10-2014

Underprivileged Children in Port-au-Prince, Haiti: Hearing and Academic Performance of Children in Public Schools in Port Au Prince

Talia Meisel
Graduate Center, City University of New York

Underprivileged Children in Port-au-Prince, Haiti: Hearing and Academic Performance of Children in Public Schools in Port Au Prince

Talia Meisel
AuD. Candidate

CUNY Graduate Center Doctoral Program in Audiology

A capstone research project submitted to the Graduate Faculty in Audiology in partial fulfillment of the requirements for the degree of Doctoral of Audiology, The City University of New York

2014

This manuscript has been read and accepted for the
Graduate Faculty in Audiology in satisfaction of the
Capstone project requirement for the degree of Au.D.

______________ Date

______________ Barbara E. Weinstein, Ph.D.
Chair of Examining Committee

______________ Date

______________ John Preece, Ph.D.,
Executive Officer

______________ Barbara E. Weinstein, Ph.D.
Capstone Advisor

THE CITY UNIVERSITY OF NEW YORK

Abstract

Underprivileged Children in Port-au-Prince, Haiti: Hearing and Academic Performance of Children in Public Schools in Port Au Prince

By: Talia Meisel

Advisor: Barbara E. Weinstein Ph.D.

Hearing loss is estimated to affect more than 360 million people worldwide, 32% of whom are children. Children with hearing loss tend to develop compromised communicative abilities and also have been found to perform more poorly academically than their normal hearing peers. Because of the lack of medical care, children in third world countries are expected to have more difficulty hearing and learning in a classroom setting than children in first world countries due to higher incidences of conductive pathology. The purpose of this study is to assess the hearing ability of underprivileged children in kindergarten and primary schools in Haiti, and then to compare the results to each child's academic record, respectively, to see if a relationship exists between hearing ability and academic records.

Key words: Haiti, hearing loss, academics, children

Acknowledgements

I would like to sincerely thank my advisor, Dr. Barbara Weinstein for her time and assistance during the completion of this review and to Dean Ebenstein for providing funding for this study. A special thank you to Dr. Veronica Barnwell and the staff at King's County Medical Hospital for their time and resources.

I would like to thank the faculty for sharing their abundant knowledge and experience throughout my four years in the Au.D. program and for motivating me to strive for excellence in my own way. I appreciate very much the dedication Dr. Wortsman has given me on a regular basis to keep me on point, the fascination I had while absorbing information during Dr. Preece's courses and I will never forget a special conversation I once had with Dr. Rubinstein that made me never want to give up.

This study would never have happened without the permission of Father Chancey of the St. Vincent de Paul primary school in Port-au-Prince, Haiti, the teachers who distributed and collected the permission slips from parents and relayed necessary data for this study, the school nurse, and the invaluable time and help provided by Chantal Papillon, translator and Kindergarten principal. Thank you as well to my best friend, Adjani Papillon, Primary School Principal, for translating the letters and documents necessary for this study, and for providing us with food, shelter and transportation for the duration of this study.

Above all, I would like to express my loving gratitude to Ellen, my Capstone research partner and fellow adventurer, for helping me make this dream, which started as a joking conversation five years ago, into a reality.

TABLE OF CONTENTS

List of Tables

LIST OF FIGURES

Underprivileged Children in Port-au-Prince, Haiti: Hearing and Academic Performance of Children in Public Schools in Port Au Prince

INTRODUCTION

The World Health Organization (WHO) defined a disabling hearing loss as a hearing loss greater than 40 dBHL in the better ear in adults (15 years or older) and greater than 30 dBHL in the better hearing ear in children (0-14 years). In a 2012 statement, the WHO estimated that 360 million people in the world have a disabling hearing loss, 32 million of whom are children. Data gathered by Mathers et al (2000) showing the prevalence of hearing impairments in children revealed essentially a mild to moderate hearing loss in developed and developing countries worldwide. According to Mathers et al. (2000), consequences of hearing impairment include inability to interpret speech sounds, often producing a reduced ability to communicate, delay in language acquisition, economical and educational disadvantage, social isolation and stigmatization.

It is important to note that the WHO estimation does not include slight or lesser degree mild losses, which, even though they are not defined as disabling losses, may unfortunately manifest as a myriad of the aforementioned communicative disabilities. Wake et al (2006) performed a cross-sectional study on school children in Australia and found that children with slight and mild sensorineural hearing losses displayed poorer phonological short-term memory and phonological discrimination.

HEARING STATUS IN DEVELOPED COUNTRIES

Based on the Center for Disease Control and Prevention's (CDC) Hearing Screening and Follow-Up Survey from 2009, 1.4 per 1000 babies screened for hearing loss present with a hearing loss. A limitation of this data though is that it is based on only the babies whose families sought out and received the proper follow-up procedures. The CDC's Metropolitan Atlanta Development Disabilities Surveillance Program, states that 1.1 children ages 3-10 years have bilateral hearing loss of 40 decibels or more. The National Institute on Deafness and Other Communication Disorders (2010) estimates that "about 2 to 3 percent out of every 1,000 children in the United States are born deaf or hard-of-hearing." Russ et al. (2010) reported that about 2% of babies do not pass their hearing screenings, and that obtaining the proper referrals and interventions moving forward from the screening is where many issues in the US system lie. This is important to note since this information highlights that even though a hearing loss is detected, children can be lost to follow-up, resulting in a child experiencing difficulty and disability until proper action is taken. It also indicates that there may be a higher percentage of children with hearing loss than published statistics relay, especially if the hearing loss is progressive.

Niskar et al. (1998), stated that 14.9% of children in the United States aged 6-19 years have a low (LFHL) or high frequency hearing loss (HFHL), defined as PTA of 16-decibel hearing level in one or both ears. Data was gathered by performing audiological testing on frequencies 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz and 8000 Hz in a mobile examination center. These findings, generalized to US children overall, estimated that 7 million children in the United States have a slight or worse hearing loss. Prevalence of LFHL, which tended to be conductive in nature, was estimated to be 7.1%, 1.5% bilateral and 5.6% unilateral, with "the proportion with slight LFHL in either ear to be 5.7%, mild to moderate was 1.4%, and severe to profound was 0.3%. The prevalence of HFHL, which tended to be sensorineural in nature, was 12.7%, 3.1% bilateral and 9.6% unilateral, with slight HFHL in either ear was 10.5%, mild to moderate was 2.6%, and severe to profound was 0.4%. For each type of hearing loss, slight degrees of hearing loss were found to be the highest percentage, either unilaterally or bilaterally.

Niskar et al. (1998) concluded that hearing screening protocols in elementary schools should be expanded to include both low (500 Hz) and high frequencies, especially frequencies 3000 Hz-6000 Hz to detect hearing losses easily affected by noise in the classroom.

In recording etiology and audioligical outcomes through a longitudinal study on 364 three year old children with hearing loss in Australia, Dahl et al. (2013) stated that childhood hearing loss is an etiologically heterogeneous condition, caused by environmental factors and/or genetic factors, with mutations in the GJB2 (connexin 26) gene, the SLC26A4 (pendred) gene and in the mitochondrial DNA at position 1555 (A1555G mutation) and congenital cytomegalovirus (CMV) infection considered as the major causes of congenital hearing loss in developed countries. Of the 364 children who participated in the study, 40% of children presented with hearing loss due to no known diagnosis, 30% presented with hearing loss due to GJB2 mutations, 9% presented with hearing loss due to SLC26A4 mutations, 8% presented with CMV, 7% presented with hearing loss due to auditory neuropathy spectrum disorder (ANSD), 2% presented with conductive pathologies, enlarged vestibular aqueduct and familial hearing loss, each, respectively. No significant percentage of children tested were found to present with other known causes of hearing loss such as rubella, perinatal trauma, Down Syndrome or mitochondrial mutation (mtDNA1555G).

Further statistical analysis revealed that 1 to 1.2 per 1000 births in Australia, increasing to 1.5 per 1000 births by the age of 3 years old, had permanent childhood hearing loss. Molecular testing on 166 of the 364 children (parental consent was obtained only for these 166 children) revealed that 83.1% (138 children) of these children had a genetic cause for hearing loss present and 16.9% (28 children) of these children had an environmental cause for their hearing loss. Of the 138 children with hearing loss attributed to genetic causes, “mutations in the GJB2 gene accounted for 76.1% of the genetic cases” (p. 4).

A study conducted in Greece by Gouma et al. (2011) looked at behavioral trends in young children with conductive hearing loss. 183 children between the ages of 6-8 years of age were recruited for this study, 117 of which had a “positive record of unilateral or bilateral acute otitis media at the age of 4 or 5,” (p. 1) as proved by tone audiometry. The 66 remaining children, comprising the control group, had no complaints of hearing loss and no reported incidents of otitis media with effusion from the age of 2 years old and older. 70% (82 children) of the 117 children with OM episodes had recurrent unilateral OM between the ages of 4-5 years, ranging from 10-27 days. The other 30% of the children were reported to have 1-3 episodes of bilateral OME in addition to recurrent episodes of unilateral OME. Statistically significant hearing differences were found at 500 Hz and 1000 Hz for the study group when compared to the control group, who obtained on average 25 dBHL thresholds. The control group obtained an average of 10 dBHL thresholds at those frequencies. Children in both groups were then evaluated for competence in general activity, social activity and academic activity in accordance with the Child Behavior Checklist questionnaire, for which no statistical differences were found. Statistical differences were found, though, for the study group when comparing results for anxiety/depression and attention problems to results from the control group.

This indicates that, along with under-achievement and productivity issues, children may also experience psychological effects that come along with hearing loss that develops at young age. Dahl et al. (2013) wrote that “hearing loss is associated with under-achievement…and lost productivity” (p.1), and Most et al. (2011) positively correlated prelingual hearing loss in children ages 4-7 years old to loneliness and reduced social competence and speech intelligibility when compared to normal hearing children. These outcomes can be prevented performing routine hearing screenings at birth, and regular follow-up. This allows for congenital and progressive hearing losses to be detected and the correct intervention to be sought out in a timely manner.

HEARING STATUS OF CHILDREN IN HAITI AND OTHER DEVELOPING COUNTRIES

The Pan American Health Organization (PAHO) published an article ten days after the January 2010 earthquake that devastated Haiti that discussed the country's health assessment prior to the earthquake. As the poorest country in the Americas, Haiti is expected to have, and does have, a poor healthcare system. PAHO stated: "The precariousness of the Haitian's health care system is reflected at all levels: low regulatory and supervisory capacity by the national health authority, inaccessibility to health care services, health information systems deeply fragmented and poorly developed, essential public health functions unassumed by the national health authority, essential drugs system weakly regulated, funding mainly based on international cooperation, and insufficient human resources, unsuitable and poorly distributed throughout the territory" (p. 2).

PAHO continues, stating this inaccessibility to health care can be a result of Haiti's skewed distribution of wealth, in which 66% of wealth is concentrated in 4% of the Haitian population. About 5% of the population does not have access to basic health care including medications and some seek the help of traditional healers. The mortality rate is reportedly low, with 1 in 12 children dying before the first birthday, with 32% of deaths occur from preventable infectious diseases, and HIV/AIDS, tuberculosis, malaria and malnutrition which are the five leading causes of death in children (PAHO 2010). According to a 2011 survey report published by Elizabeth Parks and, SIL International 33% of Haitians are urbanized and 67% live in more rural areas, with 80% of the Haitian population live under the poverty level and 54% live in abject poverty. Only 6% of Haitians have access to electricity. Parks (2011) continued that some Haitians believe disabilities are God-given due to fault in the family, and that genetics do not play a part. In less educated areas, disabilities are seen as punishment from their God or from family spirits. Families “may completely avoid interaction or touch in order to keep themselves from contracting the spell or curse” (p. 5). Since hearing loss is a disability that cannot be seen, children with hearing impairments tend to already be integrated into the family by the time their hearing loss is discovered, allowing for the stigma of disability to have allayed as opposed to families with children born with visible disabilities (p. 5).

According to Dowell et al. (2011), child mortality before the earthquake was 171 per 1000 children, and the rate at which women died during childbirth was unacceptably high. A study performed by Jules et al. (2010) discussed at least five harmful medications used by pregnant women delivering in hospitals Haiti. Women were asked to detail their medication used from anytime between their last menstrual period and delivery. More than half of the women who participated in this study reported use of at least one medication during pregnancy, 6% reported use of three or more during pregnancy and sixty one mothers reportedly used harmful to the fetus in pregnancy, some for the intent of abortion. Some of the women who reported use of medication had taken medications other than that which they had originally reported. These drugs were prescribed by a physician, bought over the counter, received from friends or family or bought in the black market. The most commonly used harmful medicines were misoprostol and tetracycline, which can impair bone development of the fetus and can induce abortion (Ogbru 2013). Of the births from the sample population, only three babies were found to have birth defects. Two of these babies were born to mothers who reported no medicinal use during pregnancy. No studies were found to like these medications to hearing loss, but it can be speculated that hearing issues can result from bone development defects in utero, since the inner ear is comprised of bony labyrinths and cranio-facial abnormalities are known to have accompanied hearing losses (Bamiou et al. 2000).

Perry et al. (2007) conducted a study discussing the mortality rate in Haiti for children 0-5 years of age through the years 1958-1999. Data was collected from HAS, a local system of health and other community development programs in the Artibonite Valley of Haiti. The data compiled showed a decrease in the infant mortality rate, the 1-4 year mortality rate and under-5 mortality rate in rural Haiti and overall nationally for Haiti, since the HAS establishment. The mortality rate had decreased from 174 infant deaths, 92 1-4 year old deaths and 250 under-5 year olds deaths per 1000 children under the age of five years old in 1958-1962 to 47.3, 15.8 and 62.3, respectively during the years of 1990-1999 per 1000 children. Perry et al. (2007) stated that from the data collected, they found no significant difference between education level, access to electricity and level of sanitation of the household between homes in the Artibonite Valley and other rural areas of Haiti, and attempt to answer why the mortality rate has not improved more consistently or significantly. Reasons stated discuss malnutrition and HIV/AIDS as contributing factors.

Gupta and Agrawal (2010) discuss the impact of HIV on Haitian children, along with asthma and, since the 2010 earthquake, post-traumatic stress disorder (Gupta & Agrawal, 2010). Asthma, on its own or as resulting from allergy, can affect hearing health of the outer, middle and inner ears. Because airways become constricted (Orange et al. 2006, S532), fluid can become trapped in the middle ear, leading to acute otitis media (Hay 2014). In relation to HIV, Gupta and Agrawal (2010) stated that many children, primarily female, are subject to physical and sexual abuse, especially those that are orphaned. These children also fall into sex trafficking which exposes them to sexually transmitted diseases, such as HIV. While investigating otorhinolaryngological differences and hearing in HIV- positive and HIV-negative children in Angola, a developing country in Africa, Taipale et al. (2011) found that even though the control group of HIV-negative children, which was age and sex matched to the sample population of HIV-positive children, had high prevalence of chronic suppurative otitis media (CSOM), HIV positive children tended to present with bilateral chronic ear discharge. Of the HIV positive population, one quarter of the children was found to have hearing loss in one or both ears, with bilateral impairment present in 10% of these children. This study overall showed otorhinolaryngological diseases to be significantly common in HIV-positive children, of which, in conjunction with the presence of other life-threatening diseases, is increasing across third world countries.

Monasta et al. (2012) reported that global AOM incidence rate, new episodes per hundred people per year, is 10.85%, equivalent to 709 million cases each year. 51% of these episodes were said to occur in children under five years of age, with the highest incidence in Sub-Saharan Africa West and Central in children under five years of age. CSOM incidence rate was found to be 4.76 per thousand people for a total of 31 million cases, with 22.6% of these cases occurring annually in children in West and Central Sub-Saharan Africa under five years of age. Monasta et al. (2012) continued that the WHO estimated that 28 thousand deaths every year are attributable to complications of OM, that OM and CSOM can lead to death mainly through meningitis and brain abscess. In addition, Monasta et al(2012) stated that the WHO estimated that between 65 and 330 million individuals suffer from CSOM (show signs of CSOM), 50% of whom suffer from hearing impairment.”

More specifically in Haiti, children were exposed to typhoid, diphtheria, meningococcal meningitis and leptospirosis after the earthquake in addition to the vast cholera and malaria epidemics (Dowell et al., 2011). A study conducted by Sejvar et al. (2012) conducted in Mozambique found that acute and severe neurological illness may develop in individuals with typhoid fever, and that hearing loss and visual problems manifested in patients diagnosed with and suspected of having typhoid fever as well. In contrast, a study performed in Kenya by Carter et al (2005) on children exposed to different types of malaria found no correlation to increased hearing issues, even with damage to the mesial temporal lobe, and a study by Roine et al (2010) found no correlation between bacterial meningitis and increased hearing impairment.

A more pressing matter in Haiti is the polluted water supply. Varma et al. (2008) states that this is an ongoing issue due many reasons including political violence and a long-standing national debt, and that this inability to further itself politically and economically continually reflects and causes the country's contaminated water, deficient public sanitation, poor health, and chronic poverty. Exposure to contaminated water can affect outer, middle and inner ear function. The most prevalent pathologies due to contaminated water exposure to the outer ear include acute diffuse otitis externa, exostoses, and fungal infections such as otomycosis. Infections to the middle and inner ear resulting from contaminated water exposure occur with perforated tympanic membranes, the perforations occurring either from excessive water pressure or from a previous condition otherwise. Contaminated water entering the middle and inner ear can result in varying degrees of otitis media accompanied by otorrhea and excessive debris in the auditory meatus, leading to conductive and or sensorineural hearing loss with a possibility of compromised vestibular function (Wang et al. 2005).

Specifically to Haitian children, the effects of malnutrition have severely compromised health. According to Ayoya et al. (2013), Haiti has the highest rates of childhood underweight and wasting in the Latin America and Caribbean Region, which is a direct result of malnutrition. Ayoya et al. (2013) cited the Haiti Demographic and Health Survey (HDHS 4), conducted in 2005–06, which stated that due to malnutrition, one in every three children unfer the age of 5 was stunted, one in 10 was wasted and two in 10 were underweight, Stunting rates in this age group were almost twice as high in rural areas as in urban areas. In every 3 children under age 5, Ayoya et al (2013) stated that the HDHS reported lower rates of undernutrition: 21.9% stunted, 5.1% wasted, and 11.4% underweight. Cripps et al (2005) connect malnutrition to CSOM, and it can be speculated that malnourished children are immunocompromised, opening them up to diseased that can be linked to or cause hearing loss.

In performing a systematic review of otitis media based on WHO estimates for the year 2005 from data collected from 114 publications, Monasta et al. (2012) found that studies in developed countries revealed that by their third birthday, 80% of children will have had at least one bout of acute otitis media (AOM) with 40% having six or more recurrences by the age of seven years. The burden of AOM varies substantially across countries, the main differences residing in the frequency of suppurative complications such as mastoiditis and meningitis and of sequelae such as hearing loss due to CSOM. CSOM is a known cause of preventable hearing loss, particularly in the developing world and a reason of serious concern, particularly in children, because it may have long-term effects on early communication, language development, auditory processing, psychosocial and cognitive development, and educational progress. With life-threatening illnesses rampant in developing countries, and unsafe living conditions due to living in a low socioeconomic environment, audiological care is often overlooked or not considered

(Goulios & Patuzzi, 2008). This is associated with negative outcomes in terms of language and communication skills. According to Stevenson et al. (2010) children with hearing loss are more prone to emotional and behavioral issues, including a shortened attention span. Data for this study was gathered in Southern England via questionnaires answered by parents and teachers of 120 children with permanent childhood hearing impairment (PCHI) of moderate or greater severity. 67 male and 53 female children with hearing loss were recruited for this study, with a mean age of 7 years and 11 months old with an age range of five years five months old to 11 tears 8 months old. 37 male and 26 female hearing children were recruited as well, with a mean age of eight years one month ranging in age from six years four months to nine years 10 months old. Their findings in comparing receptive language scores with behavior and age of hearing impairment diagnosis showed approximately a 0.6 standard deviation difference between diagnosis before 9 months of age and after 9 months of age later for receptive language abilities, in favor of the children with earlier diagnosis. This score, for the early diagnosis group, was still 1.5 standard deviations below their hearing peers. The implications of this on communicative ability translate into a lack of language skills and speech quality, even if the hearing impairment manifests unilaterally. Lieu et al. (2010) found that children aged 6-12 with unilateral hearing loss had significantly lower scores in oral and written language scales (OWLS) than their normal hearing siblings who had served as the control group. The OWLS included oral expression and oral composite. Similar results were found by Lieu et al (2012) for a longitudinal study performed on children aged 6-8 with mild, or worse, stable, unilateral hearing loss.

The aforementioned data reveal many different possible etiologies of hearing loss in Haitian children and children in developing countries worldwide, along with some of the dire risks that late diagnosis can pose on communicative and educational status and ability, and, in some situations, psychological and physical health as well. Because of a health care system that is lacking in resources and accessibility, and a population that mostly living under the poverty level, Haitian children likely do not receive the healthcare they require, resulting in overall immunodeficiency and compromised hearing health. A cost-effective and efficient way to improve this system and raise awareness in relation to hearing health would be to institute hearing screening, starting at the newborn level. Even questionnaires for parents of children who are school ages, though not as specific as hearing screenings, can be of help in identifying hearing loss.

In an attempt to develop and analyze a low-cost hearing screening tool for developing countries, Samelli et al. (2011), 214 children aged 2-10 were recruited for audiological testing in Sao Paolo, Brazil. Audiological results were compared to questionnaires filled out by the children's parents. Results were indicative of conductive hearing loss in 39.3% of children, sensorineural hearing loss in 7.4% and normal hearing in 53.3%, and that the questionnaire given to parents had been a good indicator of the revealed hearing losses in the test population. This inexpensive manner of identifying hearing loss may be beneficial to Haitian school children and their families, and can lead to proper intervention in the classroom such as preferential seating. There are no published data on conditions in Haiti in regard to hearing loss and communicative disability. However, previous literature state health deficiencies in developing countries and discuss that they have varied negative effects on hearing and speech abilities- a study conducted in Mozambique, a developing country in Africa, points out the prevalence of conductive pathologies in school age children aged 3-18 years and discusses high rates of otitis media and external auditory meatus obstruction. The same conditions can generally be expected of children living in third world countries, such as Haiti, where hearing impairment is bound to be overlooked due to the importance of other health issues and social and political events (Clark 2008).

To address communicative ability and hearing loss in developing countries, Khoza-Shangase et al. (2010) distributed self-administered questionnaires in Guateng, South Africa. The questionnaire aimed to verify and validate protocols and practices for audiology early intervention and to measure their compliance with existing audiological EI protocols. Eighty six professionals working in government hospital settings participated in this study: 20 audiologists, 33 pediatricians, 7 ENTs and 26 nurses. The results of this study indicated that even in professional medical settings, the role of an audiologist is not known past identifying hearing loss. On many occasions, nurses did not refer patients to audiologists when ototoxic drugs were prescribed or when a patient presented with risk factors correlated to hearing loss. Such referrals are paramount to identifying hearing loss in young children, and can help provide the child with the tools necessary to succeed in academia and move forward. It was found that there was also resistance from the ENT group to include an audiologist on the early intervention team for a child with suspected or diagnosed communicative disability. Team work unsuccessfully designated or recognized resulted in such patients not receiving the necessary care. This lack of team work is documented in the study to demonstrate the results of a late diagnosis of communicative disability due to hearing loss, which in turn results in late amplification solutions.

Late diagnosis of hearing loss in developing countries is usually due to a lack of resources, which, in turn, is a reflection of the poor socio-economic status of that region. With no means of identification of hearing loss and its impending communicative consequences, there are no means available to intervene at the early and crucial stages of development (Moeller et al., 2007). In a literature review compiled by Moeller et al. (2007), language and literacy skills of children with early and late diagnosis of mild to severe hearing loss were compared to each other and to the language and literacy skills of normal hearing children. Children with later diagnosis were found to have a “differing auditory-linguistic experience” (Moeller et al., 2007, p. 2). Though many studies were stated in this review as having contradictory views, the results overall show that children with hearing loss were found to have poor receptive and expressive vocabulary development, poor novel word learning and semantic development, morphological development, syntactic development, reading and literacy. Some studies stated that with the appropriate and timely intervention, children with hearing loss were able to catch up with their normal hearing peers. It is important to understand that intervention can be sought out after the effects of a hearing loss manifest, but it is always more effective to seek intervention in a timely fashion.

Van der Linde et al. (2009), in aiming to describe early identification methods and processes, resources and limitations in implementing an early intervention program in a rural community in South Africa, stated that developing countries have a high rate of infants born with hearing loss and are not cared for properly due to mothers who are physically unfit (whether they be malnourished or of adolescent age), have sexually transmitted diseases, or due to mother-to-child transfers of disease. In their study, they follow an implemented Early Communication Intervention (ECI) program set in Primary Health Clinics (PHC). The purpose of the ECI is to provide comprehensive integrated health services instead of divided services that don’t focus on teamwork and could potentially result in ineffectual service delivery. The ECI framework addresses collaborative partnerships between parents and caregivers and between caregivers of differing disciplines, including audiologists and speech-language pathologists. In this model, audiologists were grouped as primary caregivers, and were acknowledged to have an optimal and positive impact in advancing communicative ability in children with these specific needs.

Responsibilities would include providing preventative information on normal hearing and development to parents prior to a child's birth, performing hearing screenings and identifying risks for communicative delays once the child is born, and then performing follow-up screenings thereafter. Despite this great progress, there is no mention in this study of comprehensive audiological testing. This is most likely the result of a lack of resources and demonstrates that even with beneficial programs such as ECI in place in developing countries, the necessary care and communicative need and intervention are not being delivered adequately.

There is no known integrative program to facilitate with communicative disability in Haiti. Being the poorest third world country in the region of the Americas, there is no doubt the country is lacking in resources and would greatly benefit from an elementary ECI until more thorough means of diagnostics and intervention can be established. According to Chisholm et al. (2012), in prioritizing prevention and control of non-communicable diseases in sub-Saharan Africa and South East Asia, "in terms of value for money, health conditions that are often left out of priority lists or action plans (such as sensory loss or mental disorders) have as much a case for funding as do cancer, cardiovascular disease, or diabetes. For example, antibiotic treatment of chronic otitis media (a persistent inflammation of the middle ear) is the most cost effective intervention in the two regions, while extraction of cataracts and proactive screening for hearing loss are among the biggest potential contributors to population health gain" (Chisholm et al. (2012), p. 2).

In essence, Haiti would greatly benefit from a screening program, and no doubt a stronger healthcare system or framework to ensure efficient and timely identification, and ultimately intervention, for hearing loss. To institute a screening program to identify hearing loss in newborns or a questionnaire for parents to identify hearing loss in their school aged children may prove to be efficient and cost-effective once instituted.

ACADEMIC PERFORMACE AND HEARING

It is appropriate to assume that hearing ability has an impact on a child's academic performance. A study by Bess et al. (1998) on 1218 students with mild hearing loss in 3rd, 6th and 9th grade showed that children in the 3rd grade with hearing loss scored lower academically than their normal hearing peers and that 37% of children with mild sensorineural hearing loss failed at least one grade. The scores were not as significant for the 6th and 9th grade students, but results indicated that bilateral and high frequency hearing loss increased slightly with increasing grade. A different study by Tharpe & Bess (1991) demonstrated that children with unilateral and mild bilateral hearing loss have greater difficulty with communicative skills and educational progress than has previously been believed. The incidence of unilateral hearing loss appears to be difficult to exact, and may range from 0.1% to 14.9% of school children, and can result in poor performance in early education and a higher rate of repeating classes (Wake & Poulakis 2004).

In addition to hearing loss being a factor in academic achievement, other factors may impede students' progress. Crandell and Smaldino (2000) wrote that background noise, signal to noise (SNR) ratio, noise effects on teacher performance, reverberation time (RT) and speaker-to-listener distance can influence speech perception in the classroom. Crandell and Smaldino (2000) explained that noise and reverberation combined "adversely affects speech perception to a greater extent than the sum of both effects taken independently…. their combined effects on speech perception might actually equate to a 40% to 50% reduction in speech" (p. 4).They explain that this reduction in speech perception occurs due to resulting noise filling in the time gaps between speech sounds, making perception of the noise steadier in nature and making speech sounds less discernible. A study by Klatte and Hellbruck (2010) in Germany using differing reverberations times corroborates these results. Seventeen classrooms with reverberations times ranging from

0.49 to 1.1 seconds that did not exceed 39 dB of extraneous noise levels were used for this study. 398 second graders, mean age eight years with a standard deviation of six months were placed in these classrooms, which were grouped according to their reverberations times as either RT_1 (RT 0.49-0.56 seconds with 126 participants), RT_2 (RT ranging from 0.49-0.56 seconds with 175 participants) or RT_3 (RT times ranging from 0.69 to 0.92 seconds with 97 participants). No hearing loss was listed for any of the participants.

Klatte and Hellbruck (2010) wrote that RT_1 was the optimal classroom acoustic level according to national guidelines, and found that performance on academic tasks declined in groups RT_2 and RT_3. Children in groups RT_2 and RT_3 obtained lower scores on overall cognitive performance, annoyance in the classroom, and were found to behave more noisily and have more issues being silent while doing work. Teachers also tended to be rated by the students as more impatient and unfriendly in classrooms with higher reverberation time, adding hostility to an already unfavorable learning environment. A systematic review by Klatte et al. (2013) analyzing chronic noise effects in children's cognitive development and performance on auditory and non-auditory tasks stated that children are prone to informational masking, which can impair cognitive ability. Since children are still developing cognitively, attentional control would not be not up to par allowing for distraction to easily occur due to noise, hence emphasizing the need for favorable learning conditions in the classroom. (Klatte et al. 2013). Results stated by Klatte et al. (2013) demonstrated that children exposed to noise have more difficulty reconstructing degraded speech signals, and that younger children will have more difficulty making used of contextual queues to understand masked signals. Klatte et al. (2013) also stated that informational masking due to ambient noise is enhanced by inability to focus on certain auditory channels also resulting from high noise levels, a skill that tends to improve throughout childhood through adulthood.

Crandell and Smaldino (2000) wrote that the most at risk students were those 15 years of age or younger because “adult-like performance on perception tasks in noise or reverberation is generally not reached until the child reaches approximately 13–15 years of age” and that “children with normal hearing sensitivity require higher SNRs and lower RTs than adult normal hearers to achieve equivalent perception scores” (p. 2). Data compiled by Crandell and Smaldino (2000) on hearing impaired children showed that, across most classroom listening conditions, hearing impaired children did significantly worse than normal hearing children.

A study by Nicolas and Geers (2006) discussed results of communicative progress in 76 children aged 3 years and four months to 3 years and 8 months across the United States and Canada, with hearing loss discovered within the first month to 30 months of age. The children received cochlear implantation between 12 to 38 months of age after using hearing aids for 11 months, and were further assessed for their communicative abilities at the age of three and a half years. This age was chosen for the study so that the children with hearing impairments could be compared to normal-hearing children in school settings to see where they fell short on communicative ability scales, since children with normal childhood development for speech and language usually have achieved vocabulary and syntax skills that enable both cognitive and social development measurement. Nicolas and Geers (2006) stated that it is crucial that both parents and educators know what to expect from these children, and if need be, refer to or seek out the appropriate assistance. The children were videotaped in 30 minute play sessions with their parents, during which parents were instructed to communicate with their children as they regularly would, and new sets of toys were introduced every 7-8 minutes to stimulate conversation.

Results indicated that children with poorer hearing pre- implantation had worse language skills, and children who had worn the cochlear implant longer had better language at the time of assessment. Hearing aid use showed to not be as effectual without leading to cochlear implantation and without being paired with early educational intervention. Nicholas and Geers (2006) concluded that early diagnosis of hearing loss leads to hearing aid fitting at a younger age, which in turn led to longer periods of improved auditory perception due to the amplification use. It was also found that early diagnosis allowed for an earlier and longer period of speech and language instruction and development as well as the opportunity for earlier cochlear implantation when needed.

Prior to newborn hearing screenings, children with mild or unilateral hearing losses tended to receive later diagnosis in the US, which also led to later intervention and ensuing consequences academically (Kuppler et al., 2013). In a systematic review of unilateral hearing loss and academic performance, Kuppler et al. (2013) wrote that children with unilateral hearing experience fatigue, loss of signal from noise discrimination, and stress. Loss of localization is mentioned as well, but Kupper et al. (2013) cited a recent study that shows that children with unilateral hearing loss may learn compensated localization, but that this is no substitute from natural localization of sounds via binaural hearing.

RESEARCH QUESTIONS

The hearing ability of children is essential to each child’s development and the opportunity for success. With consideration of the consequences of late diagnosis in developed and developing countries, it seemed imperative to investigate hearing status in Haiti, a country with a dearth of resources and a high incidence of crises and struggles. No previous studies have been published on hearing status and academic performance of children in Haiti. With this in mind, the examiners of this study attempted to answer the following research questions:

1) What is the relation between pure tone screening outcomes and performance on the diagnostic pure-tone air conduction testing in Haitian pre-school and school children?

2) What proportion of students present with hearing loss and what proportion of students presented with normal hearing?

3) What proportion of students with hearing loss have unilateral and bilateral hearing loss?

4) What is the relationship between academic performance (repeating grades, poor performance) and hearing status (unilateral and bilateral hearing loss)?

METHODS

Participants

50-80 children were randomly selected from the St. Vincent de Paul primary school in Port-au-Prince, Haiti to participate in this study. Exclusion criteria included presence of a cold and cough based on examiner observation, occluded ear canals, known hearing loss and hearing aid use.

Materials and Instrumentation

Audiometric testing and screening were performed using a Maico-39 audiometer, complete with air and bone conduction capabilities. Air conduction values were obtained using Ear Tone 3-A insert earphones. French monosyllabic words were delivered via interpreter. The first 10 French words on the word list obtained from King’s County Hospital Audiology Department in Brooklyn, New York were used. The words were: Chat, Un, Elle, Place, Plume, Un, Quatro, Cinque, Poire, Bien, and Pan.

Instrumentation utilized for the hearing screenings, complete audiological evaluations, tympanometric evaluations, and otoscopic evaluations included the following: Firefly DE500 videoscope, R.A. Bock Diagnostics otoscope, Maico QT-1 Tympanometer, Micro Tymp , Extech Digital Sound Level Meter model 407730, and the Maico (MA-39) Audiometer. Disposable probe tips for the tympanometer as well as otoscope tips were utilized for testing each child. The audiometer was calibrated for used with insert receivers according to ANSI s3.6~2004. Testing was conducted in a resource room on the school grounds, in the church on the school grounds and in the houses of the interpreter and her son. On the first day of testing at the school, the noise levels elevated due to construction on the school grounds, conditions that the examiners were not made aware of until the noise set in. Children were tested initially in a resource room, and when more acoustically favorable surroundings needed to be sought out, testing was moved to the grounds' church, and ultimately to the houses of the translator and her son. With no construction active on the school grounds, noise levels fluctuated between 40-45 dB SPL. In the homes of the translator and her son, ambient noise levels centered around 40 dB SPL. Noise levels in each test room were assessed and recorded with the digital sound level meter using an A-weighted filter. Ambient levels for each test environment in which testing results were used were below 47.0 dB SPL, the peak intensity allowed for testing at octave frequency 1000 Hz outside of a soundproof audiometric test booth as published by Frank (2000). The other octave test frequencies did not require as low an SPL so the cutoff for ambient noise levels used was 47.0 dB SPL. Cutoff levels are shown in Table 1.

Table 1: From *ANSI Update: Maximum Permissible Ambient Noise Levels:* Ambient noise levels in dBSPL required to test down to a reference equivalent threshold SPL of 0 dB for test frequency ranges as specified in ANSI S3.1 when using insert earphones (Frank, 2000).

Octave Band Intervals	125 - 8000 Hz range	250 - 8000 Hz range	500 - 8000 Hz range
250 Hz	53.0	53.0	53.0
500 Hz	50.0	50.0	50.0
1000 Hz	47.0	47.0	47.0
2000 Hz	49.0	49.0	49.0
4000 Hz	50.0	50.0	50.0
8000 Hz	56.0	56.0	56.0

Procedures

Written permission was obtained from the children’s parents or acting guardian in the form of a letter written in Creole. Teachers collected the letters prior to testing. Testing took place over the course of five days in November 2013. The quietest room that was available within the school grounds was sought out. It was imperative to choose a room far away from environmental sounds that could have interfered with testing results and possibly could have caused false negatives or incorrect threshold recording. When noise levels were too high, adjustments and relocations were made to accommodate the ambient noise. Testing began with otoscopy performed on all the participants, first by one examiner and then by the other examiner, at which time the status of the outer ear, external ear canal, and tympanic membrane were assessed and presence of excessive cerumen, scarring, perforations, and discoloring were noted. Each examiner recorded findings independently. Ears were classified as: clear, impacted cerumen or as presenting with outer-ear abnormality, such as microtia, excessive cerumen, possible infection, atresia, stenosis, foreign bodies present in the external auditory canal, or as having a perforation (Martin & Clark, 2006). Video-otoscopic findings were intended to be recorded and saved for each patient, but did not present clear visuals of the children's tympanic membranes. Immitance testing was conducted and interpreted independently by each examiner following otoscopy. Tympanograms were classified according to Clark & Martin (2006), and were referred to when analyzing screening and diagnostic audiological results. Normal measurement cutoffs are shown in Table 2:

Type A: normal tympanogram; static admittance of 0.2-0.9 mmhos and peak pressure -139 to +11 daPa

Type A_D: high static admittance, usually associated with a flaccid tympanic membrane; static admittance higher than 0.9 mmhos

Type A_S: low static admittance, usually associated with stiffening pathologies, e.g. stapes mobilization, otosclerosis; static admittance below 0.2 mmho

Type B: flat tympanogram, usually associated with fluid in the middle ear, tympanic membrane perforations, or cerumen impaction

Type C: indicates negative middle ear pressure, and is consistent with Eustachian tube dysfunction or can be associated with head colds, will have peak pressure -140 daPa or below

Table 2: **Tympanometric Norms for Children (JCIH, 2007; Jerger et al. 1972)**

Ear Canal Volume	0.3-2.0 cubic centimeters
Static Acoustic Admittance	0.35- 1.3 mmhos
Peak Pressure	-150 - +50 daPa

Following tympanometry, hearing screening was conducted using the ASHA (1997) Panel on Audiological Assessment Guidelines for Audiologic Screening. Each ear was screened at pure tone frequencies 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz at 20 dBHL. The right ear was tested first, followed by the left ear. A pass was defined as a hand-raise time-locked to the tone presentation at 20 dBHL. A refer was defined as no response to any of the screening stimuli at the frequencies tested.

Parental consent forms were sent out to the children's parents or acting guardians before the examiners arrived in Haiti, so that approval to obtain audiometric results and to compare the results to the children's academic records was provided (Appendix A). Parents and teachers were also asked to list any known developmental delays or illness their child may have or exhibit. For the study to commence, the quietest room in the school was made available for testing, and a translator was available to help obtain consent from the children to participate in the study and to help instruct the children for behavioral testing. Audiometric results were recorded on a standard audiogram, on which there were sections to record each child's age, academic performance and any remarkable information as noted by the parent, guardian or teacher (Appendix B).

The complete audiological evaluations were conducted using insert receivers. Testing included: air and bone conduction testing in accordance with the Hughson & Westlake method at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz and 8000 Hz (Carhart & Jerger, 1959), and word recognition testing using French monosyllabic words presented at soft speech levels by the interpreter. Since testing was not performed in a soundproof booth, word testing was served to keep the child interactive. Post audiological evaluation, each student's academic record/progress report was obtained, reviewed and recorded on the checklist on the audiogram, shown in Appendix A.

RESULTS

40 students participated in this study, but one student could not be conditioned to respond to the pure-tone stimuli and one student fatigued after audiometric results were obtained for the right ear. Both students were excluded from this study, reducing the sample size to 38 students. The mean age of participants was 6.5 years with a standard deviation of 1.1 years, with ages ranging from 5.4 to 7.6 years. 26.3% of the students were 5 years of age (Kindergarten), 23.7% of the students were 6 years of age (1^{st} grade), 26.3% of the students were 7 years of age (2^{nd} grade) and 23.7% of the students were 8 years of age (3^{rd} grade). The mean three frequency pure tone average (PTA) for the right ear on 38 ears was 7.7 dBHL with a standard deviation of 4.4 dBHL, ranging from 3.4 dBHL to 12.1 dBHL. One ear fell below this range with a PTA of 0 dBHL and six ears fell above this range, two ears with PTAs of 13.3 dBHL, one ear with a PTA of 15 dBHL and three ears with PTAs of 16.7 dBHL. The mean three-frequency PTA for the left ear on 38 ears was 8.2 dBHL with a standard deviation of 3.4 dBHL, ranging from 4.8 dBHL to 11.7 dBHL. One ear fell below this range with a PTA of 0 dBHL and five ears fell above this range with PTAs, two ears with PTAs of 13.3 dBHL and three ears with PTAs of 16.7 dBHL. Tympanometric results for the right ears and the left ears on which seals could be obtained are shown in Figure 1 with the corresponding percentages shown in Figure 2. Of 38 right ears, nine ears, equal to 23.684% of right ears, presented with normal Type A tympanograms, 20 ears presented with type As tympanograms indicative of shallow admittance, equal to 52.632% of right ears respectively and one ear presented with a Type Ad tympanogram, indicative of high

static admittance and equal to 2.6% of right ears. Of 38 left ears, eight ears equal to 21.1% of left ears presented with normal type A tympanograms and nine ears equal to 23.7% of left ears presented with type As tympanograms indicative of shallow admittance. In all, seals could not be obtained for 13 ears. Only two of the 38 students presented with normal tympanometric results bilaterally, equal to 5.3% of the sample population.

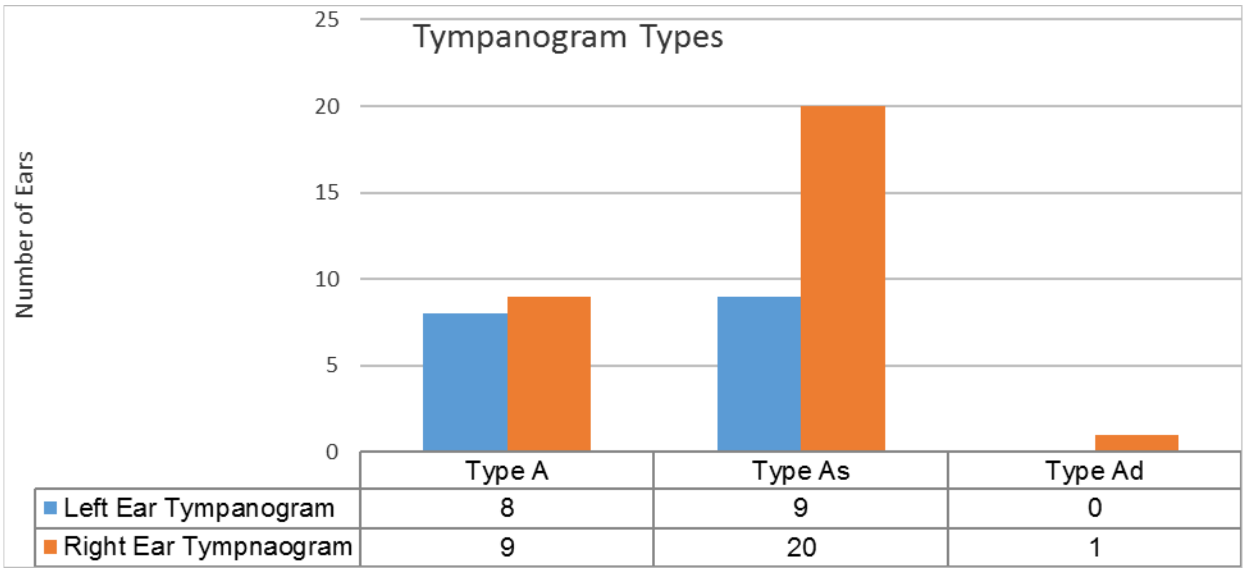


Figure 1: Tympanogram types obtained for left and right ears for all students in this study during tympanometry (29 left ears and 34 right ears).

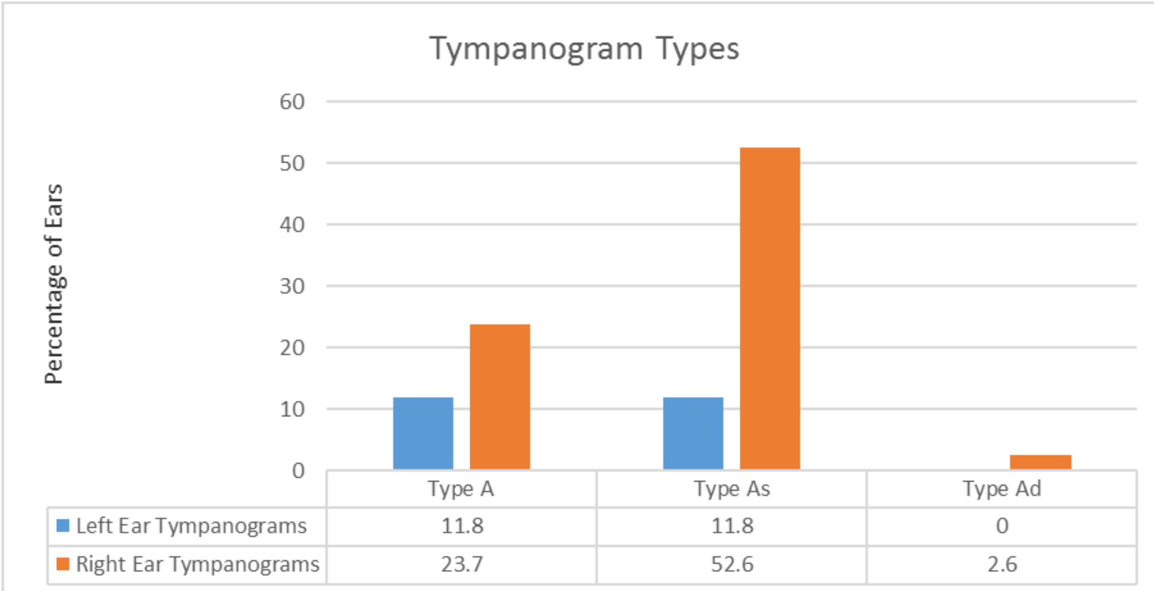


Figure 2: Percentage of tympanogram types obtained for left and right ears for all students in this study during tympanometry performance (29 left ears and 34 right ears).

1) What is the relation between pure tone screening outcomes and performance on the diagnostic pure-tone test in Haitian school children?

There was an almost perfect relation between pure tone screening results and pure tone diagnostic results at 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz. Of the 38 students, one student failed the screening at 500 Hz in the left ear (a response was obtained at 30 dBHL), but later obtained hearing within normal limits bilaterally with the exception of a slight hearing loss at 8000 Hz in the right ear. The remainder of the students passed at 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz on the screening portion of the study and obtained results for hearing within normal limits for test frequencies 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz on the diagnostic threshold testing portion of this study.

Of all 38 students, 2.6% failed the screening and 97.4% passed the screening. Of all 76 ears, 1.3% failed the screening and 98.7% passed the screening. These percentages are show in Figure 3 with the corresponding number values shown in Figure 4. It is notable that the student who failed the screening at 500 Hz in the left ear later obtained hearing within normal limits at 500 Hz in the left ear on the diagnostic portion of the audiometric testing, Additionally, the pure tone screening test was not sensitive to the nine students, 23.7% of the test population, who presented with hearing loss at 6000 Hz and or 8000 Hz. Of the 76 ears, 15 ears were found to have hearing loss at either 6000 Hz and or 8000 Hz, equal to 19.7% of the test population, and 61 ears were found to have hearing within normal limits at all diagnostic pure tone testing octave and interoctave frequencies, equal to 80.3% of the test population.

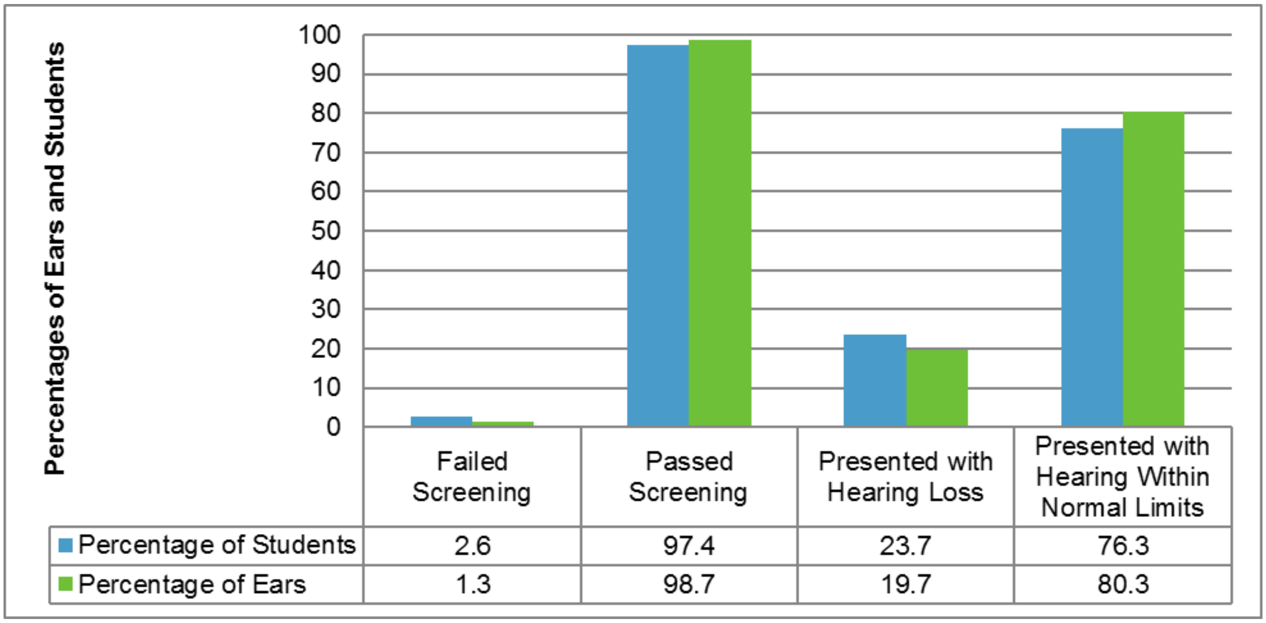


Figure 3: Summary of results for percentages of ears who passed and failed the hearing screening and who presented with hearing loss and with hearing within normal limits (N= 38 students, N= 76 ears).

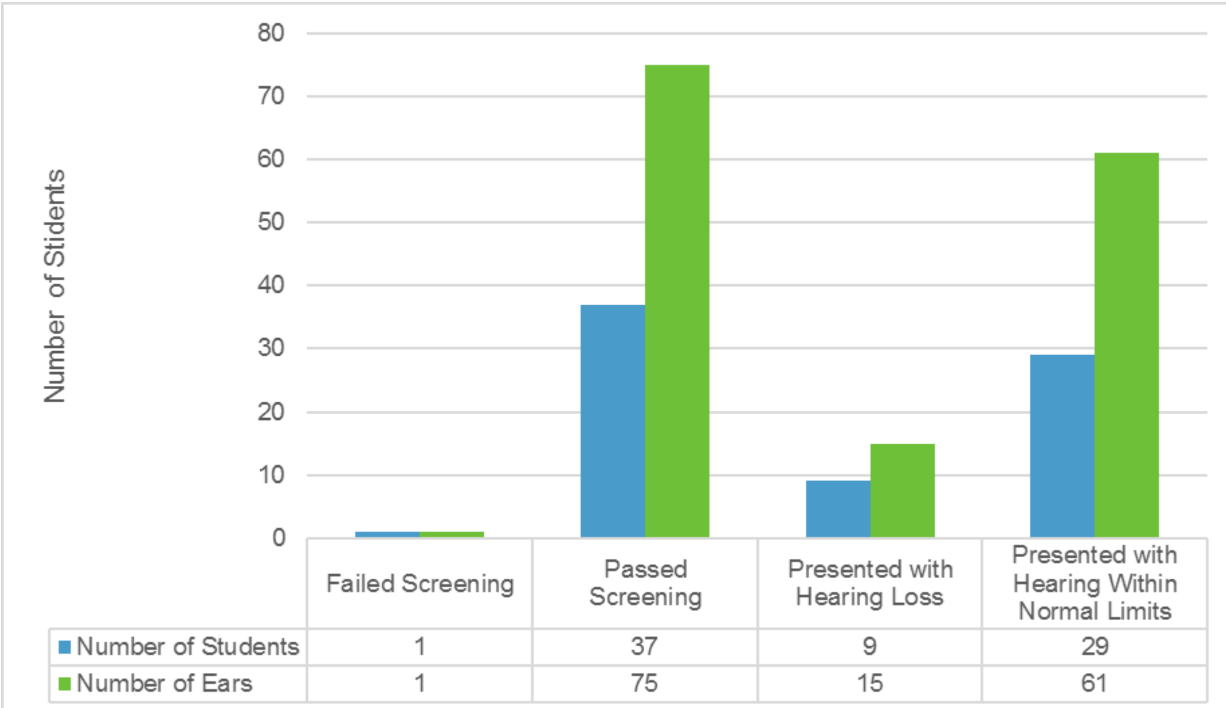


Figure 4: Summary of results for numbers of students who passed and failed the hearing screening and who presented with hearing loss and with hearing within normal limits (N= 38 students, N= 76 ears).

2) What proportion of students present with hearing loss and what proportion of students presented with normal hearing?

Between the 38 students tested, 29 students presented with hearing within normal limits, equal to 76.3% of the test population, and nine presented with hearing loss, comprising 23.7% of the test population. All students with hearing loss presented with high frequency losses, either unilateral or bilaterally.

Three out of ten students in the age 5 group presented with hearing loss, one out of nine students in the age 6 Group presented with hearing loss, two out of 10 students in the age 7 Group presented with hearing loss and three out of nine students in the age 8 group presented with hearing loss. Relative to the entire test population, each age group presented with the following percentages for hearing status according to each ear. The age 5 Group presented with hearing within normal limits for 9.2% of right ears (7 ears) and 10.5% of left ears (8 ears), slight high frequency hearing loss in 2.6% of right ears (2 ears) and 2.6% of left ears (2 ears) and mild high frequency hearing loss in 1.3% of right ears (1 ears). From the age 6 group, 10.5% of right ears (8 ears) and 11.8% of left ears (9 ears) presented with hearing within normal limits, and 1.3% of right ears (1 ear) presented with slight high-frequency hearing loss.

From the age 7 group, 10.5% of right ears (8 ears) and 10.5% of left ears (8 ears) presented with hearing within normal limits, 1.3% of right ears (1 ear) and 1.3% of left ears (1 ear) presented with slight high-frequency hearing loss, and 1.3% of right ears (1 ears) and 1.3% of left ears (1 ear) presented with mild high-frequency hearing loss. From the age 8 group, 9.2% of right ears (7 ears) and 7.9% of left ears (6 ears) presented with hearing within normal limits, 1.3% of right ears (1 ear) and 2.6% of left ears (2 ears) presented with slight high-frequency hearing loss, and 1.3% of right ears (1 ear) and 1.3% of left ears (1 ear) presented with mild high-frequency hearing loss.

In all, 19.7% of ears presented with hearing loss and 80.3% of ears presented with hearing within normal limits. The numerical proportion of students with hearing loss per age group is displayed in Figure 5. This is further broken down into percentages of hearing status according to each ear for students in all age groups, shown in Figure 6. Figure 7 shows the severity of each ear with hearing loss based on the 8000 Hz threshold, the worst threshold obtained for all ears with hearing loss.

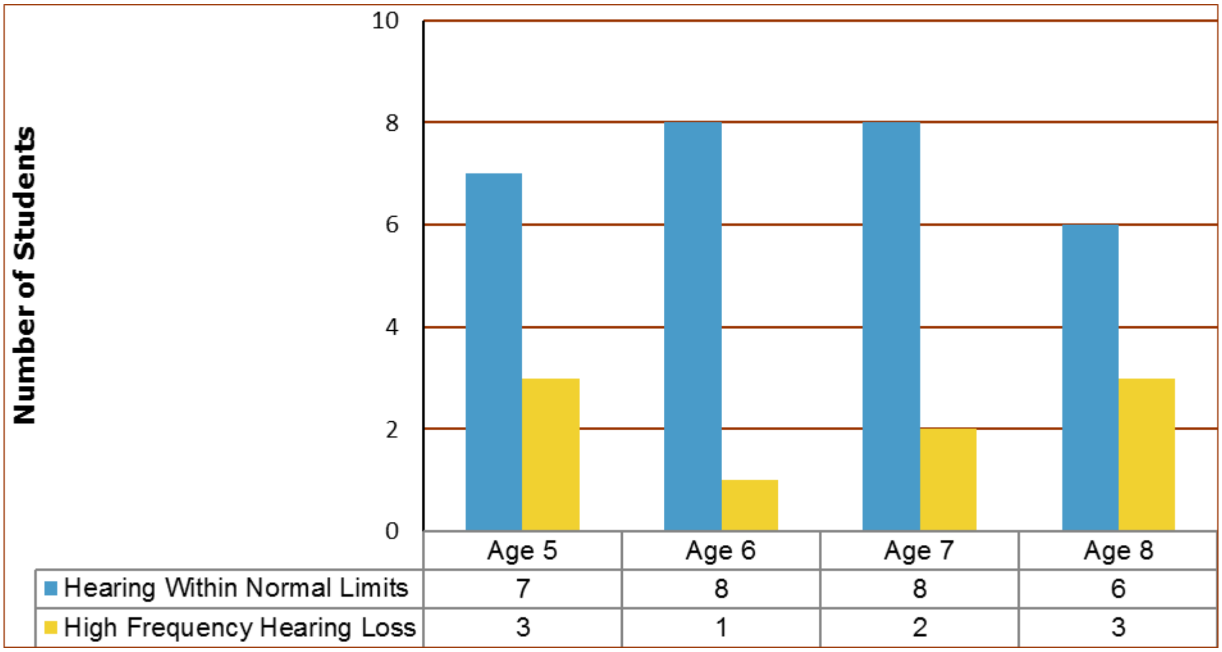


Figure 5: Proportion of students with hearing within normal limits and high frequency hearing loss for all students tested (N= 38).

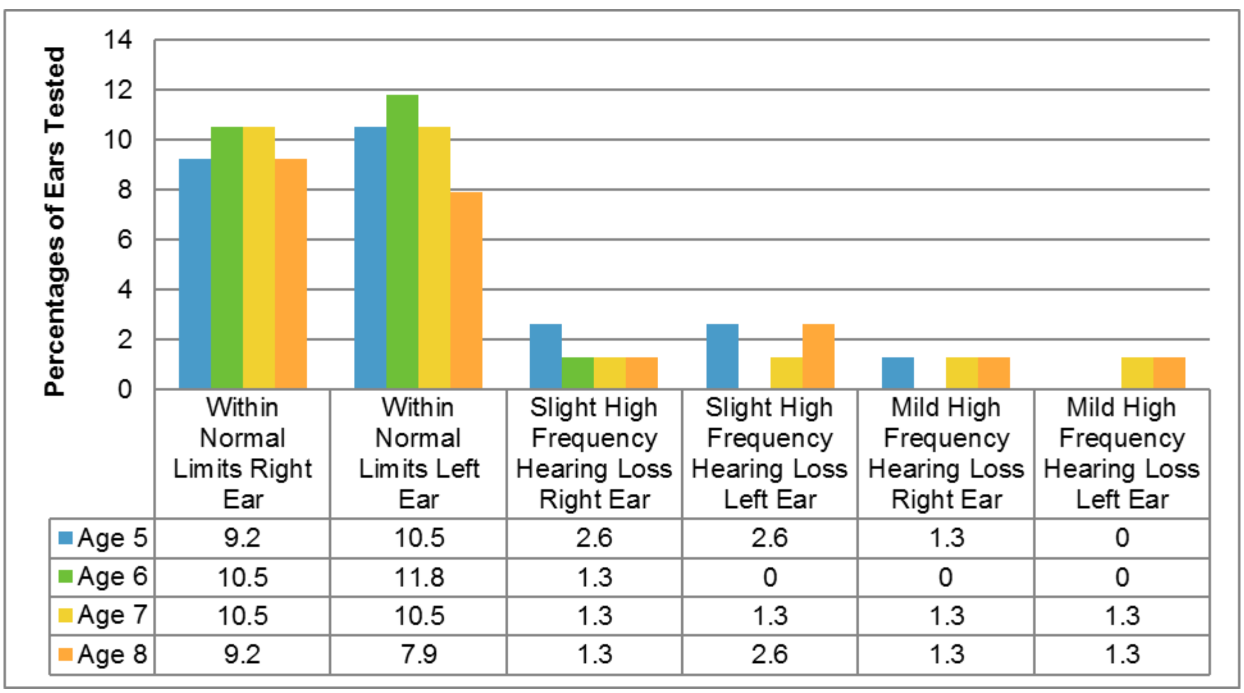


Figure 6: Percentage of ears tested (N= 76) that presented with hearing within normal limits, slight high-frequency loss or mild high-frequency losses by student age.

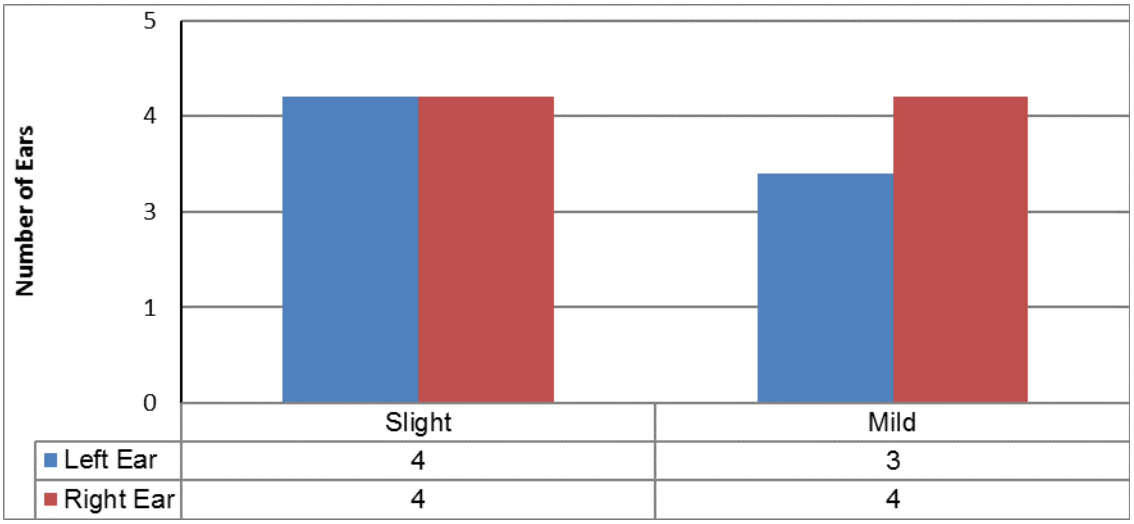


Figure 7: Severity of hearing loss of right and left ears that presented with hearing loss based on 8000 Hz thresholds (N=15).

3) What proportion of students had unilateral and bilateral hearing loss?

Of the 9 students who presented with hearing loss (23.7% of the test population), six students presented with bilateral hearing loss, comprising 15.8% of the test population. Three of these students presented with bilateral mild high frequency hearing loss, equal to 7.9% of students in test population. Two students presented with bilateral slight high frequency hearing loss, equal to 5.3% of students in the test population. One student, equal to 2.6% of the test population presented a bilateral loss of differing severities in each ear, with a slight high frequency hearing loss in the left ear and a mild high frequency loss in right ear. In all, for the bilateral losses, 9.2% of ears presented with mild high-frequency hearing losses and 6.6% presented with slight high-frequency hearing losses.

Three students presented with unilateral hearing loss, comprising 7.9% of the test population. Three unilateral losses, which manifested in two left ears and one right ear, were slight in severity and affected only 8000 Hz. Figures 8-10 show a breakdown of unilateral, bilateral or normal hearing ability for each age group.

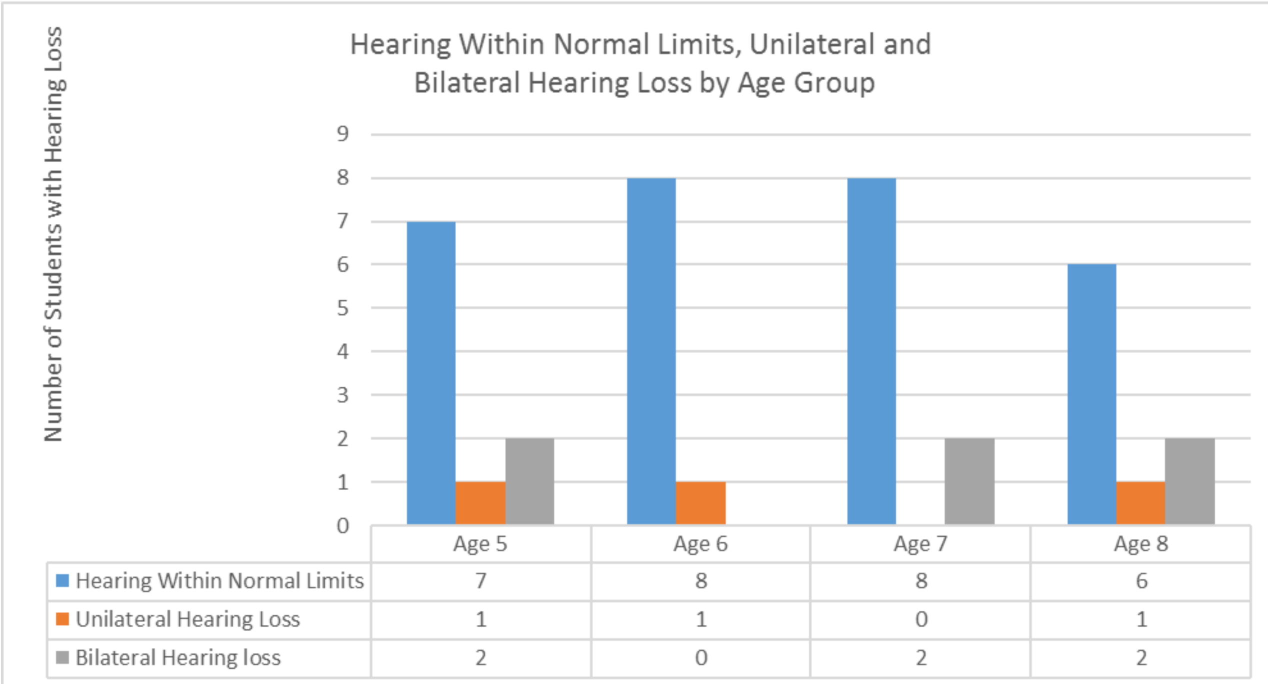


Figure 8: Proportion of students in each age group and their hearing status relative to hearing within normal limits and unilateral or bilateral hearing loss.

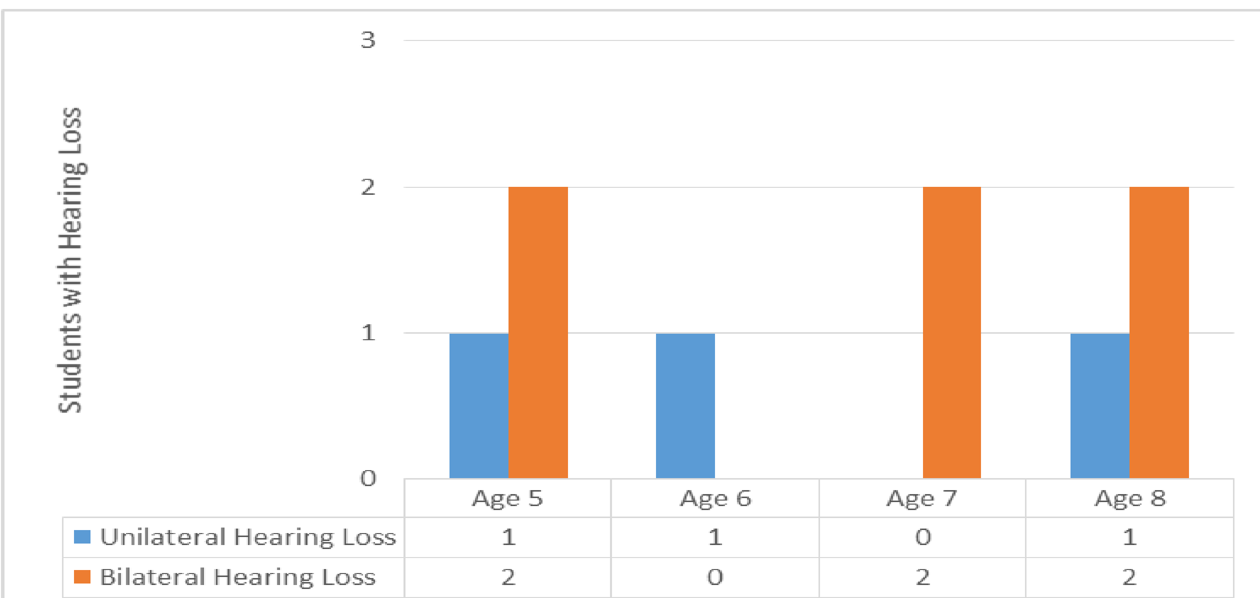


Figure 9: Unilateral and bilateral hearing loss presentation across all age groups for students with hearing loss (N= 9)

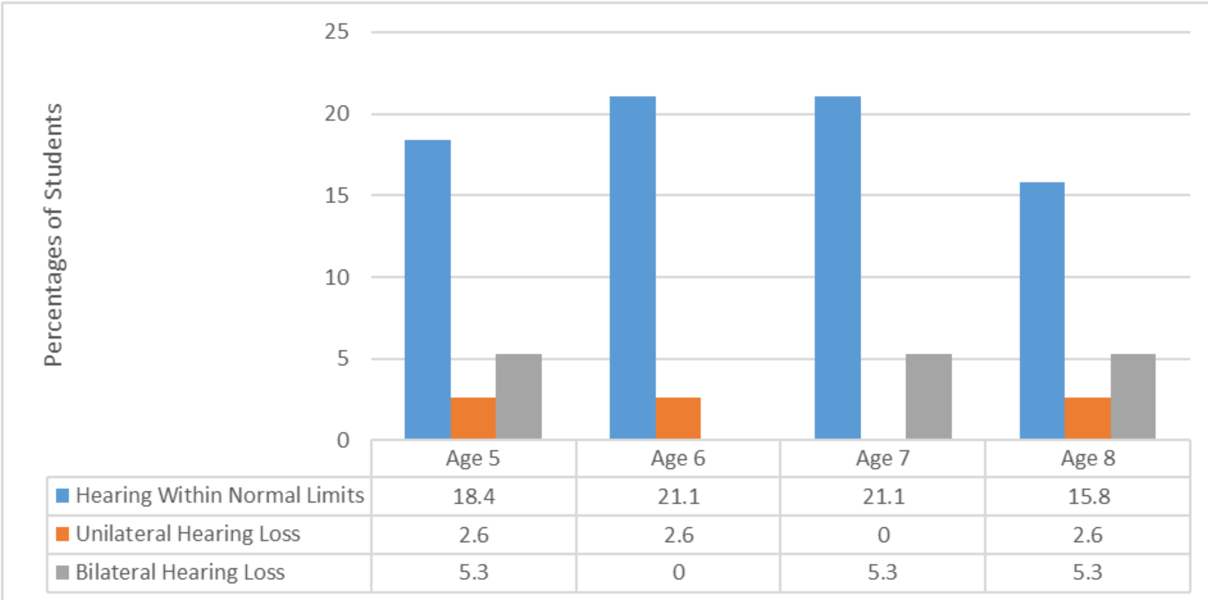


Figure 10: Percentage of students in each age group and their hearing status relative to the test population with hearing within normal limits and unilateral or bilateral expression of hearing loss (N= 38)

The average hearing threshold level at 6000 Hz for all right ears was 12.4 dBHL with a standard deviation of 6.7 dBHL ranging from 5.7 dBHL to 19.0 dBHL. Three ears with mild hearing losses of 30 dBHL at 6000 Hz fell outside this range, and one ear with a slight loss at 25 dBHL threshold fell within the second standard deviation from the mean. For all left ears at 6000 Hz, the average threshold was 12.1 dBHL with a standard deviation of 6.3 dBHL, ranging from 5.8 dBHL to 18.4 dBHL, with a second standard deviation ranging from -0.6 dBHL to 24.8 dBHL. Four ears with slight hearing losses fell above of this range, one at 25 dBHL and three at 30 dBHL.

The average threshold for 8000 Hz for all right ears was 16.6 dBHL with a standard deviation of 8.7 dBHL, ranging from 7.9 dBHL to 25.3 dBHL, with a second standard deviation ranging from -0.8 dBHL to 33.2 dBHL. Three ears with mild hearing loss fell above this range, two at 35 dBHL and one at 40 dBHL, and one ear with a slight loss fell within the second standard deviation with 30 dBHL. Four with hearing loss ears fell within the first standard deviation of the mean with thresholds of 25 dBHL. The average threshold for all left ears at 8000 Hz was 16.8 dBHL with a standard deviation of 7.9 dBHL, ranging from 8.9 dBHL to 24.8 dBHL with a second standard deviation ranging from 1.0 dBHL to 32.7 dBHL. Five ears fell within the first standard deviation of the mean, four with thresholds of 25 dBHL and one ear with the threshold of 30 dBHL. Two ears with mild hearing losses fell above this range with thresholds of 35 dBHL and 40 dBHL. Table 3 below summarizes the means and standard deviations of thresholds for right and left ears and 6000 Hz and the 8000 Hz.

Table 3: Mean thresholds in dBHL and standard deviations for right and left ears at 6000 Hz and 8000 Hz

	Standard Deviation	**Mean Threshold**
Right Ears at 6000 Hz	5.7	12.4
Left Ears at 6000 Hz	5.8	12.1
Right Ears at 8000 Hz	7.9	16.6
Left Ears at 8000 Hz	8.9	16.8

4) What is the relationship between academic performance (repeating grades, poor performance) and hearing status?

Academic performance was defined differently between the Age 5 group and the Ages 6-8 groups. For students in the age 5 group attending kindergarten classes, grades were obtained based on fine motor skills, gross motor skills, comprehension and reading. Teachers were asked to describe each student's weakness and strength then assign a number grade to each skillset since trimester reports were not detailed by number grade. Grades ranged up to 100 points, with 100 points being the best possible score for each student to obtain. The means for fine motor skills, gross motor skills, comprehension and reading were 72.5, 84, 75.5 and 73 points with standard deviations of 6.8, 7.8, 6.4 and 7.2 points, respectively. The overall grade point average for all students was 75.8 points with a standard deviation of 5.3 points. Three students presented with hearing loss, two with bilateral hearing loss and one with unilateral hearing loss. The student with unilateral hearing loss was repeating kindergarten. The student with unilateral hearing loss performed worse academically that the two students with bilateral hearing loss.

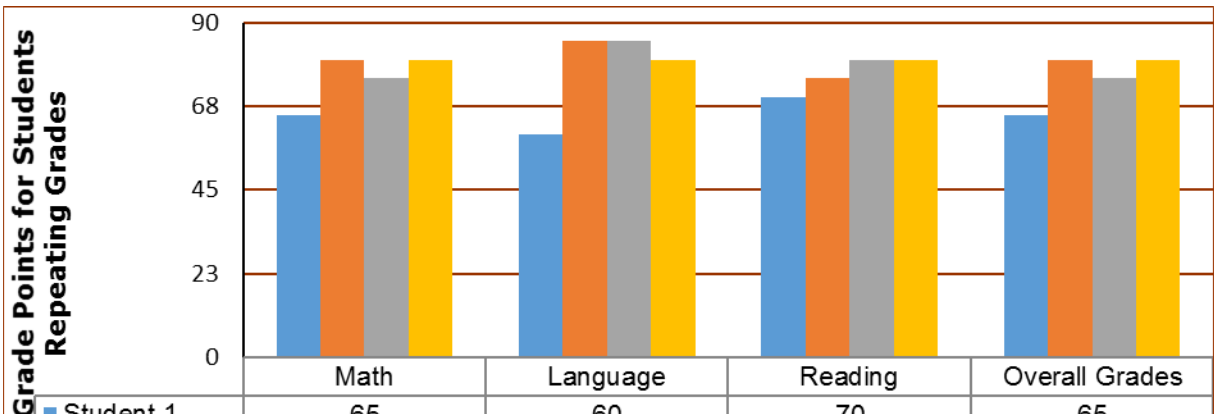
The means for fine motor skills, gross motor skills reading and comprehension for children in the age 5 group with hearing loss were 68.3, 71.7, 71.7 and 70 points with standard deviations of 2.9, 7.6, 7.6 and 5.0 points, respectively. The overall grade point average was 70.417 with a standard deviation of 5.637 points. The means for fine motor skills, gross motor skills, comprehension and reading scores for children with normal hearing in the age 5 group were 74.3, 85.0, 77.1 and 74.3 points, with standard deviations of 7.3, 2.9, 5.7, 7.9 points, respectively. The mean for overall academic performance in the age 5 group was 77.7 with a standard deviation of 7.4 points.

In all conditions, the averages obtained by the students with hearing loss in the Age 5 group were lower than the means for each subject and lower than the means for the students with hearing within normal limits.

For the 28 students in the ages 6-8 groups, grades in math, reading and language were combined and computed by subject along with their overall academic. The means for scores for all students in the age 6-8 groups for math, reading and language were 80.0, 80.7, and 80.3 points respectively with standard deviations of 10.6, 9.9 and 10.1 points, respectively. Overall the grade point average across all classes for all students was 80.3 with a standard deviation of 9.9 points.

For the six students that presented with hearing loss across the ages 6-8 groups, the average grades for math, reading and language were 77.7, 80.0 and 75.8 points with standard deviations of 4.8, 8.4 and 7.1 points, respectively. The overall grade point average for these students was 77.7 with a standard deviation of 6.5 points. For students who presented with no hearing loss, the means for math, language and reading were 81.4, 82.3 and 82.4 points with standard deviations of 10.6, 9.9 and 10.1 points, respectively. The overall grade point average was 82.5 with a standard deviation of 10.3 points. As a collective, mean scores for math, reading, language and overall were lower for the students that presented with hearing loss in comparison to students with hearing within normal limits and to the overall averages and standard deviations of the students between the ages of ages 6-8 years.

Of the six students with hearing loss, two students were repeating their respective grades. One of these students presented with a bilateral slight loss at 8000 Hz and one presented with a bilateral mild loss at 6000 Hz and 8000 Hz. Comparison of mean scores of children with hearing loss and with hearing within normal limits in math, language, reading and overall are shown in Figure 11 with the students labeled in age order. Across all 28 students in the Ages 6-8 groups, one student in the Age 6 group was repeating 1st grade (student 1), two students in the Age 7 group, both with hearing loss, were repeating 2nd grade (student 2 and student 3) and one student in the Age 8 group was repeating 3rd grade (student 4). Student 2 presented with a bilateral slight high frequency hearing loss and student 3 presented with a bilateral mild high frequency hearing loss. There was no significant difference in scores for these four students to illustrate poorer academic achievement on the part of students with hearing loss.



	Math	Language	Reading	Overall Grades
Student 1	65	60	70	65
Student 2 (HL)	80	85	75	80
Student 3 (HL)	75	85	80	75
Student 4	80	80	80	80

Figure 11: Mean grade in math, language and reading for students in the Ages 6-8 Groups repeating Grades 1-3 with hearing within normal limits and with hearing loss (N = 4). Students with hearing loss are marked with (HL).

The two students who presented with unilateral hearing losses were in the age 6 and age 8 groups. Their scores are shown in Figure 12. The student in the age 6 group with unilateral hearing loss averaged 85, 90 and 88 points in math, language and reading, respectively with an overall class average of 87 points. The student in the age 8 group with unilateral hearing loss averaged scores of 74, 70 and 72 in math, language and reading, respectively, with an overall class average of 72 points. Of the four students who presented with bilateral hearing loss, two were in the age 7 group and two were in the age 8 group. Their scores are shown in Figure 13. Of the students in the age 7 group with bilateral hearing loss, one student obtained mean scores of 80, 85, and 75 with an overall class average of 80, and one student presented with scores of 75, 85, and 80 with an overall class average of 75 for math, language and reading, respectively. Of the students in the age 8 group that presented with bilateral hearing loss, one student obtained mean scores of 80, 80 and 70 with an overall class average of 82 and one student obtained scores of 72, 70, and 70 with an overall class overage of 70 for subjects math, reading and language, respectfully.

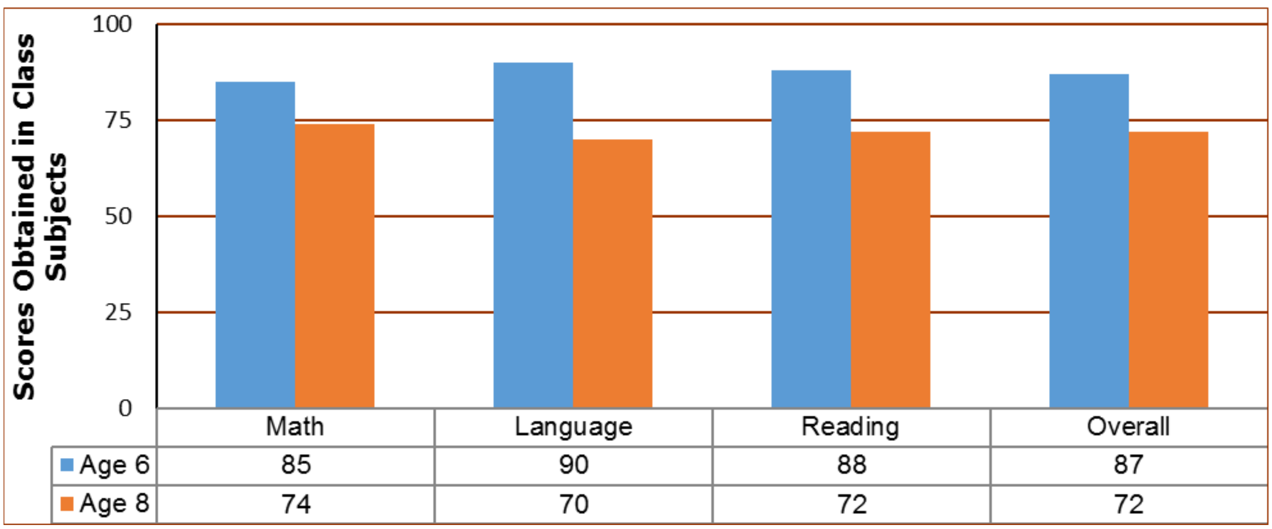


Figure 12: Grades obtained in math, language and reading by students with unilateral hearing loss in Ages 6-8 groups (N= 2)

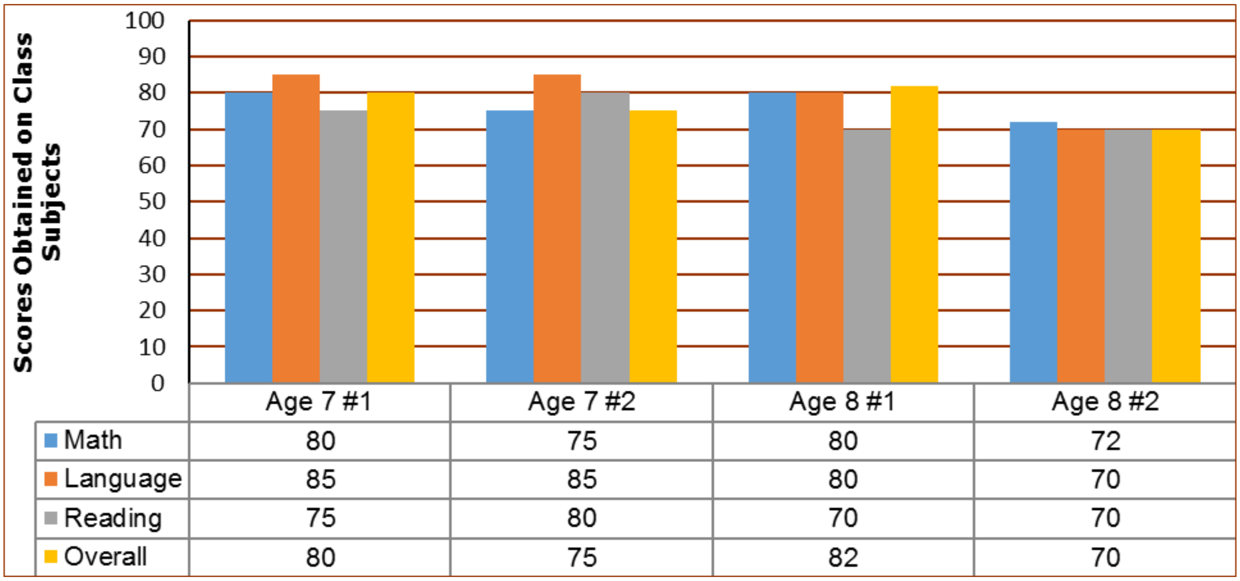


Figure 13: Scores obtained in math, language and reading for students with bilateral hearing loss in the Ages 6-8 Groups (N= 4).

DISCUSSION

The purpose of this study was to determine the hearing status of preschool and elementary school children in children in Port-au-Prince, Haiti, and its ensuing relationship and effects on academic performance. To achieve this, hearing was assessed and academic status of students with and without hearing loss was recorded. Results and academic records were then examined by each age group. Of 38 students, 9 were found to presents with high frequency hearing losses. As a group, these students performed worse academically than their normal hearing peers.

1) What is the relation between pure tone screening outcomes and performance on the diagnostic pure-tone test in a sample of Haitian pre-school and school children?

An overall positive relationship was found between the threshold results obtained for the pure tone hearing screenings and diagnostic pure tone testing. Screenings were almost completely indicative of hearing ability at test frequencies 500-4000 Hz. All but one of the 38 students included in this study passed the hearing screening, and this student later obtained hearing within normal limits on the diagnostic portion of the test. The most prevalent form of hearing loss identified during testing was high frequency loss, not due to standing wave or collapsed canal since insert earphones were used for audiological testing. Most commonly found was a slight loss at 6000 Hz through 8000 Hz in two or three students per age group, but presented to be mild in degree in the Age 7 and Age 8 groups. For this reason, pure tone screening results corroborated almost exactly to diagnostic results for screening test frequencies. As concluded by Niskar et al. (1998), it would be beneficial to extend the hearing screening protocol for air conduction to include 6000 Hz and possibly 8000 Hz so that high frequency hearing losses would not be missed.

It is also possible that these results may indicate that the conditions in Port-au-Prince may play a large role in the hearing health of Haitian school children and that vigilant health maintenance and precaution is required. Such precaution would also help lead to pinpoint genetics or environment as the main factors in these hearing losses.

2) What proportion of students present with hearing loss and what proportion of students presented with normal hearing?

Among the 38 students tested, 28 students presented with normal hearing and 9 presented with hearing loss, totaling 15 ears with hearing loss. Results revealed that 19.7% of ears and 23.6% of students in this sample presented with hearing loss and 80.3% of ears and 73.7% of students in this sample presented with normal hearing. All students with hearing loss presented with high frequency losses, either unilateral or bilateral, at 6000 Hz and 8000 Hz, with the totals indicating that nearly one quarter of the sample population presented with hearing loss.

Hearing ability was analyzed by student and by ear to obtain results, which revealed high frequency hearing loss in 9 students, totaling the 15 ears with hearing loss. Results from Niskar et al. (1998) from testing school children in the United States revealed a 12.7% high frequency hearing loss prevalence rate across seven million school children, 10.5% of which were mild in severity. Frequencies 6000 Hz and 8000 Hz were included in the screening. The 23.7% of Haitian school children that presented with hearing loss on the diagnostic test comprised nine out of 38 students. This was calculated based on a much smaller scale than the sample population available to Niskar et al. (1998) but exhibited more than double the percentage of hearing loss. Additionally, the four students that presented with mild degree hearing losses equaled 10.5% of the sample, in accordance with the results obtained from children in the United States by Niskar et al (1998).

There was no significant difference between right and left ear hearing ability. Eight of the 15 ears with hearing loss, four right ears and four left ears, were slight in hearing loss severity and seven ears with hearing loss, four right ears and three left ears, were mild in hearing loss severity. All unilateral losses were slight in severity, and one bilateral loss presented with one ear with slight hearing loss at 8000 Hz and one ear with mild hearing loss at 8000 Hz. It was noted that the older children of the group presented with a more severe hearing loss than the younger children, however was not a large enough sample size to analyze a progressive element to the hearing loss, as was found by Bess et al. (1998). This trend could potentially warrant long-term observation, given the pathogens and conditions Haitian children may be exposed to on a daily basis as is described by Varma et al. (2008). The results obtained could indicate that the hearing status of children in Haiti is on point with hearing ability of children in developed countries, but further studies are needed to accurately conclude and discuss this point. A study on a greater scale expanding on this finding could also show the impact of environmental factors in Haiti- of the hearing ability of children there being equal, better or worse than the hearing ability of children in developed countries. This can result in finding a more prevalent cause of hearing loss (environmental factors, genetics etc.) and a better allocation of already scarce healthcare resources.

Raised awareness of hearing health and the ensuing effects of hearing loss are needed for these children and their families. Implementation of newborn hearing screenings could help discover hearing loss and the manner in which is manifests, allowing parents and teachers to be more proactive in the child’s academic experience. This would thereby lessen the effects of possible delays due to a differing auditory-linguistic experience, which could result in delayed semantic, syntactic and morphological comprehension, reception and expression, as detailed by Moeller et al (2007).

3) What proportion of students with hearing loss have unilateral and bilateral hearing loss?

Of the 9 students who presented with hearing loss (23.7% of the test population), six students presented with bilateral hearing loss, comprising 15.8% of the test population. Three of these students presented with bilateral mild high frequency hearing loss, encompassing 7.9% of students in test population. Two students presented with bilateral slight high frequency hearing loss, representing 5.3% of students in the test population. One student, equal to 2.6% of the test population presented a bilateral loss of differing severities in each ear, with a slight high frequency hearing loss in the left ear and a mild high frequency loss in right ear. In all, for the bilateral losses, 9.2% of ears presented with mild high-frequency hearing losses and 6.6% presented with slight high-frequency hearing losses. It was surprising that not one student presented with flat tympanograms, as was expected based on literature describing finding from developing countries (Monsata et al. (2012); Varma et al. (2008)).

Though a larger sample size would have been suitable and advantageous for generalizing results, the findings of this study are relevant on a group basis. Lieu et al. (2010) demonstrated how unilateral losses, even slight in degree can impact academics negatively. On an individual level, the academic performance of children with unilateral hearing loss in this study did not present with any significant difference from their normal hearing peers. But further research on a grander scale would be beneficial to measuring the impact of unilateral hearing loss on Haitian school children and would help draw parallels between these children and the children in developed countries to better allocate healthcare resources and arrange for intervention and preferential classroom seating.

4) What is the relationship between academic performance (repeating grades, poor performance) and hearing status?

Academic performance was analyzed in two groups. The age 5 group was analyzed on its own due to differing grading systems between the kindergarten and primary schools. The second group was comprised of all the other students in the ages 6-8 groups. The kindergarten class was graded based on fine motor skills, gross motor skills, comprehension and reading. Teachers were asked to assign number values to each category, and then an overall average for the grades was calculated. The ages 6-8 years groups were graded based on their scores subjects math, language and reading and an overall grade point average. A notable difference between the data for these two group was that grades for all subjects for the age 5 years group tended to be more spread out for each student individually, whereas the grades for the students in the ages 6-8 years groups tend to be more similar across each child’s grade spectrum. The decreased variability in the grades obtained by students in the ages 6-8 group may have been due curriculum difficulty in comparison to the age 5 group.

For the three students with hearing loss in the age 5 group, means for fine motor skills, gross motor skills, reading and comprehension were 6.0, 13.3, 5.5 and 4.3 points lower than the students with normal hearing, respectively. Two of these students presented with a slight bilateral hearing loss and one presented with a unilateral slight hearing loss. Not enough data were available to draw conclusions.

The mean scores for the six children with hearing loss in the ages 6-8 groups for math, reading and language and overall were 3.8, 2.3, 6.5and 4.8 points lower than the means obtained for the ages 6-8 students with hearing within normal limits, respectively. In the age 6 group, the student who presented with a slight unilateral hearing loss had obtained scores higher than the class average. The means for math, reading, language and overall for the two children with hearing loss in the age 7 group were 6.9, 6.0, -2.5 and 6.875 points lower than the means obtained for the eight children with hearing within normal limits. The means for math, reading, language and overall for the three children with hearing loss in the age 8 group were 1.0, 5.5, 8.7 and 4.3 lower than the six children with hearing within normal limits. There was no significant difference found in grades between students with bilateral hearing loss or unilateral hearing loss. It is important to note that overall averages for students with hearing loss were lower than class averages and means obtained by children with hearing within normal limits as was found by Lieu et al. (2010), but not always on the individual level. Though the frequencies which were affected by hearing loss were not specified by Lieu et al (2010), Bess et al (1998) showed that minimal hearing losses, either unilateral or bilateral affected academics when comparing grades between children with minimal hearing to their age-matched normal hearing peers. A cause of this is the need for a higher signal-to-noise ratio to process the already soft high-frequency sounds of an incoming speech signal from the teacher. Without an adequate signal-to-noise ratio, students with hearing loss can easily fatigue, adding to the distraction of the student.

High frequency hearing loss could very well have an impact on the academic performance of these children. Soft speech sounds are easily masked out in classrooms that are not acoustically friendly, further compromising the hearing ability of children with existing impairment, either unilateral or bilateral, in accordance with Crandell & Smaldino (2000). During the questioning sessions with teachers about each student, students were often described as distracted, including seven of the nine students with hearing loss. As stated by Gourma et al. (2011), hearing impairment may also include attention issues which can negatively affect academics. As a group, the children in this study with hearing loss performed worse academically than their normal hearing peers, hearing loss also tended to increase slightly with grade, as Groups 7 and 8 presented with more bilateral loss in a more severe degree overall. These finding in regard to hearing loss progressing with age were also listed by Bess et al. (1998). The evidence seems compelling that means of diagnosis and intervention is needed in Haiti, at both the infant and school-age level. To identify a hearing impairment at its onset would allow for detection of its etiology and hopefully would allow for timely intervention as well. This can result in enhancing the academic performance of each child at each level of academia, and would allow for an improved academic and professional future.

However, class averages for students with hearing within normal limits and overall were lower than expected. To investigate possible reasons for this, the examiners tested the noise levels within the hallway adjoining each classroom in the primary school with an A-weighted sound level meter. With class in session, noise levels fluctuated up to a 70-80 dB SPL noise intensity level. This could have been due to the low walls that did not extend to the high ceiling and the lack of any and all sound-absorbing material. Partitions between classes were even lower in the kindergarten classroom. The windows in each room were metal gates, and each room was essentially connected to its adjoining room and the connecting hallway. Additionally, the rooms and hallway were very reverberant. These factors combined made for a very hostile acoustic and academic setting, as outlined by Crandell and Smaldino (2000). It is likely that the effects of noise from inside and outside the school contributed to the students' level of distraction and compromised learning, especially for those students with hearing loss. Reverberation also played a key role in increasing the noise levels in classroom, as it allowed for present noise in the classroom and added noise and speech signals to reflect off the walls and high ceilings, distributing a louder level of noise across the classroom. As stated by Klatte and Hellbruck (2010), such unfavorable conditions are causative factors for compromised academics, and would be so for both hearing impaired and normal hearing children alike. Unfavorable learning conditions, which are already known to mask out speech signals so that the students potentially do not hear the teacher, may very well raise the level of distraction due to noise levels present in the classroom as well. This in turn may raise annoyance levels of the students, another factor that can compromise willingness to learn and can have a chronic effect on a child's learning ability as is also pointed out by Klatte et al (2013). A favorable signal to noise ratio is needed in classrooms in order to prevent such hindrances in children's educational and learning abilities, as were occurring in the school classrooms in Haiti.

CONCLUSIONS

Clinical Implications

Of 38 students, nine were found to have hearing loss. Etiology was unknown as masking could not be conducted. The hearing loss was primarily in the 6000 Hz to 8000 Hz frequency range. Collapsed canals were ruled out as a factor or cause of these results since insert ear phones were used to obtain audiometric thresholds.

The most efficient method of early hearing loss detection is newborn hearing screening. Implementation of such a practice would allow for early detection of overall hearing loss. More specifically at the school age level, it would be of benefit to expand hearing screening ranges to include frequencies above 4000 Hz, and hence, ensure each child excels academically by taking the appropriate action for intervention after identification of a hearing loss. Awareness of an identified hearing loss, high frequency in this case, and subsequent intervention for the losses that wouldn't normally be identified would suggest and allow for better control of variable external noise levels that could potentially mask out segments of a speech signal.

A larger sample would have strengthened this study and would have made results not just speculative but generalizable as well. It also might have benefited this study to perform audiological testing in 2 dB steps. This would have given a more exact threshold for each child and would lend to a more exact relation study between hearing ability and academic performance. It would also be of benefit for teachers to be aware of hearing loss red flags and for the school systems to integrate this knowledge of such red flags to control for situations in which the academic environment can impede learning rather than enhance it. Out of six teachers, only one voiced suspicion of hearing loss in one of the children who ultimately was found to present with hearing loss. A low cost annual questionnaire issued to parents asking for their opinion of their child's hearing and listening ability, in line with Samelli et al. (2011) could be a possible solution to addressing hearing loss in the classroom. The questionnaire could subsequently be reviewed by teachers and administrators for the purpose of appointing preferential seating to students who are suspected to have hearing loss and possible ensuing compromised academics.

Limitations

Time was of the greatest essence in performing this study, and many factors interfered with the set up and execution of the study so that there was not adequate time to test all the desired subjects. Some students were placed in the wrong age group and had to be turned away. In some cases, data had to be discarded after having performed audiological testing. The tests days were also cut in half, information that was not available to the examiners until they arrived, as the school only allowed for a 3.5 test window each morning. Due to time constraints and poor picture quality as well, videoscopy could not be performed.

A great deal of time was also lost due to seeking out an acceptable environment for testing. The noise levels on the school grounds were a great limitation to this study. Construction commenced at the school on the day that the examiners arrived for testing. This resulted in ultimately transporting the children to the translator's house to accommodate to test level requirements. Noise was still a factor, though not as often, each time a motorbike or truck drove past the house. Pure tone testing was discontinued until ambient noise levels returned to acceptable levels.

Future Research Needs

Education is strongly emphasized in Haiti as it is seen as the country's key to advancement. Education and learning for Haitian school children would be more effective for students in classrooms that are prime learning environments. The reverberation in the hallway was very intense, especially when the teachers and the students in classrooms were verbal simultaneously. It was suggested to a school administrator to make a project for the school children involving egg cartons and then to glue the egg cartons on the walls to reduce reverberation in the classrooms, but this idea was rejected for the time it would take, the cost of eggs and the wall surface area.

There is a demanding need for future and further research on hearing health in Haiti. Haiti is a society that is essentially rebuilding itself with many hazards and difficulties in its path. The effects of the 2010 earthquake may still be manifesting in a myriad of ways in many individuals, and the environments that these people are exposed to on a daily basis are hazardous to their health, hearing and overall well-being. It would be of great service to Haiti and to the Audiology World to further explore the audiological status of Haitian school children and of the population overall, and the impact of hearing health or lack thereof to contribute to Haiti's further emergence as it strives to become a vibrant, successful and viable society.

References

American Speech- Language-Hearing Association. (1997). Guidelines for audiologic screening [Guildelines]. Available from www.asha.org.policy

American Speech-Language Hearing Association. (2005). Guidelines for manual pure-tone threshold audiometry. Available from http://www.asha.org/docs/html/GL1997-00199.html#sec1.3.4

Ayoya M.A., Heidkamp R., Ngnei-Teta I., Pierre J.M., Stolzfus R.J. (2013) Child malnutrition in Haiti: progress despite disasters. *Global Health Sci Pract* 1(3), 389-396. DOI: 10.9745/GHSP-D-13-00069

Bamiou D.E., Phelps P., Sirimanna T. (2000) Temporal bone computed tomography findings in bilateral sensorineural hearing loss. *Arch Dis Child (82),* 257- 260.

Bess, F.H. (1985). The minimally hearing-impaired child. *Ear Hear 6*, 43-47.

Bess, F.H., Dodd-Murray, J., Parker, R.A. (1998). Children with minimal sensorineural hearing loss: prevalence, educational performance and functional status. *Ear Hear 19*(5), 339-353.

Dahl HHM, Ching, TYC, Hutchinson W, Hou S, Seeto M, Sjahalam- King J. (2013). Etiology and audiological outcomes at 3 years for 364 children in australia. Plos One 8 (3), e59624 DOI: 10.1371/journal.pone.0059624

Carhart R., Jerger J. (1959). Preferred method for clinical determination of pure-tone thresholds: [Abstract]. *Journal of Speech & Hearing Disorders, (24)*, 330-345.

Carter J.A., Ross A.J., Neville B.G.R., Obiero E., Katana K., Mungngna KBoor V., Lees J.A., Newton C.R.J.C. (2005). Developmental impairments following severe falciparum malaria in children. *Tropical Medicine and International Health* 10(1), 3-10. DOI: 10.1111/j.1365-3156.2004.01345.x

Center for Disease Control and Prevention. (2013, October 3). Data and Statistics. National Center on Birth Defects and Developmental Disabilities. Retrieved April 18, 2014 from http://www.cdc.gov/ncbddd/hearingloss/data.html

Chisholm D., Baltussen R., Evans D.B., Ginsberg G., Lauer J.A., Ortegon M., Salomon J., Stancoile A., Tan-Torres Edejer T. (2012). What are the priorities for prevention and control of non-communicable diseases and injuries in sub-Saharan Africa and South East Asia? BMJ, 344 (586), 1-6. DOI: 10.1136/bmj.e586.

Clark, J. L. (2008). Hearing loss in Mozambique: Current data from Inhambane province. *International Journal of Audiology* 47(1), 49-56. DOI: 10.1080/14992020802291723

Crandell C.C., & Smaldino J.J. (2000). Classroom acoustics for children with normal hearing and with hearing impairment. Language, Speech and Hearing Services in Schools 31, 362-370. Retrieved April 18, 2014 from http://gofrontrow.com/files/documents/background_research_classroom_acoustics_for_children_with_normal_hearing_and_with_hearing_impairment.pdf

Cripp A.W., Otczyk D.C., Kyd J.M. (2005). Bacterial otitis media: a vaccine preventable disease? *Vaccine* 23, 2304-2310. DOI:10.1016/j.vaccine.2005.01.023

Dahl H.H.M., Ching, T.Y.C., Hutchinson W., Hou S., Seeto M., Sjahalam- King J. (2013). Etiology and audiological outcomes at 3 years for 364 children in australia. *Plos One* 8 (3), 1-7. DOI:10.1371/journal.pone.0059624.

Dowell S.F., Tappero J.W., Freiden T.R. (2011). Public health in haiti- challenges and progress. *New England Journal of Medicine* (364), 300-30. DOI: 10.1056/*NEJM*p1100118.

Frank, T. (2000). ANSI update: maximum permissible ambient noise levels for audiometric test rooms. *American Journal of Audiology* 9 (1), 3-8. DOI:10.1044/1059-0889(2000/003):

Goulios, H., & Patuzzi, R. B. (2008). Audiology education and practice from the international perspective. *International Journal of Audiology* 47(10), 647-664. DOI: 10.1080/14992020802203322.

Gouma P., Mallis A., Daniilidis V., Gouveris A., Armenakis N., Naxakis S. (2011). Behavioral trends in young children with conductive hearing loss: a case control study. *European Archives of Otorhinolaryngology* 268(1) 63-66. DOI: 10.1007/s00405-010-1346-4.

Gupta J., Agrawal A. (2010). Chronic aftershocks of an earthquake on the well-being of children in Haiti: violence, psychosocial health and slavery. *Canadian Medical Association Journal* 182(18), 1997-1999. DOI: 10.1503/cmaj.100526.

Hay D., and Associates. (2014). Allergies. Retrieved from http://www.epichearing.com/hearing-loss-prevention/problem-and-diseases/allergies/

Jerger, J., Jerger, S., & Maudlin, L. (1972). Studies in impedance audiometry: I. Normal and Normal and sensorineural ears. *Archives of Otolaryngology, 96,* 523-531.

Jules, A., Kaltenbach, L.A., Argobast, P.G., Caples, T.L., Po'e, E. K., & Cooper, W. O. (2010). Use of drugs known to cause fetal harm among women delivering infants in haiti. *Academic Pediatric*s 10(6), 395-399. DOI: 10.1016/j.acap.2010.09.003.

Khoza- Shangase K., Barratt, J., Jonosky, J. (2010). Protocols for early audiology intervention services: Views from early intervention practitioners in a developing country. *South African Journal of Child Health* 4(4), 100. DOI:10.7196/sajch.271.

Kuppler K., Lewiss M., Evans. (2013). A review of unilateral hearing loss and academic performace: is it time to reassess traditional dogmata. *International Journal of Pediatric Otorhinolaryngology, 77, 617-622.*

Klatte, M., Bergstroem, K., & Lachmann, T. (2013). Does noise affect learning? A short review on noise effects on cognitive performance in children. *Frontiers in psychology*, *4*.

Klatte, M., Hellbruck, J. (2010). Effects of classroom acoustics on performance and well-being in elementary school children: a field study. *Environment and Behavior*, *42*(5), 659-692.

Lieu, J.E.C. (2004). Speech-language and educational consequences of unilateral hearing loss in children. *Archives of Otolaryngology Head & Neck Surgery* 130(5), 524-530. DOI: 10.1001/archotol.130.5.524.

Lieu J.E.C., Tye-Murray N., Karzon R.K., Piccirillo J.F. (2010). Unilateral hearing loss is associated with worse speech-language scores in children. *Pediatrics* 125(6), 1348-1355. DOI: 10.1542/peds.2009-2448.

Lieu J.E.C., Tye-Murray N., Fu Q. (2012). Longitudinal study of children with unilateral hearing loss. *Laryngoscope* 122, 2088-2095. DOI: 10.1002/lary.23454

Margolis R.H., Heller J.W. (1987) Screening tympanometry: criteria for medical referral. *Audiology* 26(4) 197-208.

Martin F.N., & Clark J.G. (2006). The outer ear. In: *Introduction to Audiology* (9th ed.), Boston, MA: Pearson Education.

Mathers, C., Smith, A., Concha, M. (2000). Global burden of hearing loss in the year 2000. World Health Organization. Retrieved April 18, 2014 from http://www.who.int/healthinfo/statistics/bod_hearingloss.pdf

Media Centre. (2013, February). Deafness and hearing loss. World Health Organization. Retrieved April 18, 2014 from http://www.who.int/mediacentre/factsheets/fs300/en/

Moeller P.M., Tomblin B., Yoshinaga-Itano C., McDonald Conner C., Jerger S. (2007) Current state of knowledge: language and literacy of children with hearing impairment. *Ear & Hearing* (28) 740. Retrieved April 18, 2014 from http://www.infanthearing.org/coordinator_orientation/section8/33_current_knowledge.pdf

Monasta L., Ronfani L., Marchetti F., Montico M., Brumatti L.V., Bavcar A., r Tamburlini G. (2012). Burden of disease caused by otitis media: systematic review and global estimates. *Plos one* 7(4) e36226. DOI: 10.1371/journal.pone.0036226.

Most, T., Ingber, S., Heled-Ariam, E. (2011). Social competence, sense of loneliness, and speech intelligibility of young children with hearing loss in individual inclusion and group inclusion. *Journal of Deaf Studies and Deaf Education* 17(2), 259-272. DOI: 10.1093/deafed/enr049.

National Institute on Deafness and Other Communication Disorders (2010). Quick Statistics. Retrieved April 18, 2014 from http://www.nidcd.nih.gov/health/statistics/Pages/quick.aspx

Nicholas J.G., Geers A.E. (2006). Effects of early auditory experience on the spoken language of deaf children at 3 years of age. *Ear Hear* 27(3), 286-298. DOI: 10.1097/01.aud.0000215973.76912.c6

Niskar A.S., Keiszak S.M., Holmes A., Esteban E., Rubin C., Brody D.J. (1998). Prevalence of hearing loss among children 6 to 19 years of age: the third national health and nutrition examination survey. *JAMA* 279(14), 1071-1075. DOI:10.1001/jama.279.14.1071

Ogbru, O. (2013, April 4). Tetracycline. Retrieved April 18, 2014 from http://www.medicinenet.com/tetracycline/article.htm

Olusanya, B. (2001). Early detection of hearing impairments in a developing country: What options? *International Society of Audiology* 40(3), 141-147.

Orange J.S., Hossny E.M., Weiler C.R., Ballow M., Berger M., Bonill F.F., Cunningham-Rundles C. (2006). Use of intravenous immunoglobulin in human disease: A review of evidence by members of the primary immunodeing loss in individual inamerican academy of allergy, asthma and immunology. *J Allergy Clin Immunol* S525-S553. DOI:10.1016/j.jaci.2006.01.015

Parks, E. (2011). The Deaf People of Haiti. SIL International Survey Report. Retrieved April 14, 2018 from http://www2.sil.org/silesr/2011/silesr2011-032.pdf

Pan American Health Organization (2010). Haiti: Population health assessment prior to the 2010 earthquake. Retrieved April 18, 2014 from http://www.paho.org/disasters/index.php?option=com_docman&task=doc_download&gid=689&Itemid=99999999

Perry H., Berggren W., Berggren G., Dowell D., Menager H., Bottex E., … Cayemitties M. (2007). Long-term reductions in mortality among children under age 5 in rural Haiti: effects of a comprehensive health system in an impoverished setting. *American Journal of Public Health* 97(2), 240-246. DOI: 10.2105/AJPH.2006.088732

Roine I., Gerardo W., Heikki P., LatAm Bacterial Meningitis Study Group. (2010). Influence of malnutrition on the course of childhood bacterial meningitis. *Pediatric Infectious Disease Journal* 29(2) 122-125. DOI: 10.1097/INF.0b013e3181b6e7d3

Russ S.S., Dougherty D., Jagadish P. (2010). Accelerating evidence into practice for the benefit of children with early hearing loss. *Pediatrics* 126(supplement 1) 7-18. DOI: 10.1542/peds.2010-0354E

Samelli G.S., Rabelo C.M., Chaparin Vespasiano A.P. (2011). Development and analysis of a low-cost screening tool to identify and classify hearing loss in children: a proposal for developing countries. *Clinics* 66(11) 1943-1948. DOI: 10.1590/S1807-59322011001100015

Stevenson J., McCann D., Law C.M., Mullee M., Petrou S., Worsfold S.,… Kennedy C.R. (2010). The effect of early confirmation of hearing loss on the behavior in middle childhood of children with bilateral hearing impairment. *Developmental Medicine and Child Neurology* 53(3) 269-274. DOI: 10.1111/j.1469-8749.2010.03839.x

Taipale A., Pelkonen T., Taipale M., Roine I., Bernardino L., Peltola H., Pitk la H. A. (2011). Otorhinolaryngological findings and hearing in HIV-positive and HIV-negative children in a developing country. *European Archives of Otolarhinolaryngology* 268(10), 1527-1532. DOI: 10.1007/s00405-011-1579-x

Tharpe, A.M., Bess, F.H. (1991). Identification and management of children with minimal hearing loss. *Int J Pediatr Otorhinolaryng 21*, 41-51.

Van der Linde, J., Kritzinger, A., Redelinghuys, A. (2009). The identification process in early communication intervention (ECI) by primary health care personnel in Ditsobotla sub-district. *South African Journal of Communication Disorders* (56), 48-59.

Varma M.K., Satterthwaite M.L., Klasing A.M., Shoranick T., Jean J., Barry D., … Lyon E. (2008) W 08 nan soley: The denial of the right to water in Haiti. Health and Human Rights. Retrieved April 18, 2014 from http://www.hhrjournal.org/2013/09/09/woch-nan-soley-the-denial-of-the-right-to-water-in-haiti/

Wang M.C., Liu C.Y., Shiao A.S., Wang, T. (2005). Ear problems in swimmers. J Chin Med Assoc (68)8.

Wake, M., Poulakis, Z. (2004). Slight and mild hearing losses in primary school children. *J Paediatr Child Health 40*, 11-13.

Wake M., Tobin S., Cone-Wesson B., Dahl H.H., Gillam L., McCormick L.,… Williams J. (2006). Slight/mild sensorineural hearing loss in children. *Pediatrics* 118(5):1842-185. DOI: 10.1542/peds.2005-3168

Yacullo, WS. (2009). Clinical masking. In J. Katz, L. Medwetsky, R Burkard & L.J. Hood, *Handbook of Clinical Audiology- Sixth edition* Maryland: Lippincott Williams and Wilkins.
Year 2007 Position Statement: Principles and Guidelines for Early Hearing Detection and Intervention Programs. Joint Committee on Infant Hearing Pediatrics. 120 pp. 898-921.

APPENDIX A: Letter sent to Haitian parents

Chers Parents,
Sur la 19 - 22, et 25 Novembre, deux élèves en Doctorat en Audiologie de l'Université de l'État de New York viendront administrer des tests d'audition à votre enfant. Ils vont comparer les résultats scolaires de votre enfant aux résultats du test pour voir si des problèmes d'audition ne seraient pas la cause de difficultés académiques à l'école. Le test va durer 20 à 25 minutes. Veuillez vous assurer que les oreilles de votre enfant soient propres.

☐ Oui, Je souhaite que mon enfant participe à ce test d'audition.

☐ Non, Je ne souhaite pas que mon élève participe à ce test d'audition.

Chantal Papillon
Ecole Presbytérale de St. Vincent de Paul
Directrice du Préscolaire

Révérant Père Chancy
École Presbytérale de St. Vincent de Paul
Directeur Administratif

Letter written by:
Adjani Papillon M.A.T
Principal of Carrousel Elementary School
adjanipapillon@hotmail.com

APPENDIX B: Audiogram and checklist

AUDIOGRAM

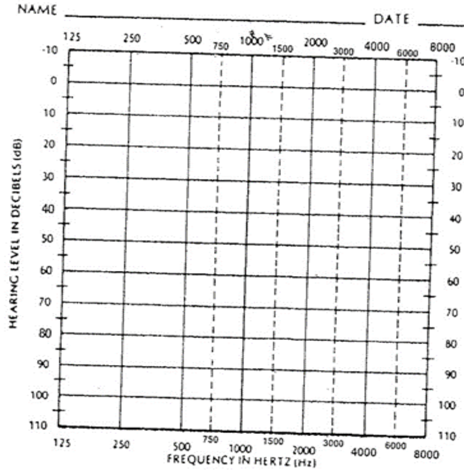
NAME ______ DATE ______ BY ______

Screening Results:

500 Hz		
1000 Hz		
2000 Hz		
4000 Hz		

Pass: ____

Refer: ____



AUDIOGRAM KEY	Right	Left
AC Unmasked	O	X
AC Masked	△	□
BC Mastoid Unmasked	<	>
BC Mastoid Masked	[	]
BC Forehead Masked	˥	Γ

Both	
BC Forehead Unmasked	↓
Sound Field	S

	Right Ear	Left Ear
SRT		
Discrim		
MCL		
UCL		

REMARKS ______

FORM 1162-417 REV 2/00 PRINTED IN U.S.A.

Hearing Loss Type:

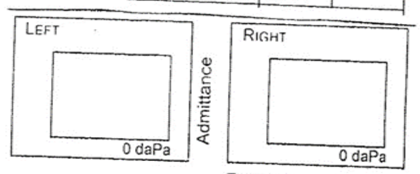
	Unilateral	Bilateral
Within normal limits		
Conductive		
Sensorineural		
Mixed		

Otoscopy:

Clear canals	
Excessive cerumen and or debris (non-occluding)	
Occluded canals	
Other	

ACOUSTIC ADMITTANCE (226 Hz) UNIT: ______

	LEFT	RIGHT
EQUIV EAR CANAL VOL (cm³)		
TYMP PEAK PRESSURE (daPa)		
STATIC ADMITTANCE (mmho)		



Tympanogram Type:

IPSI	5k Hz	1k Hz	2k Hz	4k Hz
AD Probe ear				
AS Probe ear				

Academic record:

______

______

______

______