HEARING EVALUATION OF SPECIAL POPULATIONS IN THE PHILIPPINES

Newborns, Children with Hearing Loss,
an Indigenous Population and Cochlear Implantees

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Chapter I

General Introduction

A BRIEF HISTORY OF PHILIPPINE MEDICINE

The Philippines is a beautiful country. It is made up of 7,107 islands and is well-known for being inhabited by generally happy and cheerful people. (1) In contrast, it is a developing country with a low Gross Domestic Product of 291.97 billion (as of 2016) and a growing population of 103,234,311 people - with 3 babies being born every minute or 200 babies born per hour. (2) These facts, along with its relatively recent medical beginnings, make the delivery of medical services in the Philippines both challenging and unique.

The rich history and culture of the Philippines have to be acknowledged in order to understand how and why the Philippine health system is the way it is now. The Philippines is one of the few countries that have been colonized by two powerful nations and was occupied by the Japanese regime during World War II for 3 years. During the Spanish rule, which started with the arrival of the Miguel Lopez de Legaspi's expedition in February 13, 1565 and ended after more than 300 years, majority of the people who were sick or had an accident were being brought to the local *curanderos, herbolarios* or *albularyos* (folk healers or medicine men). These local healers would use rituals, sacrificial offerings, prayers, "chiropractic" manipulation and massage for diagnosis and healing. (3) They would attribute the cause of the illnesses to strange and supernatural beings so that rituals were performed to appease them. There were very few sick people who would ask for the services of the limited number of physicians coming from Spain. One reason is because they viewed this unfamiliar practice with suspicion and because most of these Spanish physicians were based in the large provincial capitals with exclusive Spanish clientele. There were also very few Spanish physicians because of the huge distance from Spain to the Philippines and, even fewer physicians would like to travel to such an unknown place. Public health activities for the Filipinos (called degoratorily as *Indios* at that time) by Spain were slow. It was during this time when the Philippines was ravaged by infectious disease epidemics like cholera, typhoid, dysentery, dengue and small pox. Near the end of Spanish rule, there were five general hospitals, four contagious disease hospitals and two military hospitals. Our national hero, Dr. Jose P. Rizal, who had his pre-medical schooling at the University of Santo Tomas (UST) in Manila, his licentiate in Medicine at Universidad Central de Madrid in 1882 and specialized in Ophthalmology from studying with Dr. Louis de Wecker in Heidelberg, Germany, also made important contributions to health in terms of education, as well as, environmental sanitation work when he was exiled in the

Dapitan, Zamboanga in the Philippines for allegedly inciting rebellion. When America took over the Philippines from Spain in 1898, the state of sanitation and hygiene in the Islands were found to be disturbing and deplorable. With the American occupation, the health situation of the Philippines drastically changed in the field of hygiene, sanitation, health, medical education and scientific research. American teachers effectively used English as the mode of teaching in all schools compared to the Spaniards who kept the general public ignorant of their Spanish language - thus, at present the literacy rate of the Philippine population is 94% and 70% are fluent in English, making the Philippines one of the largest English speaking countries in the world. (4) American doctors became the heads of the two medical universities: UST and the second medical school, which is now the University of the Philippines College of Medicine (UPCM). However, World War II and the occupation of the Philippines by Japan in 1942, certainly pushed back all the ongoing health and medical progress which was happening in the Philippines. The post–war situation showed high prevalence of malnutrition, malaria, tuberculosis (TB), dysenteries and other infections. Fortunately, after the war, the leaders of the country gave health the highest priority. During the 1940's and 1950's because of the established links with America and because Europe had been greatly affected by the war, Filipino medical scholars where sent to leading American medical centers to learn, specialize in their chosen or assigned field. They then brought back home new knowledge, ideas and skills. This is probably why the Philippines is very much influenced by the American medical and health advances. (5)

Philippine medical education compared to the rest of the world

The clinical study of medicine started in the Philippines in 1871 with the foundation of the University of Santo Tomas Faculty of Medicine and Surgery (UST) - which is the oldest university in the Philippines. (5) In comparison, the earliest study of medicine and the first medical school in the world where in Ancient Greece during the 700 BC -600 AD and the Schola Medica Salernitana in Italy during the 1100 AD to 1200 AD. (6) The first University in the Dutch speaking countries was the University of Leuven (1425) even before The Kingdom of Belgium (1835) was started. It is positioned in Flanders, a part of Belgium. (7) The first Medical School in the United States was the University of Pennsylvania in 1765. (8) From the early 19th century a systematic and analytical approach to the study of diseases and their etiology started and so scientific basis in medical care began. Thus, in the study of medicine, Philippines is more than 100 years behind the rest of the developed world.

The specialization in otology and laryngology started separately and independently of each other in the middle of the 19th century having their own specific scientific journals. It took until the end of the 19th century before both clinical and scientific separate fields joined each other separately at national levels to build the specialty of Oto-Rhino-Laryngology.

As was mentioned above, the first scientific otological and laryngological journals were also began individually at about the same time. These were edited in their own national languages such as French, German and English. During the 20th century, English became the common medical language, however, there were still separate scientific otorhinolaryngological scientific journals edited in the national language of some European countries. (9)

In the Philippines, the Philippine Society of Otolaryngology and Broncho-esophagology (PSOB) was started in 1956. At that time, the specialty of Otorhinolaryngology was part of a broader specialty formerly known as EENT (Eyes, Ears, Nose and Throat). However, in 1961 the University of the Philippines Board of Regents - of which the UPCM is under - granted the separation of EENT into 2 distinct specialties due to the many developments and advances in all aspects of EENT: ophthalmology and otorhinolaryngology. Slowly but surely, the other medical universities and hospitals in the Philippines would have a separate department for the two specialties. In 1981, the society was renamed as the Philippine Society of Otolaryngology-Head & Neck Surgery (PSO-HNS). In this same year, the maiden issue of the Philippine Journal of Otorhinolaryngology-Head & Neck Surgery was published which was and still is written in the English Language. (10)

History of audiology in the Philippines

In the same vein, the field of audiology in the Philippines is also quite young and, similar to other countries, audiology – which is the study of hearing and hearing disorders, was an offshoot of otology – which is the study of the ear and its diseases. The first audiologists in the Philippines were otorhinolaryngologists (or ENT specialists) or were taught by them. Hearing aid companies would have “audiometricians” or “audio technicians” who would perform the hearing tests. These “audiometricians” probably would have had informal training on using the audiometers and tympanometers by the company selling them or by otolaryngologists who have observed them abroad during their training. The professionalization of audiology started in 1999 when the post-graduate training or Master in Clinical Audiology program started in 1999 by two (2) universities: the UP

and the UST. (11) It is not surprising that the profession of audiology in the United States and Europe started much earlier - in the 1940s - when individuals learned to perform hearing tests on young servicemen and women who returned from World War II with noise induced hearing loss. (12,13) Thus, in terms of the study of audiology, the Philippines is about 60 years behind.

The Department of Otorhinolaryngology, section of otology, under the chairmanship of Dr. Vicente L. Santos (1975) saw the beginnings of audiology. He helped procure machines for audiological testing like the Bekesy audiometer, the diagnostic puretone audiometer which was capable of doing the tone decay test (TDT) and the short increment sensitivity index test (SISI). Dr. Carlos Reyes, a consultant and faculty in the department at that time was interested in audiology, and through diligent study and practice became the expert in audiology. Another consultant and faculty member, Dr. Ernesto Nueva Espana was sent by Dr. Santos to England to pursue a formal masters degree in Audiology, unfortunately, he went back to the Philippines only for a few years before leaving for good to work abroad. It was Dr. Generoso T. Abes who took over supervising the otology section which included the use of the diagnostic audiological equipment. The rising interest of the Filipino otorhinolaryngologist in audiology most likely began when scientific journals and articles in English detailing the speech and language delays as well as other issues that may arise when children with hearing loss are identified late. Also, when Dr. Charlotte Chiong of the Department of ORL UP-PGH took her research fellowship in Otology in Harvard Medical School in Boston in 1991 as well as clinical fellowship in Neurotology and Skull Base Surgery in Sunnybrook Health Science Center, University of Toronto, Ontario in 1993. There, she learned about the new technological advances happening at that time: cochlear implants and how children with profound hearing loss, with the help of cochlear implant surgery and the patience and skill of the audiologist and speech pathologist, could now have a chance for developing normal hearing and speech. When she came back to the Philippines to teach neurotology, she encouraged the new ORL graduates to take up masters of clinical audiology. Later on, one of these new ORL graduates who also trained in pediatric otorhinolaryngology in New York witnessed the growth and development of Universal Newborn Hearing Screening in the United States and brought this knowledge and new technology back to the Philippines. Audiology, as a distinct and separate field, was further bolstered during the chairmanship of Dr. Joselito C. Jamir (1998). He was instrumental in the establishment of the Master of Clinical Audiology Program both in UP and UST which was conceived in cooperation with Macquarie

University and with the support of Australian AID (AusAID). Professor Philip Newall – presently a Professor Emeritus of Macquarie University, Sydney Australia, in his desire to maximize utilization of funding from Australian AID, conducted talks not only with UP but also with UST. Thus, parallel programs were being held in the two institutions. The only difference is that the UP program is a joint endeavor of the UPCM and the UPM College of Allied Medical Professions (CAMP) with the present Dean, Professor Jocelyn Marzan as the key person. Another new ORL graduate, Dr. Elmer dela Cruz, who was an AusAid scholar who was and the first ORL graduate to take up Masters in Clinical Audiology in Macquarie University, Australia and when he finished the course, he also taught in the UP “Masters of Clinical Audiology Program". It was only in June 9, 2015 when the Association of Clinical Audiologists of the Philippines (ACAP) was born. It is a society made up of audiologists who have finished a Master of Clinical Audiology degree and whose mission is to be at the forefront of hearing and balance health in the Philippines through professionalization of hearing health care, setting of ethical and practice standards, advocacy and continuing professional education. The professionalization of audiology to develop individuals who are knowledgeable, proficient and competent in performing audiologic tests is crucial to the realization of a historic development in the field of pediatric public health in the Philippines: Universal Newborn Hearing Screening.

Challenges in providing medical services in the Philippines

We have seen from the previous passages that the Philippines is many years behind progress in medical and audiological advances. Added to this, the Philippines is also a country made up of many islands which makes the delivery of medical services quite difficult. Indeed, in some cases, a person in need of medical care would need to travel by land and by sea to reach the closest health facility. This, plus the expense they need to take the trip, and the need to bring along companions for help, makes seeking medical attention a frustrating and challenging endeavor. Thus, the local *arbularyo* (herbalist, witch doctor) or *manghihilot* (midwife or someone who employs chiropractic-like manipulation for treatment) might get the consultation that should have been presented to a medically trained doctor. (3)

Also, because the Philippines is a developing country, the problem of hearing loss may not be seen as an urgent problem. Taking a back seat to the more pressing and basic needs like food, clothing and shelter. Thus, medical consults are usually done when the problem or the disease is in an advanced and complicated stage.

Ear and hearing health of an indigenous community in the Philippines

An example of this problem is the Ati community in Boracay, a group of indigenous peoples of about 40 families who work as laborers and beach combers in an island who are under the care of a religious group, The Daughters of Charity. (14, 15) Their only exposure to medical treatment is through medical missions or when it is severe enough to warrant an expedition to the closest medical facility and since their main focus is surviving from day to day, they cannot afford proper medical attention. (16,17) Because of this, a high rate of ear problems and possibly hearing loss might be expected in this population. A study has shown that middle ear disease in an indigenous community – which subsequently leads to conductive or mixed mild to moderate hearing loss -may have a genetic origin and not only due to poor living conditions, poor nutrition, education and hygiene. The rare *A2ML1* (alpha-2-macroglobulin like 1) has been found to have a role in the pathophysiology and to confer susceptibility to otitis media in this type of community. (18,19) Consanguinous marriages which are common in small communities such as this, may have also lead to autosomal recessive congenital hearing loss. Studies have shown that there is a strong association between family history of deafness and consanguinity. (20)

High prevalence of otitis media which may lead to hearing loss is also found in other indigenous populations around the world. According to the WHO, high CSOM rates which means that urgent attention is needed to deal with the massive public health problem includes the Aborigines of Australia and Greenlanders. (21) More disturbing is that despite the use of pneumococcal vaccines which have helped decrease the incidence of middle ear infection in the general population, the ear health of the children of Australian Aborigines showed no substantial improvement after its introduction. (22)

Not all indigenous populations have high rates of ear disease and hearing loss. The native population of New Zealand known as the Maori must be taken as separate from the Australian Aborigines. The Australian Aborigines originate from India about 60,000 BC while the Maori sailed to New Zealand from Polynesia in 1,200 BC. They are different with regards to prevalence of ear disease. Twenty percent of Australian Aboriginal children have ear disease compared to only 4% of Maori children. (23)

Thus, in the Philippines, it would be interesting to know if these findings of increased ear infection and hearing loss may also be found in the indigenous Ati population in Boracay.

Challenges in newborn hearing screening in the Philippines

The impetus to begin a nationwide newborn hearing screening initiative began when researches, medical journals and lectures on the importance of newborn hearing screening and the advantages of early identification and habilitation reached Filipino otorhinolaryngologists in the early 1990's. Since then local studies were performed to determine the prevalence of hearing loss in the Philippines (24) and the feasibility and cost effectiveness of newborn hearing screening in the Philippines (25). These data were gathered mainly by the Ear Study group of the Philippine National Ear Institute (PNEI) of which Dr. Charlotte Chiong is also a pioneer. From these studies, the PSO-HNS Task Force position paper was written in 2007 and forwarded to Senator Loren Legarda who championed the Senate Bill and in August 12, 2009 Republic Act 9709 or the Universal Newborn Hearing Screening and Intervention Act of 2009 was approved and signed into law. Before the law was passed, children with hearing loss would be diagnosed at an age greater than 2 years old. Pediatricians would not take seriously the mother's concern that their child was not developing speech and language. They would be told not to worry because it would develop in time. If the child were a boy, they would just say that boys normally develop speech and language later than girls. At present, given the technological advancements in audiology, hearing evaluation can be performed even in very young children. Targeted newborn hearing screening in the neonatal intensive care unit (26) at the largest university hospital the Philippine General Hospital showed a high prevalence of failed hearing screening of which only 8% were brought back for follow-up. (27)

Although the Filipino have many good and positive traits, there are also some Filipino traits that may get in the way of early medical treatment. One of this is "fatalism" which means that bad circumstances cannot be changed but just accepted. Another one is the "*manyana* habit" where one puts off doing what can be done today – which means that they may never get to follow up with the doctor if there is a need - and "*hiya*" which means covering up or hiding issues or conditions that may put the family or the person or their child in a negative light. Thus, with newborn hearing screening, a mother or caregiver's "worrying" over the hearing screening results may expose these issues that may come to play and that ultimately leads to the delay in diagnosis of hearing loss in the child. (28, 29) Thus, we would like to know the reaction of Filipino mothers to newborn hearing screening and if they think it is a worthwhile procedure. Getting the least number of false positives in newborn hearing screening is important because it will mean less worry and less expense for the

parent or caregivers to bring the child back for a re-screen. Studies have shown that issues with the external and middle ear, like retained vernix caseosa, may affect the results of newborn hearing screening and that cleaning the external ear prior to hearing screening (which also means longer preparation times and more trained personnel) may improve the results. (30) In a country with a high birthrate, such as the Philippines, it would be good to know if the presence of vernix caseosa in the ear and/or collapsed ear canals is clinically significant because this would mean added procedures such as the need to do otoscopy prior to hearing screening and cleaning the external ear canal which are time and personnel intensive.

Once they “fail” or “refer” during re-screen, diagnostic audiologic tests need to be done to determine the level of hearing loss, if there is any. A test like the auditory brainstem response (ABR) and auditory steady state response test (ASSR) will determine the presence or absence of hearing loss as well as the severity. The challenge is to determine auditory brainstem response tests the integrity of the hearing pathway up to the brainstem and provides a general idea of the hearing threshold while the ASSR, with generator sites in the subcortical and cortical regions, provides frequency specific information for the hearing loss. (31,32) Because the auditory steady state response test can record responses at higher intensity levels, it may give us an idea that the auditory nerve is present if responses are noted and may help in the decision – making for cochlear implantation. It may even ameliorate the need to do MRI to document the presence of a cochlear nerve. Thus it would be important to know if those patient who do not show repeatable and reproducible waves on ABR testing may still show responses on ASSR.

The Philippine experience with cochlear implantation

There are already more than 500 cochlear implantations done in the Philippines. With the passage of the Universal Newborn Hearing Screening and Intervention Act of 2009 (33) younger and younger children are diagnosed to have hearing loss. The challenge to determine whether the child is a candidate for cochlear implantation and then, afterwards, whether the device programming or mapping is appropriate for a young child. (34) During this process, audiologists as well as the parents would like to know the proper amount of time when improvement with the use of cochlear implants is expected. The question of when to expect the child to at least reach the speech frequency thresholds is important for the parents and the therapists so that they will know if the child’s hearing is developing as it

should or if further evaluation and therapies may be warranted to uncover and manage concomitant problems.

There are indeed many challenges facing our country in our push to take care of those with hearing impairment. Early screening, evaluation and intervention is key for hearing impaired children to development of speech and language properly but we have to take into consideration the land and the culture of the Filipinos. However, with the developments in technology and new understanding through local and international research, progress is happening to help in the promotion of education, early screening and intervention for hearing loss in the Philippines.

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Chapter II

Otoscopic and Audiologic Findings in an Ati Community in Boracay

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ABSTRACT

Background: Certain indigenous populations have been noted by the World Health Organization (WHO) to have the highest prevalence rates for chronic suppurative otitis media (CSOM), including the Australian Aborigines (28-43%), Greenlanders (2-10%) and Alaskan Eskimos (2-10%).

Objectives: To determine the prevalence of common ear problems, particularly CSOM, among the indigenous Ati or Aeta community in Bolabog, Boracay, and to determine their hearing sensitivity using screening audiometry.

Methods:
Study Design - Descriptive cross-sectional study.
Setting - A small Ati community in Bolabog, Boracay.
Population - A total of 63 adults and children underwent medical interview and otoscopy.
Additionally 24 had their hearing screened by audiometry.

Results: About a quarter of the population participated in the study, including 41 children (40% of all children) and 22 adults (18% of all adults). Forty-six percent of children and 23% of adults who were examined had previous history of ear discharge, while 22% of children and 45% of adults who were examined had history of hearing loss. Seventeen percent of children had history of hearing loss in the family. CSOM was found in 18 (43.90%) children and 8 (36.36%) adults. Impacted cerumen was found in 17.1% of children. Eleven female children underwent screening audiometry. Of these, eight had normal hearing and three had abnormal findings. Thirteen adults were also tested, five of whom were male and had normal hearing bilaterally. Four of eight female adults had abnormal hearing, of which three were unilateral.

Conclusions: The Ati population in Bolabog, Boracay belongs to a group with the highest prevalence rates for CSOM (27.0%). A bigger sample for screening audiometry is required for proper estimation of hearing loss prevalence. Both environmental and genetic factors may have increased the prevalence of CSOM in the Ati population of Boracay.

INTRODUCTION

Chronic suppurative otitis media (CSOM) is described as persistent middle ear discharge through a tympanic membrane perforation. It is a major cause of preventable hearing loss in the developing world. According to the World Health Organization (WHO), even without otoscopy, it can be assumed that any ear that continues to discharge after 2 months is already CSOM and that an otolaryngologist is able to diagnose CSOM more than 95% of the time just noting the discharge alone. The most effective means of treating CSOM involves the use of topical antiseptics or antibiotics for at least 2 weeks. In some cases intravenous antibiotics may be required along with surgery.

In 2004, the global burden of CSOM involved 65 to 330 million people, 60% of whom had significant hearing loss. CSOM caused 28,000 deaths daily. Ninety percent of CSOM cases are found in countries in South-east Asia, the Western Pacific Region and Africa and among ethnic minorities along the Pacific rim. The prevalence rate of CSOM is classified by the WHO as belonging to the following groups: lowest if < 1%; low if 1-2%; high if 2-4%; and highest if >4%. The Philippines is noted to have a high prevalence rate of 2-4% but the populations with the highest prevalence rates are in Tanzania, India, Solomon Islands, and Guam (>4). Certain indigenous groups also belong to the group with the highest prevalence of CSOM such as the Australian Aborigines (28-43%), Greenlanders (2-10%) and Alaskan Eskimos (2-10%). (1,2)

The Ati is one of several indigenous populations in the Philippines. They are dark-complexioned, small-framed, short in stature, often frizzy haired people found all over the archipelago from northeastern Luzon to the Visayan Islands and to the northeastern interior of Mindanao. (3) Our study focused on an Ati community in Bolabog in the Visayan island of Boracay. The Ati community in Bolabog, Boracay is composed of more than 200 individuals who belong to over 40 households. They live in wooden homes of approximately 4 meters by 5 meters clustered closely together with an average of 5 family members per household. They work as laborers either as carpenters and beach sweepers earning 125 to 150 pesos a day. They also receive private donations through the Sisters of Charity, St. Vincent de Paul. According to a volunteer pediatrician who routinely checks the children, the children are generally poorly nourished and underweight and their ears have never been evaluated medically.

This study aims to determine the prevalence of common ear problems,

particularly CSOM, among the Ati in Bolabog, Boracay, and to determine their hearing sensitivity using screening audiometry.

METHODS

This is a descriptive cross-sectional study. Initially, the community was organized through communication with the lead sister from the Sisters of Charity, St. Vincent de Paul. Community consent for the study was obtained.

Included in the study are those who consented to have their ears checked and tested, while excluded from the audiologic screening are those who cannot follow testing instructions and those with impacted cerumen and actively discharging ears due to ear infection.

A questionnaire was administered by trained personnel. This contained information about name, age, occupation, present health, history of ear and hearing problems and treatment that they might have undergone. Otoscopy was performed by an otolaryngologist. Appearance of the ear canal and tympanic membrane and presence of ear wax/cerumen, ear discharge and ear infection were documented. Cerumenolytics and antibiotic otic drops were given to those with impacted cerumen and suppurative otitis media, respectively. The medicines were left to the care of the Sisters of Charity who were advised on how to administer the drops and to coordinate with the local physician for patient follow-up. The hearing test was done using a screening audiometer (model MT-3A made by Nagashima Medical Instruments Company Ltd, Tokyo, Japan) in a separate room. Ambient noise was documented using a sound level meter (model TES1350A made by TES Electrical Electronic Corp., Taiwan, R.O.C.). Prevalence rate of CSOM, other ear pathologies and hearing loss were calculated.

RESULTS

Based on a local registry, the Ati population in Bolabog, Boracay is composed of 222 individuals, including 119 adults and 103 children. Sixty-three individuals participated in the study (28.38% of the entire population): 41 were children (40% of all children) and 22 adults (18% of all adults).

Otologic History

Majority of the participants were children and most were female (Table 1). Nineteen (46.3%) children and five (22.7%) adults had previous history of ear discharge, while nine (22.0%) children and ten (45.5%) adults had history of hearing loss. This makes the overall percentage of individuals with previous history of ear discharge to 38.1 and of hearing loss to 30.2. Seventeen percent of children (7 of 41) had history of hearing loss in the family.

Table 1. Number of study participants according to age group and sex.

	N Male (%)	N Female (%)	N Total (by age Group)
Children*	17(41.5)	24(58.5)	41(61.5)
Adults	7(31.8)	15(68.2)	22(34.9)
Total	24(38.1)	39(61.9)	63
*Includes participants below 18 years of age			

Table 2. Otoscopic findings by age group and sex*

Otoscopic finding	Male children	Female Children	Female Adults
Impacted cerumen	Bilateral: 3 Unilateral: 1	Bilateral: 1 Unilateral: 2	None
Otitis media with effusion	Bilateral: 0 Unilateral: 1	Bilateral: 2 Unilateral: 1	Bilateral: 0 Unilateral: 1
Perforated eardrum, dry	None	Bilateral: 0 Unilateral: 3	Bilateral: 0 Unilateral: 2
Perforated eardrum, wet	Bilateral: 3 Unilateral: 1	None	Bilateral: 1 Unilateral: 3
Active discharge	Bilateral: 2 Unilateral: 1	Bilateral: 3 Unilateral: 1	Bilateral: 0 Unilateral: 1
*Only one adult was found to have active discharge in both ears. Also one adult female was found to have otomycosis in one ear.			

Otoscopic Findings

The otoscopic findings according to age group and gender are presented in Table 2. Impacted cerumen was found in 7 (17.1%) children; otitis media with effusion in 4 (9.8%) children and 1 (4.5%) adult; perforated tympanic membrane (dry)

in 3 (7.3%) children and 2 (9.1%) adults; CSOM and active ear discharge in 11 (26.8%) children and 6 (27.3%) adults; and otomycosis in 1 (4.5%) adult. The overall prevalence of CSOM among the Ati participants is therefore 27.0%. Impacted cerumen was also common among children, with a prevalence of 17.1% (equivalent to 11.1% of entire population tested).

Using otoscopy as gold standard for diagnosing chronic otitis media, history of ear discharge showed a sensitivity of 93.8% and specificity of 80.0%.

Audiologic Findings

Audiologic screening was done in a relatively quiet room with background noise of 49 to 60 dBA, averaging 55 dBA when tested every 30 minutes. Because of the high ambient noise in the room normal hearing thresholds were determined to be 40 dB across frequencies (500-4000 Hz).

Eleven female children underwent screening audiometry. Eight children had normal hearing while 3 children had abnormal findings (1 unilateral). Five male and 8 female adults were also tested. All the males had bilaterally normal hearing. Four females had normal hearing bilaterally and 4 had abnormal hearing (3 unilateral). None of those with CSOM and actively discharging ears were tested.

Using screening audiometry as a gold standard for hearing, history taking for hearing loss alone showed a sensitivity of 20% for children and 80% for adults and a specificity of 33% for children and 80% for adults.

DISCUSSION

The Ati in Bolabog, Boracay belong to the group with the highest CSOM prevalence rates (27%) based on the WHO classification. It is much higher than the overall prevalence rate in the Philippines and is approaching the prevalence rate of the Australian Aborigines which currently has the highest rate. This could be due to observed overcrowding in the homes, poor hygiene, poor nutrition, poor access to health care (4) and possible genetic factors (5) leading to predisposition to poor immune resistance. Interestingly the Ati community is composed of a handful of families that intermarried through generations, thus, consanguinity and increased sharing of genetic material may play a role in greater predisposition to CSOM. This is further strengthened by the similar environmental background and lifestyle factors that all individuals in the community are exposed to.

Audiologic tests were not done for all participants because many of the children were too young to follow instructions. During testing most of the adult males were at work, while many of the younger children were available for testing. Also the presence of active ear discharge and failure to obtain consent precluded audiologic testing in many cases. On the other hand, the presence of drainage in the ear is highly indicative of hearing loss. Only 10.8% of the population was tested with audiometry. Thus the prevalence estimate of 29.2% (7 of 24) for documented hearing impairment may not be reflective of the entire community.

Predisposing factors such as personal history and family history of hearing loss had low sensitivity and specificity in detecting hearing loss in children, while history of hearing loss in adults is sensitive and specific. Also, history of ear discharge is highly sensitive and specific in detecting presence of ear discharge in both children and adults. This means that history alone is very useful in suspecting CSOM, particularly in adults. For children, hearing should be tested objectively (e.g. by play audiometry) to get reliable hearing sensitivity rates.

There were two children and one adult with abnormal audiometric but normal otoscopic findings. In these cases the hearing loss may be due to an inner ear problem and thus formal evaluation of these individuals is needed to determine true hearing sensitivity.

The limitation of this study includes the fact that only 28% of the entire population was screened, so that the prevalence of CSOM in children is at least 10.7% (11/103) and 5% (6/119) if only those who participated in the study had the disease and as much as 71% (73/103) in children and 86% (103/119) in adults if all of those who did not participate had the disease! In any case, they would still have a high prevalence of CSOM in this population. Also, although we can deduce that the hearing loss from CSOM would be mostly conductive in nature, we were not able to qualify the type of hearing loss in this study.

It is recommended that another visit be done on the community to screen a larger sample of the population, specially the adults. Evaluation of the otologic and audiologic profiles of other Ati communities in the country should also be performed in order to determine possible cultural/environmental and genetic factors that predispose to ear disease. It would also be important to determine the impact of CSOM and hearing loss on the Ati way of life. (6,7)

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Chapter III

Maternal Emotional Reactions towards Results of Newborn Hearing Screening: A Cross Sectional Survey

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ABSTRACT

Objectives: This study aims to determine the maternal reactions and emotions towards an initial “refer” result in the newborn hearing screening test and to determine the proportion of mothers who fully comprehended the test results of the newborn hearing screening test.

Methods: In this study, mothers of newborns with a “refer” result in the Universal Newborn Hearing Screening (UNHS) are given questionnaires which cover their understanding of the hearing screening test, the emotions they felt and attitude towards the results.

Results: Our findings showed that the UNHS program protocol was properly understood by almost all the respondent mothers. Of the emotions listed from the questionnaire, being “worried” was the most persistently felt emotion.

Conclusion: It is important that the results of the newborn hearing screening test be properly understood by the mothers. Mothers who experienced negative emotions brought about by the hearing screening test still believed that the newborn hearing screening test was important, were glad that their child underwent the newborn hearing screening test and will request it for their future offspring.

INTRODUCTION

Worldwide, hearing loss occurs in one to three of 1000 live births annually. (1) In the Philippines, bilateral permanent congenital hearing loss occurs at 1.4 per 1000 livebirths. (2) Without early detection programs, hearing impairment is detected on the average at 2 ½ years of age. (3) The critical period of speech and language development is between birth and 3 years of age. (4) Infants with severe to profound bilateral hearing loss are unable to develop normal speech and language without timely intervention. This is also the time wherein important infant-parent attachment develops. (5) So that a “refer” or “fail” result may also be a source of frustration for the family, which in turn, may interfere with infant-parent attachment.

Early detection and intervention are the two key elements that will give the infant the best chance for normal speech and language development. (6) Because of this, a number of countries have legislated universal newborn hearing screening programs for early detection of hearing loss and have provided early rehabilitative interventions.

The private tertiary hospital where this study was done has a universal newborn hearing screening (UNHS) program in place wherein all healthy newborns are screened. They use otoacoustic emissions (OAE) as a screening tool for the detection of hearing loss because the test is easy to perform and takes only a few minutes to finish. When choosing a screening tool, one must consider that it should be cost effective, easy to operate, fast and efficient. The gold standard today for detecting hearing loss is the diagnostic auditory brainstem response test (ABR). However, its cost, long testing time and need for a trained technician and interpreter make it unattractive as an initial screening tool.

Results of the hearing screening test would be either a “pass” or “refer”. A “pass” result would mean that the child has relatively normal hearing. A “refer” result however, does not immediately mean that hearing loss is present. It denotes that further testing and evaluation is required. There are factors such as vernix, collapsed ear canals and transient middle ear fluid which may lead to false positive results and thus false “refer” rates. In the U.S., the percentage of newborns who do not pass the hearing screening test prior to discharge range from 1-34%. (7) In our institution, the average refer rate is 11.37%. (8) In this study, we follow a protocol wherein the parent of the child with a “refer” result is asked to follow up with a pediatric otolaryngologist after 1 month for a rescreen. Those who still have a “refer” result after the rescreen are further tested with a diagnostic ABR.

UNHS programs have led to early detection and intervention for hearing loss. Because of this, the effects of hearing loss such as delayed development of speech and language, psychosocial issues and, later on, economic dependency may be prevented. As previously mentioned, the percentage of newborns who “refer” after the initial hearing screening test is quite high, requiring many of them to follow up after one month. When they are rescreened on an outpatient basis, only about <1% according to Spivak would require further audiologic evaluation. This has led the authors to raise the issue of the possible negative emotional impact of a “refer” result on mothers and/or primary caregivers. Does a “refer” result in the newborn hearing screening affect the mother-child relationship and will it be a cause of any anxiety on the part of the mother? Will these negative emotions lead mothers to adversely view newborn hearing screening? Studies have shown that in general, parents view the process of newborn hearing screening in a positive light, and that parents of children with confirmed hearing loss show more frustration and anger. (9,10) However, parents of children who failed the screening 2 times and are in the end found to have normal hearing (false positives) may sometimes have lingering anxiety years after the tests. (11)

The objective of this paper is to determine the maternal reactions and emotions of mothers towards an initial “refer” result in the newborn hearing screening in our institution’s outpatient setting using a self-administered questionnaire and focused discussion, to describe the proportion of mothers who fully comprehended the test results of the newborn hearing screening test and to determine the maternal feelings about their children upon disclosure of a “refer” result in the newborn hearing screening.

MATERIALS AND METHODS

This was a cross-sectional analytic study done at the nursery of a tertiary private hospital which has adopted a UNHS Program for all newborns. Otoacoustic measurements were all done in the nursery using an automated machine (Echocheck manufactured by Otodynamics). The hearing screening test was done by a trained midwife. Included in the study were all mothers whose newborns had a “refer” result from initial OAE screening from August 15 to September 15, 2004**.** These newborns were otherwise healthy, full term with no risk factors for hearing loss. The mothers were given the questionnaire (Appendix A) after they were informed of the “refer”

result and advised by the nurse prior to discharge. These are the major points advised by the nurse: 1) The baby “referred” on the newborn hearing screening test, 2) It means that they need to have the test repeated after a month, 3) It may be just something temporary but it is better to have it rechecked, and 4) Many babies pass the rescreen. All the questionnaires were gathered and tabulated. All the mothers were college graduates who are fluent in English. Informed consent was obtained for this study. The questionnaires did not include any names and other identifying personal information from the respondents.

The Research Questionnaire

The questionnaire consisted of three parts. The first part tested the knowledge of the mother on the hearing screening test. The second part consisted of listed emotions adopted from de Uzcategiu and Yoshiga-Itano’s study on emotions reported by parents after their baby failed the hearing screening test. The mothers were asked to rate each emotion from zero (0) to three (3). Zero being not felt at all and 3 being strongly felt. The third part of the questionnaire tested the mother’s attitude on future care of the baby and the hearing screening test itself.

Focused Interview

We determined the appropriateness of the questionnaire by using a focused discussion. Selected mothers were asked a set of questions regarding their comprehension of the emotions listed. Each mother from the seven selected was asked to define what each emotion in her own words. They were all each asked to give their own reactions in their own words. (Appendices A and B)

RESULTS

1. Comprehension of the Newborn Hearing Screening Test

Focused Discussion Data

A total of forty (40) mothers aged 25-35 years old, were enrolled in this study. When the mothers were asked if the meaning of the results were fully understood, the following common themes were revealed:

- I understood that a “refer” simply means re-testing to confirm the findings”
- Only a fraction or percentage of the children with “refer” results are actually deaf”

- I was reassured and made aware of what the results really meant by the technician".

Majority of the mothers (37 out of 40) knew what the term "refer" meant while one did not and another one wasn't sure. Thirty-six (36) respondents understood what the results meant while 2 did not and another 2 weren't sure.

2. Maternal Emotions after the Disclosure of the Test Results

Table 1 shows the maternal emotions after the disclosure of the test results with feelings worried or anxious being most persistently felt by the respondent mothers. To qualify these emotions our focus discussion data was subjected to content analysis.

Focused Discussion Data Content Analysis on Maternal Emotions

- *Confused* was defined as uncertainty of what will happen; not fully comprehending the results, and not knowing what to do.
- *worried/anxious* meant apprehensions of the hearing test, anticipatory fear of the hearing disability, pervasive thinking about the possibility of having a deaf child.
- *Powerless or helpless* meant unable to help, "there is nothing that I could do", "to wait is all that I can do", "if there was something that I could do."
- *Shocked* meant being surprised that my baby will be subjected again to another testing, "disbelief that there was something wrong with my child."
- *Guilty* was defined as being accountable; in retrospect that there was pre-pregnancy event that could have led to this abnormal result.
- *Upset* meant being unhappy, disappointed but not depressed.
- *Stressed* in this study meant being "pressured", "pervasive thinking" but not hassled.

Perceptions and actions taken by mothers upon disclosure of a "refer" result

Thirty-six mothers (36) felt that their children were "different" now that they knew that their child had to be brought back for rescreening, while four (4) felt otherwise. Majority (39) of our mothers informed us that they would probably treat their children differently. Most mothers intended to pay more attention to her child's ability to hear. One suggested to do self-investigation whether her child could really react to sounds by repetitively "clapping", and one mother intended to continuously observe her child's reaction to various sound stimuli in the home.

Table 1. Maternal Emotions after Disclosure of Newborn Hearing Screening Test

Emotions	Not felt at all		Minimally felt but dissipated		Persistently felt even during this consult		Strongly felt	
Angry	30	75.0%	6	15.0%	2	5.0%	2	5.0%
Confused	19	47.5%	13	32.5%	4	10.0%	4	10.0%
Worried/Anxious	9	22.5%	7	17.5%	10	25.0%	14	35.0%
Sad/Depressed	22	55.0%	7	17.5%	5	12.5%	6	15.0%
Powerless/Helpless	27	67.5%	8	20.0%	3	7.5%	2	5.0%
Shocked	24	60.0%	10	25.0%	4	10.0%	2	5.0%
Upset	25	62.5%	7	17.5%	5	12.5%	3	7.5%
Stressed	30	75.0%	5	12.5%	4	10.0%	1	2.5%
Quilty	28	70.0%	6	15.0%	1	2.5%	5	12.5%

Perceptions towards the newborn hearing screening

All mothers affirmed that they were glad to have their children tested for hearing. Furthermore, all of them wanted to have their future children tested. They all agreed that the newborn screening for hearing be recommended to other parents as well.

DISCUSSION

The hearing screening test procedure and results, particularly what a “refer” result meant was understood by almost all respondents. Of the negative emotions felt by the mothers, being worried was the most persistently felt. It would be good to keep in mind that these emotions were felt even after the test procedure and what a “refer” means was explained to them.

Assessing the emotions felt by the mothers as objectively as possible was done using an appropriate questionnaire (Appendix A). The emotions listed in the questionnaire were adopted from one used by de Uzcategiu and Yoshiga-Itano.9 In the said study, the investigators gathered all emotions listed by mothers who failed in the newborn hearing screening. These emotions were then incorporated into the research questionnaire used in this study. Added to this, the authors included in the knowledge of the mothers about what the test was for and what the result meant and the attitudes taken after a “refer” result was disclosed to them.

The appropriateness of the questionnaire was determined using a focused interview of selected mothers who had a “refer” result. This interview was conducted using uniform questions as listed in Appendix B. From this focused discussion, the respondents were asked if they understood what a “refer” result meant, define in their own comprehension the emotions listed in the questionnaire and the change in practices after the result was disclosed. From this focused discussion, the authors decided that the questionnaire was appropriate and reflected a good comprehension of the mothers since all admitted that they understood the questions and could clearly define these emotions the way the investigators had in mind.

The impact of the hearing screening test to the mothers could be generally implicated as a cause of worry. However, the questionnaire was given shortly after the disclosure of the result of the hearing screening test. It would have been better if we found out if these emotions waned after discharge or shortly prior to the repeat hearing screening testing. By this time, the mother may have observed the baby and

the appearance of a normal healthy baby may be reassuring, thus giving more security to the mother.

The understanding of the hearing screening test by a majority of the respondents was probably a factor why negative emotions were not overblown. Those who said that they did not understand the hearing screening test, all had persistent negative emotions as gathered from the questionnaire. Thus, communication between the examiner and mother is important for reassurance.
Another majority of mothers said that they would treat their child differently, meaning, they would pay more attention to their child and try to observe them if they have any response to sound, as suggested by the correspondents of the focused discussion.

All mothers felt that the hearing screening was a good idea, all were glad that their child was tested for hearing and result caused some of the mothers to worry, and yet all mothers agreed that newborn hearing screening is important. If ever there were some negative emotions or confusion involved after an initial “refer” result, it would be noteworthy that all mothers think that this test is necessary.

The authors believe that full comprehension of the test and making sure that a “refer” result does not equate that their child is deaf is an important factor to prevent unnecessary worry or anxiety. From the focused discussion, there was reassurance that only a fraction of those tested as “refer” would be truly deaf and that this would be confirmed on repeat testing. Nevertheless, the strongly felt negative emotion of anxiety should be further investigated and steps taken to make sure that the parents do not worry excessively because this may affect the success of the UNHS program.
We recommend that in similar studies that the questionnaire be re-administered after a few weeks to assess if the mothers’ feelings change over time.

CONCLUSIONS

The NBHS program was properly understood by almost all respondent mothers. Of the emotions listed from the questionnaire, worried was the most persistently felt emotion. There is a need to further investigate the reason for the strong emotion of anxiety in some of the mothers. However, despite some negative emotions felt by the mothers, all thought that the NBHS was a good idea, were glad that their child underwent the screening and will request it for their future offspring.

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APPENDIX A

Newborn Hearing Screening Questionnaire

	Yes	No	Not fully/unsure
Was the meaning of “refer” explained to you when the newborn hearing screening test was done to your child?			
Did you understand the result of the newborn hearing screening?			

Upon knowing that your child had a “refer” result, which of the following emotions did you feel? Please rate from 0 to 3.
0 - emotion described below was not felt at all
1 - emotion described below was felt a little initially but subsided before this follow up
2 - emotion described below was felt and remained till this follow up
3 - emotion described below being strongly felt.

	0	1	2	3
Angry				
Confused				
Worried/Anxious				
Sad/Depressed				
Powerless/ Helpless				
Shocked				
Upset				
Stressed				
Guilty				

	Yes	No
Did you feel that your child was different from other children?		
Did you give more care or attention to your child because he/she had a “refer” result, as compared to if he/she had a pass result?		
Were you glad that your child underwent the newborn hearing screening?		
Do you think the newborn hearing screening is a good idea?		
Would consent to a newborn hearing screening on your future siblings?		
Would you recommend the newborn hearing screening to other parents?		

APPENDIX B

I: Knowledge
Was the meaning of a refer result explained to you?
Was it explained to you that a refer result did not mean that her child truly had hearing loss and that only a small percentage of those with a refer result truly is hearing impaired?
II. Attitude
Can you define in your own words the meaning of the emotions in the questionnaire?
Did you have any concerns on the results of the hearing test?
III. Change in practice
Would you treat your child differently because of the result of the hearing test?
Can you give examples of change in the care if any?

Chapter IV

Initial Otoacoustic Emission Hearing Screening Results in Newborns with Patent Ear Canals, Vernix Caseosa and Collapsed Ear Canals

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ABSTRACT

Objectives: This study determined the initial otoacoustic emission (OAE) hearing screening results of newborns with collapsed ear canals and vernix caseosa in the ear canal and compared these to ears that were patent.

Methods: Two hundred term newborns (400 ears) with normal APGAR scores, birth weight, maternal and gestational history, who were born between August 2013 to October 2013 and who had OAE hearing screening test done by trained midwives were included in this study. All of them underwent otoscopy after the OAE hearing screening test was done to determine patency of the ear canal and presence of vernix caseosa. The examining physician was blinded to the OAE results. Comparison between the OAE results and the otoscopic findings were done.

Results: Four hundred ears were included in the study. Two hundred and fifty one ears (62.8%) had vernix caseosa and 42 ears (10.5%) had collapsed ear canal. The overall initial OAE hearing screening test pass rate of the newborns tested was 69.5%. The initial OAE hearing screening test pass rate of newborns those with ear canal vernix caseosa and collapsed ear canal were, 72.1% and 47.6%, respectively. Patent ears were found in 107 (26.7%) with a pass rate of 71.9%.

Conclusion: The pass rate of ears with vernix caseosa and collapsed ear canal were 72.1% and 47.6%, respectively. There was no significant difference between the OAE hearing screening test pass rates of ears with patent canal and ears that were collapsed and/or had vernix caseosa. However, there was a statistically significant difference in pass rates between patent ear canals and collapsed ear canals – with the patent ear canal more likely to pass the OAE hearing screening test than collapsed canals.

INTRODUCTION

Screening the hearing of newborn babies for hearing loss is now the standard of care in many countries around the world. This has led to the early detection of and intervention for hearing loss to minimize the possible negative effects of delayed management; e.g. speech and language delay, social isolation and academic difficulties. The otoacoustic emission (OAE) devices are commonly used for hearing screening because they are portable, quick, easy to use and affordable.

In a tertiary private hospital in Manila, an average of 2,100-2,500 babies are born every year. Ninety six percent of them undergo newborn hearing screening with the OAE newborn hearing screening device. In an unpublished study by Abratique, Batayola and Reyes-Quintos in the same institution, an average of 11.3% of the newborns fail their initial OAE testing. (1) An acceptable initial refer rate is 10%. (2) Some studies have shown that the presence of vernix caseosa and collapsed ear canals lead to initial high refer rates.

The Joint Commission on Infant Hearing (JCIH) in 2007 recommended that all infants should receive hearing screening by 1 month of age, that hearing loss should be identified before three months of age, and that those identified should receive intervention by six months of age. (3) A number of studies have shown that significantly better language development is associated with early identification of hearing loss, followed by comprehensive intervention before six months of age. (4) Screening for hearing loss in the newborn period and early intervention has been known to improve the chances that the child diagnosed to have hearing loss will not have lifelong delays in speech and language as well as other problems related to hearing loss. (5)

Devices such as the OAE hearing screening test and the automated auditory brainstem response test (AABR) have been used for hearing screening. OAEs are sounds produced by the outer haircells in response to acoustic signals. These biological sounds are natural by-products of energetic biological processes and their existence provides us with a valuable information on the process of hearing, allowing us to detect the first signs of hearing impairment even in newborn babies. (6) This test is done by placing a probe in the baby's ear that emits acoustic signals that in turn stimulates the outer hair cells in the cochlea. If hair cells in the inner ear are present, it will produce sounds that are then picked up by the OAE microphone.

Many factors have been described to affect the acoustic pattern in the external ear during sound transmission. One of the hypothesized explanations for newborns

who fail their initial OAE is due to the presence of vernix caseosa on their external auditory canal or a collapsed canal.(7)

Vernix caseosa, also known as vernix, is the waxy or cheese-like white substance found coating the skin of newborn human babies. While a collapsed ear canal is defined as the inability to visualize the tympanic membrane even with proper maneuvering because the walls of the ear canal are soft and caved in.

Otoscopy is a way of examining the external auditory canal and the tympanic membrane. The examination is performed by gently pulling the outer part of the ear downwards in order to straighten the external auditory canal and inserting a device that illuminates and magnifies the area. This may be more difficult to do in newborns because of their small and compliant ears. Many newborn hearing screening protocols do not involve or emphasize the use of otoscopy prior to initial newborn hearing screening. The individuals performing the screening test may be volunteers, midwives and nurses who may not have the expertise of using an otoscope.

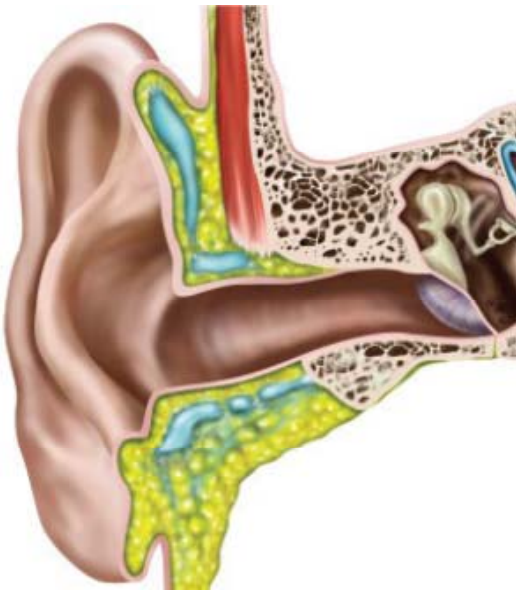
If vernix caseosa and collapsed ear canals greatly influence the result of the newborn OAE hearing screening test, then an otoscopic examination by trained personnel prior to hearing screening should be emphasized as part of the newborn hearing screening protocol. Thus, deferring the OAE hearing screening test for some days until the vernix casoesa has dried or the ear canal has sufficiently stiffened (for those with collapsed ear canals) might then be done.

MATERIALS AND METHODS

This is a prospective, cross-sectional study. Included in the study were all term newborns with APGAR score of at least 9,9, with normal maternal history, from the nursery of a private tertiary hospital, born from August 2013 to October 2013. Routine OAE hearing screening test was performed within 24 hours after which otoscopic examination to visualize the patency of their ear canal was done. Results were then recorded and tabulated. No urgent intervention was needed for those with vernix caseosa or collapsing ear canals. Excluded from the study were those with microtia, known ear infection by history and physical examination, congenital or syndromic defects, and a family history of hearing loss.

The otoscopic examination was performed using a Welch Allyn otoscope with a size 2 speculum by a single observer “blinded” to the OAE hearing screening test results. The results were recorded as being patent, with vernix caseosa (complete or

partial) or collapsed ear canal. Patent ear canal was defined as the ability to view the entire tympanic membrane (Figure 1). Partial vernix caseosa was the ability to view some parts but not the entire tympanic membrane (Figure 2). And complete vernix caseosa was defined as the inability to view the tympanic membrane at all (Figure 3). A collapsed ear canal was defined as a cavedin canal walls wherein there was inability to visualize the tympanic membrane (Figure 4).



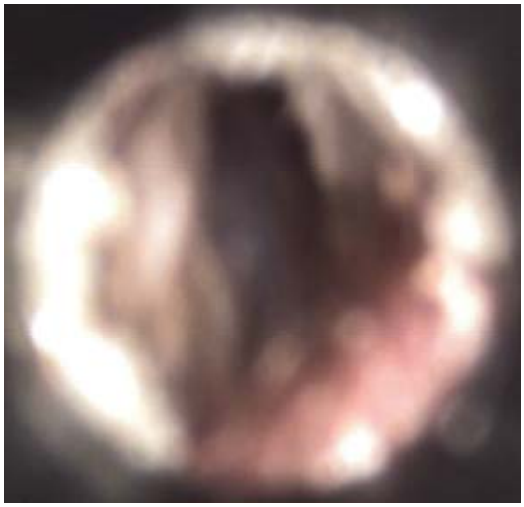
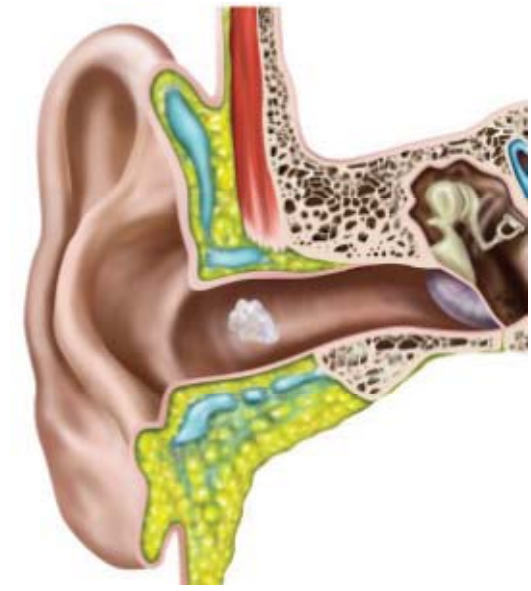


Figure 1. Patent Ear Canal



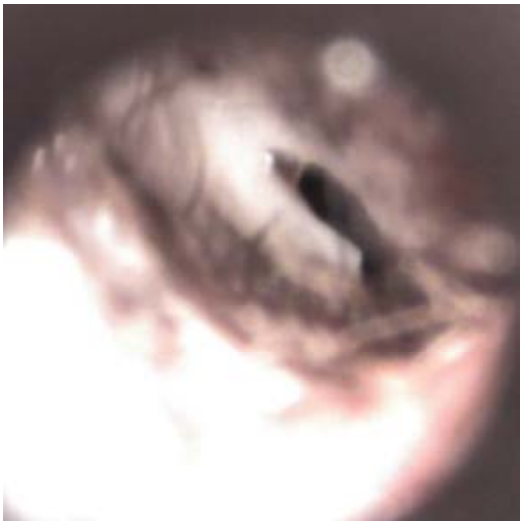


Figure 2. Partial obstruction with vernix caseosa

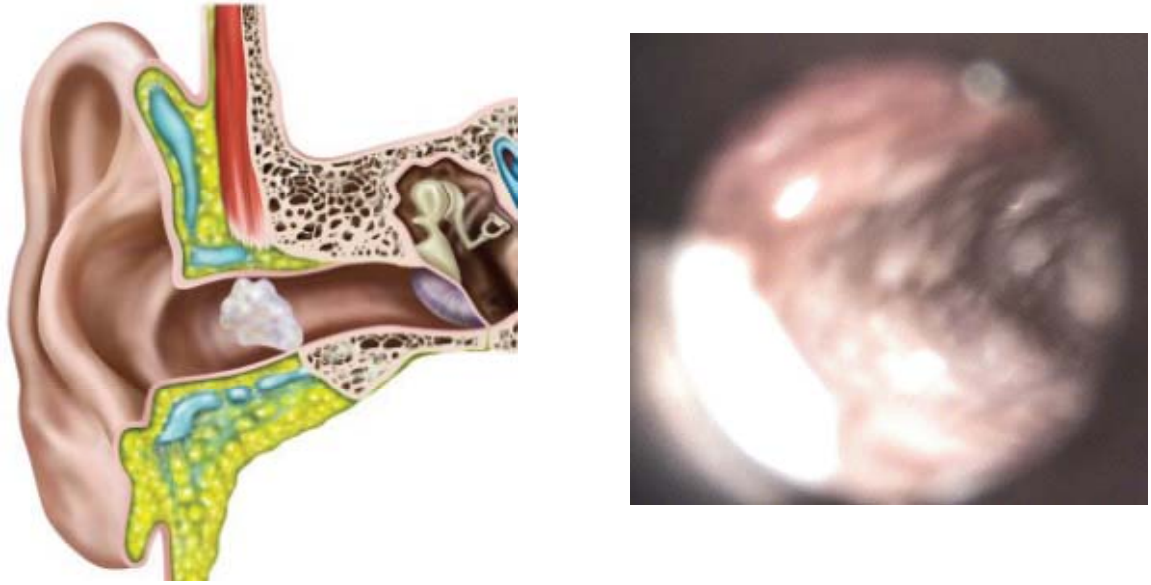


Figure 3. Completely obstructed canal with vernix caseosa.

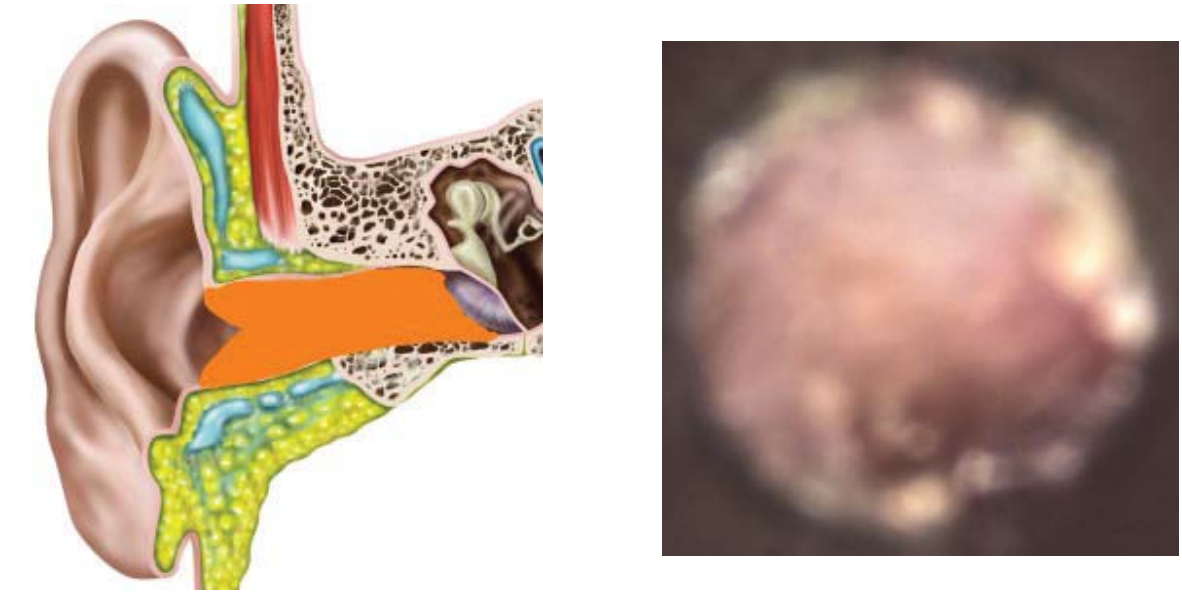


Figure 4. Collapsed ear canal.

The OAE testing was done using Otoport Lite by Otodynamics Ltd. by trained midwives in a quiet room at the newborn nursery. All results were recorded as "pass" or "fail" in a logbook. The otoscopic findings were compared to their corresponding

OAE hearing screening test result and analyzed statistically. Those who “fail” the screening test are told to return to the Hearing and Dizziness Center for a rescreen after one month.

A Chi-square test and Fisher’s exact test were done to determine if there were significant differences between 1) ears that had vernix caseosa and/or collapsed ear canal and those ears that are patent, 2) ears with vernix caseosa and ears that are patent and 3) collapsed ear canals and ear canals that are patent.

This study was approved by the Institutional Review Board (ethical and technical review) of the hospital. All parents of the newborns were informed regarding this study and informed consent was secured. Newborn hearing screening is a standard procedure in the hospital. Universal Newborn Hearing Screening is also mandated by law (RA 9709).

RESULTS

A total of 200 well newborns comprising of 107 males and 93 females at 2-24 hours of birth were tested accounting for 400 ears. All babies were term at 36-39 weeks and with normal birthweights of 2,540g-3,975g. Patent ears were found in 107 (26.7%). Vernix caseosa was found in 251 (62.8%) ears and collapsed ear canals in 42 (10.5%). Of the 251 with vernix caseosa in the ear canal, partial vernix caseosa build-up was found in 244 (97.2%) while 7 had complete vernix caseosa obstructing their canals. Out of 400 ears 278 (69.5%) “passed” the OAE hearing screening test while 122 (30.5%) ears did not. Out of the 107 patent ears, 77 (71.9%) “passed” the OAE hearing screening test. In general, 181 (72.1%) of the ears with vernix caseosa “passed” the OAE screening test. Of the 244 ears with partial vernix caseosa, 174 (71.3%) of them “passed” the OAE hearing screening test and out of the 7 with completely obstructed ears due to vernix caseosa, all “passed” the OAE. Twenty (47.6%) of the collapsed ears “passed” the OAE hearing screening test (Table 1).

There was no significant difference between ears that were patent and ears that had vernix caseosa and/or collapsed ear canals (Table 2). When the ear canals with vernix caseosa was analyzed separately from collapsed ear canals and compared to patent ear canals, there was no statistical significant difference in pass rates between ears with patent ear canals and ear canals with vernix caseosa but there was a statistically significant difference in pass rates between ears with patent ear canals and collapsed ear canal (Table 3). A patent ear canal would more likely to pass than

collapsed ear canals (Table 4). Only 20 (16.4%) of the newborns returned for re-screen.

Table 1. Ear canal condition and initial OAE hearing screening results

Ear Canal Condition	OAE Results				Total	
	Pass.	%	Fail.	%	No.	%
Patent	77	19.2%	30	7.5%	107	26.7%
Partial Vernix	174	43.5%	70	17.5%	244	61.0%
Complete vernix	7	1.8%	0	0.0%	7	1.8%
Collapsed	20	5.0%	22	5.5%	42	10.5%
Total	278	69.5%	122	30.5%	400	100.0%

Table 2. Chi-Square Test and Fisher's Test Computations of OAE results of patent ear canals and ear canals with vernix caseosa and/or were collapsed

Ear Canal Condition		OAE Results		
		Pass	Fail	Total
Patent		77	30	107
With vernix caseosa and/or collapsed		201	92	293
Total		278	122	400
Chi-square test	Not significant at $P = 0.52$			
Fischer's exact test	Not significant at $P = 0.54$			

Table 3. Chi-Square Test and Fisher's Test Computations of OAE results of patent ear canals and ear canals with vernix caseosa

Ear Canal Condition		OAE Results		
		Pass	Fail	Total
Patent		77	30	107
With vernix caseosa		181	70	251
Total		258	100	358
Chi-square test	Not significant at $P = 0.98$			
Fischer's exact test	Not significant at $P = 1.00$			

Table 4. Chi-Square Test and Fisher's Test Computations of OAE results of patent ear canals and collapsed ear canals

Ear Canal Condition		OAE Results		
		Pass	Fail	Total
Patent		77	30	107
Collapsed		20	22	42
Total		97	52	149
Chi-square test	Not significant at $P = 0.005$			
Fischer's exact test	Not significant at $P = 0.007$			

DISCUSSION

The presence of cerumen or vernix in the canal, middle ear effusion and other causes of transient conduction hearing loss have been shown by several studies to interfere with OAE hearing screening test procedures and incur false positive results. Collapsed ear canals, however, have not been studied as extensively. Ear canal debris and middle ear effusion are commonly found in newborn ears especially during the first few days after birth, which may produce mild, temporary conductive hearing loss and result in a "fail" result in the screening program. (8)

Studies have shown that vernix caseosa and collapsed ear canals are factors that can lead to a “fail” result when the child is tested < 48 hours after birth especially when using the OAE device. (9) Some institutions have thus kept their fail rates low by delaying the performance of their screening test. Furthermore, cleaning the ear canal has increased the pass rates of OAE hearing screening test from 79.0% to 84.0% and 76.0% to 91.0%. (4,10) In our study, the newborns were tested within 24 hours and the overall initial pass rate was 69.5%. This is comparable to the 70.0% initial pass rate of newborns tested soon after birth in a study by Olsha M, Newmark M, Bresloff I, et al. (11) This low initial pass rate and concomitantly high fail rate may also be due to the fact that the babies in the study were tested and examined by otoscopy only several hours apart and that those who did not “pass” have a chance to be tested again the next day if they are not yet cleared for discharge from the hospital.

However, developing countries are known for discharging newborns from the hospital ≤ 24 hours.(9) This is because of the increased cost of staying in a hospital, the lack of adequate insurance coverage and need for bed space. It may be difficult to delay discharging these newborns in order to be able to perform newborn hearing screening at a later date.

Compared to other studies, our results show that there are no statistically significant differences in the pass rates among newborns with vernix caseosa alone and those with patent ear canals. Thus the high fail initial rate may be due to other factors other than vernix caseosa. Besides collapsed ear canals, transient middle ear effusion and generally smaller ear canals of Asian newborns may add to the initial fail rate. A study by Couto and Varvallo also did not observe a statistically significant association between the otoacoustic emission screening test results and whether or not the external ear was occluded. (12)

Currently, routine otoscopy on newborns is not performed prior to their OAE hearing screening test despite findings that diagnosis and removal of vernix caseosa increases the pass rates and thus removing the need to return for rescreening within a month after the “fail” screen. This may be because performing otoscopy in all newborns would be personnel intensive and time consuming. Otoscopy is usually reserved for those who return for a rescreen.

The pass rates for those with vernix caseosa and those with collapsed ear canals were 72.1% and 47.6%, respectively. Surprisingly, those with completely occluded ear canals due to vernix caseosa had a 100% pass rate. This may be because it is difficult to predict the amount, thickness and density of vernix caseosa present in the ear canal before it affects the transmission of sound from the OAE probe tip. On the other hand, the collapsed ear canal, since it is somehow malleable, may open during manipulation of the OAE probe tip, allowing an opening to be created for the sounds from the screening device to reach and penetrate through the previously closed off ear canal and thus show an otoacoustic emission and “pass” during the test. Therefore, adding otoscopy and removal of vernix caseosa prior to newborn hearing screening may be useful but not practical. Delaying the initial testing to ≥ 48 hours has been proven to increase the pass rates and is a practical step that our institution has already instituted in order to improve initial pass rates.

The low follow-up rate for rescreen is a very important matter to discuss. To encourage returning for rescreen, the newborns were already scheduled for rescreening prior to discharge from the hospital and their pediatricians routinely inform their patients once they follow-up in a month. The reason for the failure to come for a rescreen needs to be determined so that steps may be taken to address this problem. An unpublished study done in another private hospital showed that the reason cited by 37.4% of parents who did not bring their baby back for rescreen was because the baby was perceived by the parents to have normal hearing. Although the nurses were taught the proper way to inform the parents of the results, the way the message was imparted and how the parents may have wrongly perceived the message is possible. This has to be investigated.

CONCLUSION

This study shows that there is a 69.5% overall OAE hearing screening test pass rates on newborns in our institution. Collectively, the pass rates for ear canals that

were collapsed and/or had vernix caseosa was 68.6%. Separately, the pass rates for those with vernix caseosa and those with collapsed ear canals were 72.1% and 47.6%, respectively. There was no statistically significant difference in pass rates between patent ear canals and ear canals with that are collapsed and/or had vernix caseosa. There was no statistical significant difference in pass rates between patent ear canal and ears with vernix caseosa. However, there is statistically significant difference in pass rates between patent ear canals and collapsed ear canals – with patent ear canals more likely to pass newborn hearing screening than collapsed ear canals. Clinically, it may not be expedient to perform otoscopy on all newborns prior to newborn hearing screening. This step may be time-consuming and personnel intensive given that only 10.5% of newborns in this study have collapsed ear canals wherein about half (47.6%) passed the hearing screening test. Additionally, they may subsequently pass their repeat hearing screening on follow-up after about a month which may give time for their ears to open up. Thus, this means that a preliminary otoscopic examination may not be necessary before initial OAE screening.

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Chapter V

Comparative Study of the Auditory Steady-State Response (ASSR) and Click Auditory Brainstem-Evoked Response (click ABR) Thresholds among Filipino Infants and Young Children

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** both first authors contributed equally*

ABSTRACT

Objective: To compare the results of auditory steady-state response (ASSR) and click auditory brainstem response (click ABR) among infants and young children tested at the Ear Unit of a Tertiary General Hospital.

Methods:
Design: Cross-sectional Study
Setting: Tertiary General Hospital

Population: Within-subject comparisons of click auditory brainstem response (click ABR) thresholds and auditory steady-state response (ASSR) thresholds among 55 infants and young children, 2 months to 35 months of age referred to the Ear Unit for electrophysiologic hearing assessment.

Results: Click ABR showed strong positive correlation to all frequencies and averages of ASSR. Highest correlation was noted with the average of 1-4 kHz ASSR results with Pearson r = 0.89 (Spearman r=0.80), the average of 2-4 kHz had strong positive correlation r = 0.88 (0.79). Correlation was consistently strong through all ASSR frequencies (0.5 kHz at r=0.86 (0.74), 1 kHz at r=0.88 (0.78), 2 kHz at r=0. 87 (0.79), 4 kHz at r=0.85 (0.76)). Average differences of click ABR and ASSR thresholds were 8.2 ± 12.9dB at 0.5 kHz, 8.6 ± 12.6dB at 1 kHz, 5.3 ± 11.8dB at 2 kHz and 7.8 ± 13.4dB at 4 kHz. Among patients with no demonstrable waveforms by click ABR with maximal click stimulus, a large percentage presented with ASSR thresholds. Of these, 80.5% (33 of 41) had measurable results at 0.5 kHz with an average of 107.3 ± 11.1dB, 85.4% (35 of 41) at 1 kHz with an average of 110.5 ± 11.8dB, 73.2% (30 of 41) at 2 kHz with an average of 111.2 ±11.1dB and 63.4% (26 of 41) at 4 kHz with average of 112.2 ± 8.21dB. Auditory steady-state response results were comparable to auditory brainstem response results in normal to severe hearing loss and provided additional information necessary for complete audiologic assessment especially among patients with severe to profound hearing loss wherein click ABR showed no responses. Up to 85.4% of patients that would have been noted to have no waveforms by click ABR still demonstrated measurable thresholds by ASSR.

Conclusion: Our study suggests that ASSR may be the best available tool for assessing children with severe to profound hearing loss, and is a comparably effective tool in overall hearing assessment for patients requiring electrophysiological testing. The advantages of ASSR over click ABR include: 1) detection of frequency-specific thresholds and; 2) the detection of hearing loss thresholds beyond the limits of click ABR.

Hearing screening has been employed in the Philippines for more than a decade with recent efforts to promote universal newborn hearing screening. Despite detrimental effects of childhood hearing loss documented among Filipino children, (1) we still lack widespread use of newborn and infant hearing screening programs. Advocacy and active promotion have resulted in increasing popularity of the use of otoacoustic emissions (OAE) and auditory brainstem-evoked response (ABR). However, auditory steady-state response (ASSR) has only recently become available in the Philippines despite its well established use. For instance, it has been incorporated in hearing screening programs in the United Kingdom since 2007. (2)

Auditory Steady-State Response (ASSR) and Auditory Brainstem Response (ABR) are both electrophysiologic tests with very similar basic principles. The EEG waveforms generated from the auditory stimulus are assumed to correspond to certain portions of the auditory brainstem pathway. The presence or absence of these waveforms in response to a stimulus determines the estimated threshold of the patient for ABR.

Click ABR is still the most commonly used electrophysiologic test to evaluate the auditory pathway's integrity among infants and young children. Click stimuli used for ABR are broad frequency over the spectrum 1k-4 kHz. (3) Tone-burst ABR has been shown to have good correlation for low frequency range of 250 Hz. (4) Tone-burst ABR and ASSR have frequency specific stimuli and have been shown to have accurate correlation. (5) Tone-burst ABR's need for new instrumentation and technical expertise has limited it's application locally.

Moreover, ABR requires experience in waveform analysis and can be prone to reader error. ASSR employs an objective, sophisticated, statistics-based mathematical detection algorithm to detect and define hearing thresholds. This objectivity provides an added advantage over ABR.

Several studies have confirmed the correlation of ABR to ASSR results, (5,6,7,8,9) as well as correlation to pure-tone thresholds. (10,11,12) Hearing loss

beyond 95dB are beyond the limits for ABR stimulus presentation. Compared to the limitation of click ABR, ASSR signal intensity can be as high as 120 dB.

Despite the acceptance of ASSR as a diagnostic test in the evaluation of hearing loss, there has been no local investigation on ASSR in Filipino hearing-impaired children. The results of this study can be used to estimate thresholds in cases where ABR flat waves have been recorded. These will provide information that may be important for counseling parents and clinicians regarding the rationale for hearing aid fitting and its settings in patients who would have been deprived of knowing the extent of residual hearing in areas where as yet no ASSR services are available.

The objectives of this study are 1) to compare the results of ASSR and click ABR among Filipino infants and young children tested at the Ear Unit in the Philippine General Hospital; 2) to correlate the click ABR and ASSR and; 3) to describe the ASSR results among patients with nonreactive waveforms on maximal click ABR stimulus.

METHODS

Subjects

All patients who failed a hearing screening and who were referred to the Ear Unit of the Philippine General Hospital for electrophysiologic testing were considered and informed consent was obtained. Excluded were patients who could not undergo electrophysiological testing either due to external ear abnormalities, inability to be fit with electrodes/ear inserts or undergo sedation. Fifty five patients were included, aged 2 months to 35 months. The majority of patients referred could not undergo behavioral testing.

Hearing assessment was conducted in a soundproof room. Electrophysiological audiologic assessment was performed in the same session and administered by the same tester. Patients were tested under sedation using chloral hydrate or in natural sleep state when consent for sedation was not given.

ABR stimulation and recording

Click ABRs were recorded using the Bio-logic MASTER system (Biologic Systems Corporation, Mundelein, IL). Click ABRs were measured with electrodes affixed to the vertex and to the mastoid processes. Either the forehead or the

contralateral mastoid process served as ground. Electrode impedances never exceeded 3000 mΩ.

Responses were measured to 100 ms rarefaction clicks presented monaurally. ABRs were obtained initially at 30 dB or 70dB depending on the clinical presentation of the patient. One thousand twenty four stimulus presentations were included in each average response which was replicated at least once. Waveforms recorded with artifacts of movement were re-sampled. A 10 dB increment or decrement was used to determine the threshold. The threshold was determined at the lowest level at which an ABR Wave V was present as determined by visual inspection of the waveforms displayed on the computer screen.

ASSR stimulation and recording

ASSR testing immediately followed the click ABR for patients who were still asleep or sedated. The same surface electrodes used in ABR were also used for ASSR, which was measured using a predefined program of the same Bio-logic MASTER apparatus. Patients were tested at 10dB below previously determined ABR thresholds when available. Increments/decrements of 10 dB were used depending on the required number of sweeps per frequency and threshold. Patients tested for thresholds of 80dB and above were tested monaurally and one frequency at a time. The MASTER system takes into account the variance of the noise along with the variance of the response and determines significance using an F-test.

RESULTS

Fifty five patients, aged 2 months to 35 months with mean age at 18 $\pm$ 9 months were included in this study *(Table 1)*. One patient was tested unilaterally due to aural atresia which prevented placement of ear inserts in the affected ear. Five patients woke up during ABR testing, completing only one of the ears tested. One patient did not complete ASSR testing for one ear. A total of 103 ears were tested for both ABR and ASSR. ABR test results were compared to ASSR results at 500Hz, 1,000Hz, 2,000Hz and 4,000 Hz when available.

Statistical analysis was done with Pearson and Spearman correlation using GraphPad Prism version 5.00 for Windows, *(GraphPad Software, San Diego California USA,www.graphpad.com). Table 2* lists the correlation data and values. ABR showed strong positive correlation to all frequencies and averages of ASSR.

Table 1. Classification of Patients' Hearing

Hearing Status (ABR thresholds)	Total No. of Ears	Average Age Months
0-40dB	41	15 ± 9
41-60dB	8	11 ± 7
61-80dB	9	18 ± 10
81 and above dB	4	22 ± 8
No Response	41	22 ± 8
All thresholds	103	18 ± 9

Table 2. Correlation of click ABR to ASSR thresholds

	0.5kHz	1kHz	2kHz	4kHz	1-4kHz	2-4kHz
Pierson Correlation	.86	.88	.87	.85	.89	.88
Spearman Correlation	.74	.78	.79	.76	.80	.79
Sig. (2-tailed)	.00	.00	.00	.00	.00	.00
N	62	62	62	62	62	62

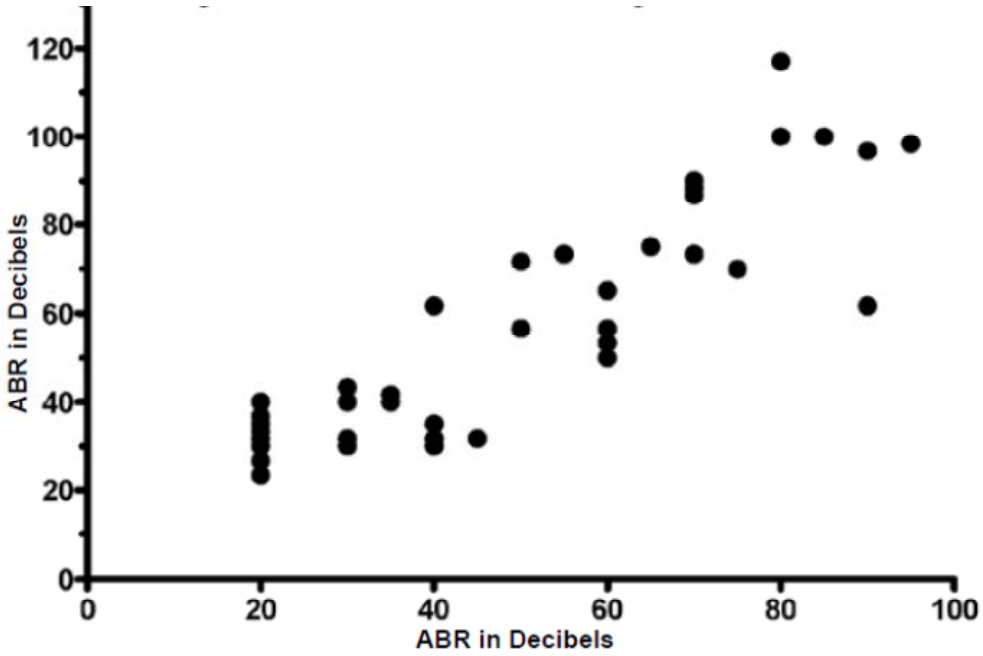

Figure 1. Shows the distribution of the average threshold of 1-4 kHz ASSR against the ABR

Highest correlation was noted with the average of 1-4 kHz ASSR results *(Figure 1)* with Pearson *r* = 0.89 (Spearman *r* = 0.80), the average of 2-4 kHz *(Figure 2)* had strong positive correlation *r* = 0.88(0.79). These results, however, are less than those determined by previous studies (Pearson *r*=0.92).13 Correlation was consistently strong through all ASSR frequencies *(Table 2, Figure 3)*. All correlations were significant at a 0.01 level of significance (2 - tailed).

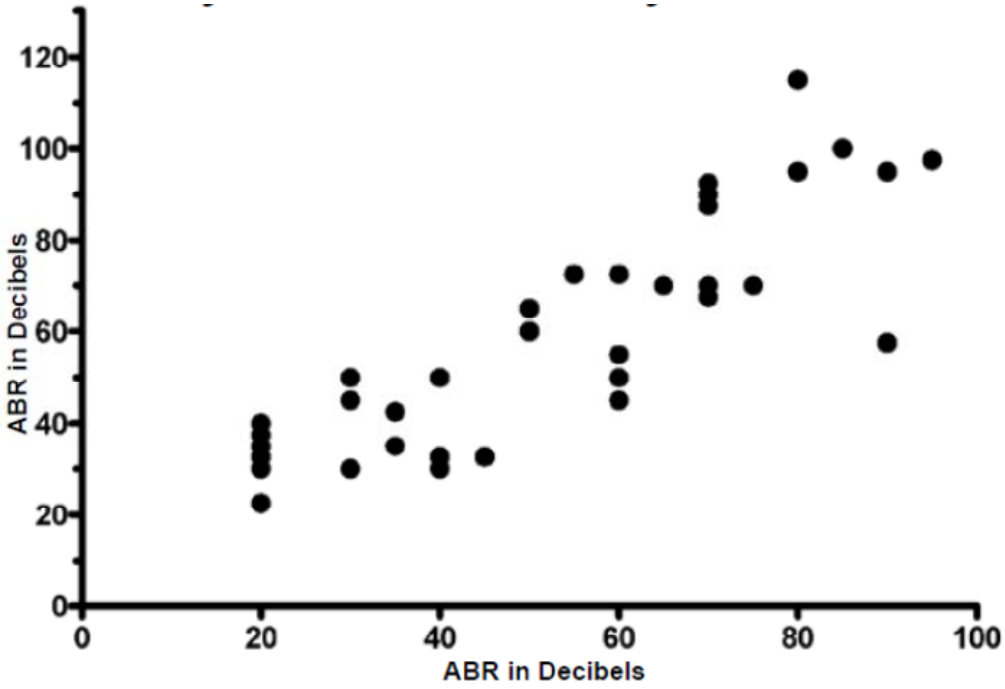

Figure 2. Shows the distribution of the average threshold of 2-4 kHz ASSR against the ABR.

Table 3. Mean difference between ASSR and click ABR

Hearing thresholds	Difference in Decibels (dB)						
	N	0.5kHz	1kHz	2kHz	4kHz	1-4kHz	2-4kHz
0=40dB	41	8.8±11.6	8.2±10.9	6.2±9.5	8.3±9.3	7.6±8.8	7.3±8.9
41-60dB	8	8.1±18.9	3.8±16.2	0.6±14.74	2.5±17.3	2.3±12.9	1.6±13.6
61-80dB	9	10±11.2	17.3±13	8.9±13.2	15±20	13.7±12.4	11.9±13.4
81 and above dB	4	-1.2±18.0	2.5±15.6	-2.5±22.2	-2.5±19.4	-0.8±19.0	-2.5±20.7
All thresholds	62	8.212.9	8.6±12.6	5.3±11.8	7.8±13.4	7.2±11.0	6.6±11.4

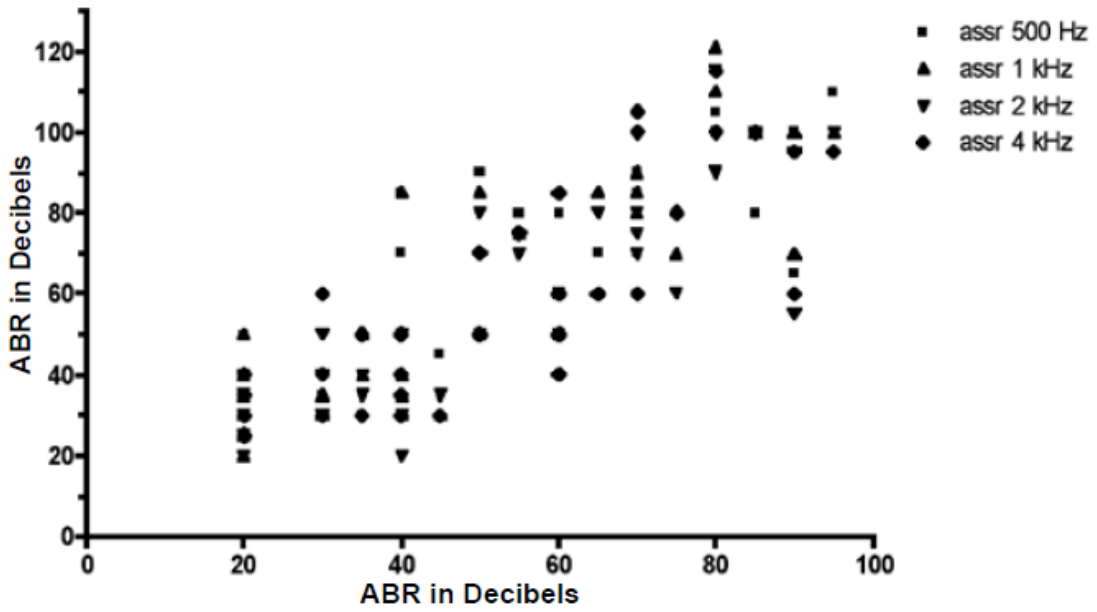

Figure 3. Shows the distribution of the ASSR against the ABR.

Differences between the click ABR and ASSR thresholds were also noted *(Table 3)*. The average differences of click ABR and ASSR thresholds were 8.2 ± 12.9dB for 0.5 kHz, 8.6 ± 12.6dB at 1 kHz, 5.3 ± 11.8dB at 2 kHz and 7.8 ± 13.42dB at 4 kHz.

Forty-one patients were non-responsive (NR) or exhibited no recognizable waveforms with maximal stimulus by click ABR. Two test ears were non-responsive (NR) by both click ABR and ASSR. Of 41 test ears non-responsive (NR) by click ABR, 39 had results with ASSR for at least one frequency.

Among patients with no demonstrable waveforms by click ABR, a large percentage presented with ASSR thresholds. Of these, 80.5% (33 of 41) had measurable results at 0.5 kHz with a mean of 107.3 ± 11.1dB, 85.4% (35 of 41) at 1 kHz with an average of 110.5 ± 11.8dB, 73.2% (30 of 41) at 2 kHz with a mean of 111.2 ± 11.1dB and 63.4% (26 of 41) at 4 kHz with mean of 112.2 ± 8.2dB *(*Table 4*)*.

Table 4. Comparison of click ABR to ASSR

	Click ABR	ASSR
Detection of Retrocochlear Pathology	Sensitivity of >90% (14)	No studies available
Neural / Auditory Neuropathy	Identified with wave I	Cannot differentiate sensory from neural
Intraoperative Monitoring	Yes (15)	No
Estimation of Hearing Thresholds		
Normal hearing	Accurate	Tendency for over-estimation if patient not sedated
Severe to profound hearing loss	Accurate only to moderate HL limited to 95dB15	Accurate from moderate to profound HL
Ski slope hearing	Results not representative of hearing loss	Frequency-specific thresholds
Frequency range	1-4kHz	0.25-4kHz
Simultaneous testing	No	Up to 8 frequencies at a time (13)

DISCUSSION

This study confirmed that ASSR is comparable to click ABR as a measure of hearing thresholds for Filipino children. The highest correlation was found to be with the average of 1-4 kHz followed by the average of 2-4 kHz due to the nature of the click stimulus being within the high frequency range. These results were very similar to those demonstrated in 48 infants and young children by Swanepoel and Ebrahim. (8) The click stimulus, as described earlier, does recruit the cochlear range of 1-4k. It could be recommended that click ABR be compared to the averages of high frequency ASSR rather than to a single frequency.

The means of the differences *(*Table 4*)* between click ABR and ASSR test frequencies were minimal (less than 10dB), which is the increment used in clinical practice. With the hearing thresholds 0-40dB and 61- 80dB, ASSR averages were generally higher by approximately 10dB and 15dB. These differences varied in the higher sound intensities. ASSR much more closely approached thresholds obtained by click ABR in the severe to profound hearing levels, though the limited number of

patients with recordable thresholds by click ABR may have influenced results greatly. The over-estimation of thresholds may have been influenced by machine calibration or affected by the statistical elimination of EEG noise which is especially prominent among lower intensity thresholds. (13) These results of over-estimation of thresholds are consistent with results from several studies. (11,12) The approach of the average ASSR threshold to the click ABR may also be due to the effect of saturation of ASSR thresholds noted at higher frequencies when using sweeps of intensities as noted by Picton. (13)

For patients without demonstrable ABR waveforms at maximal click intensity, a large percentage showed residual hearing at 500Hz at a mean close to the limit of the ABR. From 1k to 4 kHz, there were a decreasing number of patients with responses to ASSR. These results best demonstrate the limitation of testing with ABR for patients with profound hearing loss in the range of the click stimulus. Notably, up to 85.4% of patients that would have been noted to have no waveforms by click ABR still demonstrated measurable thresholds by ASSR. Table 4 shows the results of patients that still had ASSR thresholds but had no waveforms by click ABR. The majority of thresholds were distributed at 110-120dB but the variation of ASSR thresholds varied widely especially among the lower frequencies. It may therefore be necessary that patients noted to have no waveforms by ABR be crosschecked by ASSR. The recommendation is that ASSR testing be done in patients who fail to demonstrate waveform responses by click ABR.

Our study suggests that ASSR may be the best available tool for assessing children with severe to profound hearing loss and is a comparably effective tool in overall hearing assessment for patients requiring electrophysiological testing. The advantages of ASSR over click ABR (Table 4) include: 1) detection of frequency-specific thresholds and; 2) the detection of hearing loss thresholds beyond the limits of click ABR. However, it is our view that ASSR not be taken as a replacement for the click ABR but as a complement to the audiologic armamentarium.

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Chapter VI

When do Aided Auditory Thresholds Reach the Speech Spectrum after Cochlear Implant Switch on?

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ABSTRACT

It is not easy to predict when the aided auditory thresholds of a child with cochlear implants will reach speech spectrum levels.

Objectives: This paper aims to determine the length of time before a cochlear implantee would reach aided hearing threshold of ≤ 45dBHL at 5 frequencies (target threshold) and whether there is a difference depending on age of implantation and sex.

Methods: From January 2009 to February 2011, the aided hearing thresholds of 41 prelingually deaf children with cochlear implants after switch on were reviewed.

Results: There were 21 males and 20 females. Majority of children <4 years old reached the target threshold gradually before the 12th month of post-implantation; those who were 4-7 years old reached it within 3 months time while children >7 years old reached it at ≤1 month. The probability that a female would reach the target threshold on or before 6 months was 90% but was not statistically significant.

Conclusion: Sixty-six percent of the children with cochlear implants reached the target threshold within the first 3 months post fitting and 80% within the first 6 months post fitting. More of the older children reached target threshold earlier than the younger children. There was a trend that more females reached the target threshold earlier than the males but this was not statistically significant.

INTRODUCTION

Cochlear implants are devices that are surgically placed inside the cochlea to aid children with severe to profound hearing losses, who derive minimal benefit from conventional hearing aids, to hear. The main goal is the development of normal speech and language in these children.

When a pediatric cochlear implant patient (cochlear implantee) would begin to hear normal speech is often unpredictable. This information is important in order to reassure anxious patients and their parents. It is also useful for teachers, speech pathologists and audiologists because this will alert them to potential problems so that immediate step could be taken to investigate and plan possible interventions as soon as possible. Factors that may affect outcomes are many, such as age, whether the implantee is pre or postlingual, and the history of previous hearing aid use.

After cochlear implantation and switch on of the device, evaluation materials and techniques to determine outcomes include speech and language evaluation tools which may be done in quiet or in noise, and aided hearing tests in quiet and in noise. The advantage of the aided hearing test in quiet is that it is easy to perform and the results are easy to compare longitudinally and horizontally. Additionally, the maximum hearing capability of the child is obtained under ideal conditions. When evaluating the aided hearing test, attention is paid to the tones within the speech spectrum which is usually presented as the “speech banana”. The speech banana encompasses the frequencies and corresponding decibels required to hear speech from low to high frequencies. When hearing thresholds reach 45 dB HL, there is beginning access to speech sounds, particularly in the low and midfrequencies. Medline search shows that there have been no previous studies done on this topic. The consequence of reaching the speech spectrum may help in predicting speech and language outcomes in children.

This study aims to determine the time interval needed for the cochlear implantee to reach a hearing threshold of $\leq$45 dB HL at 5 frequencies (target threshold) and whether sex and age of implantation has an impact.

METHODS

The database of the cochlear implant program of the Department of Otorhinolaryngology of the University of the Philippines, Philippine General Hospital

using the Medical Electronics (Med-El) implant device recorded 59 pediatric cochlear implants from January 2009 to February 2011. Included in this study are forty one (41) congenitally deaf children (prelingual) who regularly had their cochlear implant fitting post switch on for at least one session every 2 months for a minimum of 6 months by an audiologist (Table 1). Excluded were those with neurodevelopmental disorders such as the autisma spectrum disorder and mental retardation and those with additional disabilities.

All of the children underwent CT scan of the temporal bone. Majority wore hearing aids for at least 6 months (Table 2). However, the aided threshold data using their hearing aids were not available. One of the 2 children who did not use hearing aids prior to cochlear implantation was a 3 year-old male who had a history of rubella while the other was a 5 year-old with cocngenital hearing loss of unknown cause (table 3). Hearing aids were prescribed to these children but they refused to wear them.

Switch on of the cochlear implant devices were done after 1 month to allow for stabilization and healing of the implant site. Follow-ups for cochlear implant device fitting and aided hearing thresholds were done every 2 weeks for the first 3 months, once a month for the next 3 months and every 6 months thereafter. However, patients were free to have fitting and aided test whenever they felt that there was a need, like before the school year starts or before a trip abroad.

During the switch on, the processor was connected to a computer and this communicates with the implanted device through a magnet sealed under the skin in the temporal area. Telemetry was intially done to determine the impedance of the electrodes. If there were any extracochlear electrodes, high impedance or short circuit, these electrodes were switched off.

Table 1. Age and sex distribution of cochlear implant cases (prelingual), January 2009-February 2011.

Age range	Male	Female	Total
1 to <4 years	9	7	16
4 to 7 years	8	8	16
>7 years	4	5	9
Total	**21**	**20**	**41**

Table 2. Cause of deafness and use of hearing aid among cochlear implant cases, January 2009-February 2011.

Cause of deafness	Hearing aid prior to Cochlear Implant		Total No. of Cases
	No	Yes	
Congenital rubella	1	16	17
Large Vestibular Aqueduct		3	3
Ototoxic medications (prolonged ICU stay)		4	4
Meningitis		1	1
Auditory neuropathy		1	1
Undetermined	1	14	15
Total	**2**	**39**	**41**

Table 3. Cause of deafness and sex of the cochlear implant cases (prelingual) January 2009-February 2011.

Cause of deafness	Male	Female	Total
Congenital rubella	9	8	17
Large Vestibular Aqueduct	2	1	3
Ototoxic Medications	2	2	4
Meningitis	1	0	1
Auditory neuropathy	0	1	1
Undetermined	7	8	15
Total	**21**	**20**	**41**

Fitting or mapping of the cochlear implant device was then performed. The goal of fitting is to determine their most comfortable loudness (MCL) since this is the setting wherein sounds are best heard. In children 0-3 years old, behavioral responses to increasing electrode currents were observed. The child may smile, cry or sometimes ignore the stimuli. Electrode current are maintained or painful to the child. In children who ignore the sounds initially or are not cooperative, a soft llow current level) setting is programmed in the beginning. In older children, it is usually possible to set the program at a level more or less close to their MCL. Four programs are frequently provided at increasing levels. The parents were taught and advised on how to use the device. They were also advised to continue their speech and language therapy.

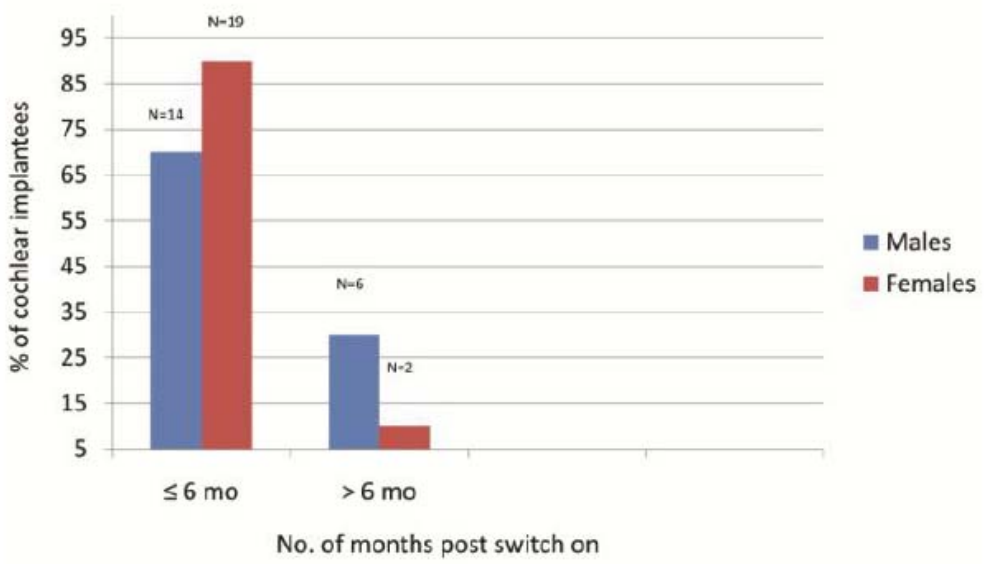
During the succeeding visits, aided hearing thresholds via soundfield were performed with an audiometer (Aurical Plus Diagnostic Audiometer by distributed by Meditron) using warble tones for the frequencies 250 Hz, 500 Hz, 1 kHz, 2 kHz and 4 kHz. Visual response audiometry were done for children less than 2 years old, play audiometry for children 2 to 4 years old and older children are asked to raise their hand if warble sounds are detected. These results were recorded and analyzed. All children were evaluated and were undergoing speech and language rehabilitation with various private and charitable institutions. Unfortunately, not all their records were available.

RESULTS

The data of 41 pediatric cochleart implantees (Med-El) from January 2009 to February 2011 were reviewed. Rubella was the most common cause of deafness. There were 20 males and 21 females. Sixteen patients were 1 to <4 years old; 16 were 4 to 7 years old and 9 were >7 years old. The aided test results were performed using age and developmentally appropriate techniques. Visual response auudiometry were done for children less than 2 years old, play audiometry for children 2 to 4 years old and older children are asked to raise their hand if warble sounds are detected.

For females, the probability (relative risk) that their aided hearing threshold would reach the target threshold on or before 6 months post switch on was 90% while for males it was 70%. However, this was not found to be statistically significant (Figure 1).

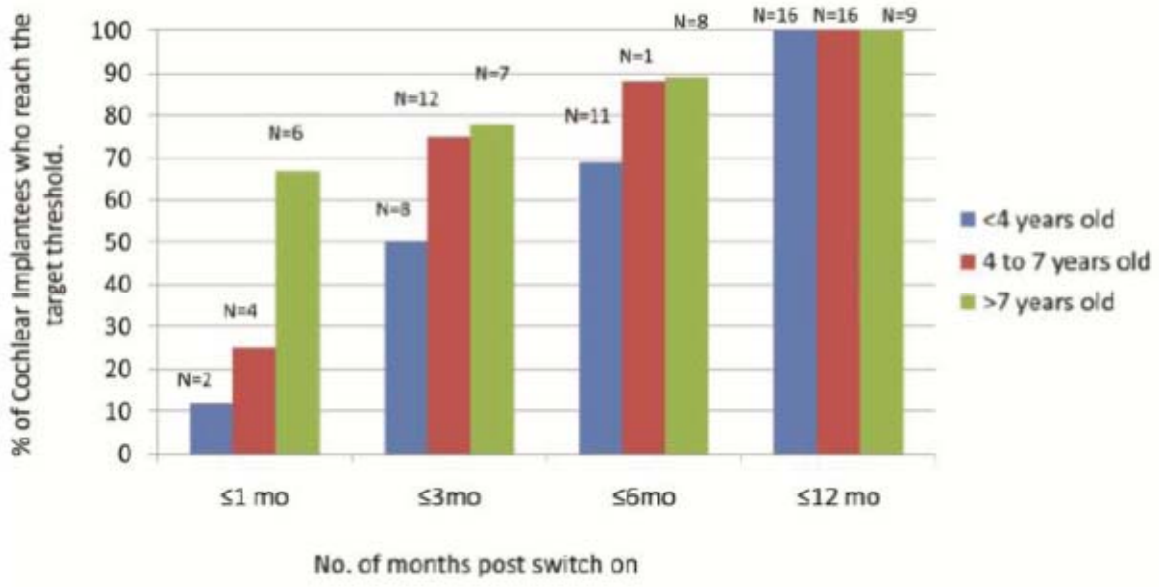
All the children reached the target threshold by the 12^{th} month of post cochlear implantation. The older children reached the target threshold earlier. For those who were <4 years old, 50% reached the target threshold by 3 months post switch on, while the other half continued to improve until tehry reached the target threshold before 12 months. For the children 4 to 7 years olf, 75% reached the target threshold by 3 months post switch on and for those >7 years old, 70% reached the target threshold during the first month post switch on. When children <4years old were compared with children 4 to 7 years old in attaining the target threshold, the probability of the former reaching the aforementioned threshold was 50% compared to the latter which had the probability of 75% (Figure 2)



% of cochlear implantees reaching target threshold on or before 6 months and after 6 months in males and females.

$p = 0.188$

Figure 1. Comparison of male and female children cochlear implantees who reached target threshold before 6 months and after 6 months.



No. of months after switch on before aided thresholds reach target threshold in children < 4 years old; 4-7 years old and >7 years old

Figure 2. Cumulative number of months after switch on before target threshold is reached among children aged <4 years old; 4-7 years old and >7 years old.

However, when taken as a whole, 66% of the implantees reached ≤45 dBHL threshold within the first 3 months post fitting and 80% within the first 6 months post fitting (figure 3).

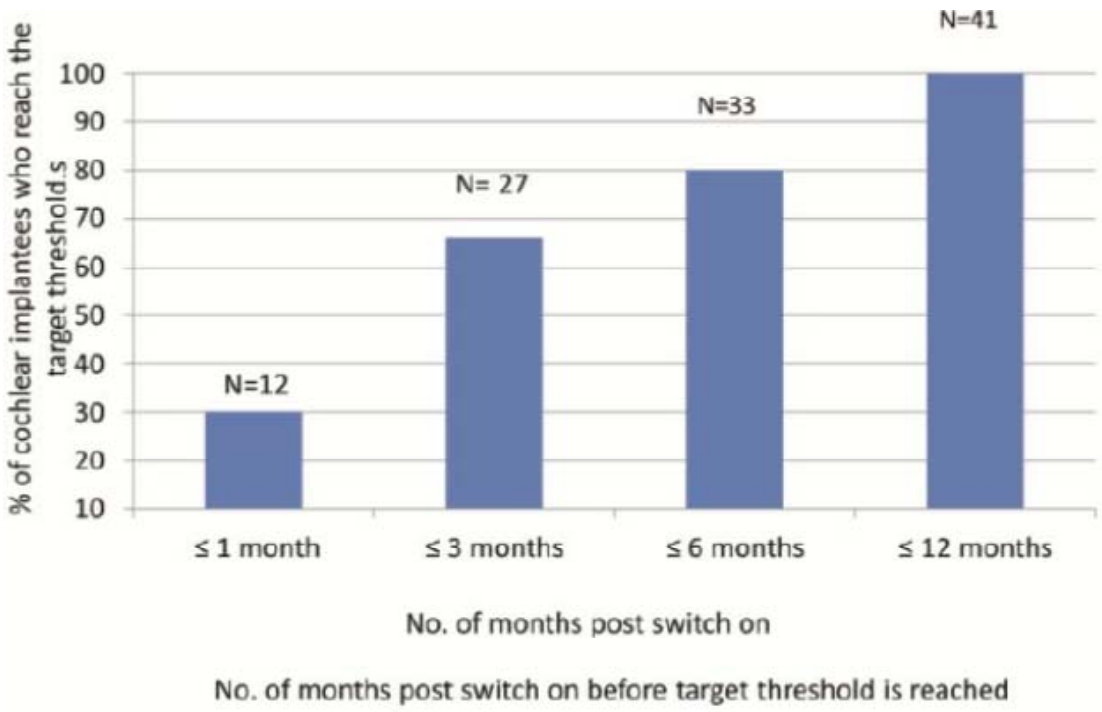


Figure 3. Number of months post switch on before target threshold is reached by cochlear implantees.

DISCUSSION

Studies have shown that there is a correlation between access to sound and development of speech. Children who have early access to sound (through hearing aids or cochlear implants) have an advantage of cortical plasticity which leads to rapid changes in the central auditory pathway often leading to normalization of the auditory cortex. (1) Children implanted at less than 4 years old, began to develop age appropriate maturation of the central auditory system (there was a gradual change in the cortical evoked latency response) starting 3 months post switch on. The same was expected for most of the older implanted children if they had history of appropriate hearing aid use. (2) In fact, it is interesting to note that in one study, pre-implantation rehabilitation using hearing aids in very young children does not have an impact on their language development after implantation (3) probably because they

were implanted during the critical period for language development. However, children implanted later are benefited by hearing aid use during this critical period before implantation wherein acoustic stimulation is vital for the development of speech and language.

Our study shows that in children <4years old, more than half of the children with cochlear implants reached the target threshold within 3 months and the others continued to improve within the year. For the 4 to <7years old group and the >7 years old group, they reached the 45 dB threshold earlier than the younger children, perhaps because they were easier to test audiologically, have had more exposure and experience with sound and longer speech and language therapy while still wearing hearing aids (before their implantation). Normalization of hearing thresholds in turn may translate to normal development of speech and language in children implanted early (4) as well as implanted older children with history of appropriate hearing aid use.

The two children (3 and 5 years old, respectively) who did not use hearing aids before implantation reached the threshold in six and ten months. Although these are within the expected one year – it may indicate a slight delay toward normalization.

Why females would show a trend of earlier improvement in reaching the target threshold has not been extensively studied. This finding could be a consequence of earlier development in speech among female children that earlier studies have already shown. (5) Indeed, males are also more likely to show speech disorders like problems in articulation and phonology. (6) However, our study showed no statistically significant difference between males and females in the time interval before reaching the target threshold.

The results of our study may be used as guide in advising parents about what to expect with regard to speech and language after cochlear implantation especially in relation to the age and prior use of hearing id. Additionally, a delay (e.g. A lack of improvement within 3-6 months in reaching the 45 dB threshold) should alert the concerned audiologist to delve into possible causes like misuse of the device, failure to attend therapy sessions and central auditory processing disorders. Appropriate interventions that include specialized tests (cortical evoked responses), change in speech and language strategies, and behavioural therapy may be needed.

Despite the aforementioned findings, there is still a need to correlate these results with the speech and language development of these children. The teaching style/method and home environment of these children as well as temperament of the child may also have some impact on how early they are to reach the target threshold.

An ongoing study in our institution on genetic markers may provide some basic answers to why some children reach the target threshold earlier than the others.

In conclusion, our findings show that young children implanted early and older children implanted with previous hearing aid use would usually reach the ≤45 dB aided hearing threshold within the first 3 months post implant.

Sixty six percent (66%) of the children with cochlear implants reached the target threshold within the first 3 months post switch on and 80% within the first 6 months. Younger children showed gradual improvement within the first year while older children with previous hearing aid use reached the target threshold within 3-6 months. For females, the probability (relative risk) that their aided hearing threshold would reach the target threshold on or before 6 months post switch on was 90% while for males it was 70%. However, this was not found to be statistically significant.

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Chapter VII

General Discussion

GENERAL DISCUSSION

The pathology of the hearing system is particular to the field of otorhinolaryngology (ORL) while the study of hearing and hearing disorders, which we call “audiology”, is an offshoot of ORL (as well as Speech and Language Pathology). (1) The process of evaluating the hearing of an individual may change depending on the situation. Newborn babies and young children, in particular, may need extensive and time-consuming hearing assessment because they cannot follow instructions and have short attention spans owing to the immaturity of their mental and physical abilities. Other factors that may affect hearing assessment and related communication must be looked into individually. The availability and cost of sophisticated audiological equipment as well as experienced audiologists may limit their use and expand the use of screening devices. Cultural and monetary concerns may play a role in whether a test will be utilized or not. Furthermore, dedicated audiologists are needed for optimal rehabilitation and guidance of the children and their caregivers.

The Philippines is relatively young with regard to audiology. Because of this, studies pertaining to hearing and hearing loss, involving the Philippine population, has only just recently started to develop. New audiological devices are also becoming available and accessible because of the expansion and availability of medical knowledge through the internet and social media. The economic growth in the Philippines and the fact that hospitals vie for more clients by offering sophisticated diagnostic tests have pushed knowledgeable individuals to ask for these tests, advocate for it and compel hospitals to acquire the equipment that perform these tests. The Ear Unit of the UP-PGH Department of ORL and the Hearing and Dizziness Center of The Medical City Department of the ORL - Head and Neck Surgery are two of the leading clinics in this field in the Philippines.

The first population that we studied was the indigenous population in Bolabog, Boracay, called the Ati. They were the recipients of free use of portable audiometers as part of a medical mission. International studies have shown that some indigenous populations have an increased prevalence of middle ear infection and subsequent hearing loss. (3) The Ati population was being taken care of by a religious group, the Daughters of Charity. The prevalence of chronic suppurative otitis media (CSOM) - which is a persistent middle ear discharge

through a tympanic membrane perforation - was determined to be 27%. However, only 11% of the population consented and was tested audiologically. The testing revealed a hearing impairment prevalence of 29% (7 of 24). Although it is not clear whether or not these data can be generalized, the CSOM prevalence of 27%, found in the Ati community, equals the highest prevalence rates according to the grading of the World Health Organization (WHO), comparable to that of Australian Aborigines. (4)

Those with CSOM were referred and treated by local medical doctors for free. Regular visits have been made by the team to monitor their ear health. A recent study suggested that their hearing loss may not only be due to unsanitary living conditions and poor diet but also to genetic factors. (5,6)

It must be noted that only 29% of the entire population was seen in this study despite the effort taken to examine them all. Thus, a more thorough evaluation and documentation is needed to make the study more accurate and meaningful.

There are ongoing steps to uplift the living conditions of the Ati community. From wooden and makeshift huts, houses made of cement with clean water supply are being built. Future studies should also address whether or not these changes affect the ear health.

It would be ideal to set up a nearby health facility to monitor and take care of the ear health of the Ati community. In the meantime, a medical team should regularly visit and monitor the ear health of this community.

The second population that we studied concerns newborn “babies”, in Manila. Newborn hearing screening is the new standard of care around the world. Otoacoustic emission devices (OAE) and ABR machines and other audiological equipment are being made available in many hospitals because of the growing awareness of the importance of early detection and intervention for hearing loss. Screening for hearing loss has resulted in early intervention of hearing impaired toddlers and consequently, in the development of adequate speech and language. It should be noted that the Philippines has a high birthrate (24 births per 1,000 women in 2016) and that the prevalence of congenital hearing loss is relatively high. (5) Studies have shown that vernix caseosa may affect the result of newborn hearing screening when using OAE shortly after birth. Checking the ears for vernix caseosa and cleaning could reduce the false positive results. (6) Being a developing country, there is a pressing need to reduce the number of false positive results since this may lead to added expense

and loss of income for the family when they need to travel back to the hospital for a rescreen and pay for another test. On the other hand, checking the ears for vernix and cleaning the ears, if present, and repeating the test, would mean added time and personnel expense not only for the hospital but to the patient as well, who will need to pay for these services. Our study shows that there was no clinically significant difference in pass rates for children with vernix caseosa and those with patent ear canals. Collapsed ear canals were also not common, accounting for only 10.5% of the population studied. Otoscopy to check for vernix may not have to be part of the newborn hearing screening protocol.

The “refer” rate in this study was quite high (30.5%). According to JCIH 2007, the acceptable refer rate is < 4%. In order to keep the “refer” rates low, some hospitals delay the screening to after 24- 48 hours. In this study, the test was done within 24 hours and this explains the high “refer” rate. Because of this finding, changes have been made in the hospital’s protocol – newborn hearing screening now is being routinely done after 24 hours. However, that means that all the women and their babies have to stay overnight. A follow up study on the present “refer” rates is planned.

Another issue that we studied with regards to newborn hearing screening is the consequence of a (possibly false) positive result as experienced by the parents, in particular, the mothers. Therefore, a study was undertaken to determine whether false screening outcomes were needlessly causing anxiety in the mothers. International studies have shown that newborn hearing screening even after a false positive result was generally well accepted. Few parents had negative emotions, however, there were parents who were still worried even after their baby had normal definitive test results. (8) In the Philippines, parental reaction to a false positive result may be affected by Filipino traits like “fatalism” which means that one should just accept ones fate because it cannot be changed, the “*manyana* habit” wherein a parent delays getting the proper treatment due to laziness and lack of perceived urgency, and “*hiya*” which means not wanting to embarrass the family over certain medical conditions that may put the family at a disadvantage in society. (9) Our study showed that, similar to studies carried out abroad, although the “refer” result caused them to worry, they still believed that the test was worthwhile, that they would want their future offspring tested and would recommend screening to other mothers. Unfortunately, the study did not document if the mothers brought their children back for rescreening. Another study documenting the attitude and emotions of

the mothers or caregivers during the whole process of screening to diagnosing hearing loss and intervention would be worthwhile in order to determine how to further strengthen and promote newborn hearing screening in the Philippines.

Our next study highlights the definitive diagnostic tests after a positive screening result using ABR and Auditory Steady State Response (ASSR). Prior to the availability of the ASSR device, estimation of the hearing loss was done using the click and tone burst ABR. Our study was done to correlate the findings of ABR and ASSR and this showed a high correlation in the 1-4 kHz region. An advantage of ASSR is that it determines frequency-specific thresholds in both ears at the same time and the ASSR can also determine hearing thresholds beyond the limits of the click ABR. This latter advantage may help in choosing and adjusting the best hearing option in severe/profound deafness. (10, 11)

The next special population that we studied were children with bilateral profound hearing loss who underwent cochlear implantation. Newborn hearing screening programs have made it possible for such children to be identified, and implanted at a young age. Adjustment of the sound processor device of the cochlear implant depends upon age appropriate tests to assess hearing. Evaluating and monitoring the progress of a young child after cochlear implantation is often challenging because of their mental and physical immaturity. Our study suggested that the acceptable timeframe for optimizing aided hearing thresholds with the implant to reach speech spectrum levels is 3-6 months, depending on the age of the child. This time frame coincides with the study of Sharma (13) which showed that in babies, cortical auditory evoked potentials reveal normal latencies at 6-8 months after cochlear implantation. With the results of our fitting and test procedures, we can properly anticipate the progress of the child and be proactive if delays in speech and language are observed.

However, an evaluation study is needed to test this statement. For use in the Philippines, other age specific tests should also be developed, validated and used to assess hearing, speech and language development more carefully.

Rehabilitation for deaf children with a cochlear implant is also challenging given our geography, economic and political situation. Telehealth which is a means for improving public health and health education using tele-communication technologies, might help to solve our problems. Indeed studies are carried out to determine if telehealth may be useful for hearing screening, diagnosis and rehabilitation programs. (14) This will enable an audiologist to work with patients from all over the Philippines while staying in his/her office. A

challenge is to provide the technology and adequate internet connections in the different provinces for efficient and timely service.

The growing number of studies performed in the Philippines highlight the growing options and interest in the field of audiology. Because hearing loss is invisible, hearing screening is vital for hearing loss identification and intervention. Hearing assessment should be made available to all Filipinos, children and adults, especially the indigenous Filipinos who are more at risk for hearing loss because of their circumstances and presumed genetic factors. With sophisticated hearing aids and cochlear implantation gradually becoming available in the Philippines, the country is slowly but surely catching up with the western world in evaluating and managing individuals with hearing loss.

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Chapter VIII

Summary in English and Dutch
Acknowledgments
Curriculum Vitae
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SUMMARY

There are three major influences affecting the progress in the delivery of medical services in the Philippines. The country being multi-island state poses challenges in the accessibility of medical services as well as the homogeneity in the standard of care. Its political history of being subjugated with foreign rule by different colonizers has resulted in their impacts distinctly shaping its medical clinical practice. Also, being still an economically developing nation, the national budget for medical care for its citizenry has to compete with other basic services. Thus, ear research performed in this setting is a reflection of the effect of these unique influencers.

The special populations that we studied were the newborns, children with hearing loss, the indigenous Ati community in Boracay and children with cochlear implants. The newborns are a special population in the sense that this is the population that has to be screened properly for hearing loss. The newborn period is the entry point for which hearing loss may be detected and intervention provided early enough to prevent the negative consequences of hearing loss, e.g. speech and language delay. One aspect of newborn screening that we studied was the possible effect of vernix caseosa and collapsed ear canals on otoacoustic emission screening. Certainly, if vernix caseosa and collapsed ear canals play a significant role in increasing the “refer” rate, then a prior otoscopy and ear cleaning might be needed before newborn hearing screening. The results of our study showed that there was no statistical significant difference in pass rates between patent ear canals and ear canals that were collapsed and/or had vernix caseosa. However, there was a statistically significant difference in “pass” rates between patent ear canals and collapsed ear canals – with patent ear canals more likely to pass newborn hearing screening than collapsed ear canals. However, the low percentage of collapsed ear wherein half of them will pass initial newborn hearing screening may not warrant a pre-newborn hearing screening otoscopy which will add time and cost to this procedure. This study also showed a high initial “refer” rate which has been corrected at the institutional level by performing the newborn hearing screening 24 hours or more after birth. Another important part of the newborn hearing screening program is the education of the parents or caregivers about the newborn hearing screening process. The parents or caregivers need to understand, accept and comply with

the newborn hearing screening protocol. This process may lead to anxiety on the part of the parents especially when the result is a “refer” after which they are asked to bring the baby back after a month for a rescreen. We do not want parents to be unduly alarmed or stressed because of a “refer” result, knowing that about 80% will pass the rescreen. Our results showed that being “worried” was the most persistently felt emotion and that future studies are needed to determine if this emotion will persist or dissipate once the baby is found to have normal hearing. Nevertheless, all the mothers interviewed believed that newborn hearing screening was important and would want it for their future children. Our next study focuses on the confirmatory diagnostic audiological tests: ABR and ASSR once a child is suspected to have hearing loss. When hearing loss is likely, because of a final “refer” on newborn hearing screening, a diagnostic confirmatory test like ABR and ASSR are usually requested. Our study showed that the click ABR showed strong positive correlation to ASSR especially in the average of 1-4 kHz. An added advantage of using ASSR is that higher intensity levels of acoustic signals can be introduced so that when click ABR shows no waveforms, ASSR may still show demonstrable measurable thresholds which may help in starting hearing aid amplification levels when hearing aids are needed. The Ati community is another special population we studied. We noted a high prevalence of CSOM in this population and, although only a few were tested audiometrically because of active ear discharge, a possible high prevalence estimate for hearing loss is also inferred because ear infection is associated with hearing loss. The possibility of hearing loss due to genetic factors because of consanguineous marriages in this community and not just to poor living conditions has also been raised and is being studied. Lastly, cochlear implantation for hearing loss is one of the options that parents of children with hearing impairment may choose. This population of children would need to be monitored closely to track the development of speech and language. Our study showed that these children’s hearing threshold reached speech spectrum levels within the first 3-6 months post switch-on of the cochlear implant device. This finding may guide teachers, therapist and parents regarding the progress or delay that the child may be experiencing so that further investigation may be done to determine the cause of this delay so that this may be addressed in a timely manner.

The research we have done on these special populations has taught us how to improve our newborn hearing screening protocol, how to diagnose and monitor hearing and speech and language development in children with hearing loss and how to help our indigenous brothers and sisters with their ear health concerns. There are also many future researches that can be built upon from these present studies.

SAMENVATTING

Er zijn drie belangrijke factoren die invloed hebben op de vooruitgang van de gezondheidszorg in de Filippijnen. Het feit dat dit land bestaat uit meer dan 7000 eilanden zorgt voor uitdagingen op het gebied van de bereikbaarheid om de gezondheidszorg te kunnen leveren. Daarnaast wordt het lastig steeds eenzelfde standaard niveau van zorg mogelijk te maken. Het feit dat de Filippijnen in vroegere jaren een kolonie was van andere staten heeft effect gehad hoe vorm is gegeven aan de wijze waarop de gezondheidszorg werd ingericht. Het feit dat de Filippijnen economisch gezien een ontwikkelingsland is, betekent dat het voor gezondheidszorg beschikbare budget in competitie is met andere basale voorzieningen. Dat betekent dan ook dat de nu beschikbare Oorheelkundige onderzoek capaciteit op de Filippijnen qua omvang sterk beïnvloed wordt door deze zo beperkende omstandigheden.

De bijzondere populaties die wij bestudeerd hebben zijn: de pasgeborenen, de slechthorende kinderen, de inheemse Ati bevolking in Boracay en de kinderen die een cochleaire implantatie hadden ondergaan. De pasgeboren zijn een aparte populatie omdat deze kinderen al op zo jonge leeftijd een screening dienen te krijgen op het mogelijk bestaan van een slechthorendheid/doofheid, ook wel neonatale gehoorscreening genoemd. De neonatale screening is uitermate geschikt om vroegtijdig een gehoorverlies te kunnen opsporen, zodat een vroegtijdige interventie tijdig verschaft kan gaan worden om de negatieve effecten van een aangeboren gehoorverlies te helpen voorkomen/verminderen, zoals een vertraging in de taalontwikkeling. Een van de aspecten die in deze proefschriftstudie onderzocht zijn is of oorsmeer en of een samengevallen uitwendige gehoorgang een negatief effect hadden bij de neonatale gehoorscreening met otoakoestische emissies. In geval zou blijken, dat oorsmeer in de (voornamelijk kraakbenige) uitwendige gehoorgang en/of een samengevallen uitwendige gehoorgang een opmerkelijk effect zouden hebben op een hogere herhaal frequentie van deze gehoortest, dan zou dat betekenen dat een otoscopie en een reinigen van de uitwendige gehoorgang voorafgaand aan een screening van het gehoor met otoakoestische emissies nodig zou zijn. De uitkomsten van onze studie tonen echter geen opmerkelijke verschillen in de slagingskansen bij een neonatale gehoorscreening tussen de groep met een open uitwendige gehoorgang en de groep met oorsmeer in de uitwendige

gehoorgang of met een samengevallen uitwendige gehoorgang. Er bleek echter wel een statistisch significant verschil in slagingskans tussen de groep met een open gehoorgang en de groep met een samengevallen gehoorgang. Neonaten met een open gehoorgang passeerden de gehoorscreening vaker dan de groep met een samengevallen gehoorgang. Echter het lage percentage neonaten met een samengevallen gehoorgang is zo laag en het feit dat desondanks de helft van deze neonaten desondanks de gehoorscreening met succes passeert, maakt het uiteindelijk niet nodig om voorafgaand aan de gehoorscreening een otoscopie te laten plaats hebben. Een systematisch invoeren van een otoscopie bij een neonatale gehoorscreening procedure zou meer tijd vragen en de kosten van de gehoorscreening procedure vergroten. Deze studie toonde evenzo aan dat de oorspronkelijk zo hoge herhaal kans kon worden verbeterd door de test pas na 24 uur of later na de geboorte te laten uitvoeren.
Een ander belangrijk aspect van de neonatale gehoorscreening is de voorlichting aan de ouders/verzorgers van het kind over het neonatale gehoorscreening programma. De ouders/verzorgers van het kind moeten de zin van dit onderzoek begrijpen, het te zullen aanvaarden en er aan te willen meewerken. Deze neonatale gehoorscreening zou kunnen zorgen voor angsten en zorgen bij de ouders/verzorgers van het kind in geval de screening door een onvoldoende resultaat herhaald zou moeten worden. Immers dan worden de ouders/verzorgers gevraagd een maand later met hun kind opnieuw te komen voor een tweede neonatale gehoorscreening. Wij zouden de ouders/verzorgers niet onnodig willen verontrusten met een onzekere eerste uitkomst van een neonatale gehoorscreening test, wetend dat 80% van de neonaten een tweede screening test met succes zal afleggen. Ons onderzoek toont aan dat "zich zorgen maken" onder de moeders de meest frequent voorkomende emotie is. Toekomstige studies zouden moeten aantonen of deze emotie blijft bestaan of toch verdwijnt wanneer de herhaal test wel succesvol is gebleken en het kind goed horend is bevonden.
Hoe dan ook, de geïnterviewde moeders meenden dat een neonatale gehoor-screening belangrijk was en zij zouden evenzo hun toekomstige kinderen die neonatale gehoorscreening willen laten ondergaan.

Onze volgende studie in dit proefschrift gaat over de mate waarin de ABR test en de ASSR test elkaar bevestigen in geval verondersteld wordt dat een kind slechthorend is. In geval een slechthorendheid met reden vermoed wordt omdat

de neonatale gehoorscreening bij herhaling dat aangeeft, is het doorgaans nodig om een diagnostische ABR of een ASSR test te laten verrichten. Onze studie toonde aan dat de click ABR een sterke positieve correlatie toonde vooral voor het gebied van de 1-4 kHz. Een aanvullend voordeel van de ASSR test is dat met een hogere intensiteit van de akoestische signalen getest kan gaan worden zodat wanneer met de ABR geen golfpatronen meer gevonden kunnen worden met de ASSR methode toch nog meetbare gehoordrempels gevonden kunnen worden. Dit kan van dienst zijn om de gehoorrevalidatie bij een ernstig gehoorverlies te optimaliseren.

De inheemse Ati gemeenschap is een andere bijzondere populatie, die wij bestudeerd hebben. Wij vonden een hoge incidentie van Chronische Otitis Media Serosa (CSOM) bij deze bevolkingsgroep, alhoewel wij slechts maar heel beperkt in de gelegenheid waren om ook gehoortesten bij hen te verrichten. Reden daarvoor was onder meer het bestaan van een actieve oorontsteking en mogelijk ook angst voor het bestaan van een aangeboren doofheid vanwege de hoge graad van bloedverwantschappen in deze bevolkingsgroep.

Cochleaire implantatie is een optie waarvoor ouders van een ernstig slechthorend/doof kind zouden kunnen gaan kiezen. Een zorgvuldige en nauwkeurige opvolging van deze kinderen met een cochleair implantaat is wenselijk om de taal- en spraakontwikkeling op te volgen. Onze studie toonde aan dat deze kinderen acceptabele gehoordrempels in het spraakgebied ontwikkelden binnen de eerste 3-6 maanden na aanpassing van het cochleaire implantaat. Dergelijke uitkomsten zullen van dienst zijn voor leerkrachten, therapeuten en ouders om een verwachting te mogen hebben over hoe snel of laat een dergelijk resultaat verwacht mag gaan worden. Dit ook om er toe bij te dragen dat aanvullend onderzoek zal gaan plaats hebben in geval van een vertraagd of uit blijven van het gewenst resultaat, opdat de oorzaak daarvoor opgespoord en zo mogelijk verholpen kan gaan worden.

De beschreven onderzoeken hebben ons geleerd hoe het protocol van ons neonatale gehoor screening programma te verbeteren, hoe de consequenties van gehoorverlies en de ontwikkeling van taal en spraak bij slechthorende/dove kinderen te monitoren als ook om inheemse broeders en zusters met oorheelkundige problemen bij te staan.

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To my husband, Ricky and daughter, Summer - nothing I do would matter without you! I love you very much!

And to God Almighty, who heard my prayers!

CURRICULUM VITAE

Maria Rina T. Reyes-Quintos was born in May 1966. She went to a Catholic elementary school and the public University of the Philippines Highschool for her early education. She was accepted at the University of the Philippines College of Medicine (UPCM) as a direct entrant from highschool into the Integrated Arts Medicine Program (Intarmed). This program admits high school graduates directly through merit into the College of Medicine and includes one year of internship. She received commendations during internship as the Most Outstanding Intern in the Department of Otorhinolaryngology and the Department of Family Medicine. After internship, she took up residency training in the Department of Otorhinolaryngology in the Philippine General Hospital (PGH) after which she was accepted at the Montefiore Medical Center, Bronx, New York for Fellowship training in Pediatric Otorhinolaryngology under the chairmanship of Dr. Robert J. Ruben. During her stay there, she was able to witness the beginnings of universal newborn hearing screening and observe the procedures for confirmatory tests for hearing loss. After her fellowship, she went to Japan for a few months for Observership in Cochlear Implantation under the tutelage of Professor Takeshi Kubo. When she went back home to the Philippines, she pursued her interest in the hearing sciences by taking up Masters of Clinical Audiology in UPM for which she was a university scholar every semester. She later on became a research faculty of the Philippine National Ear Institute (PNEI) under the National Institutes of Health (NIH), UP Manila. She received the Most Outstanding Researcher Award given by the Philippine Society of Otorhino-laryngology (PSOHNS) in 2016. At present she is an associate research professor of the PNEI, NIH, the Deputy Director of the NIH, UP Manila, an associate clinical professor of the Dept. of ORL, PGH and one of the course coordinators of the Master of Clinical Audiology Program in UP Manila. She is also a member of the consultant staff of The Medical City and is currently the Consultant Director of the Hearing and Dizziness Center in the same institution.

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LIST OF ABREVIATIONS

A2ML1:	alpha–2-macroglobulin like 1
AABR:	Automated Auditory Brainstem Response
ABR:	Auditory Brainstem Response
ACAP:	Association of Clinical Audiologists of the Philippines
APGAR:	Appearance, Pulse, Grimace, Activity and Respiration
ASSR:	Auditory Steady State Response
CAMP:	College of Allied Medical Professions
CSOM:	Chronic Suppurative Otitis Media
CT:	Computerized Tomography
EENT:	Eyes, Ears, Nose and Throat
ENT:	Ears, Nose and Throat
ICU:	Intensive Care Unit
JCIH:	Joint Commision on Infant Hearing
MCL:	Most Comfortable Loudness
MRI:	Magnetic Resonance Imaging
NBHS:	Newborn Hearing Screening
OAE:	Otoacoustic Emissions
ORL:	Otorhinolaryngology
PNEI:	Philippine National Ear Institute
PSO-HNS:	Philippine Society of Otolaryngology-Head & Neck Surgery
PSOB:	Philippine Society of Otolaryngology and Bronchoesophagology
RA:	Republic Act
UNHS:	Universal Newborn Hearing Screening
UPCM:	University of the Philippines College of Medicine
UPM:	University of the Philippines Manila
UST:	University of Santo Tomas
WHO:	World Health Organization