

**AUDITORY SCREENING OF BASIC SCHOOL CHILDREN: A  
COMPARISON OF PURE-TONE AUDIOMETRY AND IMPEDANCE  
AUDIOMETRY**

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## DECLARATION

I, **ANTHONY AZAGLO**, hereby declare that this dissertation which is being submitted in partial fulfillment of the requirements for Masters of Science degree in Audiology is the work done by me as a student of the Department of Audiology, School of Allied Health Science, and University of Ghana apart from reference to past and current literature which were duly cited in this dissertation. It has neither in whole nor in part been submitted for a degree elsewhere.

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## DEDICATION

I dedicate this work to my beloved wife Elizabeth Narkie Tetteh, sons Andy, Aaron and Austin Yeboah, friend Belinda Arkoh Tetteh and mother Catherine Yeboah.



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**LIST OF ABBREVIATION**

AAA	American Academy of Audiology
ANSI	American National Standards Institute
ASHA	American Speech-Language-Hearing Association
dB A	decibel average
dB HL	decibel hearing level
EVC	Ear Canal Volume
DPOAE	Distortion product otoacoustic emissions
EAC	External auditory canal
EMT	Electromechanical transduction
PTA	Pure-Tone Audiometry
TW	Tympanometric Width
SAA	Static Acoustic Admittance
TPT	Tympanometric Peak Pressure
MEP	Middle ear pressure
OAE	Otoacoustic emissions
HTL	Hearing Threshold Level

## OPERATIONAL DEFINITION OF TERMS

**Hearing loss:** threshold above 25 dB and above.

**Prevalence:** occurrence of occupational hearing loss as a result of exposure to solvents and/or noise.

**Ambient noise:** Any sound that a person does not wish to hear or that interferes with what they are trying to hear.

**Audiogram:** A graphic representation of a person's hearing loss.

**Impedance audiometry:** Testing to measure the ability of the middle ear to conduct sound to the inner ear.

## ABSTRACT

**Background:** School age children are faced with various forms of sensory disorders which impair academic, social and functional development. One of the most prevalent forms of sensory disorder is hearing loss. Auditory screening serves as an important process in identifying children with undetected hearing loss. The use of pure-tone audiometry has been the back bone of assessing children. In Ghana, auditory screening of school children has not been efficient due largely to the scarcity of resources including hearing health-care professionals', audiometric equipment and over-reliance on pure-tone audiometry.

**Aim:** The study investigated the impedance measurements against pure-tone audiometry as a screening method for the detection of middle ear changes associated with hearing loss in basic school pupils.

**Methodology:** The study adopted a cross-sectional design which involved 2009 children within the age range of 4-15 years in four primary schools in Winneba community. The participants were examined with an otoscope, a tympanometer and an audiometer. Tympanograms were categorized into type A, B C A<sub>D</sub> and A<sub>S</sub> while pure-tone audiometry utilized the conventional pass/refer criteria at 1, 2 and 4 kHz.

**Result:** The results obtained showed that out of 3090 ears with type A tympanograms, 2.72% were referred in the pure-tone audiometry screening test. Also, 83.33% of 672 ears with type B tympanograms referred in the pure-tone screening 56.0% of 64 ears with type C tympanograms also referred in the pure-tone audiometry screening. None of the ears with type A<sub>D</sub> and A<sub>S</sub> were referred in the pure-tone audiometry screening test.

**Conclusion:** The study concluded that auditory screening with tympanometry has a high rate of identifying children with hearing loss, as a result of middle ear pathologies and should be included in school screening exercises in Ghana.

**Keywords:** tympanometry, auditory screening, impedance audiometry

## **CHAPTER ONE**

### **INTRODUCTION**

#### **1.1 BACKGROUND**

More than 4% of the world's population (278 million) is estimated to have disabling hearing impairment (WHO, 2005). Disabling hearing loss is defined as a pure-tone average (PTA) of 31 dB HL or more in the better ear at the frequencies of 500, 1000, 2000 and 4000Hz for children (WHO, 2005). According to Smith (2008), approximately two-thirds of the 4% of the world's population with hearing loss live in developing countries.

Screening can be generally defined as the process of detecting a particular condition from a population who are likely to have that condition (Harford and Bess, 1978). Hearing screening refers to the testing of the ability of an individual to hear normal sound levels (Gelfand, 2004). Muir-Gray (1997) identified three main types of screening. These are mass or population screening, targeted or pro-active screening and opportunistic screening. The mass or population screening involves the screening of a whole population. Targeted or pro-active involves screening of identifiable members of a population at risk of having a condition. Opportunistic screening involves taking the opportunity to administer a screening test when the contact with the individual or a group is not primarily for screening purposes.

The main purpose of a school hearing screening exercise is to identify school children with possible significant hearing loss that may affect their emotional, intellectual, social, speech and language development. School hearing screening is an important process in identifying children

with undetected hearing loss during neonatal hearing screening. Rao et al., (2002) suggested that children in developing countries should be screened with an audiometer at school entry. The use of conventional pure-tone audiometry in hearing screening is an accurate method of hearing screening in developing countries (Berg et al., 2006). Furthermore, Newton et al., (2000) posits that school-based hearing screening may be classified into two groups, namely: subjective and objective methods. The subjective method or approach includes the use questionnaires and or pure-tone audiometry. The objective method involves impedance audiometry, which aims at assessing the physical condition of the middle ear, otoacoustic emissions test etc. The objective methods do not estimate an individual's hearing level (Newton et al, 2000). The advantages of the subjective methods over the objective methods include high feasibility, low costs of administering and little requirement for professionals' assistance. However, the subjective screening methods which involve the use of questionnaires have poor sensitivity and specificity (McPherson and Olusanya, 2008). The objective methods of screening are effectively used in most screening programs (Roeser and Clark, 2004). Even though the objective methods of auditory (hearing) screening are relatively expensive, their feasibility, sensitivity and specificity for hearing screening in developing countries are relatively high (Nozza, 2001).

### **1.1.1 Impedance Audiometry Screening**

Impedance audiometry screening is a measure of the ability of the middle ear to conduct sound to the inner ear. Impedance audiometry does not test the hearing sensitivity of the patient; instead it is a good predictor of conductive hearing loss (Dempster and Mackenzie, 1991). Impedance audiometry includes tympanometry, acoustic reflex test etcetare. Tympanometry is widely used in screening for the detection of otitis media and to examine the status of the middle ear by

measuring the movement of the ear drum via the application of air pressure. Tympanometry is known to have high sensitivity and specificity in the detection of otitis media. The finding of Watters, Jones and Freeland (1997) in the detection of type B tympanogram which is consistent with otitis media has shown a sensitivity of 91% and a specificity of 79% to 90%. Additionally, Vaughan-Jones and Mills (1992) showed that the sensitivity and specificity of detecting type B and C tympanograms are 88% to 94.4% and 52.9% to 71% respectively. Tympanometry screening is rapid, painless, and convenient and also has a high level of compliance to use on young children (Paradise et al., 1976).

### **1.1.2 Pure-Tone Audiometry Screening**

Pure-tone audiometry screening is a test used to determine the hearing sensitivity of an individual. The individual is required to respond to specific frequencies at a fixed hearing level, typically 20 dB HL (Wood, 2004). This method is the most commonly used procedure for hearing screening among school children in most developing countries like Ghana (Amedofu et al., 2003). The American Speech and Hearing Association (ASHA) recommended that auditory screening with pure-tone audiometry should be an integral part of a school health program. The recommended age at which children are to be screened using the pure-tone audiometry is 3 years (ASHA, 1997). The most common frequencies used for children are 500, 1000, 2000, 4000 and 6000 Hz (ASHA, 1997).

### **1.1.3 Auditory Screening with Pure-Tone Audiometry and Tympanometry**

According to ASHA (1997), auditory screening with pure-tone audiometry should be followed with tympanometry for preschool and upper grade school children. Tympanometry aids to

differentiate children who are likely to be referred due to middle ear pathology from those who have permanent hearing loss.

## **1.2 STATEMENT OF THE PROBLEM**

Hearing loss is a gradual and progressive disability often described as a hidden disability. ASHA (1997) estimates that 35% of preschoolers are likely to have recurrent ear infections that may cause a temporary hearing loss which can significantly affect language acquisition and progresses in education. Hearing loss of any degree and form can have adverse effects on the life of an individual. It is estimated that one-third of the people living in developing countries have a hearing loss that compromises their general quality of life (Berman, 1995). In developed countries, it is estimated that about 40% of hearing impairment in children are not detected at the first screening and the situation in developing countries is likely to be worse since screening to detect early hearing loss is not often done (Tweedie, 1982). Amedofu et al., (2006) suggested that the prevalence of hearing impairment varied between countries in the developing world. In Swaziland, a prevalence rate of 4.1% was reported (Swart et al., 1995). Hatcher et al., (1995) estimated that 5.6% of school children in Kenya have mild hearing loss. Olusanya, et al (2000) posited that school children with hearing loss in Nigeria constituted about 13.9%. The prevalence of hearing impairment in Africa and developing countries is estimated between 7-10% (Essel, 1999).

School children presenting with unidentified congenital hearing loss and not provided the appropriate intervention before 6 months of age may demonstrate significantly poor speech and reading comprehension (Yoshinaga-Itano and Apuzzo 1998). According to Flexer (1994) an

unidentified unilateral loss or mild hearing loss may have serious problems on the child's academic work. In particular, children with unidentified unilateral hearing loss are more likely to be repeated in a class (Bess, 1985). Again, studies have shown that at least half of the children with unidentified hearing impairment graduating from basic schools cannot read materials at their level (Gallaudet Research Institute, 1996).

Despite the adverse effects of undetected hearing loss among school children, auditory screening of school children has not been efficient in Ghana due largely to the dearth of resources. Thus, the unavailability of hearing health-care professionals, audiometric equipments, screening methods/protocols and or over-reliance on pure-tone audiometry in school screening programs impedes the efficiency of hearing screening programs. The lack of a screening method (objective) specific to middle ear conditions leaves most children with middle ear infections undetected. Wake et al., (2006) reported that most of the causes of hearing loss among school children is largely related to middle ear infections specifically, otitis media. The findings were also supported by Taha et al., (2010) and Khairi et al., (2010) who purported that most of the causes of hearing loss among school children were middle ear infections. Undetected school children with hearing loss as a result of recurrent middle ear infections may demonstrate poor speech development, impaired reading comprehension skills, poor functional abilities, and emotional, psychological and social stress. In general, school children in this health condition are less likely to be at par with their counterparts in early childhood development. Therefore, it is important that both subjective and objective methods of screening are employed in school hearing screening programs in Ghana to aid in the identification of all types of hearing disorders.

### **1.3 SIGNIFICANCE OF THE STUDY**

The data established by this study will be very useful and significant for the following reasons:

- The outcome of this research can be used as a guide in the screening of school children for early detection of hearing loss in the country.
- It can assist policy makers in Ghana and the developing world to adopt school screening programs in expanding hearing health care to remote areas.
- It can help create awareness, educate and sensitize the general population about the prevalence of hearing loss among school children and its effects on their language and academic development in Winneba, Ghana
- It can serve as a guide for future researchers to build on a comprehensive screening method using pure-tone audiometry with impedance audiometry in the assessment of school children in Ghana.
- The research findings can serve as reference material for those who want to broaden their knowledge in the auditory screening of school children.

### **1.4 AIM OF THE STUDY**

The aim of the study was to investigate the impedance and pure-tone audiometry measures as a screening method for the detection of middle ear changes associated with hearing loss in basic school pupils in Ghana.

### **1.5 OBJECTIVES OF THE STUDY**

The following specific objectives were used to achieve the aim of the study:

- To compare pure-tone audiometry with impedance audiometry in auditory screening of

basic school children.

- To determine the referral and pass rates of auditory screening with tympanometry and pure-tone audiometry.
- To determine the prevalence of hearing loss among basic school children.

## **1.6 RESEARCH QUESTIONS**

- Is pure-tone audiometry comparable with impedance audiometry in auditory screening?
- What are the referral and pass rates of auditory screening with tympanometry and pure-tone audiometry?
- What is the prevalence of hearing loss among basic school children in Winneba, Ghana?

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 INTRODUCTION**

This Chapter presents a review of studies on the prevalence of hearing loss in developed and developing countries, prevalence of hearing loss in Ghana, screening with tympanometry, screening with pure-tone audiometry, and screening with pure-tone audiometry and impedance audiometry.

#### **2.2 HEARING LOSS IN DEVELOPED AND DEVELOPING COUNTRIES**

Mourad, Farghaly, and Mohamed (1993) determined the prevalence of hearing impairment among school children in Alexandria, Egypt. The participants were 196 children from three schools. The failure rate for participants tested with pure-tone audiometry and tympanometry were 24.49 % and 36.22 % respectively. It was found that 48% of students who failed the pure-tone audiometry screening had poor academic records. The prevalence rate of pupils who failed in both screening methods was 7.65%.

Minja and Mchemba (1996) also compared the prevalence of hearing loss among school children in rural and urban schools in Tanzania. The participants for the study were 802 school children. Two hundred and twenty two school children had hearing and hearing related diseases. Sensorineural hearing loss was found in 70 children and 21 children had otitis media. The number of school children who had sensorineural hearing loss for urban and rural schools were 7.7% and 14.1% respectively. Also, the prevalence of chronic suppurative otitis media for both

urban and rural schools was 1.3% and 9.44% respectively. The conclusion was that the low occurrence of hearing loss and chronic otitis media in the urban community were due to access to better health facilities.

In another study, Mann et al., (1998) compared the incidence of hearing impairment among rural and urban schools in India. Thousand six hundred and seventy school children from rural and urban schools were screened. The main results showed that out of 1030 students from urban schools, 6.31% were identified with hearing loss. In the case of the rural community, 32.81% were also identified with hearing loss. Otitis media was the commonest cause of hearing loss among school children in rural and urban areas.

A study by Wake et al., (2006) determined the prevalence of hearing loss among children in elementary school in Australia. The participants used for the study were 6581 children. The results obtained from the survey indicated that 55 students presented slight or mild hearing loss. The study concluded that there was no strong evidence that slight/mild bilateral sensorineural hearing loss adversely affects language, reading, behavior, or health-related quality of life in children who are otherwise healthy and of normal intelligence.

Maharjan et al., (2006) investigated the prevalence of otitis media in school children in eastern Nepal. The participants were 1050 school children. The results indicated that out of 1050 children screened, 346 had hearing and hearing related problems. The prevalence of otitis media was 13.2%. The study concluded that hearing loss among school children is mainly caused by otitis media.

Kalpana and Chamyal (2007) assessed the prevalence rates of hearing loss among school going children in Indian in urban and semi urban communities' deafness prevalence rate of 11.7% and chronic suppurative otitis media was reported. The study concluded that most of the aetiological factors in causing hearing impairment in school going children are treatable and hence deafness can be prevented to a large extent if remedial measures are taken in time.

In addition, Olatoke et al., (2008) determined the prevalence of hearing loss among school children in Nigeria. A total of 1500 school children aged 9 to 15 years participated in the study. The results from the screening showed that 35 school children had chronic suppurative otitis media. Out of this number 20 (38.5%) had a mild conductive hearing loss, while 14 (26.9%) of the students had a moderate hearing loss. The study concluded that hearing loss among school children is mostly caused by otitis media which is also commonly found among low socio-economic individuals.

Khairi et al., (2010) also determined the prevalence of hearing loss among primary school children in Malaysia. The total number of participants used for the study was 257 students. Two hundred and thirty four students underwent the screening test successfully. The results obtained from the study indicated a prevalence of 15%. Thirty two percent of the cases were purely conductive losses. The total number of students who had bilateral hearing loss was 38.9%. The study recommended that auditory screening should be done for all school children.

Another study by Taha et al., (2010) examined the prevalence of hearing loss among school children in Egypt. The participants were 555 children within the age bracket of 6-12 years. The results showed a failure rate of 25.6%, and a prevalence of 20.9%. The most common hearing

loss found was slight to mild conductive hearing loss which was suspected to be caused by otitis media. The study concluded that the prevalence of otitis media among developing countries is higher than that of the developed countries.

Al-Rowaily, et al., (2012) estimated the prevalence of hearing loss among school children in Saudi Arabia. The study comprised with 2574 (370 kindergarten and 2204 primary) pupils within the age bracket of 4-8 years. The findings of the study showed a total of 45 school children with hearing impairment. Thus 84.4% of the children had conductive hearing loss while 15.6% presented with sensorineural hearing loss. A prevalence rate of 1.75% was recorded.

Absalan et al., (2013) investigated the prevalence of hearing loss among primary school children in Iran. One thousand five hundred elementary school children participated in the study. The results indicated that 15.9% of the students had conductive hearing loss (8.8% males and 7.1% females). The prevalence of sensorineural hearing loss was 1% and 0.7% for male and female children respectively. In addition, 20.2% of the elementary school children needed medical attention. The study recommended that hearing screening for hearing loss among school students should be an integral annual program.

Niskar et al., (1998) described the prevalence of hearing loss among school children in the United States of America. The participants for the subjects were 6166 children within the age range of 6 to 19 years. The study concluded that school health screening programs should include audiometric screening.

### **2.3 PREVALENCE OF HEARING LOSS IN GHANA**

In Ghana, the prevalence of hearing loss varies slightly from one community to the other. Essel (1992) evaluated the prevalence of hearing loss among basic school children in Mampong-Akwapem in the Eastern Region of Ghana. A total number of 691 school children were screened. The results from the pure-tone audiometry screening test showed a prevalence of 7-10%. Further, Essel (1999) screened 7000 school children for otitis media and hearing loss from 45 basic schools in the northern region of Ghana. The results from the screening exercise showed that 30% failed. Participants identified with hearing impairments from the screening exercise were referred for diagnostic audiometric testing. Few children diagnostically evaluated presented with profound and severe hearing loss. In addition, Essel (1995) determined the prevalence of hearing problems among school children in the Awutu-Effutu-Senya-Kasoa-Bawjiase sub-districts of the Central Region in Ghana. The participants were 56 (92 ears) school children with otitis media. The results indicated that out of the total ears involved 42 students had hearing loss in both ears while 15 students had unilateral hearing loss in either right or left ears.

A study conducted by Amedofu and Brobby (1997) determined the prevalence of hearing impairment among pre-school children in Kumasi, Ghana. A total of 960 children were screened with pure-tone audiometry and otoscopy. The study revealed that 8.2% ( $n=79$ ) of the children failed the pure-audiometric screening. Only 48.8% ( $n=37$ ) reported for further evaluation.

Again, Amedofu et al., (2003) determined the prevalence of hearing impairment among school children in Kumasi, Ghana. The participants involved were 6,156 school children. The study employed otoscopy and pure-tone audiometry in screening the participants. The results from the

study revealed that 596 school children failed and were referred for diagnostic hearing assessment. The results from the hearing assessment indicated that 145(26%) of the children referred had hearing loss greater than 25 dBHL at 1, 2 and 4 kHz. The prevalence of hearing loss among the children for the study was estimated as 6.5%. The study recommended that a screening program should not be implemented unless realistic referral systems, method of assessment and follow-up care and support services were available.

Another study by Ansong et al., (1998) determined the prevalence of hearing loss in a case study in Apewosika Municipal primary school. A total number of 120 school children from basic 1, 3, 6 and 7 with average ages 7, 9, 11 and 12 respectively were screened. The findings of the study are summarized in Table 2.1

**Table 2.1 Summary of Results from a Case Study**

<b>Class</b>	<b>No. on roll</b>	<b>Average age</b>	<b>No screened</b>	<b>Poor hearing</b>	<b>Percentage in class</b>
<b>B.S.1</b>	45	7	40	15	38
<b>B.S.3</b>	37	9	20	7	23
<b>B.S.6</b>	41	11	20	2	10
<b>B.S.7</b>	45	12	40	7	18
<b>Total</b>	168		120	31	26

**Source:** Ansong et.al (1998)

A related study conducted by Marfoh, (2009) on the prevalence of hearing impairment at the Offinso Municipality of Ghana revealed that out of 135 respondents found with hearing impairment greater than 25 dBHL, 28% were children below the age of 20 years. The pure-tone

screening results indicated that out of 161 children screened, 48 failed and were referred for diagnostic audiometry testing.

## **2.4 SCREENING WITH TYMPANOMETRY**

Historically, Paradise, Smith, and Bluestone (1976) compared the results of a tympanometry with the results of an otoscopic examination, and with findings at myringotomy. In all 280 subjects were tested with the tympanometer and 107 subjects underwent otoscopic examination. The results depicted that tympanograms suggesting high tympanic membrane mobility with atmospheric middle ear air pressure were hardly ever associated with effusion. However, tympanograms suggesting low tympanic membrane mobility were highly correlated with middle ear effusion. In infants below 7 months of age, many of the ears with effusion showed normal tympanograms. The study concluded that tympanometry is a simple and objective test that can result in improved detection of middle ear effusion and other middle ear abnormalities.

Al-Fadala and Holmquist (1984) compared the results of a tympanometry screening with an otoscopy screening. The total number of subjects involved was 893 school children in Kuwait. The findings from the study showed that otoscopic examination presented pathologic findings in 41.7% of the children. The tympanometry screening detected 30.6% of the children with type A or C tympanograms making a referral rate of 31%. The study concluded that the use of tympanometry and otoscopy in screening children is likely to reduce the referral rate to 18%.

Lučić and Mandilović (1988) investigated a screening tympanometry in the detection of conductive deafness in 82 school children. The findings from the study indicated that out of 25% of the children screened by tympanometry, 10.37% and 14.63% had type A and B tympanograms

respectively. The pure-tone results showed in children with middle ear disorder indicated a reduction of conductive auditory hearing from 21 dB to 30 dB. The study concluded that tympanometry has a very high advantage of detecting otitis media and deafness among children.

Another study by Dempster and Mackenzie (1991) involving 285 school children evaluated the use of tympanometry in the detection of hearing impairments associated with otitis media with effusion. The results showed that 20% of the participants had hearing thresholds greater or equal to 25 dB HL. The sensitivity and specificity for the detection of type B tympanometry were 93% and 76% respectively with a positive predictive value of 49%. Majority (51%) of the children with type B tympanogram had hearing within the acceptable limits. The study concluded that children who presented with type B tympanograms needed hearing evaluation, and that the use of impedance audiometry could reduce the number of fails in pure-tone audiometry.

Also, Sassen, Van Aarem and Grote (1994) assessed the validity of tympanometry in the diagnosis of middle ear effusion on 266 school children within the age range of 6 months to 11 years. The study concluded that tympanometry had a high diagnostic value in the detection of middle ear effusion.

Van Balen, de Melker (1994) ascertained the validity of handheld tympanometer by comparing with a standard tympanometer in the detection of middle ear effusion. The main results indicated that the handheld tympanometer had a sensitivity and specificity as 94% and 48% respectively. The study concluded that the handheld tympanometer was valid in detecting middle ear effusion.

Furthermore, Koivunen, Alho, Uhari, Niemelä, and Luotonen (1997) assessed the accuracy of the mini-tympanometry in the detection of middle ear effusion. The total number of school children involved was 162 within the age bracket of 7 months to 8 years. The results obtained from the study indicated a high sensitivity and specificity of 79% and 93% respectively. Among the difficult to test population, a sensitivity and specificity of 71% and 38% were obtained. The study concluded that tympanometry test gives rapid and valid results in detecting middle ear infection especially among cooperative children.

Again, Watters, Jones, and Freeland (1997) investigated the predictive value of tympanometry in the diagnosis of middle ear effusion. The participants for the study were 501 children who underwent surgery for middle ear effusion. The results indicated that type B tympanograms presented a high sensitivity of 91% and specificity of 79% which is indicative of middle ear effusion. The sensitivity and specificity of type A tympanograms were 99% and 34% respectively which was typical of normal middle ear. The study concluded that the use of tympanometry is the best clinical test for the detection of middle ear effusion.

Tunkel et al., (2011) conducted a clinical study to ascertain the prevalence of hearing loss and abnormal tympanometry in children with skeletal dysplasia. A Convenient sample of 58 individuals with skeletal dysplasias aged 18years and above constituted the sample. Auditory screening with pure-tone audiometry, tympanometry and or otoacoustic emissions test was utilized. The study concluded that abnormal tympanometry is highly associated with the presence of hearing loss.

Helenius et al., (2012) compared the results of a tympanometer with the results of a pneumatic otoscope in the detection of middle ear effusion. The study participants were 515 school children from the outpatients department of a primary health care facility. The study concluded that the tympanometer was more sensitive in detecting middle ear pathologies.

## **2.5 SCREENING WITH PURE-TONE AUDIOMETRY**

Wu et al., (2014), investigated the practical usage of smart hearing screening system (a new hearing screening system for children). The smart hearing screening was applied on 6288 school children at three frequencies: 1 kHz, 2 kHz, and 4 kHz at 30 dB (HL). The results indicated that a total of 582 children tested positive. Referral rates of four age groups from 3 to 6 years old were 18.8%, 11.9%, 6.5% and 4.0%, respectively. A total of 463 children underwent a complete audiological assessment, of which 12 cases were detected with permanent hearing loss, and 75 cases were also detected with temporary conductive hearing loss. None of the children were found with mixed hearing loss in the study. The specificity and sensitivity of smart hearing were 92.6% and 37.5% respectively. The study concluded that the screening system is a suitable preschool hearing screener.

Further, Marttila (1986) determined the prevalence of hearing loss among 40824 school children in Finland using pure-tone audiometry at 20 dB HL. The main result revealed that 2.5% of the pupils presented with different forms of hearing impairment. Majority of the pupils (41%) had conductive hearing loss while 8% presented with sensorineural hearing loss. The study concluded that pure-tone audiometry screening should be an integral part of school screening exercises.

## 2.6 SCREENING WITH PURE-TONE AND IMPEDANCE AUDIOMETRY

Renvall, and Holmquist, (1976) ascertained the usefulness of impedance audiometry as a screening method for school children. The subjects for the study were 800 children aged 7 years old. The results obtained from the two pilot studies indicated that 6.5% pathological values were obtained via the use of pure-tone audiometry screening while 13.5% pathological values were obtained via tympanometry. The second pilot was a follow up which was done between 6-12 months on 357 ears. The results from this follow up screening indicated that 20% of the ears had pathological pure-tone screening. The tympanometry screening was able to detect 40% of ears having a middle ear pressure of less than or equal to -100 mm H<sub>2</sub>O, and 14% of ears having middle ear disorder. Stapedius reflexes screening detected 57% with elevated or non-elicitable stapedius reflexes. The study concluded that tympanometry and stapedius reflex test were more efficient methods in detecting middle ear infections than otoscopy and pure-tone.

Again, Lidén, and Renvall (1980) compared the findings of impedance audiometry with pure-tone audiometry in a school screening exercise. The study involved 1027 seven years old children. The methods used in the screening were stapedius reflex, tone screening and tympanometry screening. The result obtained showed that 5.8% of the total children screened were found to have ear problems. The stapedius reflex detected 7.6% of the ears as abnormal. Tympanometry results also identified 6.4% of children with middle ear problems. The study concluded that pure-tone screening at 0.5 and 4.0 kHz should be complemented with tympanometry in screening for middle ear infections among children. Moreover, Haapaniemi (1996) investigated the sensitivity and usability of hearing and tympanometric screening examinations in school-aged children in Finland. A total number of 687 school children in the

first, fourth and eighth grades (ages, 7, 10 and 14 years old) were screened using the pure-tone and impedance audiometry. The main result indicated that 138 children (20.1%) had hearing loss greater than 15 dB in at least one frequency. Out of this number 103 children were found to have pure sensorineural losses and 35 children had conductive losses. The pure-tone audiometry hearing level at 15 dB presented 24 children with conductive losses as having middle ear effusions. Out of 38 children who presented middle ear effusion, 36 of the cases were detected by the tympanometry at a peak pressure of -150 daPa. The study recommended that pure-tone audiometry should not be used as a screening procedure for screening children of age 14 years on school entry.

Holtby, Forster, and Kumar (1997) compared the validity of pure-tone audiometry with impedance audiometry in school auditory screening. The screening was done in two stages using pure-tone audiometry and impedance methods of screening. The participants for the study were 610 school children in north east England. The sensitivity of the two methods was 74.4% and the specificity was recorded as 92.1% and 90.0% for pure-tone and impedance audiometry respectively. The predictive value of a positive test for both pure-tone and impedance test were 43.2 and 37.6 respectively. It was reported that impedance audiometry yielded relatively higher screening rates than pure-tone audiometry. The study concluded that impedance audiometry should be included in auditory screening protocols since it is technically more efficient in screening than the pure-tone audiometry.

Allen et al., (2004) evaluated the pass and referral rates in a preschool hearing screening. The participants were 1462 children who were enrolled in a Head Start Program in Eastern North

Carolina. The criteria for pass and refer were adopted from ASHA panels on audiological assessment (1997). The methods used were pure-tone audiometry, tympanometry, and otoscopy. The results showed from these methods indicated that 54% (n = 787) out of the total participants passed the initial screening which gave the pass rates as 90%, 71%, and 71% for otoscopy, tympanometry, and pure-tone audiometry, respectively. The referral rates were 83%, 2%, and 15% for pure-tone audiometry, tympanometry and otoscopy respectively. The study concluded that the use of pure-tone, tympanometry and otoscopy in auditory screening increases the referral rate.

Śliwa et al., (2011) compared pure-tone audiometric test with objective methods in hearing screening of school children. Hundred and ninety 12 years old children constituted the sample size. The screening protocol included a four tone audiometry; tympanometry and Transient evoke otoacoustic emission (TEOAE). The result from the protocol indicated a sensitivity of 65% and a PPV of 46% when the four tone audiometry test was combined with tympanometry test. The use of TEOAE in the screening protocol had lowered the performance of the screening. The study concluded that screening of school children is more effective when pure-tone audiometry and tympanometry are used.

## **2.7 CONCLUSION**

The literature reviewed depicted limited studies on the utilization of otoscopy, pure-tone audiometry, and impedance audiometry in a school screening exercise in Ghana. The current study was conducted to address the paucity of data on school screening for hearing loss in Ghana.

## **CHAPTER THREE**

### **METHODOLOGY**

#### **3.1 INTRODUCTION**

This Chapter presents the methods and techniques used in carrying out the study and include research design, population, and sample size, sampling technique, instruments/materials, and procedure for data collection, data management plan and ethical consideration.

#### **3.2 RESEARCH DESIGN**

A prospective cross- sectional design was adopted in selecting a total of 2009 participants for the study. A cross sectional design provides for one time collection of data. It is a good design for estimating the prevalence of a condition among a population.

#### **3.3 STUDY SITES**

The site for the study was basic schools in the Winneba community. The study involves in four primary schools in the community.

#### **3.4 SAMPLE POPULATION**

The population for the study consisted of pupils from basic school (4- 19 years). This population was chosen because the determination of any forms of middle ear pathologies required a large number of children with high risk factors.

### **3.5 SAMPLE SIZE AND SAMPLING TECHNIQUE**

A sample size of 2009 school pupils aged 4-19 years was selected for the study. The study involved four basic schools in Winneba.

The study adopted convenience sampling techniques in selecting participants for the study. According to Vanderstoep and Johnson (2009) convenience sampling involves choosing the participants from the nearest and readily available site.

### **3.6 INCLUSION AND EXCLUSION CRITERIA**

#### **3.6.1 Inclusion Criteria**

Children from kindergarten to basic 6 who were found in the study site were screened.

#### **3.6.2 Exclusion Criteria**

Children with any physical condition which did not allow for pure-tone testing were excluded. Example, children with complains of severe pain in the ear etcetera. In addition, school children who could not follow test instructions (pure-tone audiometry) were exempted from the study.

### **3.7 INSTRUMENTS/MATERIALS**

#### **3.7.1 Video otoscope**

A video otoscope was used to examine the ear canal walls and tympanic membrane.

#### **3.7.2 Impedance device**

Interacoustics IMP440 Titan hand held middle ear analyzer was utilized in assessing middle ear pathologies. Impedance audiometry screening is a measure of the ability of the middle ear to conduct sound to the inner ear. Impedance audiometry does not test the hearing sensitivity of the

patient but it is a good predictor of conductive hearing loss (Dempster and Mackenzie, 1991). Impedance audiometry includes tympanometry, acoustic reflex etc. Tympanometry is widely used in screening for the detection of otitis media and to examine the status of the middle ear by measuring the movement of the ear drum via the application of air pressure. Tympanometry is known to have high sensitivity and specificity in the detection of otitis media. The finding of Watters et al (1997) in the detection of type B tympanogram which is consistent with otitis media has shown a sensitivity of 91% and a specificity of 79% to 90%. Additionally, Vaughan-Jones & Mills (1992) showed the sensitivity and specificity of detecting of both type B and C tympanograms as 88% to 94.4% and 52.9% to 71% respectively. According to Paradise et al. (1976) tympanometry screening is rapid, painless, and convenient and also has a high level of compliance to use on young children.

The tympanometer is an instrument used to measure the acoustic admittance of the middle portion of the ear. The basic components of the tympanometer are a loudspeaker which produces a probe tone into the ear, a microphone which record and analyze the reflected sound produce via the loudspeaker, and a pressure pump which causes pressure variation in the ear during testing.

Figure 3.1 below depicts a basic component of a typical impedance device. The arrows show the directions at which sound, pressure change and electrical impulse flow. The open arrows in the diagram are depicting the direction at which sound energy flows and the closed arrows also show the direction at which the pressure change flows. Double arrows depict the flow of the electrical impulse.



### **Pressure Transducer**

The pressure transducer in the probe tip automatically changes the pressure in the external ear canal. It produces a positive and negative pressure sweep between +200 and -400 daPa relative to the ambient pressure. The pressure transducer plots the admittance values of the middle ear as against the pressure.

### **Tympanogram**

The plot of the values of the admittance of the middle ear as against the function of the pressure is the tympanogram. The classification of the various forms of tympanogram is based on the morphology (Jerger, 1970). The use of the 226 Hz frequency gives a normal curve with a peak. A probe tone of higher frequency probe tone gives a wider variability of tympanometric curves that makes the interpretation of the tympanogram difficult (Margolis and Shanks, 1985). The maximum admittance value is equivalent with the ambient pressure during the pressure sweep across the tympanic membrane. The tympanogram curve has the following parameters; static acoustic admittance, tympanometric peak pressure, gradient, tympanometric width and ear canal volume.

### **Tympanometric Peak Pressure (TPP)**

The tympanometric peak pressure is the point at which the maximum admittance on the pressure scale is relative to the ambient pressure. The tympanometric peak is obtained when pressure in the ear and the outside are the same. The range of measure for the tympanometric peak pressure is between +400 and -200 daPa. A normal tympanometric peak pressure is between -100 and +50 daPa. TPP value lower than -100 is termed abnormal and is consistent with middle ear fluid

while abnormal high TPP values is an indicative of an early onset of acute otitis media (Ostergard and Carter, 1981). A low or abnormal TPP alone cannot be used to predict the presence of middle ear fluid and has been excluded as a criterion for the detection of middle ear effusion (ASHA 1990)

### **The Gradient**

Brooks (1968) described the gradient of the tympanogram as the steep of the tympanometric curve. It is expressed as the ratio of the curve height divided by the height of the entire curve. When the gradient of a tympanogram is less than 0.2 it is considered as abnormal and is in consistent with the presence of middle ear fluid, however a gradient value that is greater than 0.1 is considered as normal (Nozza, 1992).

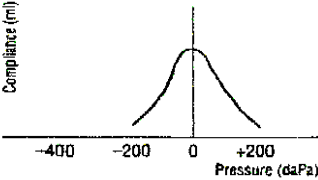
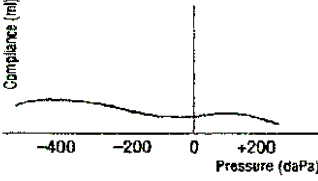
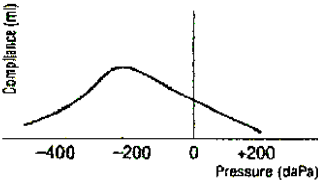
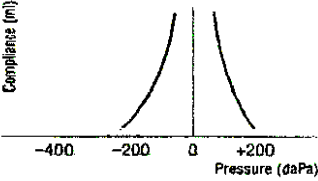
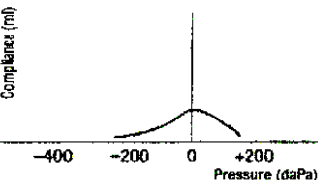
### **Tympanometric Width**

The width of the tympanogram is the shape of the curve. De Jonge (1986) expressed the width of the tympanometric width as the width of the tympanogram in half of the static acoustic admittance with daPa as its unit of measurement. Normal tympanometric width for a child is between 60 and 150 daPa as been expressed in the 90% range (Koebsell and Margolis, 1986). A too wide tympanometric width occurred as a result of middle ear effusion while a low width tympanometric is as a result of flaccid or highly compliance of the tympanic membrane.

### **Ear Canal Volume**

Rock (1991) expressed the ear canal volume as the volume of air in the external ear canal in front of the probe tip. The ear canal volume is measured at +200 daPa with a unit of measurement as  $\text{cm}^3$ . The age of a person has slight influence on the canal volume. A perforated tympanic

membrane will have a large canal volume while a canal occluded with wax, foreign body or a probe tip against the canal wall will give a low canal volume (Haapaniemi, 1996). For screening purposes, the tympanogram is categorized into 5 main types they include type A, A<sub>D</sub>, A<sub>S</sub> B and C tympanograms (Jerger, 1970). A type A tympanogram is indicative of a normal tympanic movement with a normal middle ear pressure showing that the individual has functional middle ear. The type B tympanogram in the diagram (figure 3.2) below is a line indicates a little or no movement of the tympanic membrane. This is consistent with fluid build-up behind the tympanic membrane. A perforation of the tympanic membrane may also cause the slow or no movement of the tympanic membrane. Type B tympanogram is a good predictor of a conductive hearing impairment  $\geq 25$  dB in about 49% to 66.4% of cases and consistent with middle ear effusion (Kazanas and Maw, 1994). Krueger and Ferguson (2002) in their findings identified a high rate of false positives (6.4%) for students failing tympanometry screening as compared to pure-tone screening at 35 dB HL. Type C on the other hand is consistent with malfunctioning of the Eustachian tube as a result of persistent with cold and an indicative of the early phase of fluid accumulation behind the tympanic membrane. On the diagram the type C has a peak to the left of the normal pressure range which shows adequate movement of the tympanic membrane with a negative pressure. Type A<sub>D</sub> has normal middle ear movement with flaccid tympanic membrane this happened when the ossicular chain is disrupted. While type A<sub>S</sub> on the other hand has reduced tympanic mobility with a normal ear pressure as seen in otosclerosis.

SHAPE	READINGS	INTERPRETATION
<p><b>TYPE A</b></p> 	<p>MEP: -100 to +100 daPa            Comp: 0.3 to 1.6ml            P. Vol: (approx)            Adults: 1.0 to 1.5ml            Children: 0.7 to 1.0ml</p>	<p>normal            normal            normal            normal</p>
<p><b>TYPE B</b></p> 	<p>MEP: not definable            Comp: less than 0.3 ml            P.Vol: smaller than normal            within normal range            significantly larger            than normal            (ie &gt;2.5 in adult)            (ie &gt; 2.0 in child)</p>	<p>wax            middle ear effusion            perforation or            grommet</p>
<p><b>TYPES C</b></p> 	<p>MEP: more negative than            -100 daPa            Comp: normal            P.Vol: normal</p>	<p>eustachian tube            obstruction</p>
<p><b>TYPE Ad</b></p> 	<p>MEP: normal            Comp: greater than 1.6ml            P.Vol: normal</p>	<p>Healing perforation.            Possible ossicular            chain discontinuity            Atrophy of ear drum</p>
<p><b>TYPE As</b></p> 	<p>MEP: normal            Comp: less than 30ml            P.Vol: normal</p>	<p>Scarring or adhesions            Possible ossicular fixation</p>

**Fig 3.2:** A diagram showing the various tympanograms with their respective middle ear conditions as adopted from Department of Health (1992).

### 3.7.3 Pure-tone audiometer and Sound level meter

AD299e Interacoustics Audiometer with TDH49 headphone was utilized in hearing assessment.



Fig.3.3: AD299e Interacoustics audiometer

Realistic radio shack-33-2050 type 2 sound level meter was used to monitor ambient noise.

## 3.8 PROCEDURE FOR DATA COLLECTION

The screening procedure included examination methods. The first included otoscopy and cerumen management. The second constituted middle ear examination (tympanometry) and the third was hearing screening with a pure-tone audiometer.

Otoscopic examination was conducted to assess the status of the ear canal walls and tympanic membrane for each participant. Participants with conditions such as middle ear effusion which did not allow for pure-tone testing were referred for medical intervention after the otoscopic examination. Ambient noise average of 42 dBA at the pure-tone audiometry hearing screening was monitored throughout the screening procedure with a Realistic Radio Shack-33-2050 type 2 sound level meter. All the test equipment were within calibration as at the time of data collection. Biological calibration was used to validate the audibility of the pure-tone test signal in the

aforementioned ambient noise to establish a pass/refer criteria of 35 dB at 500Hz, and 25 dB at 1000, 2000 and 4000 Hz. There was no re-test at any of the test frequencies. Participants sat facing the examiner and were instructed to respond to pure-tone test signal by raising one hand. Participants were given the following instructions: “I will guide you to wear this headphone. Your responsibility in this task is to listen and respond to beep-tones in either ear by raising your hand, irrespective of how faint the tone is” Middle ear screening with the tympanometer (+200 to -300 daPa) using a 226 Hz probe tone was used in the second screening procedure. Tympanograms were categorized into type A, B C A<sub>D</sub> and A<sub>s</sub>.

### **3.9 DATA ANALYSIS**

A response to the pure-tone test signal at all the tested frequencies was referred to as a pass and a no response in at least one test frequency in either ear was as a referral. Type B, C, A<sub>D</sub> and A<sub>s</sub> tympanograms were denoted as a referral and type A tympanograms were denoted as normal. Data was analyzed using the Statistical Package for Social Scientist (SPSS) version 16.0. The software was used to compute descriptive and inferential statistics.

### **3.10 ETHICAL CONSIDERATIONS**

Ethical clearance was sought from the Ethics and Protocol Review Committee of the School of Allied Health Science prior to the collection of data. Further, permission and authorization was sought from the management of the selected schools. Consent of the parents of the children was sought and the children were made to conform to the ethical guidelines regarding the use of human beings as subjects. Also, the objectives, methods and testing procedures of the study were duly explained to the participants.

## CHAPTER FOUR

### RESULTS

#### 4.1 INTRODUCTION

This Chapter presents the results of the study in descriptive statistics. In pursuing the study, four research questions were formulated. These are: Is the pure-tone audiometry comparable to the tympanometry in auditory screening? What are the referral rates of auditory screening with tympanometry and pure-tone audiometry? What is the prevalence of hearing loss among the basic school children in Winneba? What are the pass rates of auditory screening with tympanometry and pure-tone audiometry?

#### 4.2 DEMOGRAPHIC CHARACTERISTICS OF THE POPULATION

A total of 2009 pupils out of an initial 2114 agreed to participate in the study, yielding a response rate of 95.03%. A distribution of the gender and age demographics, as well as the schools and educational levels of the pupils are presented in Tables 4.1, and 4.2 respectively.

**Table 4.1: Gender and age distribution of study participants**

Demographic variable		Frequency	Percent,%
<b>Gender</b>	Male	901	44.8
	Female	1108	55.2
$\Sigma$		2009	100.0
<b>Age (yrs)</b>	4 – 6	206	10.30
	7- 9	861	42.90
	10 12	804	40.02
	13 – 15	138	6.87
<b>Total <math>\Sigma</math></b>		2009	100.0

**Table 4.2: School and educational level distribution of study participants**

<b>Variable</b>	<b>Number of pupils</b>	<b>Percent</b>
<b>Basic school</b>		
<b>Gyengyenadze School</b>	554	57.6
<b>A.M.E. Zion Basic School</b>	622	31.0
<b>University of Education Basic School</b>	484	24.1
<b>Essuehyia Basic School</b>	349	17.4
<b>Educational level</b>		
<b>Pre-school</b>	712	35.0
<b>Primary school</b>	1297	65.0
<b>Total</b>	2009	100.0

From Table 4.1, 2009 children participated in the study. Out of this, there were 901 (44.8%) males and 1108 (55.2%) females. There were 206 (10.3%) children within the age bracket of 4 to 6 years, 861 (42.9%) within the age bracket of 7 to 9 years, 804 (40.02%) within 10 to 12 years and 138 (6.87%) were between 13 to 15 years. The study sample constituted preschool (901 children) and primary (1108 children) school children. As can be seen in table 4.2, four schools were involved in the study. Five hundred and fifty four children were from Gyengyenadze School, 622 (31%) children from AME Zion Basic School, 484 (24%) children from University of Education Basic School and 349 children Essueyia Basic School.

### **4.3 DISTRIBUTION OF TYMPANOGRAMS AND PURE-TONE AUDIOMETRY**

From Table 4.3, out of 544 (57.58) children from Gyengyendaze School, 242 (35.6%) ears referred. Among the pupils from AME Zion Basic School, University of Education Basic School and Essuehyia Basic School, 85(12.5%) 98 (14.4%) and 255 (37.5%) ears referred respectively.

**Table 4.3: Distribution of pure-tone audiometry results at the various schools**

School	Pure-tone audiometry	
	Pass	Refer
Gyengyenadze school	866	242
AME Zion basic school	1159	85
University of education basic school	870	98
Essuehyia basic school	443	255
Total	3338	680

**Table 4.4: Distribution of tympanograms at the various schools**

School	Tympanograms				
	Type A	Type B	Type C	Type A <sub>D</sub>	Type A <sub>S</sub>
Gyengyenadze school	852	185	35	18	15
AME Zion basic school	957	208	40	20	23
University of education basic school	744	162	31	15	10
Essuehyia basic school	537	117	22	11	16
Total	3090	672	128	64	64

Table 4.4 shows the distribution of tympanograms at the various schools. For type A tympanograms, 852, 957, 744, and 537 ears at Gyengyenadze School, AME Zion Basic School, University of education basic school and Essuehyia basic school were identified respectively. For type B tympanograms, 185, 208, 162, 117 and 672 ears at the respective schools were identified. In addition, 35, 40, 31, 22 and 128 ears at the respective schools presented with type C

tympanograms. Also, 18, 20, 15, 11, and 64 ears presented with type A<sub>D</sub> tympanograms at the respective schools. Finally, 15, 23, 10, 16 and 64 ears presented with type A<sub>S</sub> tympanograms at the respective schools.

#### 4.4 COMPARISON OF TYMPANOGRAMS WITH PURE-TONE AUDIOMETRY

Table 4.5 shows a comparison of tympanograms with pure-tone audiometry results from the school screening exercise conducted.

**Table 4.5: Comparison of tympanograms with pure-tone audiometry results**

Tympanogram	Pure-tone Audiometry	
	Pass	Refer
Type A (n=3090)	3006	84
Type B (n=672)	112	560
Type C (n=128)	92	36
Type A <sub>d</sub> (n=64)	64	-
Type A <sub>s</sub> (n=64)	64	-
Total	3338	680

Out of 3090 ears with type A tympanograms, 84 (2.72 %) referred in the pure-tone audiometry screening test. Five hundred and sixty (83.3%) ears out of 672 ears with type B tympanograms referred in the pure-tone screening and 36 (56.0%) ears out of 64 ears with type C tympanograms also referred in the pure-tone audiometry screening. None of the ears with type A<sub>D</sub> and A<sub>S</sub> referred in the pure-tone audiometry screening test.

#### 4.5 PASS AND REFERRAL RATES

Table 4.6 referral and pass rates of auditory screening with tympanometry and pure-tone audiometry.

**Table 4.6: Pass and referral rates**

Audiometric procedure	N	Referral rate (%)	Pass rate (%)
Tympanometry	928	23.10	76.90
Pure-Tone Audiometry	680	16.92	83.08

A cursory look at Table 4.6 showed that the referral rates of auditory screening with pure-tone audiometry and tympanometry were 16.92% and 23.10% respectively. The pass rates of auditory screening with pure-tone audiometry and tympanometry were 83.08% and 76.90% respectively. Therefore, the prevalence of hearing loss among the basic school children in Winneba is 16.92%.

#### 4.6 PURE-TONE AUDIOMETRY AND TYMPANOMETRY SCREENING RATES

Table 4.7 reveals the effect of test method (tympanometry and pure-tone audiometry) on screening rates.

**Table 4.7: Effect of test method on screening rate**

Test Method	<i>N</i>	Mean	<i>Std. dev (s.d)</i>	<i>df</i>	<i>t</i>	<i>P</i>
Tympanometry	4018	232.0	9.2	4017	0.22	.02
Pure-tone Audiometry		226.7	6.1			

$\alpha=0.05$

Table 4.7 depicts a significant difference between the screening rates of the two test methods [ $t_{(4017)} = 0.22, p < 0.05$ ]. Tympanometry had a greater score [mean=232.0 s.d=9.2] than the pure-tone audiometry [mean=226.7, s.d=6.1].

#### **4.7 SUMMARY OF RESULTS**

The results showed that out of 3090 ears with type A tympanograms, 84 (2.72%) were referred in the pure-tone auditory screening test. Also, 560 ears (83.3%) out of 672 ears with type B tympanograms referred in the pure-tone screening and 36 (56.0 %) ears out of 64 ears with type C tympanograms also referred in the pure-tone auditory screening. None of the ears with type A<sub>D</sub> and A<sub>S</sub> referred in the pure-tone auditory screening. In addition, the referral rates of auditory screening with pure-tone audiometry and tympanometry were 16.92% and 23.10% respectively. The pass rates of auditory screening with pure-tone audiometry and tympanometry were 83.08% and 76.90% respectively. Finally, there was a significant difference between the screening rates of auditory screening with tympanometry and pure-tone audiometry.

## **CHAPTER FIVE**

### **DISCUSSION**

#### **5.1 INTRODUCTION**

The study investigated impedance audiometry measures against pure-tone audiometry in auditory screening. The chapter is divided into three sections. These include:

- (1) Demographic characteristics of respondents
- (2) Pure-tone Audiometry versus Tympanometry in Auditory Screening
- (3) Prevalence of Hearing Loss among the Basic School Children in Winneba

#### **5.2 Demographic characteristics of respondents**

The data collected depicted that 2009 school children participated in the study. The demographic characteristics of the respondents indicated that there were more females screened than males. The most prevalent age range was 7 to 9 (42.9%) years followed by 10 to 12 years (40.02%). The average ages of study participants were relatively higher than the average ages of pre-school and primary school children in urban areas in Ghana. This is because some of the participating schools (Gyengyenadze and Essuehyia schools) were from rural communities in Winneba.

Furthermore, the descriptive statistics also revealed that majority of the participants who referred were from Gyengyendaze and Essuehyia schools. These schools are situated in rural areas in Winneba compared to AME zion school and University of education basic school which are in the urban/developed areas of Winneba.

### 5.3 Pure-tone Audiometry versus Tympanometry in Auditory Screening

Six hundred and eighty ears referred in the auditory screening with pure-tone audiometry. Out of 3090 ears with type A tympanograms, 84 (2.72%) referred in the pure-tone audiometry screening test. Five hundred and sixty ears out of six hundred and seventy two ears with type B tympanograms referred in the pure-tone screening and 36 (56%) ears out of 64 ears with type C tympanograms also referred in the pure-tone audiometry screening test. None of the ears with type A<sub>D</sub> and A<sub>S</sub> referred in the pure-tone audiometry screening test. In addition, the *t*-statistic depicted a significant difference between the screening rates of auditory screening with tympanometry and pure-tone audiometry. In particular, there were more referrals presented at the screening with tympanometry than at the screening with pure-tone audiometry. This finding is due to fact that a significant proportion of the study sample with middle ear pathologies were missed by the pure-tone audiometry screening test. Thus, the tympanometry was more sensitive to middle ear pathologies than the pure-tone audiometry screening test. The current findings are consistent with researches by Holtby, et al. (1997), Dempster, et al. (1991), Watters, et al. (1997) and Sassen, et al (1994) who purported that impedance audiometry should be included in auditory screening protocols since it is technically more efficient in screening for middle ear pathologies than the pure-tone audiometry.

Many participants with middle ear pathologies were not detected by the pure-tone audiometry because the screening procedure did not include air and bone conduction threshold search. Thus, the pass/refer criteria is relatively less sensitive to middle ear pathologies.

#### **5.4 Prevalence of Hearing Loss among the Basic School Children in Winneba**

Six hundred and eighty out of 4018 ears referred in the hearing screening with the pure-tone audiometry. Therefore, the prevalence of hearing loss among the basic school children in Winneba was 16.92%. The implication of this is that there are quite a large number of students with unilateral and bilateral hearing loss in the population of basic school children in Winneba. The high prevalence of hearing loss is consistent with studies by Al-Rowaily et al. (2012) and Khari et al (2010) who reported a relatively high prevalence of hearing loss.

There are many factors that might have accounted for the high prevalence of hearing loss. Some of these factors may be due to the poor socio-economic status of parents, inadequate hearing health-care facilities in the community and the low level of awareness about hearing healthcare. The findings of the current study are also in agreement with studies by Mann et al. (1998) and Minja et al. (1996) who reported a high prevalence of hearing loss in rural communities compared with urban communities. The studies further concluded that the low occurrence of hearing loss and chronic otitis media in the urban communities were due to access to better health-care facilities.

However, the findings of this study are not consistent with the findings of Amedofu et al. (1997) and Essel (1992) who reported a relatively lower prevalence of hearing loss among children in Ghana. This difference may be due to the following reasons: (1) conducting hearing screening with only pure-tone audiometry and (2) the difference in the socio-economic background of study participants, thus rural versus urban communities.

## **CHAPTER SIX**

### **CONCLUSIONS, RECOMMENDATIONS AND STUDY LIMITATIONS**

#### **6.1 INTRODUCTION**

A prospective cross-sectional design was adopted in a study to compare pure tone audiometry with impedance audiometry in the auditory screening of a population of 2009 pupils in four basic schools in the Winneba community of Ghana. The conclusions and recommendations arising from the findings and discussions of the study are presented in this Chapter. The limitations encountered during the course of the research study are also indicated.

#### **6.2 CONCLUSION**

The findings from the study indicated that tympanometry detected more middle ear pathologies than the pure-tone audiometry. However, the use of pure-tone audiometry was also sensitive to the detection of some types of hearing loss. Therefore, the combination of pure-tone audiometry and tympanometry in auditory screening is more effective and efficient in detecting hearing loss and middle ear pathologies.

#### **6.3 RECOMMENDATIONS**

Based on the findings and discussions of this study, the following recommendations are suggested:

1. It is also recommended that diagnostic audiometry should be included for future studies in order to establish the sensitivity and specificity of the pure-tone and tympanometry in auditory screening in Ghana.
- 2 Health care policy makers should adopt school screening program as an annual event for school children to detect early hearing impairment among children, Ghana.
- 3 It is highly recommended that auditory screening with pure-tone audiometry should be complemented with tympanometry in Ghana.

#### **6.4 LIMITATIONS OF THE STUDY**

The major limitations of the study were time and financial constraints. This did not allow for the performance of test-retest reliability studies. In addition, the limited availability of test equipment impeded the rate of data acquisition.

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## APPENDIX I

### PARTICIPANTS INFORMATION SHEET (FORM)

**Name of principal investigator:** Anthony Azaglo (MSc. Student)

**Name of supervisors:** Prof. G.K. Amedofu, Dr. S. Anim-Sampong

**Name of school:** School Allied Health Sciences, University of Ghana

**Name of sponsor:** School Allied Health Sciences, University of Ghana

**Project title:** AUDITORY SCREENING OF BASIC SCHOOL CHILDREN-A  
COMPARISON OF PURE-TONE AUDIOMETRY AND IMPEDANCE AUDIOMETRY

I agree to partake in the above mentioned research and I have been told that the purpose of this research study is to the study investigated the impedance measurements against pure-tone audiometry as a screening method for the detection of middle ear changes associated with hearing loss in basic school pupils.

I have been told the procedure of the study.

**The discomforts are:** by taking part in this study, will surely experience some degree of discomfort while undergoing lying during the examination from labor pain.

**The benefits:** are to determine hearing status and associated disorders.

**Confidentiality:** The information collected from this research project will be kept confidentially. The information about me will be filed which would not bear my name but a number assigned to it. Results from the study may be discussed at meetings or in any journal but my name will not be used.

**My right to refuse or withdraw;** I can decide to take part or not and I will not be denied the examination. I will be treated equally as anyone who is undergoing the examination. I may also

decide to stop participation in the study anytime that I wish to without losing any of my rights there.

Signed by participant..... Date.....

Singed by researcher..... Date.....

Place.....

**SCHOOL OF ALLIED HEALTH SCIENCES**  
**COLLEGE OF HEALTH SCIENCES**  
**UNIVERSITY OF GHANA**  
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**My Ref. No. SAHS/ 10395116**  
**Your Ref. No.**



P. O .Box KB 143  
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Accra  
Ghana

12<sup>th</sup> May, 2014.

Mr. Anthony Azaglo,  
Dept. of Audiology,  
SAHS,  
Korle Bu.

Dear Mr. Azaglo,

**ETHICS CLEARANCE**

Ethics Identification Number: SAHS – ET. /10395116/AA/2A/2013-2014.

Following a meeting of the Ethics and Protocol Review Committee of the School of Allied Health Sciences held on Monday 24<sup>th</sup> March, 2014, I write on behalf of the Committee to approve your research proposal as follows:

**TITLE OF RESEARCH PROPOSAL: "Auditory Screening of Basic School Children – A Comparison of Pure Tone Audimetry with Impedance Audimetry"**

This approval requires that you submit six-monthly review reports of the protocol to the Committee and a final full review to the Committee on completion of the research. The Committee may observe the procedures and records of the research during and after implementation.

Please note that any significant modification of the research must be submitted to the Committee for review and approval before its implementation.

You are required to report all serious adverse events related to this research to the Committee within seven (7) days verbally and fourteen (14) days in writing.

SCHOOL OF ALLIED HEALTH SCIENCES  
COLLEGE OF HEALTH SCIENCES  
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Your Ref. No.



P O Box KB 143,  
Korle Bu, Accra

Marc5, 2014

The Special Education Coordinator  
Effutu Education Service  
Winneba

Dear Madam,

**PERMISSION TO CARRY OUT MSc RESEARCH PROJECT VIA THE EFFUTU  
EDUCATION SERVICE CHILDREN HEARING SCREENING PROGRAMME**

Mr. Anthony Azaglo is a 2<sup>nd</sup> year MSc Audiology student in the Department of Audiology, University of Ghana School of Allied Health Sciences (SAHS), Korle Bu.

He is conducting an MSc research dissertation project on prevalence of otitis media among school children in first cycle institutions using non-invasive instrumentation under the supervision of Prof. G.K. Amedofu, a Clinical Audiologist at Komfo Anokye Teaching Hospital and Dr. S. Anim-Sampong of SAHS. The School's Ethics and Protocols Review Committee has temporarily passed his research proposal as meeting associated ethical requirements.

In this regard, the Department would be most grateful if you could kindly grant Mr. Azaglo permission to join the on-going School Hearing Screening Programme under the auspices of the Effutu Education Service in order to carry out this important research project in March 2014 for the common good of the University and the Effutu community at large. Thank you.

Yours faithfully,

A handwritten signature in black ink, appearing to read 'S. Anim-Sampong'.

Dr. S. ANIM-SAMPONG  
(Coordinator)

cc Dean, SAHS