest of the clinic, which allowed for a quiet and controlled screening environment.
- Chairs and tables were available in each screening room.
- Gloves and disinfectant were supplied by clinic personnel.
- Electricity and enough power points were available for the equipment.
- Bathrooms with toilet facilities were available at each clinic although running water was not always present.
- Although facilities were not ideal they were adequate in both cases.

BARRIERS:

- External noise levels were the main problem. Noise was primarily due to mothers talking outside the test room; clinic staff moving through the screening area; nearby construction and a sewage

TABLE 6.1 Continued

truck which came every other day and halted screening for 30 minutes. If mothers outside were instructed to keep quiet during the screening they obeyed for a period of time and would have to be asked again after some time. It was also noted that noise levels were least early in the morning and became gradually more as noon approached.

- Running water was not consistently available.
 - Five electricity failures that lasted between one hour and one day were counted during the 6-month screening period.
 - A lack of large enough waiting rooms for all the caregivers and infants makes accommodating all persons in poor weather conditions difficult and causes noise levels that are too high to allow hearing screening.
 - Distance from Pretoria was noted as a significant barrier for fieldworkers to travel to and fro.
 - A poor gravel road had to be travelled on for 1 km before reaching each of the clinics – to the one clinic an especially poor road with many potholes had to be driven.
 - Safety was a concern at times. Unfamiliar men including an inebriated man illicitly entered the screening area on isolated occasions, alarming fieldworkers and caregivers.
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The prominent findings indicated both clinics had adequate basic (separate furnished room, toilet, electricity points) and support (gloves and disinfectant) facilities available for the implementation of infant hearing screening programmes. The most prominent barriers included high external noise levels due to patients, nursing staff, sewage trucks and construction. Other barriers were the travelling distance and poor roads with intermittent barriers including no running water, electrical power breaks, and safety issues.

Generally the developing contexts of the world are reported to have an absence of proper facilities for newborn and infant hearing screening (Mencher & DeVoe, 2001:19). The quality of primary healthcare clinic facilities is an important determinant of the satisfaction of patients and staff with the health service and South African healthcare facilities indicate much room for improvement (Day et al., 2004:343).

Previous reports indicated that South African clinics and especially rural clinics offer very little in the way of facilities, even though there may be adequate medicine available (Strachan, 1999:1). Although there is substantial variability

between provinces a national survey done in 2003 indicated that only 59% of primary healthcare facilities had adequate consultation rooms, 48% had adequate waiting areas, and only 42% had adequate toilets for patients and staff (Day et al., 2004:343). The current study also reported a lack of adequate waiting areas and although toilets were available for staff, running water was not always available. In addition to this, interruptions in electricity were also reported as a barrier. The survey of primary healthcare facilities indicated that although there has been a substantial improvement in water provision at facilities with 98% having on-site water supply, and electricity supplied to 95% of facilities, interruptions in supply were still far too frequent (Day et al., 2004:343). The fact that new hearing screening equipment is battery-operated means that short interruptions in electricity supply need not affect the screening process although longer breaks will certainly be a barrier.

The reported barrier of high noise levels in the current study is primarily due to inadequate waiting areas close to a room without soundproofing. Although this did not make screening impossible there were times in which the noise-levels were too high to screen in. Strategies to address this problem included regularly informing all caregivers in the waiting area regarding the importance of silence in order to conduct the screening and closing all doors and windows. Provision of adequate waiting areas as recommended by the 2003 survey of primary healthcare facilities (Reagon et al., 2004:29) will provide a solution to the barrier posed by excessive noise to the screening of infant hearing.

The reported safety concern at the clinics investigated in this study is also a significant problem identified by the 2003 survey of primary healthcare facilities (Reagon et al., 2004:34). The provision of adequate security measures is essential to ensure the protection and security of patients and staff. A call has been made for the improvement of security measures at the majority of these facilities especially those where the incidence of crime is highest (Reagon et al., 2004:34).

6.2.2. Summary of results and discussion for sub-aim #1

An investigation of MCH clinics as a screening context revealed the following conclusions as summarised in Table 6.2.

TABLE 6.2 Summary of results and discussion for sub-aim #1

Prominent obstacles to infant hearing screening which were evident in the clinics were:

- high noise levels
- interruptions in electricity and water supply
- safety concerns

Despite the obstacles observed at the MCH clinics and the identified areas requiring improvement, the clinics proved to be an adequate platform with sufficient basic assets for conducting an infant hearing screening programme.

6.3. RESULTS AND DISCUSSION OF SUB-AIM #2: INFANTS AND CAREGIVERS ATTENDING THE MCH CLINICS

The second sub-aim of the study was to describe the infants and caregivers attending the two MCH clinics in the Hammanskraal community. The descriptions are part of the dominant quantitative research method and were accrued by conducting a structured interview with caregivers and by consulting patient files. The results are presented and discussed for the infants first followed by the caregivers.

6.3.1 Description of infants attending the MCH clinics

The infants are described in terms of age and race in this section. The risk factors for hearing loss, which is a further description of the infants, is presented and discussed in sub-aim #3.

▪ **Infant age**

510 infants between the age of 0 – 12 months and with an even gender distribution (51/49%) were enrolled in the study. Figure 6.2 provides a distribution of the infants according to their age.

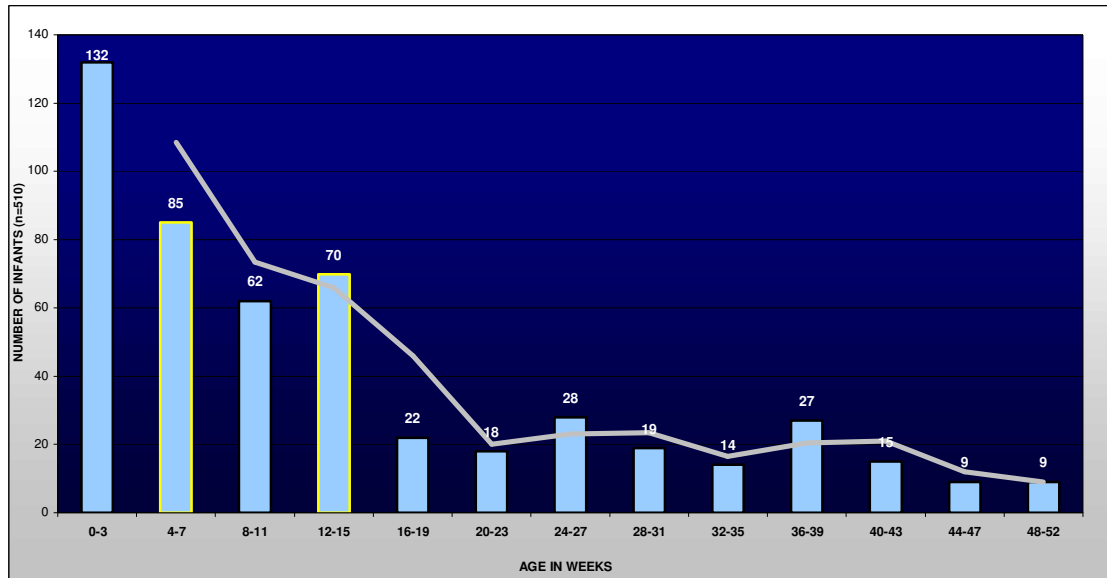


FIGURE 6.2 Age distributions of infants (n=510)

The mean age of the group was 14 weeks with 68% of infants younger than 16 weeks (4 months). The majority of infants were younger than or equal to 10 weeks of age. Figure 6.3 provides a frequency distribution of these infants younger than 10 weeks (n=252).

A large proportion (26%) of infants screened was younger than one month of age with 43% younger than two months and 55% younger than three months. The large number of infants younger than one month of age can be attributed to a significant number of births at the clinics and caregivers attending for an initial evaluation of their newborn infants. At the age ranges for scheduled immunisation visits a visible increase in attendance is evident (Figure 6.2) even though infants of all ages across the first year of life are represented. The scheduled immunisation visits are at 6 weeks of age, 14 weeks of age (3.5 months), and 36 weeks of age (9 months) (Day et al., 2004:404).

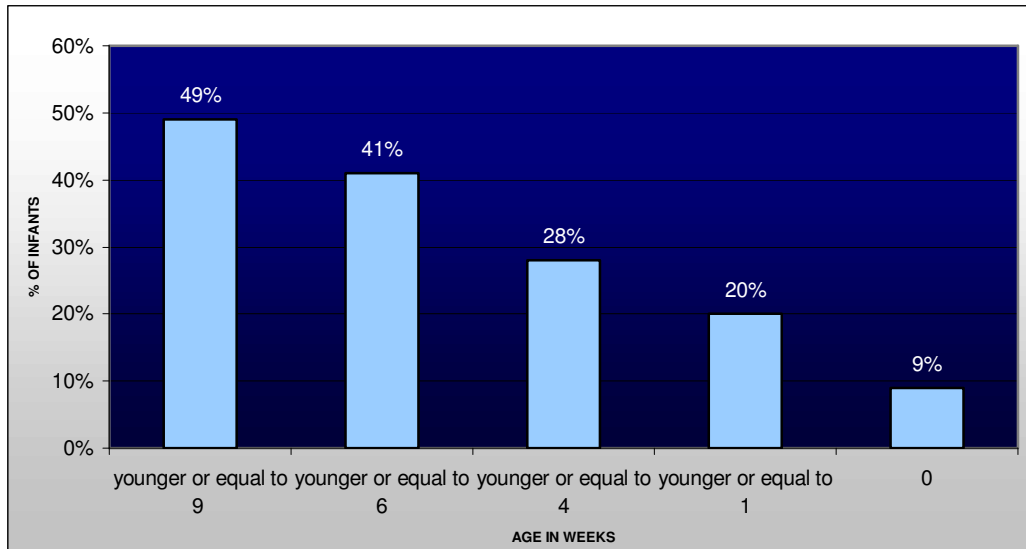


FIGURE 6.3 Frequency distribution of infants younger than 10 weeks (n=252)

▪ **Infant race**

The subject race was almost exclusively black (n=508) with the exception of two coloured infants. This is in agreement with the demographical indicators specified for this community, which is predominantly representative of black South Africans (Tshwane 2020 Plan, 2002:28). The mere fact that these infants are born as black South Africans places them in the least developed group of South African citizens with 66% of black South Africans living in poverty compared to less than 2% of white households, 8% of Asian households and 25% of coloured households (Woolard & Barberton, 1998:27). In addition to this the fact that the infants are from the Hammanskraal district also places them at an increased risk since it is a developing context characterised by socio-economic strains (Tshwane 2020 Plan, 2002:28,29).

6.3.2 Description of caregivers

The following discussion of results describing the caregivers is presented according to the questions in the interview schedule on the data recording sheet section A (Appendix A).

▪ **Primary caregiver and marital status of mother**

Figure 6.4 provides the number of different primary caregivers for the infants in this sample.

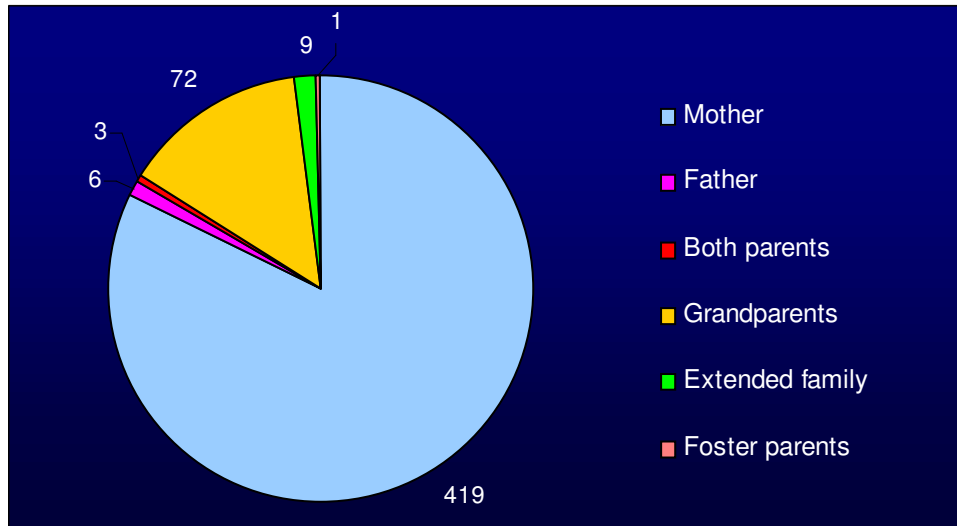


FIGURE 6.4 Primary caregivers of infants (n=510)

Single mothers were the primary caregivers in 82% of cases with both parents involved for only three cases. The second largest numbers of primary caregivers were the grandparents, who comprised 14% of the sample. Figure 6.5 provides a graphical presentation of the marital status of the mothers to the infants included in this study.

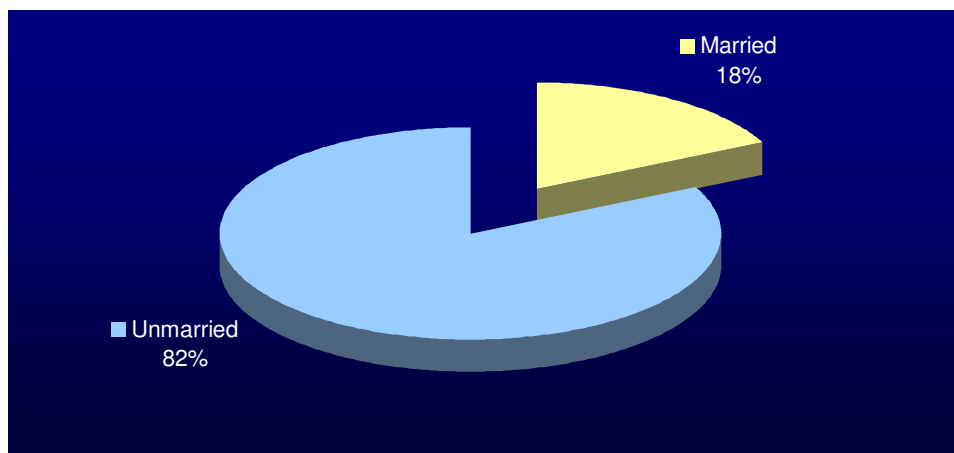


FIGURE 6.5 Marital statuses of mothers (n=504)

South Africa has seen an increase in female-headed households with a staggering 42% of South African children younger than seven years of age reported in 1995 to be living only with their mother (Nyman, 1999:4). The figure is almost twice as high in the current study. Possible reasons for the high percentage of single mothers in the current study left to care for the children are probably due to the following reasons:

- Peri-urban developing community representing the most underprivileged sections of the South African population (Tshwane 2020 Plan, 2002:28).
- High numbers of children are born out of formal partnerships (Children in 2001, 2001:55).
- High number of pregnancies among teenagers in temporary relationships (Children in 2001, 2001:55).
- A number of South African men establish dual households. Typically a man from a rural area will establish a second town household (Children in 2001, 2001:55).

It is not uncommon, with a reported 25%, for grandparents to be the primary caregivers of children in South Africa (Children in 2001, 2001:55). This is often due to the mother and/or father working far away from home or due to death, which is increasingly becoming the case with the spreading HIV/Aids pandemic (Children in 2001, 2001:55). It is therefore not surprising that grandparents are playing an increasing important part in caring for the children of South Africa.

These factors also hold important implications for EHDl programmes since effective early intervention is heavily reliant on parental or caregiver involvement (JCIH, 2000:17). Single mothers and grandparents are under increasing strain due to economic pressure and the breakdown of the family structure and single parenthood places a child at an increased risk for developmental delays (Rossetti, 1996:6; Children in 2001, 2001:55). In addition to this, the breakdown of family structures create stressors, which could seriously impede the nurturing of family-centred intervention programmes for infants identified with hearing loss.

▪ **Age of mothers and number of children**

The age of mothers of infants in this study varied between 15 to 43 years. Figure 6.6 provides the distribution (in percentage) of mothers for different age categories.

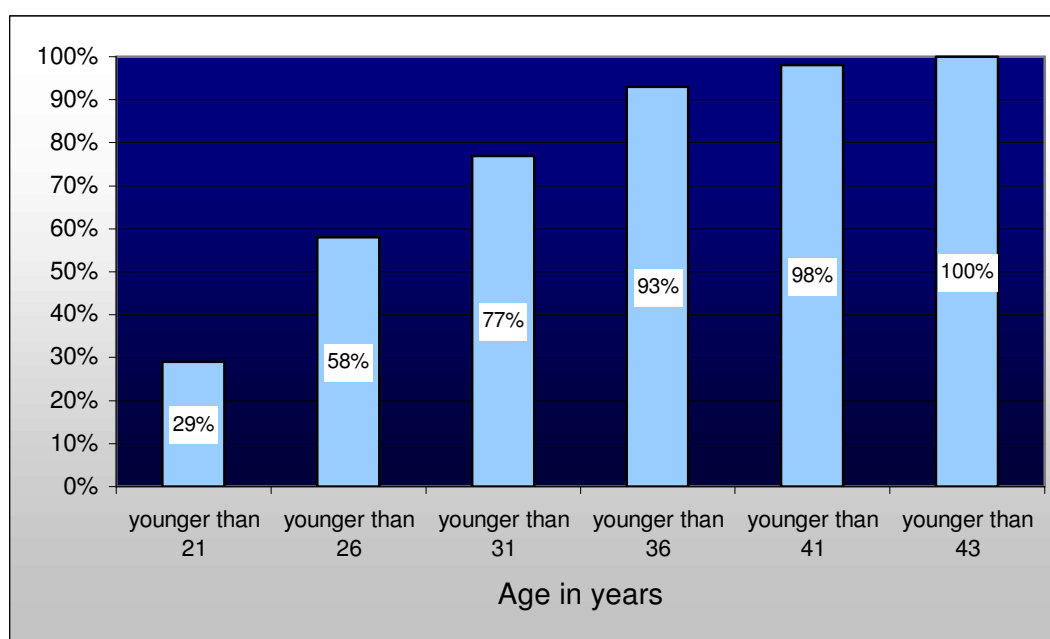


FIGURE 6.6 Frequency distribution of mothers according to age (n=510)

It is clear that majority of mothers are in their late teens and early twenties. 58% of the mothers were 25 years of age and younger with almost two-thirds (29%) of mothers 20 years of age and younger. The numbers of children borne of mothers included in this study are presented in Table 6.3.

TABLE 6.3 Number of children borne of mothers (n=503)

# of children by mother	1	2	3	4	5	6	7	9
# of mothers	217	148	71	38	20	6	2	1
# of sample	43 %	29 %	14 %	8 %	4 %	1 %	0.4 %	0.2 %

A majority (72%) of the mothers had 1 or 2 children. This corresponds to the high percentage of young mothers in the sample who had their first or second child. 21% of mothers were 19 years of age and younger meaning that they were still school-going age and 29% were 20 years of age and younger. These percentages are in close approximation of the estimated South African average of 19% of female learners (18 years of age) and 30% of females 19 years of age who have been pregnant at least once (Bhana, 2004:131; Department of Health, 1999:38). The high incidence of teenage pregnancies is not surprising considering a 41% sexually active teenage population in South Africa exacerbated by limited use of contraceptives (Bhana, 2004:132).

It is a common fact in maternal and child health programmes that the youngest mothers are at the highest risk for adverse reproductive and parenting outcomes (Ventura et al., 1998:6). The high rate of teenage pregnancies in this study therefore increases the risk of developmental disabilities in this community. This is even more so due to an increased low-birth weight incidence present in adolescent mothers, which already predisposes the infant to developmental disorders such as hearing loss (Rossetti, 1996:21; Northern & Downs, 2002:284). Another factor that must be considered is the increase in school dropout rates among adolescent mothers, which adds to the economic burden of the household and limits future prospects due to poor education (Children in 2001, 2001:82).

These factors put this community at an increased risk for having a higher incidence of developmental delays and disabilities (Kubba et al., 2004:125; Rossetti, 1996:21-22) and it is these same factors that have been reported to correlate with mothers who do not complete the infant hearing screening/follow-up process (Prince et al., 2003:1204). This population, therefore, is at risk not only for developmental delays and disabilities but also for not completing the screening/follow-up process.

▪ **Home languages**

The home languages of the families were primarily Tswana (37%) and Shangaan (31%). Figure 6.7 gives the percentages of different languages spoken by the families.

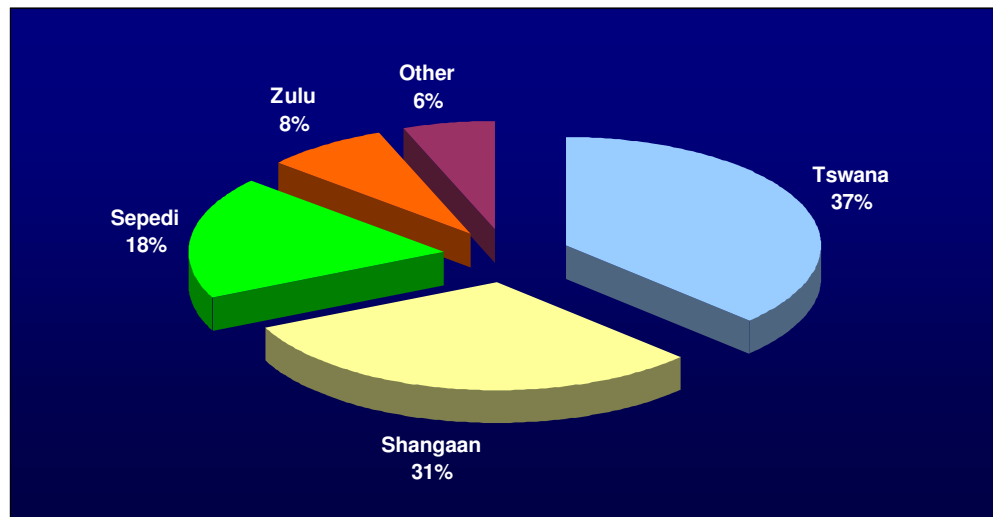


FIGURE 6.7 Home languages of families (n=508)

A variety of home languages were recorded with Tswana being the most prominent in this community. The group speaking other languages included African languages such as Xhosa and Ndebele and one English-speaking and two Afrikaans-speaking families.

The diverse number of languages poses a significant challenge to delivering culturally sensitive early intervention services to infants with hearing loss in their home language. This is especially so since early intervention services should be based on a family-centred approach where professionals empower the family to provide the best stimulation and guidance for their infant (JCIH, 2000:17). Currently, only a very small percentage of African language mother tongue speakers have qualified as audiologists (Uys & Hugo, 1997:24). Thus, delivering linguistic and culturally appropriate EHDI services to this population remains a significant challenge that can only be met by training more audiologists and

speech-language therapists fluent in African languages or by the use of interpreters in an accountable responsible manner.

▪ **Educational qualifications of parents**

The highest educational qualifications attained by the group of mothers and fathers are presented in Figure 6.8.

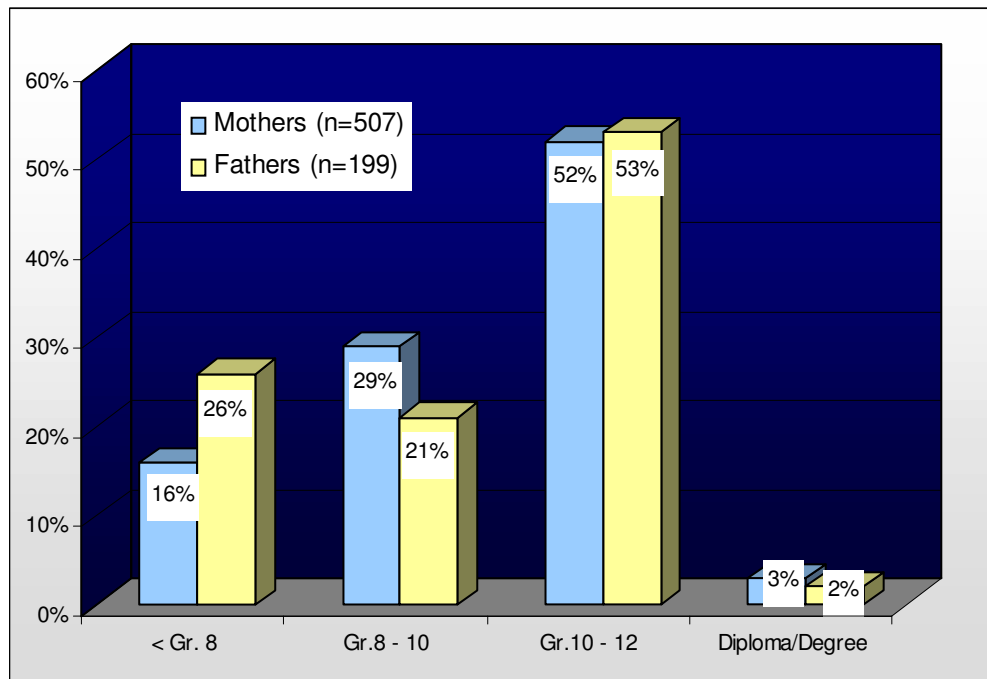


FIGURE 6.8 Educational qualifications of mothers (n=507) and fathers (n=199)

The majority (52%) of mothers had a grade 10 to 12 educational qualification. A significant percentage (26%) of the fathers had obtained less than a grade 8 school qualification and this figure rises to 47% if all fathers with a less than a grade 11 school qualification is considered. In general, the fact that the number of responses for paternal educational qualifications is much less than for the mothers and that caregivers, who were mostly mothers, reported the fathers' qualifications must be considered as possible factors which may affect the results.

Previous reports have indicated that 1 in five African females have had no education at all (Central Statistics, 1998:11). There has, however, been a steady improvement in educational qualifications among South Africans with a reported 28% of Africans between 20 – 24 years of age having obtained at least a grade 12 qualification (Central Statistics, 1998:11). Very few post grade 12 educational qualifications were reported for both fathers and mothers. According to a large study with a cohort of 17,091 infants and caregivers in Hawaii the mothers who had not completed high school were less likely to have their infant complete the hearing screening/follow-up process than were more educated women (Prince et al., 2003:1204). Educational level is therefore significantly correlated to the completion of a screening/follow-up process.

A close correlation also exists between educational qualification and unemployment. Among the economically active in South Africa, the proportion of unemployed is 34% or higher for those who have attended but who have not completed school and drops to 18% among those who have completed at least Grade 12 (Central Statistics, 1998:18). According to these figures the vast majority of mothers and fathers in this study are at risk for unemployment. This is a certain risk factor for child development since secure parental employment is one of the factors most closely related to child well being (Children in 2001, 2001:34).

The poor level of education and subsequent high vulnerability to unemployment are factors that place the population of infants in this study at an increased risk for developmental delays and disabilities as well as for poor involvement of parents in the early hearing loss detection and intervention process (Prince et al., 2003:1204; Rossetti, 1996:5-6).

▪ **Average household income**

The distribution of average household incomes recorded for this study is presented in Figure 6.9.

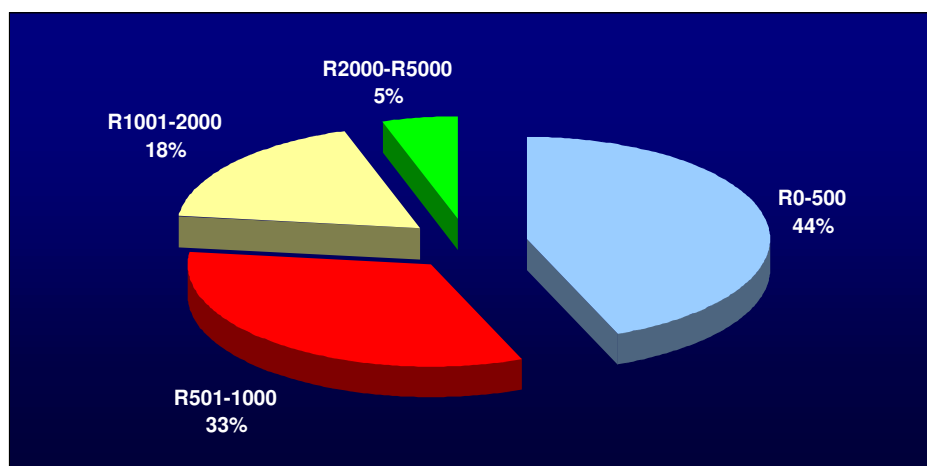


FIGURE 6.9 Average monthly household income (n=184)

A significant majority of respondents (77%) reported an average monthly household income less than R1000. And only a small minority (5%) reported an average monthly household income of more than R2000. According to the 1996 Census, African women earned the least with 47,5% earning less than R500 per month and a further 21,4% earning between R500 and R1000 (Census, 1996:49). This is comparable to the results in of the current study with 44% of households earning less than R500 per month and a further 33% earning between R500 and R1000. The only difference is that this data comes from seven years after the census date. Also, the fact that inflation has taken its toll over these years, exacerbates the picture of poverty in Hammanskraal.

Poverty is unequally distributed between race with 61% of Africans classified as poor compared to 38% of coloureds, 5% of Indians and 1% of whites (Children in 2001, 2001:34). The almost exclusively African sample taken in this study is therefore a large contributing factor to the poverty evident in this sample. Another major reason for the poverty evident in this study, apart from the developing peri-urban region itself, is the fact that the sample is primarily represented by female-headed homes which are more likely to be poor than those headed by a resident male (Children in 2001, 2001:34).

Poor households have less access to essential services such as water and sanitation, communications, roads and energy sources, particularly in rural and peri-urban regions such as Hammanskraal (Children in 2001, 2001:34). These factors create enormous time burdens on poor households and promise to be serious barriers to the implementation of family-centred early intervention services for infants with hearing loss. On the other hand, poverty related stressors also place this population of infants at an increased risk for developmental delays and disabilities such as hearing loss (Kubba et al., 2004:125; Rossetti, 1996:5-6), which emphasises the need for early detection and intervention programmes.

6.3.3 Summary of results and discussion: sub-aim #2

The description of infants and caregivers sampled for this study indicates that this developing Hammanskraal population is a predisposed high-risk group. The factors placing the infants at risk and the most prominent implications are summarised in Table 6.4 (Kubba et al., 2004:125; Rossetti, 1996:21; Prince et al., 2003:1205):

TABLE 6.4 Summary of results and discussion for sub-aim #2

Risk factors

- The sample consisted of predominantly single unmarried (82%) mothers in female-headed family structures, which are more prone to poverty than male-headed families (*Children in 2001*, 2001:55)
 - The majority (58%) of mothers are 25 years old and younger with almost two-thirds of the mothers (29%) school-going age. Teenage pregnancies constitute a biological and environmental risk factor because of an increased low birth weight incidence and higher school dropout rates adding to the economic burden of the household (Ventura et al., 1998:6; *Children in 2001*, 2001:82).
 - An extremely small number of parents had obtained post-Grade 12 qualifications and the majority had not yet obtained a Grade 12 education. The fact that education level is a significant predictor of mothers completing the hearing screening/follow-up process and of unemployment, is one of the factors that most closely affect child well-being and that put this sample at increased risk (Prince et al., 2003:1205; Central Statistics, 1998:18; *Children in 2001*, 2001:34).
 - The average household income evidenced outright poverty, which causes enormous burdens on families and results in poorer education opportunities and increased risk of teenage pregnancy (Census, 1996:49; *Children in 2001*, 2001:34 & 82).
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TABLE 6.4 Continued

These factors have a two-fold implication for implementation of EHDI programmes among developing populations such as the sample taken from the Hammanskraal community:

1. These factors are indicators of socio-economic depravity, which has been associated with an increased incidence in congenital hearing loss and which was discussed in Chapter 3 (Kubba et al., 2003:125). Thus this population of infants and caregivers are at an increased risk of having a congenital hearing loss, which emphasises the importance of infant hearing screening programmes.
 2. Secondly, the mentioned socio-economic burdens and environmental risk factors cause increasing stressors (*Children in 2001*, 2001:34), which erect barriers toward delivering effective hearing screening and follow-up services, including family-centred early intervention. Thus, the study population is at higher risk for congenital hearing loss, insufficient participation in the hearing screening/follow-up process, and subsequent poor involvement in a family-centred early intervention process for infants identified with hearing loss.
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6.4. RESULTS AND DISCUSSION OF SUB-AIM #3: HIGH-RISK REGISTER AND TEST PROCEDURE RESULTS

The third sub-aim of the study aimed to describe the results of the High-Risk Register (HRR) and test procedures conducted for the infants and caregivers attending the two MCH clinics in the Hammanskraal community. The descriptions are part of the dominant quantitative research method and were accrued by conducting a structured interview with caregivers and consulting patient files for identifying risk indicators, and by performing various tests of auditory integrity. The results and discussion will be presented according to the results for each procedure (HRR, High frequency immittance, OAE, AABR) followed by a section concerning these procedures for subjects returning for follow-up appointments.

6.4.1. High-Risk Register results

The following presentation and discussion of results represent data collected by completing the HRR during the caregiver interview supplemented by the clinic file (Appendix A, Section B). The obtained results are summarised in Table 6.5.

TABLE 6.5 Summary of the risk indicators for the sample

RISK INDICATOR	RESULT		DESCRIPTION
a) Family History of childhood hearing loss (n=501)	YES	13 %	65 subjects reported a family history of childhood hearing loss
	NO	87 %	
	No info	0.4 %	
b) Hyperbilirubinaemia (n=500)	YES	0.2 %	Only 1 subject had reported high bilirubinaemia levels and only this subject had the levels available
	NO	98.6 %	
	No info	1.2 %	
c) Congenital infections (n=495)	YES	5 %	Syphilis – 17 Rubella – 1 HIV – 5
	NO	95 %	
d) Craniofacial defects (n=506)	YES	1 %	7 subjects – atresia and ear tags
	NO	99%	
e) Birth weight less than 1500 grams (n=503)	YES	1 %	6 subjects weighed less than 1500 grams and info was unavailable for 1
	NO	99 %	
	No info	0.2 %	
f) Bacterial meningitis (n=500)	YES	0 %	No subjects reported bacterial meningitis
	NO	99.4 %	
	No info	0.6 %	
g) Asphyxia (n=500)	YES	0.8 %	3 subjects had a 1 min Apgar less than 4 and 1 subject had a 5 min Apgar less than 6
	NO	97.8 %	
	No info	1.4 %	
h) Ototoxic medication (n=504)	YES	1.2 %	6 subjects were reportedly exposed to ototoxic medication
	NO	97 %	
	No info	1.8 %	
i) Persistent pulmonary hypertension. Prolonged mechanical ventilation \geq 5 days (n=504)	YES	0.4 %	2 subjects were reported to have persistent pulmonary hypertension
	NO	98.6 %	
	No info	1 %	
j) Syndrome present (n=504)	YES	0.2 %	1 subject had a syndrome – Albinism
	NO	99.8 %	
k) Admitted to the NICU for more than 48 hours (n=505)	YES	2.4 %	12 subjects were admitted to the NICU for between 3 and 30 days
	NO	97.6 %	

Risk indicators were reported for all categories except meningitis. The cases where no information regarding risk factors was available either in the clinic file or from the caregiver varied between 0,3 and 1,8% across the different risk categories. In the majority of these cases a relative brought the infant and the mother was not present to provide all the required information. The high response rate for reporting risk indicators indicates promise for the effective use of a HRR for this population in a MCH clinic.

The distribution of the reported risk indicators for the current study is presented in Figure 6.10.

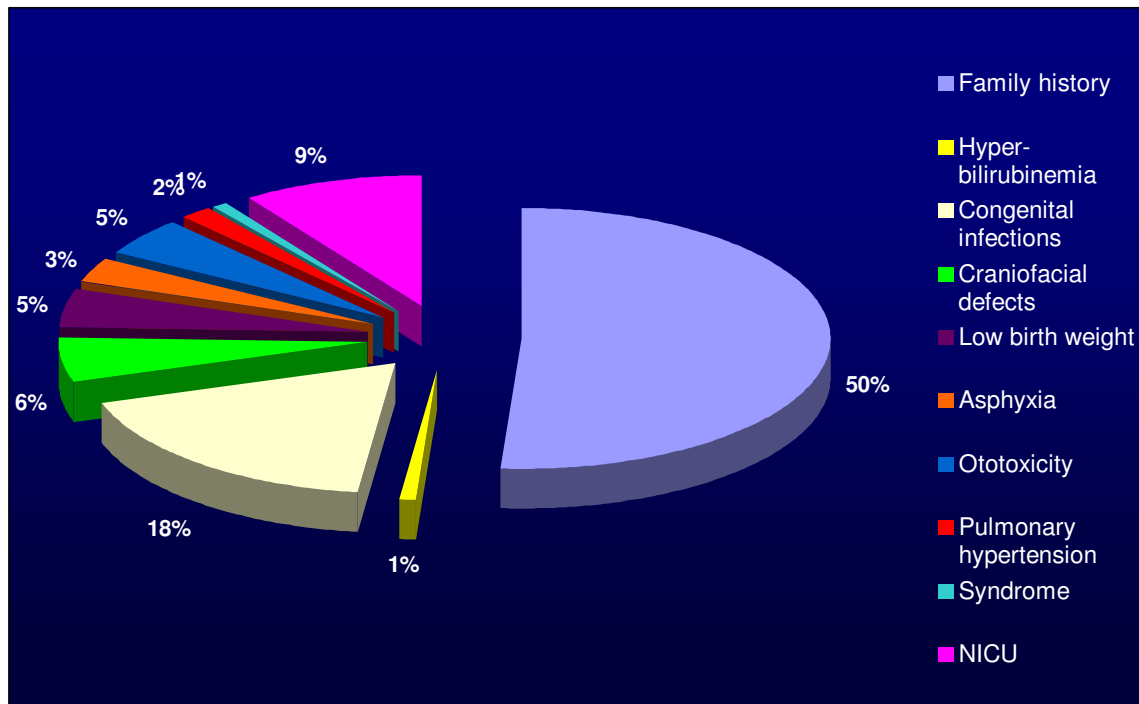


FIGURE 6.10 Distribution of risk indicators identified for the sample (n=127)

The risk factor with the highest incidence was family history of congenital hearing loss (13%) followed by congenital infections (5%), NICU admittance (2,4%), ototoxic medication (1,2%), low birth weight (1%), craniofacial defects (1%), asphyxia (0,8%), persistent pulmonary hypertension (0,4%), presence of a

syndrome (0,2%) and hyperbilirubinaemia (0,2%). The risk factors present in the group of NICU infants (n=12), from most prevalent to least, included low birth weight (n=5), asphyxia (n=4), ototoxic medication (n=4), family history (n=2), and craniofacial defects (n=1).

The incidence of all risk factors in this study, except for family history of congenital hearing loss, is similar to previous reports. Kennedy et al. (1998:1959) in a sample of 21,279 infants reported incidences of 6,6% for family history of hearing loss; 4,2% for congenital infections; 1% for asphyxia; 0,2% for chromosomal abnormalities; and 0,3% for exchange transfusion due to high bilirubinaemia levels. The fact that family history was the most prominent risk factor in this study is similar to previous studies investigating large samples of infants differing only by the incidence margin (Mahoney & Eichwald, 1987:160; Kennedy et al., 1998:1959; Vohr et al., 2000b:380). Previous studies have reported a 6 to 7% incidence of family history of congenital hearing loss compared to the 13% reported in the current study (Mahoney & Eichwald, 1987:160; Kennedy et al., 1998:1959; Vohr et al., 2000b:380).

The high incidence of family history of congenital hearing loss in the current study may be explained by two possible factors. Firstly, depravity is known to correspond with increased incidence rates of congenital hearing loss (Kubba et al., 2004:125) and therefore the existing depravity in this community as evidence in discussion of sub-aim #1 can contribute to this high incidence of family history with congenital hearing loss. The second reason relates to the difficulty in obtaining an accurate history of family hearing loss and the importance of correctly phrasing the question to avoid misunderstandings or erroneous responses (Cone-Wesson et al., 2000:501; Kountakis et al., 2002:136; Northern & Downs, 2002:277). It is possible that caregivers misunderstood or misinterpreted the posed question and gave an incorrect answer, which may have inflated the incidence slightly. This risk factor, however, is very important since it is commonly reported as the most prevalent (22 – 42%) risk factor in at-risk children identified with hearing loss and therefore accurate documentation of its presence is essential (Vohr et al., 1998:355; Mahoney & Eichwald, 1987:160).

This emphasises the importance of parent or caregiver education and counselling about the increased risk for hearing loss when there is a family history.

Another important aspect requiring consideration is the incidence of congenital infections reported by mothers in this study. Due to the HIV/Aids pandemic in South Africa, with an estimated 11,4% of the general population infected, HIV was included as one of the congenital infection risk factors for infants in this study (Department of Health, 2002:4; UNAIDS, 2003:2). Children born of HIV/Aids infected mothers are at increased risk for hearing loss due to significantly lower birth weights, increased vulnerability for acquiring infections such as meningitis and cytomegalovirus (Spiegel & Bonwit, 2002:128). These children are also at a much greater risk of developing otitis media, which results in conductive hearing loss that may lead to sensori-neural hearing loss in certain cases (Bam, Kritzinger & Louw, 2003:40; Matkin et al., 1998:153; Singh et al., 2003:2).

The fact that only five mothers, comprising only 1% of the sample, indicated that they were HIV infected compared to a reported 26,5% of women attending MCH clinics in South Africa being infected, indicates gross underreporting in the current study (Mngadi, 2003:1). According to the estimated average rate of HIV infection in this population of mothers approximately 135 should have reported being infected. This under reporting can be ascribed to a number of reasons including unawareness among mothers regarding their status or reluctance to disclose such information.

A recent initiative implemented by the Department of Health aimed at increasing the HIV testing rate among mothers attending their first antenatal visit promises to improve awareness of HIV status. This will provide representative coverage since 96,9% of mothers in South Africa are reported to attend at least one antenatal visit (Doherty & Colvin, 2004:195; Smit et al., 2004:63). Reluctance among mothers to disclose HIV status may be due to fear of isolation or stereotyping but requires further investigation in the South African context as it

relates to disclosing HIV status as a risk factor for hearing loss. Another aspect that requires investigation is collaboration with nursing staff to assist in the documentation of risk factors and acquisition of HIV status. This may ensure more reliable and comprehensive documentation of risk indicators for hearing loss.

The distribution of the number of risk factors present for subjects identified as at-risk in the sample (n=510) is presented in Figure 6.11.

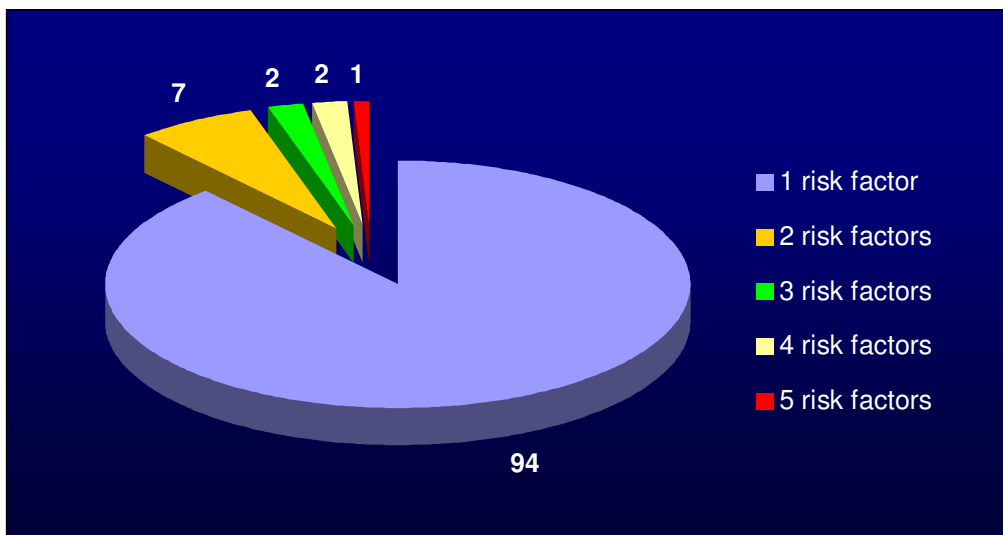


FIGURE 6.11 Number of infants with one or more risk factors (n=106)

In the current study 21% of infants (106/510) presented with at least one risk factor for hearing loss. 11,3% of these at-risk infants had more than one risk factor meaning that 2,4% of infants tested had more than one risk factor for hearing loss. 17% of the documented risk factors, apart from the NICU as risk factor, was forthcoming from the NICU population (n=12), despite only comprising 2,4% of the entire sample (n=510). This means that risk factors in this study were 10 times (1/1,5) more prevalent in the NICU population than in non-NICU exposed infants (1/0,15). Since NICU admittance was considered as a risk factor by itself in the current study the incidence of risk factors for this sample, in actual fact, was 16 times (1/2,5) more prevalent in the NICU population than for

the rest of the sample (1/0,15). Five of the NICU infants (42%) exhibited at least two additional risk factors in addition to NICU admittance. This is compared to only one infant (1%) from the non-NICU exposed at-risk group (n=94), presenting with more than one risk factor. This makes NICU infants in this study 42 times more likely to have more than one risk indicator apart from NICU admittance.

The percentage of high risk factors (21%) present in this study is considerably higher than previous reports. Kennedy et al. (1998:1959) reported that 11,6% of a sample of 21,279 infants in England had risk factors for congenital hearing loss. A larger study (n=283,298) from the USA reported a 9% incidence of risk factors and a more recent report indicated a 13.1% incidence of one or more risk indicators in a sample (n=2701) of infants from well-baby nurseries (Mahoney & Eichwald, 1987:161; Vohr et al., 2000b:380). Reasons for the high incidence of infants with risk factors in the current study were discussed in previous paragraphs and relate to the high incidence of a family history of hearing loss in the study sample. For NICU infants, Vohr et al. (2000b:380) reported that 59% presented with one or more risk indicators compared to 42% reported in the much smaller sample investigated in this study. When compared to the well-baby nursery, risk factors in the NICU population were 18 times more prevalent apart from the established risk of being in the NICU (Vohr et al., 2000b:380). Speculation still exist as to whether the presence of more than one risk factor for hearing loss imparts greater risk and further large scale studies are required to investigate this phenomenon (Vohr et al., 2000b:379).

Risk factors for hearing loss, as reported in this study (21%), suggests a significantly increased number of infants at risk compared to reports from developed countries (9-13%) (Kennedy et al., 1998:1959; Mahoney & Eichwald, 1987:161; Vohr et al., 2000b:380). This number will be even higher if accurately documented HIV status is included as a risk indicator. In general, the small percentage of unavailable information and risk incidence comparable to previous reports, except for family history, suggest that a HRR could be useful in identifying infants at risk for hearing loss at MCH clinics.

6.4.2. High frequency immittance measurements

The following presentation and discussion of results are for high frequency immittance testing. Immittance results represent data collected by conducting high frequency tympanometry and acoustic reflex measurements. These measures will be discussed separately in the following paragraphs.

- **Tympanograms using a 1000Hz probe tone**

The obtained tympanograms were divided into two groups – those presenting with a discernable peak, including double-peaks, and those without a discernable peak. Recent reports indicate that a peaked 1000Hz tympanogram suggest normal middle-ear functioning whilst the absence of a peak suggests the presence of middle-ear effusion (MEE) (Purdy & Williams, 2000:16; Kei et al., 2003:25). Figure 6.12 indicates the incidence of 1000Hz tympanograms with and without discernable peaks obtained in this study.

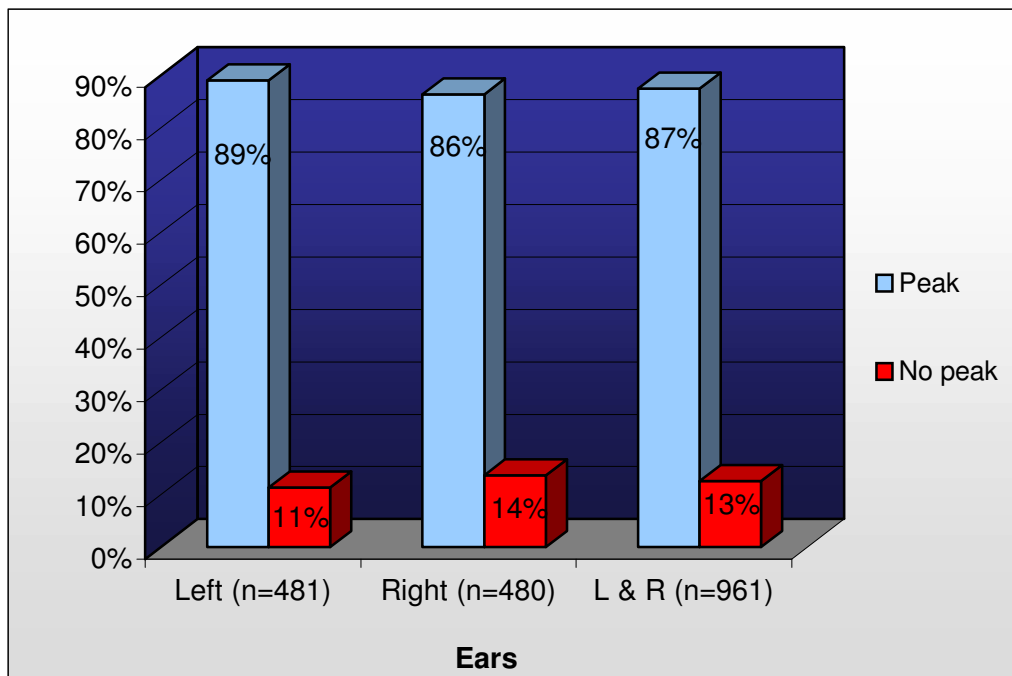


FIGURE 6.12 1000Hz Y-admittance tympanogram peaks (961)

Tympanograms were recorded from 961 ears and no was indicated between the left and right ears. As illustrated in Figure 6.13, 87% of the ears indicated peaked tympanograms indicative of normal middle-ear transmission. If neonatal ears only (0-4 weeks of age) are considered the incidence of peaked tympanograms increase from 87% to 92% (23/280). This is in contrast with a peaked tympanogram incidence of 86% (91/654) for infants between 5-52 weeks of age. Although no right and left ear effect was recorded for infant ears (5-52 years of age) a significant difference of 5% was obtained between the tympanometric data for the right and left neonatal ears of neonates, with the latter having the higher incidence of peaked tympanograms (94 compared to 89%). Double peaked tympanograms were recorded in 43 ears (4.5%) of 961 ears evaluated with 1000Hz Y-admittance tympanometry which is 5% of the tympanograms with discernable peaks. The majority (64%) of the double peaked tympanograms were from male infants and 88% of the ears with double peak tympanograms had OAE pass results.

Although no large-scale 1000Hz probe tone tympanometry studies for infants from birth to one year of age has been reported the incidence of peaked tympanograms for neonatal ears in this study is similar to that of a recent report for a group of 170 babies between 1 – 6 days of age (Kei et al., 2003:23). Using 1000Hz probe tone tympanometry, a peaked tympanogram incidence of 93,4% was reported in 228 ears. Kei et al (2003:24) also reported double peaked tympanograms in 1,2% of the peaked tympanogram ears which corresponded with OAE pass results indicative of normal middle-ear transmission. These results also correspond to previous reports suggesting that double peak tympanograms are not uncommon and are suggestive of normal middle-ear transmission for 1000Hz probe tone measurements (Thornton et al., 1993:320). The 1000Hz tympanometric peak results for neonates in the current study and those reported by Kei et al. (2003:24) are also similar to a 678Hz probe tone study conducted on a group of 200 special care baby unit babies indicating a 91% incidence of discernable peak tympanograms (Sutton et al., 1996:11). These studies only considered neonatal ears and there is a dearth of comparative reports in the literature for 1000Hz tympanometry in infant ears

older than 4 weeks. The fact that a significantly lower incidence (86%) of peaked tympanograms were measured for infants between 5-52 weeks of age may be suggestive of a higher incidence of MEE and will be investigated further in section 6.5.

Table 6.6 summarises results for subjects in which 1000Hz probe tone tympanograms were recorded for both the right and left ears of subjects.

TABLE 6.6 Results of 1000Hz Y-admittance tympanograms recorded for both ears in each subject (n=472)

CATEGORY	NUMBER OF SUBJECTS *	PERCENTAGE OF SAMPLE
Peak both ears	387	82 %
No-peak both ears	32	7 %
No-peak left ear	20	4 %
No-peak right ear	33	7 %

*Subjects with Y-admittance results for both ears

Bilateral tympanograms were obtained for 93% of the sample (472/510). At least one ear's tympanogram had no peak in 18% of subjects whilst at least one ear had a peak in 93% of subjects as indicated in Table 6.6. Only 7% of the sample had flat tympanograms bilaterally. No tympanometric measurements were made in 4% (n=21) of subjects whilst only one ear could be evaluated in 3% (n=17) of the subjects (13 peak and 4 no-peak results).

▪ **Acoustic reflexes using a 1000Hz probe tone**

Acoustic reflexes using a 1000Hz probe tone were evaluated at 1000Hz in 915 ears. Thresholds were obtained in 786 (86%) of the ears evaluated for acoustic reflex thresholds. Figure 6.13 indicates the incidence of present and absent acoustic reflex thresholds obtained in this study.

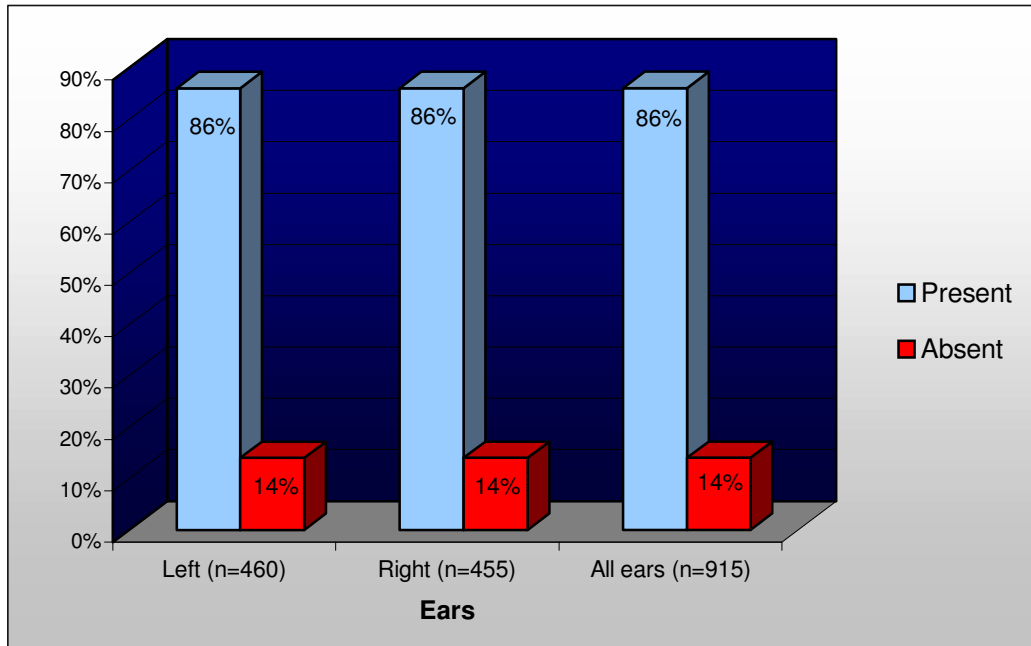


FIGURE 6.13 1000Hz acoustic reflex thresholds using a 1000Hz probe tone (n=915)

Of the ears evaluated in the sample (n=915) no significant difference was observed between left and right ears. An analysis of the acoustic reflex data for neonatal ears (0-4 weeks of age) compared to the rest of the sample ears (5-52 weeks of age) reveals a small difference in the incidence of acoustic reflexes. Neonatal ears indicate present acoustic reflexes in 88% of cases compared to 85% of ears for the rest of the sample. This suggests a similar trend to tympanometry, indicating a lower incidence of peaked tympanograms for older infants (5-52 weeks of age) suggestive of a higher incidence of MEE compared to neonates.

Table 6.7 indicates the mean, standard deviation, range and percentile values for the thresholds obtained for the sample.

TABLE 6.7 Mean, standard deviation, range and 5th and 95th percentile of acoustic reflex thresholds

# AR thresholds	Mean threshold (dB)	Standard deviation (dB)	Min (dB)	Max (dB)	5 th percentile (dB)	95 th percentile (dB)
785	93	± 9	60	110	80	105

Acoustic reflex thresholds were obtained for 785 ears and did not demonstrate any significant difference between left and right, male and female, and neonatal and infant ears. The percentiles calculated for this study indicate that 90% of all acoustic reflex thresholds in the current study were obtained between 80 – 105 dB with a mean score of 93 ± 9 dB.

Table 6.8 summarises results for subjects in which acoustic reflexes using a 1000Hz probe tone were recorded at 1000Hz both the right and left ears of subjects.

TABLE 6.8 Presence of 1000Hz probe tone acoustic reflexes recorded at 1000Hz for both ears in each subject (n=440)

CATEGORY	NUMBER OF SUBJECTS *	PERCENTAGE OF SAMPLE
Present both ears	348	79 %
Absent both ears	27	6 %
Absent left ear	31	7 %
Absent right ear	34	8 %

*Subjects with acoustic reflex results for both ears

Bilateral reflex measurements were obtained from 68% of subjects in this sample due primarily to the fact that acoustic reflex measurement proceeded after

tyimpanometry which caused some infants to be restless and irritable during reflex testing. Of those subjects for whom bilateral reflex measurements were performed at least one ear had an absent reflex in 21% of subjects whilst at least one ear had a present reflex in 94% of subjects as indicated in Table 6.8. No reflex measurements were attempted in 10% of ears whilst only one ear could be assessed in 7% of subjects.

The high percentage of present reflexes recorded (86%) in the current study compared to the poor reliability of recording present reflexes using low frequency probe tones in infants can be attributed to the following facts: 1) A 1000Hz probe tone was used, 2) an ipsilateral stimulus was used, and 3) a mid-frequency (1000Hz) stimulus was used to activate the reflex (Weatherby & Bennett, 1980:107; Rhodes et al., 1999:805; Purdy & Williams, 2000:14). Although using a much smaller sample (n=35) Weatherby and Bennett (1980:106) reported present acoustic reflexes for all subjects. These results may suggest that using a broadband stimulus elicits more acoustic reflexes. Another study by Sutton et al. (1996:12) using a high frequency probe tone (678Hz) to elicit reflexes in high-risk special care neonates, reported the presence of acoustic reflexes in only 42% of ears (71/168). This reduced incidence compared to the high incidence rate in the current study can be attributed to the risk status and young age of the neonates as well as to the use of a 678Hz probe tone instead of a 1000Hz probe tone. The incidence of reflexes for infants in the current study is similar to an 89% incidence of 660Hz probe tone reflexes for neonates reported by McCandless and Allred (1978:63).

The mean reflex thresholds in the current study correlated well with adult norms even though mean reflex thresholds for neonates using a 1000Hz probe tone and a broadband stimuli have been reported to be 14dB lower than in adults (Weatherby & Bennett, 1980:106). The fact that mean threshold in the current study did not appear lower than for adults and may be attributed to the fact that the age of the sample exceeded the neonatal period up until one year of age.

The immittance results in the current study demonstrated that a high incidence of tympanometric and acoustic reflex results (86-87%) suggestive of normal middle-ear transmission in infants could be obtained using a 1000Hz probe tone.

6.4.3. OAE and AABR hearing screening measurements

The following presentation and discussion of results are for hearing screening measures including OAE and AABR. These measures were utilised according to the protocols specified in Chapter 5. The results of each measure will be discussed separately in the following paragraphs.

▪ OAE screening results

The initial OAE screening procedure was performed on 964 ears, which constitute 95% of the ears in the sample of subjects. Some subjects could not be tested due to irritability and restlessness. No significant differences were obtained between the screening results for the left and right ears and therefore all ears were considered as a single group. The OAE pass and refer percentages for this sample of ears is presented in Figure 6.14.

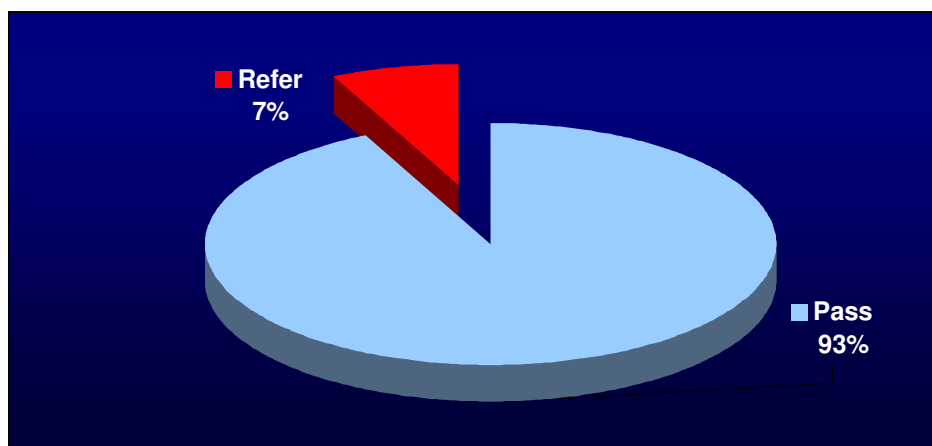


FIGURE 6.14 Percentage of ears with pass and refer results (n=964)

The 93% OAE pass rate represents infants between 1 day and 1 year of age. An analysis of neonatal ears only (n=278) reveals a 95% pass rate compared to older (5-52 weeks of age) infant ears (n=654) presenting with a 92% pass rate. This lower pass rate for older infants is similar to results reported for tympanometry and acoustic reflexes and may be indicative of a higher incidence of MEE in the older infant population. The 7% general referral rate and 5% neonatal referral rate fall well within the range of referral rates for sample ears reported for DPOAE by the NIDCD multi-centre investigation, which varied between 3 and 10% depending on the stimuli specifications and group composition (Norton et al., 2000c:532).

Although the screening protocol specified a bilateral OAE screening for all subjects no measurements could be performed in 4% (n=21) of subjects whilst only one ear could be screened with OAE in 3% (n=14) of the sample. Table 6.9 summarises results for subjects in which an OAE screening result was recorded for both the right and left ear of a subject.

TABLE 6.9 OAE screening results for subjects in which a result was reported for both the left and right ear (n=475)

CATEGORY	NUMBER OF SUBJECTS *	PERCENTAGE OF SAMPLE
Pass both ears	421	89 %
Refer both ears	15	3 %
Refer left ear	20	4 %
Refer right ear	19	4 %

*Subjects with OAE screening results for both ears

The subjects for whom a bilateral screen could be performed (93% of the sample) presented with at least a unilateral OAE pass result in 97% of subjects as indicated in Table 6.9. The initial OAE bilateral pass result of 89% in the current study is similar to previously reported results. According to Watkin (2003:169) bilateral initial TEOAE pass results are on average between 89 -

92%. This is similar to the range of initial bilateral DPOAE pass results of 82 – 91% reported for different DPOAE screening protocols by Norton et al. (2000c:532). Generally the OAE pass rates for the current study were therefore within the range of reported values for an initial screening procedure (Norton et al., 2000c:532; Vohr et al., 1998:355; Watkin, 2003:169).

▪ **AABR screening results**

According to the screening protocols specified in Chapter 5 a total of 90 ears (69 referred ears and 24 NICU exposed ears of which 3 referred) should have received an AABR screening. The AABR screening, however, was successfully performed for only 3% (n=17) of the entire sample of subjects which is a mere 27% (17/63) of the total number of subjects requiring an AABR screen according to the screening protocols specified in Chapter 5. The results of the AABR screening procedure are indicated in Table 6.10.

TABLE 6.10 AABR screening results for evaluated subjects (n=17)

CATEGORY	NUMBER OF SUBJECTS
Pass both ears	4
Refer both ears	1
One ear pass – other ear not tested	3
One ear refer – other ear not tested	9

Table 6.10 shows that in 12 cases only one ear was evaluated whilst both ears were evaluated in 5 subjects. This means that 76% (22/90) of ears requiring an AABR screening, according to the protocols in Chapter 5, did not receive it. Reasons for this low percentage of successful AABR evaluations on infants attending the MCH clinics can be attributed to the following factors. Firstly, infants requiring AABR screenings varied in age from birth to 52 weeks with a mean age of 18 weeks \pm 14 weeks standard deviation. Since most of the subjects were older than 1 month it was difficult to prepare and test an infant without the infant becoming irritable and restless which made further screening

impossible. Secondly, the AABR screening was performed after OAE and immittance measures were already conducted which contributed to infants already being restless and irritable. Lastly, those infants on whom AABR evaluations could not successfully be performed were referred to return within a week or two to complete the screening. Unfortunately very few mothers returned with their infants. These facts demonstrate the inefficiency of utilising an AABR technique to screen infant hearing at MCH clinics.

6.4.4. Comparison of test procedure results

The high frequency tympanometry and acoustic reflex measurements, and OAE screening results are compared in the following paragraphs. The AABR results are not included in this comparison since it was only performed on 17 subjects. Figure 6.15 compares results of the three test procedures indicative of normal functioning, which are a pass on the OAE, a peak for the tympanogram and a present acoustic reflex threshold. These are compared for all ears in sample and for all subjects for whom both ears were evaluated.

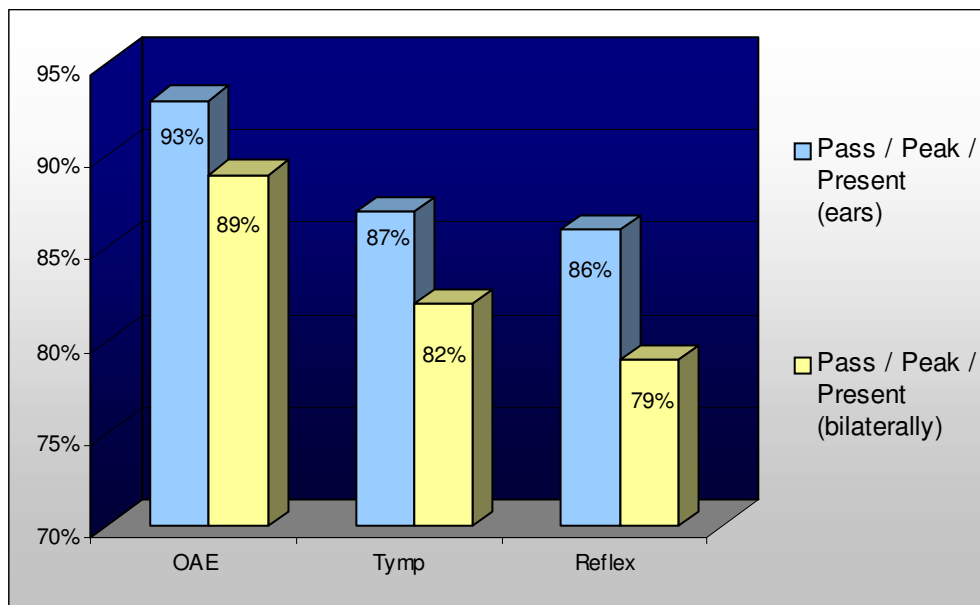


FIGURE 6.15 Comparison of OAE pass, tympanogram peak, and acoustic reflex present results

As evident from Figure 6.15 OAE indicated the highest percentage of positive results suggestive of normal or near normal middle-ear functioning and cochlear integrity (Thornton et al., 1993:323; Taylor and Brooks, 2000:53). This was followed by 1000Hz probe tone tympanometry with the second highest percentage of positive results suggestive of normal middle-ear functioning. Acoustic reflexes presented with only slightly less (1%) positive results indicative of normal middle-ear functioning. It is clear that the positive results (pass, peak, present) for these procedures decrease once a bilateral positive criterion is used. Results decrease by 4, 5 and 7% for OAE, tympanometry and acoustic reflexes, respectively. This points toward better bilateral results when using OAE than when using the other two procedures. The results, as indicated by Figure 6.16, may suggest a higher specificity for normal auditory functioning using OAE compared to a higher sensitivity for auditory dysfunction using acoustic reflexes. This relationship will be investigated further in section 6.5.

Figure 6.16 compares the positive results (pass, peak, present) for OAE, tympanometry and acoustic reflexes for neonatal ears (0-4 weeks of age) and infant ears (5-52 weeks of age).

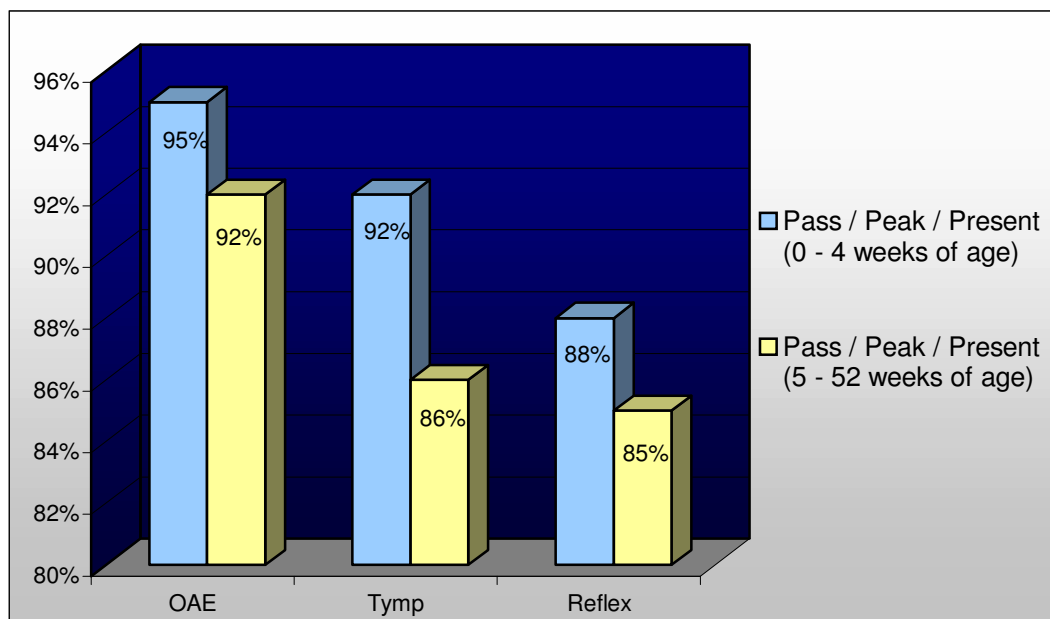


FIGURE 6.16 Comparison of OAE pass, tympanogram peak, and acoustic reflex present results for neonatal and infant ears

Figure 6.16 demonstrates a similar pattern of positive (pass/peak/present) result incidence for the two age groups with OAE presenting with the highest incidence of positive results followed by tympanometry and acoustic reflexes. This pattern is similar to that of the entire sample of ears and for bilateral positive (pass, peak, present) results for subjects as illustrated in Figure 6.15. The difference between the neonatal ears and older infant ears in this study is the decrease in positive result (pass, peak, present) incidence for older infants (5-52 weeks of age). The most significant drop in incidence is for discernable tympanometric peaks where a 6% drop is recorded for infant ears compared to neonatal ears. The decrease of OAE pass, peaked tympanogram, and present reflex results for older infants may be suggestive of an increased incidence of MEE, and even late-onset or progressive types of sensori-neural hearing loss, for these ears compared to neonatal ears.

Generally, the results for these three test procedures evaluating the structures of the middle and inner ear are within 7% of each other indicating a close relationship between their measuring specificity. The strong relationship between these three test procedures has been reported previously and will be discussed and compared in section 6.5 (Purdy & Williams, 2000:12; Sutton et al., 1996:11; Thornton et al., 1993:321).

6.4.5. Summary of results and discussion: sub-aim #3

A description of the HRR and test results obtained in this study reveals the following conclusions, summarised in Table 6.11, regarding each procedure for the sample of subjects investigated.

TABLE 6.11 Summary of results and discussion for sub-aim #3

High-Risk Register

- A significantly increased incidence (21%) of risk indicators for hearing loss were documented for the study population compared to reports from developed countries (9-13%) (Kennedy et al., 1998:1959; Mahoney & Eichwald, 1987:161; Vohr et al., 2000b:380).
- The higher incidence of risks was primarily due to an increase in reported family history of congenital hearing loss reported by caregivers.
- Reasons for the higher incidence of family history for congenital hearing loss as a risk indicator was attributed to increased depravity among this population, as evidenced in sub-aim #2, which leads to a higher prevalence of hearing loss (Kubba et al., 2004:125) and to the difficulty in accurately ascertaining family history in subjects (Kountakis et al., 2002:136; Northern & Downs, 2002:277).
- The incidence of risk factors may also increase significantly if mothers' HIV status is included as a risk indicator that can be accurately documented.
- In general, the small percentage of unavailable information and a risk incidence comparable to previous reports, except for family history, suggest that a HRR could be useful in identifying infants at risk for hearing loss at MCH clinics.

High frequency immittance

- The immittance results in the current study demonstrated that a high incidence of tympanometric and acoustic reflex results suggestive of normal middle-ear transmission in infants (86-87%) could be obtained using a 1000Hz probe tone.
- Double peaked tympanograms were obtained in 4,5% of the sample ears and comprised 5% of the group with discernable peaks. 64% were male ears.
- The high percentage of acoustic reflexes obtained in the current study compared to previous studies in infants was attributed to the fact that a 1000Hz probe tone and an ipsilateral mid-frequency (1000Hz) stimulus was used to activate reflexes (Weatherby & Bennett, 1980:107; Rhodes et al., 1999:805; Purdy & Williams, 2000:14).
- Immittance result indicated a higher incidence of peaked tympanograms and present reflexes for neonatal ears than for infant ears (5-52 weeks of age) and may suggest a higher incidence of MEE in older infants.

OAE and ABR hearing screening

- OAE pass rates were 93% for all sample ears whilst neonatal ears indicated a higher pass rate of 95% compared to 92% for infant ears (5-52 weeks of age). These results are in agreement with the pattern for peaked tympanogram and present reflex results.
- ABR evaluations could only be performed on 26% of the ears requiring it. This inefficiency was due to several reasons including infant age, test order effect, and few returning mothers on whom no successful ABR could be performed initially.

Comparison of test procedure results

- All test procedures indicated higher incidences of positive results (pass, peak, present) for neonatal ears than for infant ears (5-52 weeks of age), which may be indicative of higher MEE, and even late-onset, or progressive sensori-neural hearing loss, incidence for older infants.
 - Generally, the tympanometry, acoustic reflex and OAE results for this study were within 7% of each other indicating a close relationship between their measuring specificity for middle-ear transmission and inner ear integrity which has also been reported previously (Purdy & Williams, 2000:12; Sutton et al., 1996:11; Thornton et al., 1993:321).
-

The HRR and test results summarised in Table 6.11 for sub-aim #3 describes the range of results and points toward their possible usage as procedures for hearing screening in this population of subjects. The results and discussion for sub-aim #4 will build on these results to investigate the issue of screening protocol performance and efficiency in this population.

6.5. RESULTS AND DISCUSSION OF SUB-AIM #4: PROTOCOL PERFORMANCE AND EFFICIENCY

The fourth sub-aim of the study aimed to describe the performance and efficiency of the screening protocol implemented for infants and caregivers attending the two MCH clinics in the Hammanskraal community. The descriptions are part of the dominant quantitative research method and were accrued by conducting a structured interview with caregivers; consulting patient files for identifying risk indicators; performing various tests of auditory integrity; and documenting subjects' follow-up rate. This data is analysed and compared between the various test procedures and between initial and follow-up evaluations. The results and discussion will be presented according to an evaluation of screening procedure performance, compilation of normative data for high frequency immittance testing as a result of test procedure comparisons, and protocol efficiency in terms of coverage, referral and follow-up statistics for the current study.

6.5.1. Screening procedure performance

The relationship between the OAE, tympanometry and acoustic reflex results obtained in the current study is presented and discussed in the following section. Positive results indicative of normal middle-ear transmission as measured by each procedure was specified as a pass for an OAE, a peaked tympanogram, and a present reflex. Negative results indicative of possible abnormality in middle-ear transmission, indicative of middle-ear effusion (MEE), was specified as a refer for an OAE, a flat tympanogram, and an absent reflex. The OAE result

was considered to be the gold standard of middle-ear functioning in this sample because no other standardised non-invasive procedure has been reported as a gold standard for normal middle-ear functioning in neonates and young infants. Although reports have indicated that in certain cases OAE pass results may be obtained in a small number of ears with MEE, a normal middle-ear system is presupposed in the vast majority of OAE pass results (Van Cauwenberge et al., 1996:139; Sutton et al., 1996:15; Taylor & Brooks, 2000:52). No standardised normative data for high frequency tympanometry in young infants is currently available to evaluate middle-ear functioning and therefore results are compared to OAE (Margolis et al., 2003:384; Kei et al., 2003:22; Taylor & Brooks, 2000:53). The positive and negative result correspondence between OAE, tympanometry and acoustic reflex results are presented in Figure 6.17.

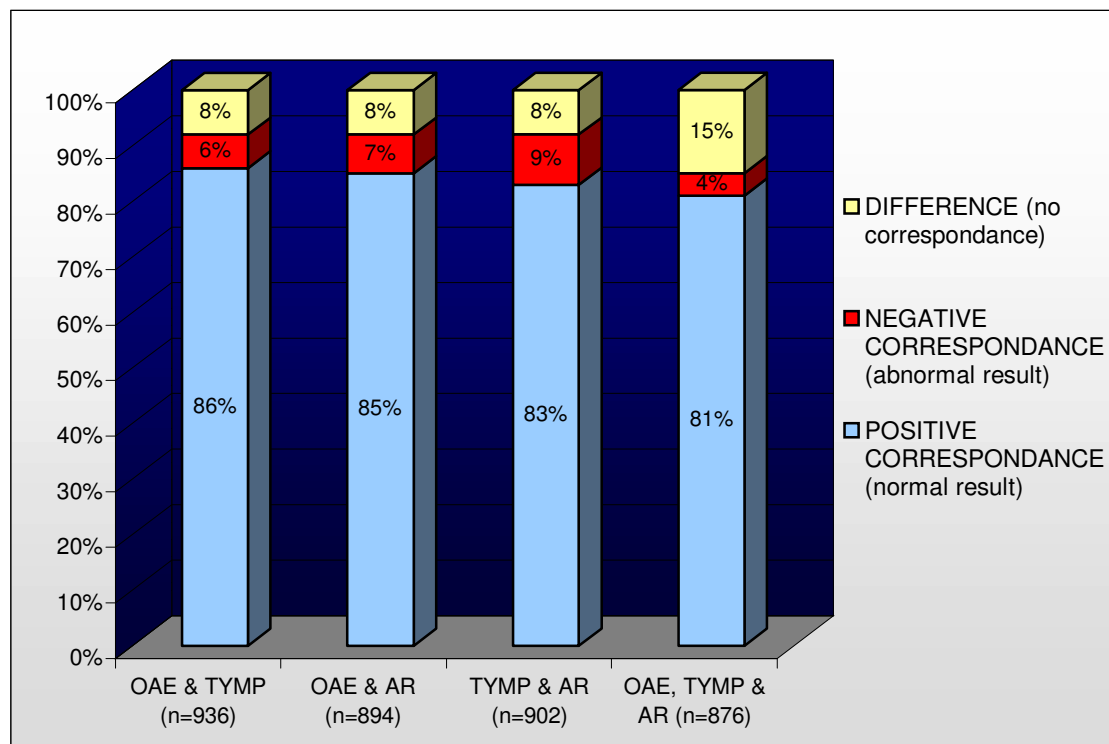


FIGURE 6.17 Positive and negative correlations between OAE, tympanometry (TYMP) and acoustic reflex (AR) results

The percentages presented in Figure 6.17 indicate that results for OAE and tympanogram, OAE and acoustic reflex, and tympanogram and acoustic reflex corresponded in 92% of cases in all instances. Results for all three procedures corresponded in 85% of cases with both the positive and negative correspondences slightly less than for correspondence between only two measures. This can be attributed to the fact that three test measures are required to indicate the same result compared to only two measures in all other instances. It does however indicate a high degree of correspondence between all three-test procedure results. A Chi-square analysis verifies this correspondence by indicating a strong and highly significant association between all combinations of OAE, tympanometry and acoustic reflex result comparisons ($p < 0,0001$). Contingency coefficients confirmed this strong relationship between all test procedure results.

Results reported by Sutton et al. (1996:12) also indicated strong associations between these three variables using TEOAE and a 678Hz probe tone for tympanometry and reflexes for a smaller group of infants ($n=84$) from special care baby units. In another study by Taylor and Brooks (2000:53) the relationship between TEOAE and 226Hz probe tone tympanometry was investigated in young children, which indicated similarly strong associations between tympanometry and OAE results for the group of infants in the current study.

The strong association between OAE, tympanometry, and acoustic reflex results can be illustrated by specifying predictive values for obtaining a positive (normal) or negative (abnormal) result for one test procedure when compared to the test result of another. These probability percentage values are presented in Table 6.12.

TABLE 6.12 Positive and negative predictive values for OAE, tympanogram, and acoustic reflex results for all ages

PREDICTIVE MEASURE	TYMPANOGRAM		ACOUSTIC REFLEX	
	Peak (n=823)	No-peak (n=113)	Present (n=770)	Absent (n=124)
OAE pass	93%	7%	92%	8%
OAE refer	21%	79%	11%	89%

PREDICTIVE MEASURE	OTO-ACOUSTIC EMISSIONS		ACOUSTIC REFLEX	
	Pass (n=869)	Refer (n=67)	Present (n=775)	Absent (n=127)
Tymp peak	98%	2%	94%	6%
Tymp no-peak	53%	47%	27%	73%

PREDICTIVE MEASURE	OTO-ACOUSTIC EMISSIONS		TYMPANOGRAM	
	Pass (n=829)	Refer (n=65)	Peak (n=790)	No-peak (n=112)
AR present	99%	1%	96%	4%
AR absent	53%	47%	35%	65%

The results in Table 6.12 indicate the probability of obtaining a positive or negative result for each test procedure based on the results of the predictive measure. Using the result of the predictive measure, a sensitivity and specificity count can be obtained for the other two procedures (Taylor & Brooks, 2000:52). Measured against the OAE result the sensitivity and specificity of tympanometry compared with OAE screening was 79% and 93%, respectively. Sensitivity and specificity of acoustic reflex compared with OAE screening were 89% and 92%, respectively. Since OAE was considered as the gold standard for establishing normal middle-ear transmission in this study these comparisons can be considered reliable (Kei et al., 2003:22; Taylor & Brooks, 2000:53). Immittance results also proved reliable measures of middle-ear transmission especially for establishing normal functioning as measured by OAE. This is evident in the fact that both peaked tympanogram (98%) and present acoustic reflex (99%) results predicted an OAE pass result with a probability of approximately 100%.

Using tympanometry and acoustic reflexes as predictive measures can be useful but since OAE was considered the gold standard procedure and no standardised norms for high frequency tympanometry is yet available these procedures cannot truly serve as a standard normal middle-ear functioning against which the OAE can be compared. The results do indicate that if a peaked tympanogram is obtained an OAE pass is predicted in 98% of cases and if a flat tympanogram is obtained no emissions were obtained in 47% of cases. For an acoustic reflex being present an OAE pass is predicted in 99% of cases with an absent reflex predictive of an OAE fail in 47% of cases. The sensitivity and specificity of acoustic reflexes compared with tympanometry were 73% and 94%, respectively. This is similar to the sensitivity and specificity of tympanometry compared with acoustic reflex screening which was 65% and 96%, respectively.

An analysis of the predictive values for OAE, tympanogram, and acoustic reflex results in neonates and older infants are presented in Table 6.13.

According to the comparison of abnormal and normal results with the various test procedures in Table 6.13 a significant difference emerges between neonatal (0-4 weeks of age) and infant (5-52 weeks of age) ears. Measured against the OAE result the sensitivity and specificity of tympanometry compared with OAE screening was 57% and 95%, respectively, for neonatal ears compared to 85% and 92% for infant ears. Similar differences were obtained for acoustic reflex results. This suggests significantly higher immittance sensitivity for infant ears compared to neonatal ears. It must be mentioned however, that the smaller number of neonatal OAE referred ears and a higher OAE failure rate (8% compared to 5%) for older infants, may account for this difference.

TABLE 6.13 Positive and negative predictive values for OAE, tympanogram, and acoustic reflex results for infants 0-4 and 5-52 weeks of age

PREDICTIVE MEASURE	TYMPS 0-4 WEEKS OF AGE		TYMPS 5-52 WEEKS OF AGE		AR 0-4 WEEKS OF AGE		AR 5-52 WEEKS OF AGE	
	Peak (n=256)	No-peak (n=22)	Peak (n=563)	No-peak (n=91)	Present (n=236)	Absent (n=33)	Present (n=530)	Absent (n=91)
OAE pass	95%	5%	92%	8%	90%	10%	93%	7%
OAE refer	43%	57%	15%	85%	43%	57%	2%	98%
PREDICTIVE MEASURE	OAE 0-4 WEEKS OF AGE		OAE 5-52 WEEKS OF AGE		AR 0-4 WEEKS OF AGE		AR 5-52 WEEKS OF AGE	
	Pass (n=264)	Refer (n=14)	Pass (n=601)	Refer (n=53)	Present (n=234)	Absent (n=33)	Present (n=537)	Absent (n=94)
Tymp peak	98%	2%	99%	1%	93%	7%	95%	5%
Tymp no-peak	64%	36%	51%	49%	32%	68%	26%	74%
PREDICTIVE MEASURE	OAE 0-4 WEEKS OF AGE		OAE 5-52 WEEKS OF AGE		TYMPS 0-4 WEEKS OF AGE		TYMPS 5-52 WEEKS OF AGE	
	Pass (n=264)	Refer (n=14)	Pass (n=570)	Refer (n=51)	Peak (n=245)	No-peak (n=22)	Peak (n=541)	No-peak (n=90)
AR present	98%	3%	100%	0%	97%	3%	96%	4%
AR absent	76%	24%	45%	55%	55%	45%	29%	71%

The results suggest that acoustic reflex results for infant ears compared to the gold standard of the OAE result showed the highest sensitivity of 98% compared to a significantly reduced sensitivity of 57% for neonatal ears. The specificity of OAE results compared to acoustic reflex outcome was 100% for infant ears compared to 98% for neonatal ears. These figures indicate that in general OAE results present with the highest specificity for both groups whilst acoustic reflexes present with the highest sensitivity for auditory dysfunction in both groups. Although the number of neonatal ears is significantly smaller than the infant ears, which could affect the reliability of comparisons, results indicate increased tympanometry and decreased reflex specificity for neonatal ears compared with infant ears. Sensitivity of tympanometry and acoustic reflexes increases

significantly for infant ears compared to neonatal ears. These results demonstrate better correspondence of test results for infants older than 4 weeks of age. This suggests that 1000Hz probe tone immittance is more reliable in correctly identifying MEE in infants over 4 weeks of age compared to neonates.

A combination of a tympanometry and acoustic reflex results predictive of OAE outcome for the whole sample is presented in Table 6.14.

TABLE 6.14 Predictive values of combined tympanometry and acoustic reflex results for OAE outcome

TYMP / AR	OTO-ACOUSTIC EMISSIONS		
	Pass (n=814)	Refer (n=62)	% of sample (n=876)
Peak / Present (n=720)	98%	2%	82%
Peak / Absent (n=38)	79%	21%	4%
No-peak / Present (n=38)	84%	16%	4%
No-peak / Absent (n=80)	55%	45%	9%

The results in Table 6.14 indicate that if a peaked tympanogram and present reflex are obtained, an OAE pass is predicted in 98% of cases. Also, if no tympanometric peak and an absent reflex are obtained, an OAE refer result can be expected in 45% of cases. These results, using a combined tympanogram and acoustic reflex threshold to predict OAE outcome, are very similar to results when only a tympanogram or acoustic reflex was used.

An important group of the entire sample to consider are those ears (n=8) that had a peaked tympanogram, absent reflexes and an OAE refer result. This combination of results suggests a high probability of sensori-neural hearing loss since both the OAE and acoustic reflex results, reliant on cochlear integrity, were referred in contrast to normal tympanometry, which is only reliant on normal

middle-ear transmission (Margolis et al., 2003:389; Purdy & Williams, 2000:20). Only 0,9% of the entire sample of ears (n=876) for whom all procedures were conducted presented with this set of results. If those infants for whom present reflexes were measured and peaked tympanograms obtained and OAE refer results were recorded (n=12) are included the sample percentage increases to 2,3%.

Another important group to consider are those ears (n=36 ears) with no tympanogram peaks, absent reflexes, and referred OAEs. All these results together provide a strong indication of a middle-ear transmission problem such as MEE and these numbers of cases suggest an incidence of 4% in the ears of this sample (Purdy & Williams, 2000:20). The small group of ears (n=6) with flat tympanograms, present reflexes, and absent OAE may also be indicative of a milder condition of MEE which obliterates the OAE and gives a flat tympanogram but is not sufficient to obliterate the reflex at higher intensities (Gelfand, 2002:213). If these results are considered together with the group with flat tympanograms, absent reflexes and OAE refer results, an incidence of 5% for MEE (42/876) in ears tested in this population is evident. Although the published estimates of MEE in healthy newborns are varied and consensus is currently lacking there is general agreement that it is more common in NICU infants (Hall et al., 2004:423; Balkany et al., 1978:398). Sutton et al. (1996:15) confirmed this by reporting a higher incidence of 20% (29% of infants) for abnormal high frequency tympanometric results indicative of MEE for babies in special care units, which is similar to previous reports for NICU neonates of 30% (Berman et al., 1978:198).

The predictive values of the OAE result for combined tympanogram and acoustic reflex results are presented in Table 6.15.

TABLE 6.15 Predictive values of OAE results for combined tympanogram and acoustic reflex results

PREDICTIVE MEASURE	TYMPANOGRAM / ACOUSTIC REFLEX			
	Peak / Present	Peak / Absent	No-peak / Present	No-Peak / Absent
OAE pass (n=814)	87%	4%	4%	5%
OAE refer (n=62)	19%	13%	10%	58%

Results presented in Table 6.15 indicate the probability of obtaining different combinations of tympanogram and acoustic reflex results compared to the OAE result. As OAE is considered the gold standard for determining normal middle-ear transmission properties the sensitivity and specificity of combined tympanometry and acoustic reflex usage can be determined by comparing it with OAE results. The sensitivity and specificity of the combined use of high frequency tympanometry and acoustic reflexes were 58% and 87%, respectively. This means that the combined method is able to identify normal middle-ear functioning in 87% of cases and able to identify abnormal middle-ear functioning in 58% of cases as compared to OAE results. Although the sensitivity and specificity of a combined tympanometry and reflex criteria is reduced compared to sensitivity and specificity of each single procedure, a higher degree of reliability is ensured. Reports suggest that the use of both high frequency tympanometry and acoustic reflexes increases the reliability of determining middle-ear functioning in young infants (Purdy & Williams, 2000:18).

If only neonatal ears (0-4 weeks of age) are considered (n=6) the sensitivity percentage of the combined procedure drops from 58% to 43%. For infants between 5-52 weeks of age (n=62) the probability of obtaining abnormal tympanometric and reflex results rises to 65% whilst the probability of obtaining a peaked tympanogram and present reflex is 0% when an OAE refer result is obtained. This data suggests, although the data for neonatal ears is limited, that a closer relationship exist between OAE refer, and flat tympanogram and absent

reflex results for infants older than 4 weeks compared to neonatal ears. This may be due to a higher OAE refer rate in the older infants which may indicate a higher incidence of MEE in these ears, which abolishes OAE, tympanogram peaks, and acoustic reflex measurements (Thornton et al., 1993:320).

Results in the current study suggest that a protocol using high frequency tympanometry and acoustic reflexes in conjunction with OAE may be useful in classifying ears into risk categories for sensori-neural hearing loss and MEE. If a peaked tympanogram is obtained an acoustic reflex is present, normal middle-ear functioning is strongly indicated. If the tympanometry indicates a flat tympanogram and an absent acoustic reflex threshold it will be strongly indicative of a middle-ear conduction problem such as MEE. A mixed result indicating an OAE refer, tympanogram peak and absent reflex will be a high-risk combination for sensori-neural hearing loss. More difficult to interpret is an absent OAE and a flat tympanogram with a present reflex. This may be due to a mild conductive MEE which could lead to an OAE refer and a flat tympanogram but presents with a present reflex at maximum intensities.

Although recent studies have reported preliminary normative data for 1000Hz tympanometry compared to OAE results, the sample sizes were limited, age distribution was confined to neonates, and acoustic reflexes were not included (Kei et al., 2003:23-25; Margolis et al., 2003:385-388). Data from the current study can therefore be used to establish a normative data basis for 1000Hz tympanometry and acoustic reflexes on a large sample of infants varying in age from one day to one year. The following section will discuss this normative data.

6.5.2. High frequency immittance norms

Fowler and Shanks (2002:202) recommend that further studies be performed to establish guidelines for use in distinguishing normal from pathological ears in neonates and infants. The large sample of infant ears on which OAE and high frequency tympanometry and acoustic reflexes were performed in the current study allows for the compilation of comprehensive normative data for 1000Hz

probe tone immittance measures. This type of normative data is becoming increasingly necessary with the implementation of widespread UNHS programmes and a dearth of reliable tests of middle-ear functioning to distinguish sensori-neural hearing loss from middle-ear pathology for infants younger than 7 months of age (Kei et al., 2003:21; Purdy & Williams, 2000:9; Margolis et al., 2003:384; Northern & Downs, 2002:226).

Since OAE was considered the gold standard for normal middle-ear transmission in this study, the tympanometric data was divided into two groups based on the OAE screen result (Taylor & Brooks, 2000:53; Kei et al., 2003:22). The majority (93%) of tympanograms recorded for ears with an OAE pass result had a discernable tympanogram peak. For the other 7% of tympanograms no discernable peak could be identified but the highest point on the tympanogram was marked to obtain a maximum admittance value (mmho) with a corresponding pressure value (daPa). The distribution of these admittance and tympanic peak pressure (TPP) values for the recorded tympanograms in these two groups are presented in Figures 6.18 and 6.19.

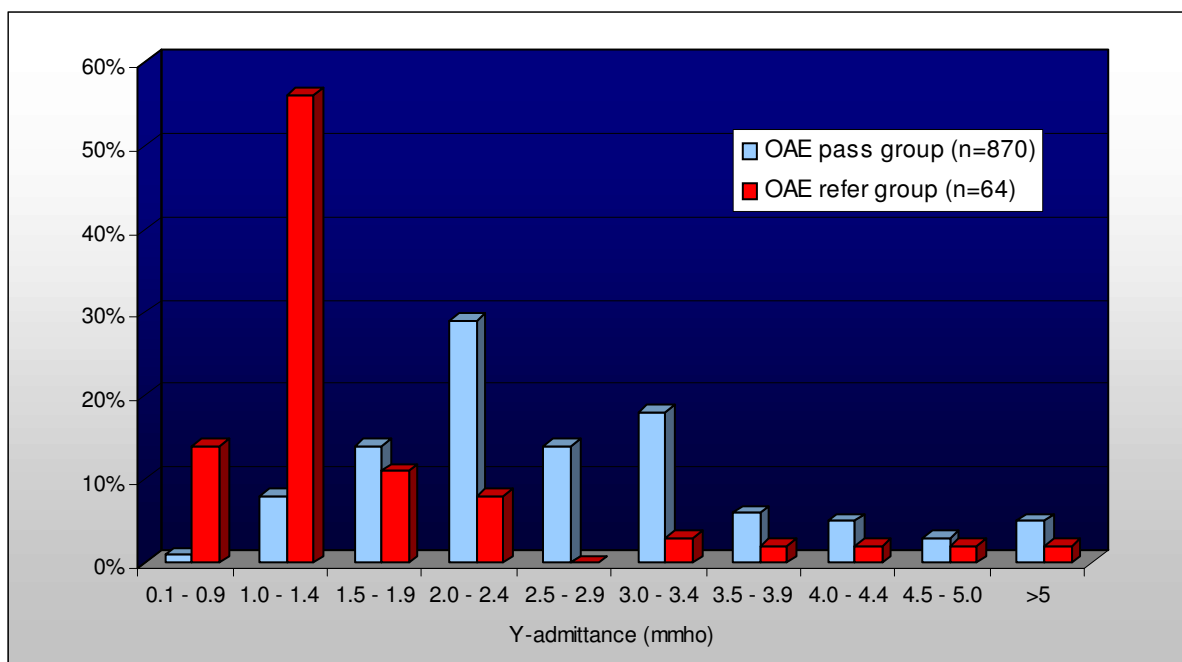


FIGURE 6.18 Distribution of maximum admittance values for ears with OAE pass and refer results (n=934)

The majority (77%) of admittance values for the OAE pass group were 2 mmho and larger compared to the majority (81%) of admittance values for the OAE refer group being less than 2 mmho. Although there is an overlap of results a clear trend toward lower Y-peak admittance values for the OAE refer group is evident from Figure 6.18. Previous studies on 1000Hz tympanometry only reported normal ranges of admittance results for subjects with OAE pass results (Margolis et al., 2003:384; Kei et al., 2003:23). The reported results do however confirm that normal middle-ear functioning is primarily related to higher admittance values in contrast to lower admittance values as also evidenced in this study (Margolis et al., 2003:389; Kei et al., 2003:25).

Figure 6.19 provides the distribution of tympanic peak pressure values for ears with OAE pass and refer results.

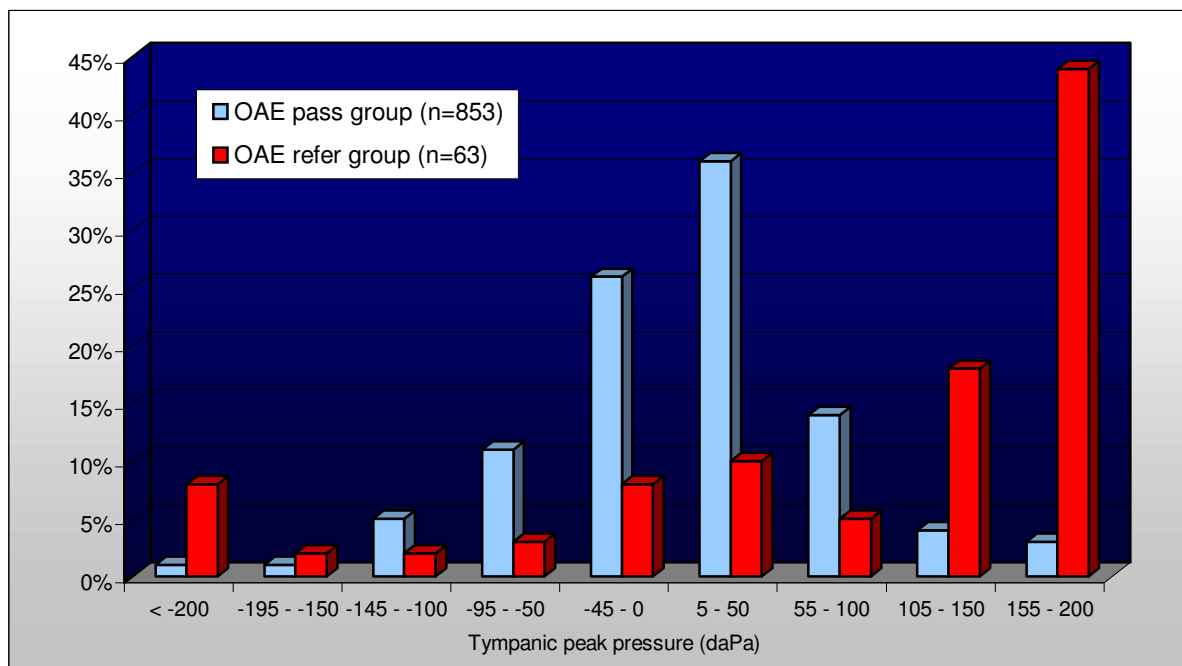


FIGURE 6.19 Distribution of tympanic peak pressure values for ears with OAE pass and refer results (n=916)

A clear pattern of findings is also visible for the tympanic peak pressure values presented in Figure 6.19. The majority (62%) of tympanic peak pressure values

for the OAE refer group was larger than 105 daPa compared to the majority (62%) of tympanic peak pressure values for the OAE pass group being between -45 and 50 daPa. Although there is a similar overlap pattern as for the admittance values in Figure 6.18 a clear trend indicating more positive pressure values for OAE refer, compared to OAE pass, results is visible. An interesting finding requiring investigation is an 8% incidence of tympanic peak pressure values less than -200 daPa for the OAE refer group compared to a 1% incidence among the OAE pass group. This indicates that not only are more positive peak pressure values exceeding 105daPa prone to OAE refer results but so are negative peak pressure results of -200 and smaller compared to pressure values for the OAE pass group. These results are in agreement with Thornton et al. (1993:321) who reported high positive middle-ear pressures (>150 daPa) to correspond with OAE failures.

Although the importance of peak pressure values for determining pathology in infant ears is not clearly understood and further studies have been recommended (Margolis et al., 2003:389) results from the current study indicates a statistically significant effect of middle-ear pressure values on OAE results. This association is also evident in the fact that 87% of ears with OAE pass results presented with peak pressure values larger than -100 daPa and smaller than 100 daPa compared to 26% of ears with OAE refer results presenting with peak pressure values larger than -100 daPa and smaller than 100 daPa. This is consistent with previous reports indicating a relationship between middle-ear pressure, using a 1000Hz probe tone, and OAE failure in neonatal ears (Owens et al., 1992:55; Thornton et al., 1993:322).

To establish reliable norms for 1000Hz immittance testing two criteria was set for including ears from the current sample to be used for compiling the normative data. The first criterion was an OAE pass result. The reason why this was not included as the only criterion was because previous reports have indicated that in a small number of cases with MEE a pass result may still be obtained with OAE (Van Cauwenberge et al., 1996:139). To assure reliable norms are specified, as far as the performed procedures accuracy allows, a second criterion

requiring a discernable tympanogram peak for inclusion was set. A recent report indicated that an OAE pass result was obtained in 5.7% of ears with no discernable tympanometric peak although reduced OAE amplitudes were observed (Kei et al., 2003:26). Since these cases may indicate a degree of compromised middle-ear functioning and a discernable tympanometric peak is generally accepted as indicative of normal middle-ear functioning with 1000Hz tympanometry for infants, this criterion was specified alongside an OAE pass result to ensure ears with normal middle-ear functioning was included (Purdy & Williams, 2000:18; Kei et al., 2003:22; Sutton et al., 1996:13).

According to the two criteria, normative data was compiled for 809 ears (52% male). Table 6.16 presents these norms for 1000Hz tympanometry for all ears compared to norms for male and female ears.

TABLE 6.16 1000Hz tympanometry norms for the sample

SAMPLE	ALL EARS <i>Y_a (n=809 ears)</i>		MALE EARS <i>Y_a (n=424 ears)</i>		FEMALE EARS <i>Y_a (n=385 ears)</i>	
	Peak admittance	TPP (daPa)	Peak admittance	TPP (daPa)	Peak admittance	TPP (daPa)
Mean	2.9	0	3.1	5	2.6	-5
Std Deviation	1.1	61	1.3	61	0.8	61
Max	9.6	185	9.6	160	8.7	185
Min	0.9	-275	1.1	-275	0.9	-205
5th Percentile	1.5	-110	1.7	-100	1.4	-115
50th Percentile Median	2.6	5	2.9	10	2.4	5
95th Percentile	4.9	90	5.4	95	4.2	90

The peak admittance values presented in Table 6.16 indicated a statistical significant difference between male and female ears with static admittance

higher for boys than girls. No statistically significant difference was obtained for tympanic peak pressure values between genders. A study by Palmu et al. (2001:182) investigating infant ears at 7 and 24 months of age with 226Hz probe tone tympanometry indicated similar results. A statistically significant difference was reported between static acoustic admittance values for male and female ears the admittance values for boys significantly higher than for girls. This was attributed to the difference in middle ear and tympanic membrane sizes (Palmu et al., 2001:183). Similar differences between male and female ears in adults have been widely reported for 226Hz probe tone tympanometry (Fowler & Shanks, 2002:178). It is therefore important to consider that 1000Hz probe tone tympanometry peak admittance values are significantly lower for females compared to males when assessing infant ears. The distribution of peak admittance values for this normative sample is presented in Figure 6.20.

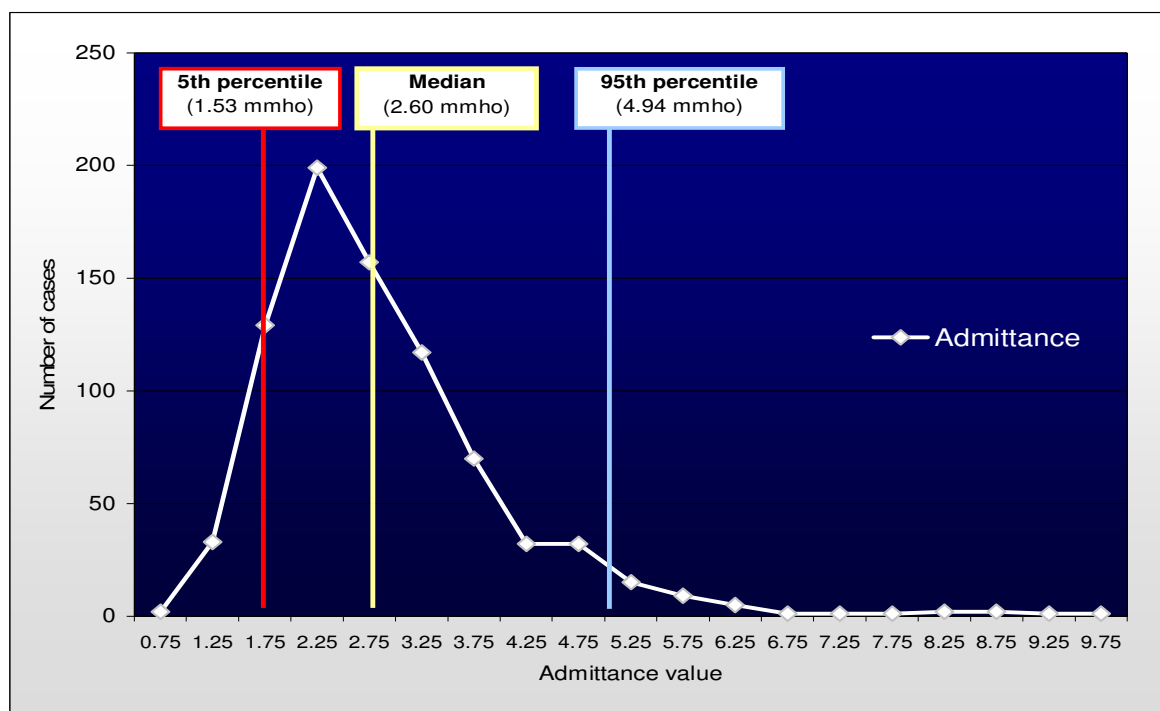


FIGURE 6.20 Distribution of peak admittance values for normative sample (n=809)

Another important aspect that must be considered is the fact that static acoustic admittance values have been shown to increase substantially with age and therefore normative data for different age groups becomes essential to avoid

high numbers of false-positive results due to inappropriate normative values (Palmu et al., 2001:183; Keefe & Levi, 1996:368; Meyer et al., 1997:192; Holte et al., 1991:12). The normative data was therefore calculated for neonates represented in Table 6.17 and for older infants in Table 6.18.

TABLE 6.17 1000Hz tympanometry norms for neonates

SAMPLE	0 WEEKS OF AGE (n=73 ears)		1-4 WEEKS OF AGE (n=177 ears)		0-4 WEEKS OF AGE (n=250 ears)	
	Peak admittance	TPP (daPa)	Peak admittance	TPP (daPa)	Peak admittance	TPP (daPa)
<i>Mean</i>	2.2	-10	2.4	5	2.4	-1
<i>Std Deviation</i>	0.9	48	0.7	49	0.8	49
<i>Max</i>	7.7	185	5.1	115	7.7	185
<i>Min</i>	1	-130	1.2	-185	1	-185
<i>5th Percentile</i>	1.2	-70	1.5	-80	1.4	-75
<i>50th Percentile Median</i>	2.0	-10	2.3	5	2.2	-5
<i>95th Percentile</i>	3.4	70	3.8	85	3.7	80

Table 6.17 presented normative peak admittance and tympanic peak pressure values for different age neonates whilst Table 6.18 provides the same norms for infants 5 weeks and older up to one year of age. Statistically significant differences were obtained for static peak admittance values between all age groups. Neonatal ears presented with the lowest mean and smallest standard deviation for peak admittance with a range of values from the 5th to 95th percentile of 2.3 mmho compared to 3.2 and 4.3 mmho for infants 5-16 weeks and 17-52 weeks of age, respectively. The admittance result therefore indicates increasingly higher peak admittance values with increasing age accompanied by an increasing range of variability as demonstrated by higher standard deviation values as infants become older.

TABLE 6.18 1000Hz tympanometry norms for infants 5-52 weeks of age

SAMPLE	5-16 WEEKS OF AGE (n=361 ears)		17-52 WEEKS OF AGE (n=194 ears)		5-52 WEEKS OF AGE (n=555 ears)	
	Peak admittance	TPP (daPa)	Peak admittance	TPP (daPa)	Peak admittance	TPP (daPa)
Mean	2.8	-3	3.5	8	3.1	1
Std Deviation	1.0	63	1.4	70	1.2	66
Max	6.4	155	9.6	170	9.6	170
Min	0.9	-275	1.2	-205	0.9	-275
5th Percentile	1.7	-120	1.9	-115	1.8	-120
50th Percentile Median	2.5	5	3.3	15	2.8	10
95th Percentile	4.9	90	6.2.	105	5.3	95

The peak admittance results for the different age groups are in agreement with previous reports indicating an increase in peak admittance with age (Palmu et al., 2001:183; Keefe & Levi, 1996:368; Meyer et al., 1997:192; Holte et al., 1991:12). The peak admittance norms for neonatal ears are similar to a recently reported sample of 46 neonatal ears evaluated with 1000Hz tympanometry (Margolis et al., 2003:386). This study reported a mean peak admittance of 2.7 mmho compared to 2.4 in the current study and a 5th to 95th percentile range of 1.2 – 4.8 mmho compared to 1.4 – 3.7 mmho in the current study. The close relationship between the 5th percentiles indicates the significance of this value as a more robust diagnostic criterion compared to the more variable 95th percentile which is not usually an indication of pathology in neonates (Margolis et al., 2003:389). The increase of the lower percentile peak admittance values with increasing age are primarily attributed to: an increase in size of the external and middle-ear cavity and mastoid; a change in the tympanic membrane orientation; fusion of the tympanic ring; a decrease in the overall mass of the middle ear due to changes in bone density and loss of mesenchyme; tightening of the ossicular

joints; closer coupling of the stapes to the annular ligament; and the formation of the bony ear canal wall (Purdy & Williams, 2000:9; Meyer et al., 1997:194; Holte et al., 1991:21).

The tympanic peak pressure values for neonates were significantly different compared to the rest of the infant ears. The neonatal ears presented with a narrower 90% tympanic peak pressure range (5th to 95th percentile) of 155 daPa compared to 215 daPa for infant ears between 5-52 weeks of age. Neonatal ears also indicated less variability for tympanic peak pressure values than infant ears with a standard deviation of almost 30% less than that of the infant ears. The mean pressure values were very similar with all age groups approximating 0 daPa. Although little is known regarding the significance of tympanic peak pressure in the infant population the results in the current study indicate a normal distribution of results for normal infant middle ears ranging around the 0 daPa with increasing variability with increasing age. These results are similar to the 90% range for static admittance (-133 – 113 daPa / 5th – 95th percentile) reported for neonatal ears using 1000Hz probe tone tympanometry reported by Margolis et al. (2003:386). The results of this study therefore demonstrate an increase in tympanic peak pressure ranges with increasing age, allowing more stringent criteria for normality in neonates especially for those in the first week of life.

It is clear that the effect of positive middle-ear pressure above 80 - 90 daPa strongly affects the presence of OAE and a discernable tympanometric peaks as also indicated by previous studies (Owens et al., 1992:55; Thornton et al., 1993:322). The results of the current study therefore suggest that increasingly positive middle-ear pressure may be an important indicator of the presence of MEE in neonates and infants. This phenomenon, however, requires further investigation to ensure that other conditions such as poor Eustachian tube functioning are not the cause of positive middle-ear pressures which lead to OAE refer results.

A summary of the normative tympanometric data for the different age groups is presented in Figure 6.21.

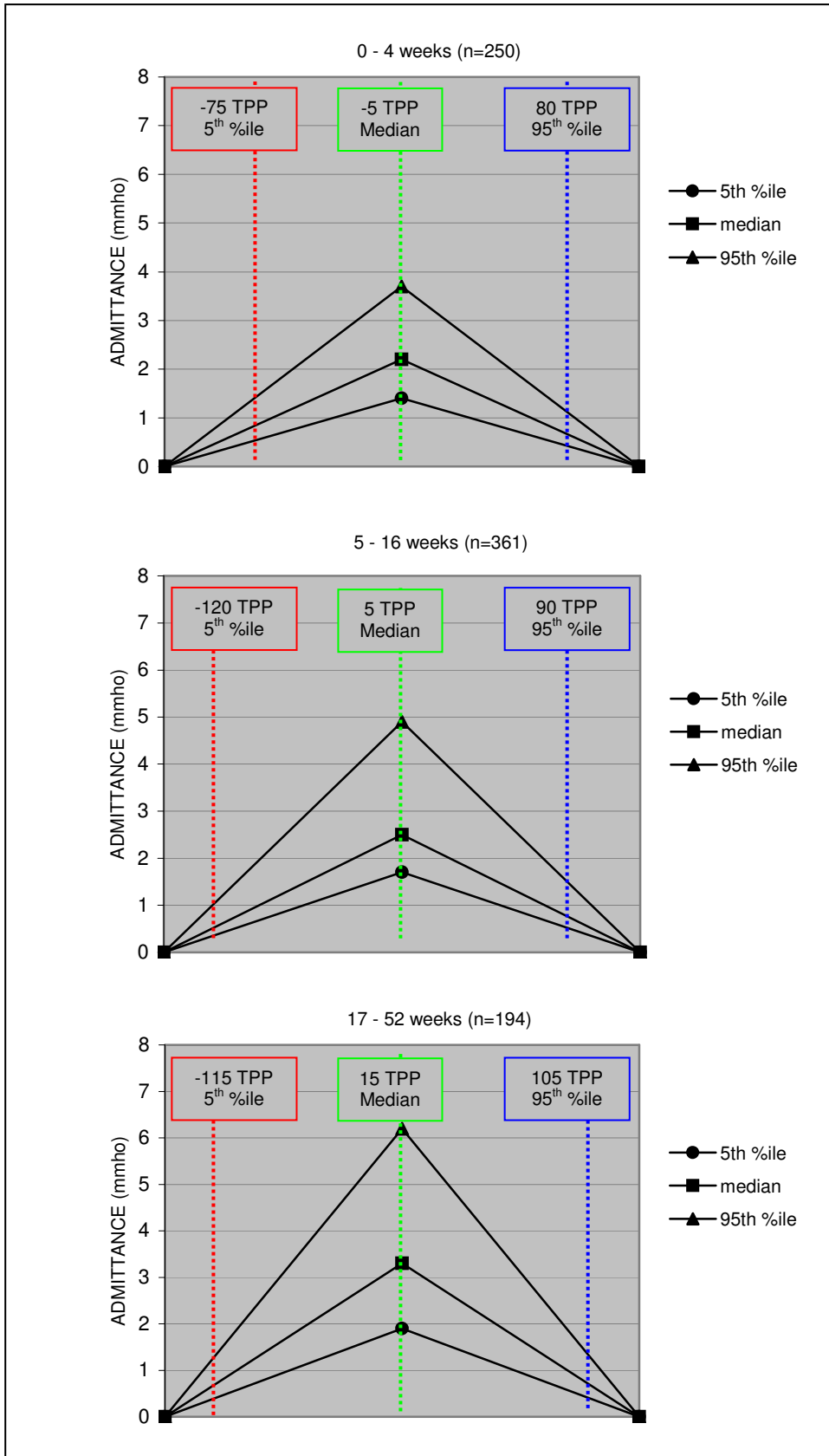


FIGURE 6.21 Peak admittance and tympanic peak pressure norms

Acoustic reflex threshold normative data for the current study was also investigated as part of the 1000Hz immittance norms. A summary of the acoustic reflex thresholds, compiled from 727 ears (52% male) and adhering to the two criteria set for including ears in normative data, is presented in Table 6.19.

TABLE 6.19 1000Hz probe tone acoustic reflex norms for the sample

SAMPLE	MALE & FEMALE (n=727 ears)	MALE (n=379 ears)	FEMALE (n=348 ears)
VARIABLES	AR Threshold (dB)	AR Threshold (dB)	AR Threshold (dB)
<i>Mean</i>	93	92	94
<i>Std Deviation</i>	9	9	9
<i>Max</i>	110	110	110
<i>Min</i>	60	65	60
<i>5th Percentile</i>	80	75	80
<i>50th Percentile Median</i>	95	95	95
<i>95th Percentile</i>	105	110	105

A high incidence of present reflexes was obtained and in the presence of a peaked tympanogram an acoustic reflex threshold was present in 94% of cases. Table 6.19 indicates that no significant difference was observed between reflex thresholds for male and female ears in contrast to peak admittance values for infants. Similarly no significant differences were indicated between the various age groups. Thus all ears were considered together indicating a mean threshold of 93dB with a 9dB standard deviation and a 90% range of 25dB (80 – 105dB). The 95th percentile for this group was at 105dB, which is close to the maximum output of the equipment (110dB), meaning that it does not seem to indicate any

diagnostic significance. Thus the value of the acoustic reflex normative data may be limited and its usefulness for infants should further be investigated in ears with pathology. The importance of the acoustic reflex seems to lie simply in the fact that its presence is usually reassuring of a normal middle ear (Gates et al., 1994:56; Purdy & Williams, 2000:14).

No large-scale studies reporting normative 1000Hz probe tone acoustic reflex thresholds have been reported previously. Although few reports are available results suggest that a 1000Hz probe tone is preferable for testing reflexes in newborns and young infants (Northern & Downs, 2002:228; Weatherby & Bennett, 1980:108; Purdy & Williams, 2000:14). The fact that reflex presence seems to be the important acoustic reflex criteria indicative of normal middle-ear functioning means that the most efficient stimuli for evoking the reflex should be used. Early 1000Hz probe tone reports indicated a 100% acoustic reflex presence in a small sample of newborns (n=35) using a broadband stimulus compared to a 92% presence in the OAE pass group of ears. Further research is however required to compare the different stimuli.

6.5.3. Protocol efficiency

Aspects indicative of the efficiency of the hearing screening protocol implemented at the two MCH clinics in the Hammanskraal community will be discussed in the following section. The efficiency aspects to be discussed include the coverage of the screening protocol using the various screening techniques and apparatus; the referral rate for the individual screening techniques and the protocol referral rate; and the follow-up process according to the specified protocol. The coverage of the population by the screening protocol will be presented and discussed firstly.

▪ Screening protocol coverage

The coverage of the screening protocol for the population of infants and caregivers enrolled over the 5 months of data collection at two MCH clinics in the Hammanskraal district is presented according to the HRR and test procedures

performed. Figure 6.22 provides a summary of the coverage of the HRR and each screening procedure for the population of 510 infants and caregivers.

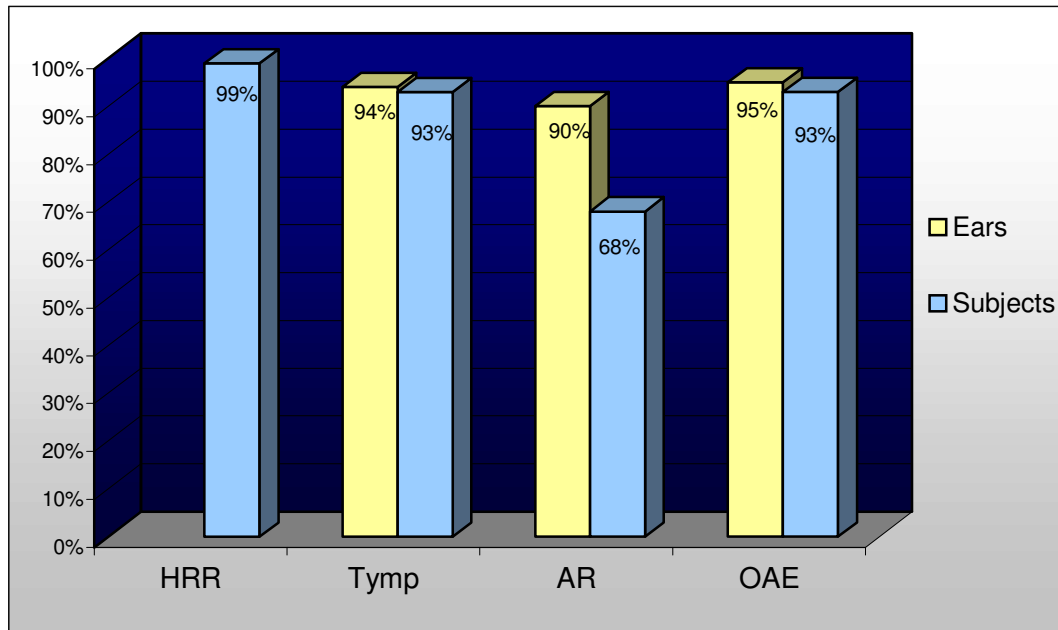


FIGURE 6.22 Coverage of population by HRR and test procedures

The coverage rates are discussed according to each individual procedure:

- *High-Risk Register*

The HRR was conducted for almost all subjects (99%). This provides evidence for the recommendation by the South African year 2002 HSPS that TNHS be implemented at MCH 6-week immunisation clinics in 2005 (HPCSA, 2002:2). The high coverage rate for this procedure holds promise for its use as a way of identifying infants at increased risk of hearing loss to receive an electrophysiological hearing screening at these clinics. This type of screening is recommended as an intermediate step towards establishment of necessary systems and manpower to introduce UNHS in 2010 (HPCSA, 2002:2).

- *High frequency tympanometry*

Evaluating middle-ear functioning bilaterally using high frequency tympanometry could be successfully performed on 93% of subjects and 94% of ears in this sample. A higher coverage of ears than subjects were reported because for a small number of subjects only one ear could be evaluated with tympanometry. The tympanometric coverage in this study falls within the range of reported success rates for conducting high frequency tympanometry on neonates and infants, which varies between 87 – 99% (Thornton et al., 1993:320; Sutton et al., 1996:11; Palmu et al., 1999:211; Kei et al., 2003:27).

Primary reasons for an inability to obtain successful tympanometric results in infants are reported to be due to the lack of a secure seal because of infant movement or irritability (Kei et al., 2003:23; Sutton et al., 1996:11). A study investigating infants past the neonatal stage reported a better success rate for infants younger than 7 months compared to infants older than 7 months because older infants became restless faster, were shy of people outside their home and were also more suspicious of tests done by unfamiliar personnel (Palmu et al., 1999:211). Similar observations were made in the current study. The tympanometry coverage suggests that using a 1000Hz probe tone tympanometric results can successfully be conducted in almost all infants attending MCH clinics with higher success in younger infants. The fact that the South African year 2002 HSPS specifies hearing screening to be conducted 3 months of age improves the probability of obtaining successful tympanometric results (HPCSA, 2002:3).

- *Acoustic reflexes*

The smaller percentage of successful acoustic reflex measurements compared to tympanometry measurements can primarily be attributed to the fact that reflex testing was conducted after OAE and tympanometry measurements. This caused some infants to be restless and irritable by the time reflex testing was conducted. A significant difference was also noted,

as illustrated in Figure 6.22, between conducting an acoustic reflex measurement on at least one ear (90%) compared to performing a bilateral acoustic reflex measurement (68%). This can similarly be attributed to the fact that acoustic reflex measurement proceeded after tympanometry and many infants endured reflex testing for the first ear but became too restless and irritable for bilateral testing. These results therefore suggest that successful 1000Hz probe tone reflex measurements can be made for the majority of ears (90%) in the population of infants attending the MCH clinics in Hammanskraal even if the procedure follows other procedures. Higher percentage coverage can be expected if both OAE and tympanometric testing do not precede reflex testing.

- *OAE screening*

95% coverage for all ears and 93% coverage for bilateral screening of subjects in the sample was obtained. Some subjects could not be tested, or only one ear tested, due to irritability and restlessness. The JCIH (2000:15) recommends an OAE screening coverage benchmark of 95% for bilateral screening also accepted as benchmark by the South African year 2002 HSPS (HPCSA, 2002:4). This means that the coverage for bilateral measurements in the current study falls short of this benchmark by 2%. Reports on hearing screening coverage at primary healthcare clinics have not been previously reported since the vast majority of neonatal and infant hearing-screening programmes are hospital based. Although it is widely accepted that the majority of these programmes achieve an acceptable coverage of >95%, significant variability is also reported in certain cases (Watkin, 2003:168; White et al., 1997:227; Iwasaki et al., 2004:1100; Kennedy et al., 1998:1963). Initial screen coverage varying between 99.8% in a Japanese hospital and 87% reported for the Wessex trial in the UK has been reported (Iwasaki et al., 2004:1100; Kennedy et al., 1998:1963). Thus the coverage in the current study is close to the specified benchmark and within the range of reported coverage for hospital-based programmes. If the bilateral (93%) and small percentage of unilateral screens (3%) in the

current study are considered together a comprehensive coverage of 96%, adhering to the JCIH (2000:15) benchmark of 95%, is obtained.

- *AABR screening*

According to the screening protocols specified in Chapter 5 the AABR was recommended for a small subset of infants in the sample including all NICU exposed infants and all infants referring the initial OAE screen. The AABR was therefore successfully performed for only 24% of the ears (22/90) requiring an AABR screening according to the specified protocol. This low percentage of successful AABR evaluations on infants attending the MCH clinics in this study can be attributed to the following factors already mentioned in paragraph 6.4.3. Firstly, infants requiring AABR screenings varied in age from birth to 52 weeks with a mean age of 18 weeks \pm 14 weeks standard deviation. Since most of the subjects were older than 1 month it was difficult to prepare and test an infant without the infant becoming irritable and restless which made further screening impossible. Secondly, the AABR screening was performed after OAE and immittance measures were already conducted which contributed to infants already being restless and irritable. Lastly, those infants on whom AABR evaluations could not successfully be performed were referred to return within a week or two to complete the screening. Unfortunately very few mothers returned with their infants. These reasons make the AABR an inefficient screening option for use at MCH clinics. Despite its advantages in terms of identifying auditory neuropathy and being less sensitive to mild conductive hearing losses (Mehl & Thomson, 2002:6) the low success rate for its use in primary healthcare clinics on slightly older infants compared to newborns in hospital-based programmes make it unfeasible for screening in these clinics.

In general, reasonably high coverage rates were obtained for all procedures, except the AABR, especially in light of the number of procedures performed on each subject pair in the current study. The AABR was the only procedure that

proved to be inefficient for hearing screening at the MCH clinics investigated in this study.

▪ **Protocol referral rate**

The referral rate of the individual procedures performed in this study are summarised in Figure 6.23 according to the rate for the sample of ears and subjects according to the specified criteria of a unilateral refer result.

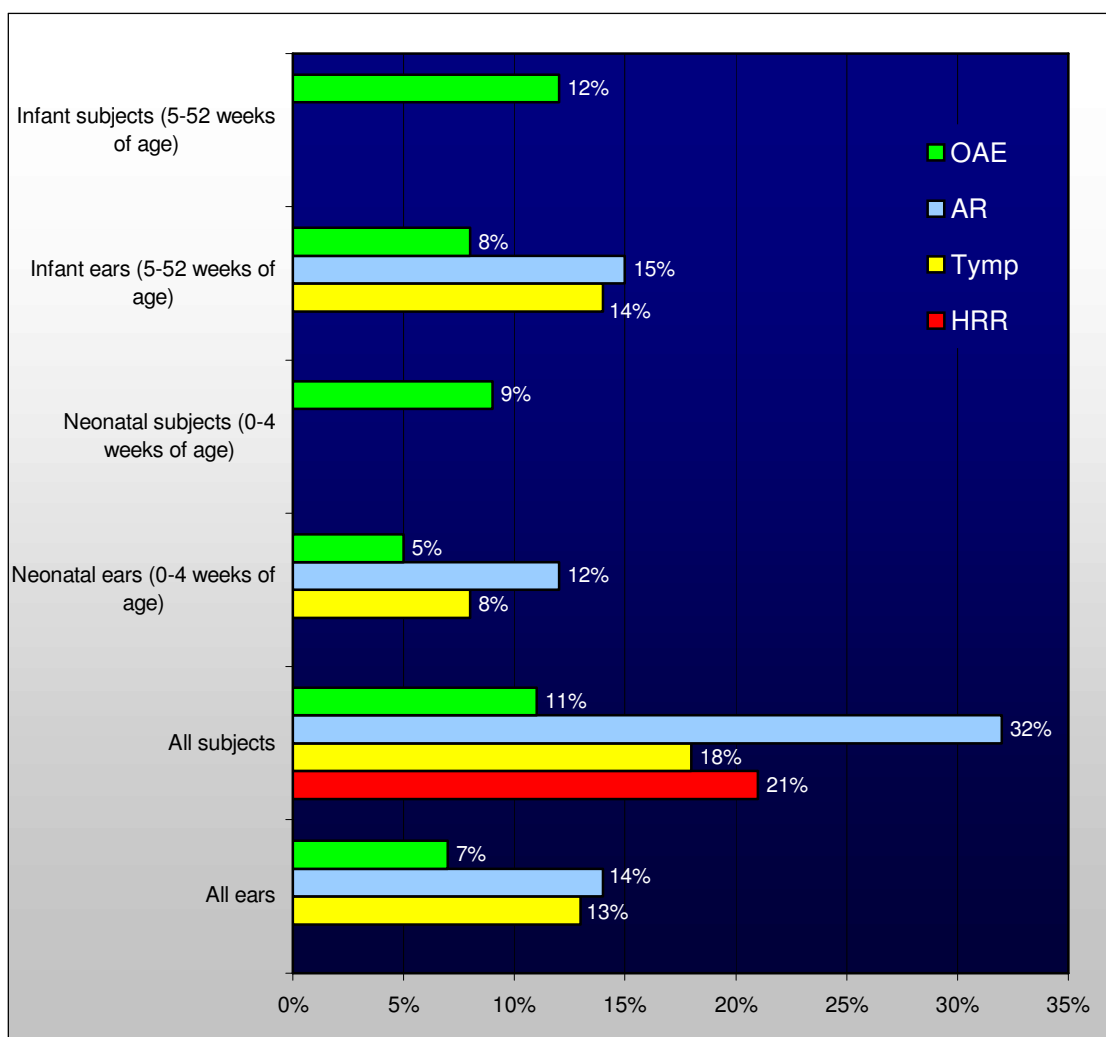


FIGURE 6.23 Refer results for procedures in terms of ears and subjects

The referral rates for the procedures in Figure 6.23 are summarised from the results of sub-aim #3. Since the hearing screening protocol of the current study was based on OAE and AABR screening tests the following discussion will focus on the referral results for the hearing screening protocol.

As illustrated in Figure 6.22, 11% of subjects for whom a bilateral OAE screen could be performed (93% of sample) were referred on a criteria requiring at least one refer result per subject. If subjects with at least one risk indicator for whom a bilateral OAE screen was performed are considered a slightly higher OAE referral rate of 12,5% was recorded compared to 11% for the rest of the sample. Thus a slightly higher incidence of risk factors (22%) was present in the group of subjects with OAE refer results compared to the group of subjects with OAE pass results (20%). Five of the subjects with bilateral OAE refer results (33%) had at least one risk factors compared to seven subjects with unilateral OAE refer results (18%). According to the OAE screening protocol specified in Chapter 5, which also took into account the referral of subjects for whom only one ear could be evaluated no matter what the outcome, the referral rate increases to 14%. This incidence rate is comprised of 8% who referred one ear, 3% referred who referred both ears and 3% were referred because only one ear was evaluated.

The subject referral rate for those receiving successful screens is close to the reported average of 8-11% of initial TEOAE referrals based on one or both ears referring (Watkin 2003:169). This is similar to a 10% referral rate reported by Vohr et al. (1998:355) for initial OAE screening and falls within the range of 9 - 18% initial referral rate reported for DPOAE protocols by Norton et al. (2000c:532). Although the initial OAE referral rate in the current study is similar to previous reports this figure is still significantly higher than the benchmark of a 4% follow-up referral rate recommended by the JCIH (2000:15) and the South African HSPS (HPCSA, 2002:3). Even though this benchmark is specified to be obtained within one year of programme initiation and the current programme was only implemented for 5 months, a single OAE screen requires a second step screen to obtain acceptably low refer rates.

An AABR evaluation was required for 90 ears according to the screening protocol criteria specified in Chapter 5, of which only a small sample received successful AABR screens (24%). Despite this small number of second step AABR screens performed, the overall OAE refer rate was reduced from 7% to 6% for the group of ears. The subject referral rate for subjects for whom bilateral OAE results were obtained drops from 11% to 10% and for this same group including subjects with a unilateral screen no matter the result, dropped from 14% to 13%. This is similar to a recent report using a combined OAE and AABR screening device which indicated improved refer rates using both techniques in newborns (Hall et al., 2004:423). The AABR therefore proved effective in reducing the referral rate although it proved unsuccessful as a screening tool for the majority of infants requiring this type of screening at the MCH clinics investigated in this study.

If a screening protocol requiring only an OAE pass from one ear is applied to the current group of subjects, the referral rate drops from 14% to 3%, which is within the specified benchmark of the JCIH (2000:15) and South African HSPS of <5% (HPCSA, 2002:3). This means that if only a single ear OAE screening protocol was followed at these clinics, 22% of infants referring according to the bilateral hearing screening protocol would also refer for further testing using the unilateral screening policy. A unilateral screening protocol would therefore reduce the referral rate sevenfold resulting in 78% less follow-up evaluations. These two factors will significantly reduce the monetary and human resource requirements for a hearing screening programme and for this very reason certain hospitals have opted to implement such protocols (Hall et al., 2004:423).

The fact that a unilateral screening protocol will save resource expenditure must however, be evaluated against the cost of not identifying a group of infants with unilateral hearing loss. Although research shows that unilateral hearing loss does influence developmental and emotional outcomes in children (Bess et al., 1998:339), limited resources inevitably places a larger emphasis on identifying bilateral hearing loss above the more expensive identification of unilateral

hearing loss also (Lutman, 2000:368). The question of unilateral versus bilateral hearing loss detection becomes a compromise between the effectiveness of the treatment and the costs of the screening and the final decision of selecting a target disorder should be decided within the context of available resources. Considering the South African national health context with limited resources and health priorities skewed toward more life threatening diseases such as HIV and tuberculosis, a screening protocol for bilateral hearing loss may be a suitable initial option for this country.

▪ **Follow-up results**

A hearing screening result, in at least one ear, was obtained in 489 of the 510 subjects enrolled in this study. A small percentage (4%) of the 510 enlisted subjects attending the two MCH clinics during the 5-months of data collection did not receive any hearing screening. These subjects were lost during the initial screening process and therefore no referral for follow-up evaluations could be made. The remainder of the sample (n=489) resulted in 68 subjects referring according to OAE results, with 15 referring both ears and 39 referring either the left or right ear. The other 14 subjects in the follow-up group were subjects for whom OAE results could only be obtained for one ear. 13 of these subjects had a pass in the one ear and one subject presented with a refer result in one ear. When the AABR results are also considered the total number of subjects referring according to the protocols specified in this study comes to 61 subjects. The follow-up process and return rate for these 61 subjects is illustrated in Figure 6.24.

As illustrated in Figure 6.24 only 27 subjects returned for follow-up evaluations, which is less than half (44%) of the infants and caregivers at the two MCH clinics who were referred for a follow-up screen during the data collection period of this study. 33% of the subjects who returned for follow-up evaluations presented with risk factors. Risk factors were recorded for 9 subjects of whom 2 subjects presented with 2 risk factors and 1 subject presented with 3. Altogether 13 risk factors were recorded of which 7 were for a family history of hearing loss, 2 were

for NICU admittance for longer than 48 hours, and one recording of asphyxia, ototoxic medication and the presence of a syndrome was recorded.

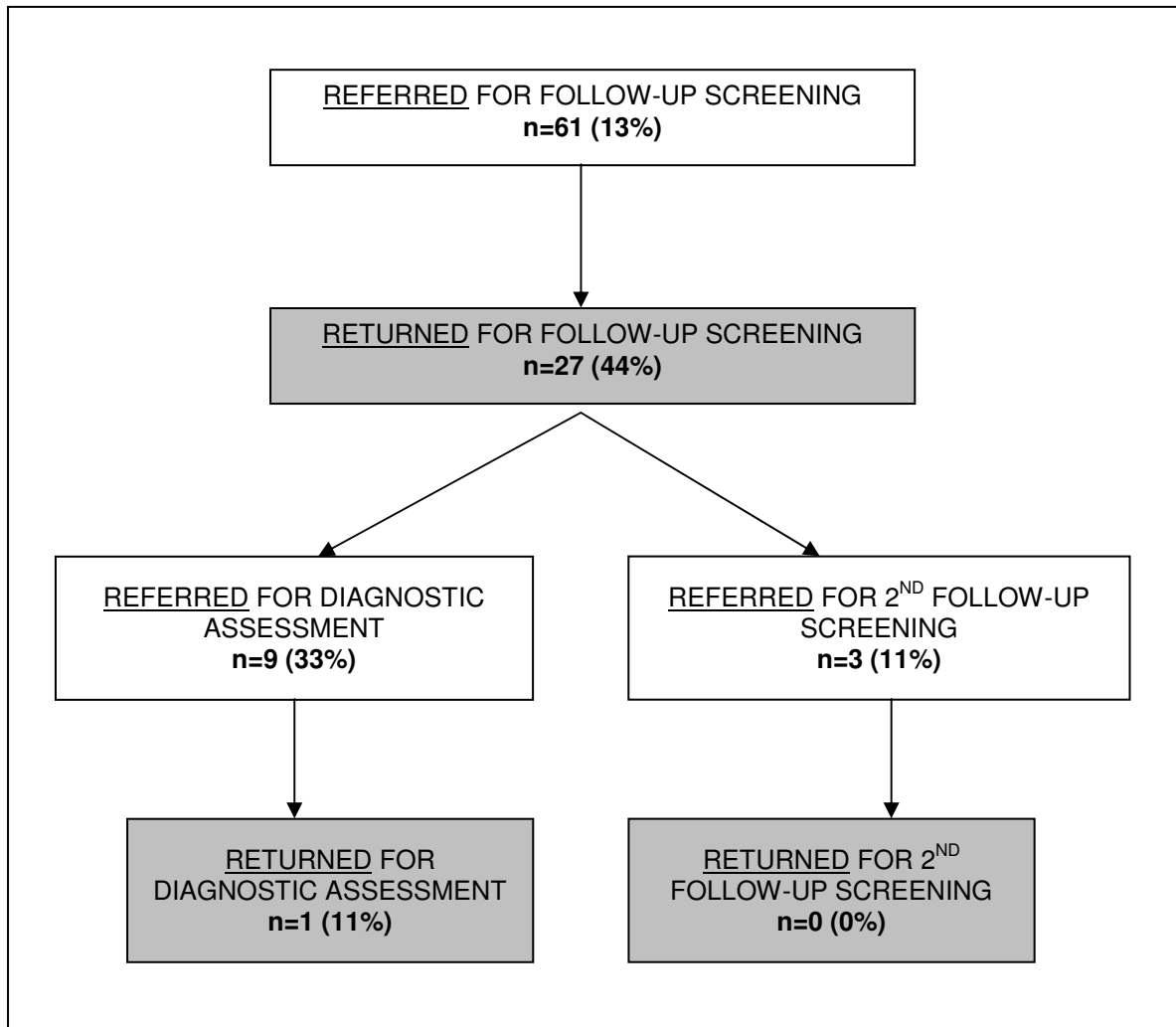


FIGURE 6.24 Results of the follow-up process

There was a significant increase in risk factor incidence for the group returning for follow-up (33%) compared to risk incidence in the sample (21%). The increased incidence of risk factors in the subjects returning for follow-up evaluations can be attributed to three facts. Firstly, there is a slightly higher incidence of risk factors present in subjects who referred (22%) compared to subjects who passed (20%) according to the OAE screen result. Secondly, there

is a slightly higher referral rate among the high-risk (12,5%) group compared to the no-risk group (11%) based on subjects receiving a bilateral OAE screen (n=475). This is similar to results reported by previous studies (Norton et al., 2000c:532). Lastly, caregivers cognisant of the fact that their infant has a risk factor for hearing loss may be more prone to return for a follow-up evaluation. All three these facts together may account for the increased prevalence of risk factors in the group of caregivers and infants returning for follow-up.

Of these 27 subjects returning for a follow-up evaluation, three (2 requiring a bilateral and 1 requiring a unilateral screen) could not be screened due to restlessness and irritability and were therefore referred for a 2nd follow-up screening. Of the follow-up ears that could be screened and which initially referred the OAE screen, 65% passed the follow-up OAE screen. This means that if OAE is considered a measure of external and middle-ear functioning transient MEE and/or external ear canal obstruction can account for approximately 65% of OAE refer results as determined in this sample of follow-up ears. Only 3 of the follow-up subjects with OAE refer results could be evaluated with the AABR. In each case only one ear could be evaluated revealing one pass and two refer results.

Considering tympanometric results in conjunction with the OAE results allows a closer investigation of the MEE and/or ear canal obstruction incidence in this sample. In 23 ears both OAE and tympanometry results were obtained for the initial and follow-up screen. 15 of these ears had an OAE pass for the follow-up screen and tympanogram results for these subjects were as follows, 1) five (33%) had an initial flat tympanogram result with a subsequent follow-up tympanogram peak, 2) three (20%) had an initial tympanogram peak result with a subsequent follow-up tympanogram peak, 3) seven (47%) had an initial flat tympanogram result with a subsequent flat tympanogram result for the follow-up screen. The first group (33%) clearly indicate transient MEE as explanation for the initial OAE referral. The third group (47%) may also indicate transient MEE in its resolution stage, with adequately resolved MEE to allow the recording of an OAE pass result but inadequate resolution for recording a tympanogram peak.

The second group (20%) is difficult to define but may have produced an OAE refer result due to an obstruction in the external ear canal which did not affect the tympanogram result. Published estimates of MEE prevalence in neonates and infants vary widely (Hall et al., 2004:423). The results for the current study does however indicate that more than 50% of OAE initial refer results for infants younger than one year of age may be due to MEE and/or obstruction of the external ear canal.

A second referral was made for 12 subjects after the follow-up screening. As illustrated in Figure 6.24 three of these subjects were referred for a 2nd follow-up screen because they could not be screened and the other 9 subjects were referred for diagnostic testing. No subjects returned for the 2nd follow-up screen and only one subject (11%) returned for diagnostic testing. This subject was assessed with a diagnostic ABR and revealed no sensori-neural hearing loss in either ear.

Follow-up return rates are primary indices of the efficiency and effectiveness of screening programmes (Gravel et al., 2000:132; Finitzo et al., 1998:1459). The poor follow-up return rates for the hearing screening programme implemented at the two MCH clinics in this study undermines the programmes ability to identify hearing loss. This is not an uncommon problem however, since most operational programmes identify inadequate follow-up return rates as the most significant challenge toward early identification of hearing loss (White, 2003:85). Great variability has been reported for follow-up rates with high follow-up rate reported for a UNHS programme in Brazil indicating an 82% follow-up rate compared to a 54% follow-up rate for a hospital-based UNHS programme in Bulgaria (Chapchap & Segre, 2001:34; Rouev et al., 2004:808).

The relatively short period of time in which the hearing-screening programme was implemented at the clinics is an important contributing factor to poor follow-up return rates. In one of the most successful state-wide screening programmes in the USA the initial follow-up rate was 48% for the first five years which is

similar to 44% for the current study over a period of only 5 months (Mehl & Thomson, 2002:1). This follow-up return rate has now improved to 76% with 9 hospitals achieving a 95% follow-up rate (Mehl & Thomson, 2002:1). It is clear therefore that as programmes develop and mature better tracking procedures are implemented which increases the follow-up rate.

The poor follow-up return rate in the current study is to be expected compared to the initial years of other programmes (Mehl & Thomson, 2002:1). The results only emphasise the importance of developing a comprehensive integrated system for tracking and follow-up within the South African national healthcare system. Ensuring high follow-up rates is a process that improves over time with the application of sustained effort and dedication.

6.5.4. Summary of results and discussion: sub-aim #4

A description of the performance and efficiency of the screening protocol implemented in this study reveals the following conclusions, presented in Table 6.20, regarding the procedures used in the protocol and the efficiency of the process as.

TABLE 6.20 Summary of results and discussion for sub-aim #4

Screening procedure performance

- A strong and highly significant association between all combinations of OAE, tympanometry and acoustic reflex result comparisons was found ($p < 0,0001$).
- High frequency immittance results proved reliable measures of middle-ear transmission especially for establishing normal functioning as measured by OAE. This is evident in the fact that both peaked tympanogram (98%) and present acoustic reflex (99%) results predicted an OAE pass result with a probability of approximately 100%.
- Results across various age groups of infants suggest significantly higher immittance sensitivity for infant ears compared to neonatal ears. In contrast increased tympanometry and decreased reflex specificity was found for neonatal ears compared with infant ears. Despite the smaller number of neonatal OAE referred ears and a higher OAE failure rate (8% compared to 5%) for older infants – which may contribute to this difference – results suggest that 1000Hz probe tone immittance testing is more reliable to correctly identify MEE in infants over 4 weeks of age than for neonates.
- Screening procedure performance in the current study suggest that a protocol using high frequency tympanometry and acoustic reflexes in conjunction with OAE may be useful in classifying ears into different risk categories for sensori-neural hearing loss and MEE.

High frequency immittance norms

- Peak admittance values for 1000Hz probe tone tympanometry in infants with normal middle-ear functioning are significantly lower for females compared to males whilst no statistically significant gender difference was obtained for tympanic peak pressure values. Similar results have been widely reported for 226Hz probe tone tympanometry (Palmu et al., 2001:182; Fowler & Shanks, 2002:178).
 - Statistically significant different peak admittance values were evident for across infant age groups with higher peak admittance values and increasing variability with increasing age. The peak admittance results for the different age groups are in agreement with previous reports indicating an increase in peak admittance with age (Palmu et al., 2001:183; Keefe & Levi, 1996:368; Meyer et al., 1997:192; Holte et al., 1991:12).
 - The tympanic peak pressure values for neonates were significantly different compared to the rest of the infant ears, presenting with a narrower 90% tympanic peak pressure range (5th to 95th percentile) and less variability with a standard deviation almost 30% less than for infant ears.
 - The effect of positive peak tympanic pressure above 80 - 90 daPa strongly affected the presence of OAE and a discernable tympanometric peaks as also indicated by previous studies (Owens et al., 1992:55; Thornton et al., 1993:322). Thus results of the current study suggest that increasingly positive middle-ear pressure may be an important indicator of the presence of MEE in neonates and infants.
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TABLE 6.20 Continued

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- Acoustic reflexes revealed no significant differences for gender or infant age. A mean threshold of 93dB with a 9dB standard deviation and a 90% range of 25dB (80 – 105dB) was obtained for the sample of ears. The importance of the acoustic reflex seems to lie simply in the fact that its presence is usually reassuring of a normal middle ear as previously also reported (Gates et al., 1994:56; Purdy & Williams, 2000:14).

Protocol efficiency

- Reasonably high coverage rates were obtained for all procedures, except the AABR, especially in light of the number of procedures performed on each subject pair in the current study. The AABR was the only procedure that proved to be inefficient for hearing screening at the MCH clinics investigated in this study.
 - Initial OAE screening coverage of 95%, adhering to the JCIH (2000:15) benchmark of 95%, was obtained when considering all subjects for whom a bilateral screen was performed (93%) and a small number of cases (3%) for whom only a unilateral screen could be performed.
 - The AABR coverage was poor, having been successfully performed for only 24% of the ears (22/90) and requiring an AABR screening according to the specified protocol. This low percentage of successful AABR evaluations on infants attending the MCH clinics in this study can be attributed to several reasons related primarily to the infant age range in this study.
 - Generally the OAE referral rate of the current study, 7% of all ears and 14% of subjects referring at least one ear or only having a unilateral screen, was within the range of reported values for an initial screening procedure (Norton et al. 2000c:532; Vohr et al., 1998:355; Watkin, 2003:169).
 - Implementing a screening protocol only requiring a unilateral OAE pass result for the current group of subjects, cause the referral rate to drop from 14% to 3%, which is within the specified benchmark of the JCIH (2000:15) and South African HSPS of <5% (HPCSA, 2002:3). Such a protocol would reduce the referral rate sevenfold and result in 78% less follow-up evaluations. Considering the South African national health context with limited resources and health priorities skewed toward more life threatening diseases, a screening protocol for bilateral hearing loss may be a suitable initial option for this country.
 - Poor follow-up return rates were obtained for the hearing screening programme at the two MCH clinics. Results, however, are similar to the initial refer rates of programmes that have become some of the most successful state-wide screening programmes in the USA (Mehl & Thomson, 2002:1). It is clear therefore that as programmes develop and mature better tracking procedures are implemented which increases the follow-up rate, The short 5-month data collection period at the MCH clinics did not allow enough time to develop appropriate tracking and follow-up systems.
 - The follow-up OAE results indicated that if OAE is considered a measure of external and middle-ear functioning, transient MEE and/or external ear canal obstruction may account for approximately 65% of initial OAE refer results for this study.
-

The results and discussion of sub-aim #4 described the performance and efficiency of the screening protocol implemented in this study. The summary presented in Table 6.20 indicates that the screening protocol proved effective in the vast majority of cases except for the inefficiency of the AABR screening procedure and the follow-up return process.

6.6. RESULTS AND DISCUSSION OF SUB-AIM #5: INTERACTIONAL PROCESSES IN THE IMPLEMENTATION AND MAINTENANCE OF A SCREENING PROGRAMME IN MCH CLINICS

The last sub-aim of the study was to describe the interactional processes involved in the implementation and maintenance of a screening programme at the two MCH clinics in the Hammanskraal community. The descriptions were part of the less-dominant research method being qualitative in nature. All descriptions were recorded and analysed from field notes and critical reflections by the fieldworkers involved and was compiled according to three general themes for this sub-aim. These themes were, 1) collaboration with nursing staff, 2) experiences with caregivers and, 3) experiences with the screening of infants 0-12 months of age. A summary of the fieldworkers' descriptions according to these themes and classified in terms of positive and negative aspects are presented in Tables 6.21, 6.22, and 6.23.

6.6.1. Presentation and discussion of results for sub-aim #5

Table 6.21 presents a summary of the collaboration between the fieldworkers and nursing staff at the clinics.

TABLE 6.21 Summary of fieldworker and nursing personnel collaboration

COLLABORATION WITH CLINIC PERSONNEL

POSITIVE ASPECTS:

- For the most part nursing staff were cooperative, helpful, friendly and positive toward the screening project.
- Although the nursing staff were initially hesitant about the presence of the fieldworkers, this attitude later changed as the nurses themselves reported that it was reassuring for them to see that the screening project was continuing in a consistent manner for the specified period.
- Personnel were helpful in accommodating the fieldworkers with regard to workspaces and disposables such as gloves and disinfectant.
- Nurses were eager to share information regarding the clinic statistics once a mutual trust developed between the nurses and the fieldworkers over the first month of screening.
- The nurses encouraged the mothers to have their infants' hearing tested and explained the importance to the caregivers.
- Giving feedback to the nurses about the screening results encouraged a collaborative relationship and established an ownership of the screening project among the nursing staff.
- Demonstrating respect toward the nurses by greeting them first thing in the morning and greeting them when leaving in the afternoon was reported by the nurses to be greatly appreciated and fostered a healthy collaboration.
- The good relationships allowed freedom for the researchers in the managing and organising the screening programme within the existing structure of the clinic.
- In a few instances when the one fieldworker fluent in many of the South African languages was not present and a caregiver was interviewed who did not understand English, the nurses were willing to act as interpreters.

NEGATIVE ASPECTS:

- Initially nurses were hesitant toward the implementation of a new hearing screening project.
- Only in isolated cases did one or two nurses not cooperate in referring and motivating mothers to come for the hearing screening and these instances were for the most part confined to the first few weeks of the research project.
- Once or twice nurses enquired to find out if we were asking a fee for the hearing screening. When they were assured that it was a free service they were very pleased.
- Nurses did not indicate a desire to learn what the hearing screening procedure entailed and did not offer to help screen the infants.

In general a positive collaboration between nurses and fieldworkers was evident with a natural resistance to change only reported initially (Olusanya, 2000:169). The collaborative relationship was fostered over time by providing a consistent service and maintaining an open channel of communication accompanied by basic courteousness. The only persistent negative aspect regarding the collaboration was the nurses' complacency and lack of interest in learning more about the effect of infant hearing loss and the screening process. According to Olusanya (2000:169) this is a result of a natural resistance to change and an inherent complacency, which is encouraged by the invisible nature of hearing loss. The prospect of implementing widespread hearing screening programmes at these clinics will however, require nurses or volunteers to perform the screening. This therefore emphasises the importance of making nurses collaborative partners in the screening process.

Developing effective collaborative partnerships require that both partners possess common core knowledge and share a common philosophy about the outcome of their services (Moodley et al., 2000:26). Utilising interdisciplinary training programmes to improve nurses' knowledge regarding hearing loss and the hearing screening process are the only means of establishing effective partnerships that share a common philosophy regarding the outcome (Olusanya et al., 2004:302; Gopal et al., 2001:106; Moodley et al., 2000:37). It is essential to be proactive once the widespread implementation of hearing screening programmes are conducted in South Africa by accompanying this process by interdisciplinary training programmes to raise the awareness and collaboration of nurses. In so doing the effective implementation of screening programmes at these clinics will be ensured to a much greater extent (Moodley et al., 2000:37).

The experiences of the fieldworkers with the caregivers are summarised in Table 6.22.

TABLE 6.22 Summary of fieldworker experiences with caregivers

EXPERIENCES WITH THE CAREGIVERS

POSITIVE ASPECTS:

- The vast majority of caregivers were very positive about the screening of their infants and indicated a genuine thankfulness. Most were at ease after explanation of the procedure and reassurance that the screening is not painful.
- The caregivers were very willing to share most of the information requested regarding identifying information and high risk indicators for hearing loss.
- The vast majority of caregivers embraced a certain degree of ownership in the screening process by often calming their infants through breastfeeding so that the screening could be performed.
- Waiting in line to have their infants' hearing screened did not seem to be a negative experience for the caregivers.

NEGATIVE ASPECTS:

- Language was a persistent barrier. Although most caregivers could speak and understand a little bit of English, many could not. Having two fieldworkers fluent in most of the official native languages in South Africa was an important asset.
- Some of the young mothers were anxious initially about the screening of their infants' hearing.
- The caregivers were sensitive about questions regarding sexually transmitted diseases.
- Among some of the mothers a fatalistic attitude toward disability was experienced. One mother did not want to wait for the hearing screening and stated that "if my child is deaf, he's deaf".
- Caregivers demonstrated very little insight into the implications of hearing loss and the importance of early intervention.

The interactional processes documented in Table 6.22 indicate that the caregivers generally had a positive attitude toward the hearing screening programme and demonstrated a certain degree of ownership by actively participating in the screening process. This active participation indicates an important asset in terms of assuming responsibility for the infant's hearing (Louw & Avenant, 2002:147). This is essential for effective transdisciplinary teamwork

with caregivers as the primary agents in the process of identification of hearing loss and subsequent intervention (Moodley et al., 2000:26).

A variety of barriers were identified with a significant barrier being poor awareness and ignorance among caregivers regarding hearing loss and the screening process in infants, which is not uncommon in the developing world (Olusanya et al., 2004:301). This was also the primary reason for initial anxiousness among some of the younger mothers during the screening even after the process was carefully explained. The poor awareness was also accompanied by a fatalistic attitude toward the possibility of having a hearing loss in a number of cases, which may reflect a cultural perception regarding disability (Louw & Avenant, 2002:146; Fair & Louw, 1999:20). Positive changes will therefore require culturally sensitive efforts towards enhancing public awareness in antenatal clinics and in communities regarding the benefits of early identification compared to lack of timely intervention (Bamford, 2000:365; Louw & Avenant, 2002:147).

Another important barrier was the reluctance of caregivers to report infection with sexually transmitted diseases such as HIV and syphilis. This was probably due to embarrassment and a negative social stigma associated therewith. Nursing staff may be better able to extract such sensitive information from caregivers. The recommendation by the year 2002 HSPS (HPCSA, 2002:3) to implement HRR screening at MCH clinics specifies nurses to conduct the screening and this may therefore result in more accurate documentation of risk factors such as congenital infections.

The experiences of the fieldworkers in regards to the screening of infants between 0 – 12 months of age are summarised in Table 6.23.

TABLE 6.23 Summary of fieldworker experiences with the screening of infants 0-12 months

EXPERIENCES WITH THE SCREENING OF INFANTS 0-12 m

POSITIVE ASPECTS:

- Sleeping infants are much easier to test. It was noted that neonates and young infants were easier to screen because they sleep more often and more readily.
- Testing the children who were restless while they breast-fed was an appropriate course of action in many instances.
- If infants were extremely restless, it sometimes worked to send the caregiver outside to calm the infant and bring him/her back once he/she is asleep or more restful.
- A technique that also worked for many infants who were awake was to distract them visually with moving objects in their field of vision (e.g. coloured objects, wriggling fingers etc.) to ease the insertion of the probe and occupy the infant for the duration of the test.

NEGATIVE ASPECTS:

- Awake and restless infants were a continual challenge. It was noted that older infants were often more difficult to evaluate because they were awake more often.
- Infants visit the clinic for an immunisation. After they received the injection it was near impossible to screen them as they were very uncomfortable and were often crying. All infants were recommended to come for the hearing screening first before they go for immunisation.
- Older children were also more wary of being screened because many of them had not seen a white person before and 3 of the 4 fieldworkers were white.
- Although breastfeeding helped to calm the infants in some cases, it was in cases where infants were drinking fervently not possible to screen with OAE as the internal noise from the sucking action was too loud.

According to the summary of fieldworkers' experiences with screening infants at the MCH clinics, presented in Table 6.23, breastfeeding was often used as a way of calming infants allowing for subsequent screening. In certain cases, however, the sucking action also proved to be a barrier due to excessive internal noise prohibiting OAE recordings. An important deduction evident from the summary in

Table 6.20 is that in general, neonates and younger infants were easier to test than older infants. This is also the primary reason why the AABR screening did not prove efficient for this group of infants. Similar difficulties in testing older infants have been reported previously and indicated a better success rate for younger infants because older infants became restless faster, were shy of people outside their home and were also more suspicious of tests done by unfamiliar personnel (Palmu et al., 1999:211). Fortunately the proposed initial screening recommended by the year 2002 HSPS is for young infants attending their 6-week immunisation clinic (HPCSA, 2002:2). Follow-up evaluations when they are older may however prove more difficult than the initial screening.

6.6.2. Summary of results and discussion for sub-aim #5

A summary of the results and discussion for sub-aim #5 is provided in Table 6.24.

TABLE 6.24 Summary of results and discussion for sub-aim #5

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- The interactional processes allowed for an effectively functioning screening programme at the two MCH clinics that were investigated in this study.
 - Collaborative relationships were fostered over time by providing a consistent service and maintaining an open channel of communication accompanied by basic courteousness.
 - Assuming an active responsibility for the hearing screening was also evident in the majority of caregivers, indicating promise for effective collaborative transdisciplinary teamwork with the caregivers as primary role players.

The **primary barriers** toward effective interaction processes according to the three specified themes were

- a complacency and lack of interest on behalf of the nurses to learn more about the effect of infant hearing loss and the screening process;
- poor awareness of the benefits of early intervention for hearing loss. accompanied by a fatalistic attitude toward the possibility of having a hearing loss in some cases; and
- older infants becoming more difficult to screen because they sleep less and are more shy of people outside their home.

Although the general interactional processes were satisfactory for a screening programme, the challenges must be addressed. This will require efforts towards enhancing public awareness in MCH clinics and in communities regarding the benefits of early identification compared to the negative impact of delayed intervention.

6.7. CONCLUSION

The current study described an early hearing detection programme at two MCH clinics in a developing, semi-urban, South African community to provide contextual data for the planning of future screening programmes in similar settings according to the year 2002 HSPS (HPCSA, 2002:5). Conducting such pilot studies are in line with the governmental priority to conduct Essential National Health Research (ENHR) and will provide a means of estimating the true costs and efficiency of implementing these programmes (Swanepoel et al., 2004:634). This information will serve to direct the development of an EHDI service delivery model at primary healthcare clinics for the provision of contextually relevant services to newborns and infants.

The results obtained in the empirical study revealed the potential uses of MCH clinics as a platform for conducting infant hearing screening and provided valuable information regarding the utilisation of different screening protocols and procedures suited to these settings. The findings challenged current recommendations by the year 2002 HSPS (HPCSA, 2002:5) and have generated a number of contextual recommendations toward implementing screening programmes and protocols that are efficient and effective within the primary healthcare clinic context of South Africa. The dearth of South African and international reports regarding the utilisation of primary healthcare centres as platforms for infant hearing screening programmes puts an important onus on the current results to serve as direction markers for future programme implementation. This is a first step in a process toward ensuring that South African infants with hearing loss, especially those from previously disadvantaged communities, are afforded the best opportunities for optimal development and societal integration through accountable EHDI services.

6.8. SUMMARY

This chapter provided a presentation and discussion of the results obtained in the empirical study. This included quantitative results, from the dominant data collection method, obtained from interview schedules and test procedures in conjunction with qualitative data, from the less-dominant data collection method, comprised from field notes and critical reflections. The results were presented and discussed according to the five sub-aims specified for this study aiming to address the main aim of the study. The discussions integrated the findings with the current body of knowledge to demonstrate the relevance thereof. The chapter was concluded with a conclusion and summary.