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Prevalence Of Hearing Impairment And Ear Disorders In Beni, Bolivia: A Population Based Study

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PREVALENCE OF HEARING IMPAIRMENT AND EAR DISORDERS IN BENI, BOLIVIA: A POPULATION BASED STUDY

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ABSTRACT:

Hearing impairment is a significant source of morbidity worldwide. It is estimated that over 278 million people in the world experience moderate to profound hearing loss. The goal of this study was to provide population based data on hearing loss and ear disease in Beni, Bolivia and to specifically answer the question of whether particular population demographics are associated with hearing impairment so that hearing loss prevention measures may be implemented effectively. From April 2009 through December 2009, a cross-sectional population based household survey of 5,826 individuals of all ages was conducted. The population was composed of 1111 systematically identified households in the sixteen largest population centers in the Department of Beni in eastern Bolivia. Hearing function assessment and physical exam data were collected on all subjects using a modified version of the World Health Organization Ear and Hearing Disorders Survey Protocol. Data were also collected regarding living conditions and occupation of each subject. This thesis provides analysis regarding hearing impairment of 4,957 individuals in fifteen of the sixteen population centers. This study found that the overall prevalence of hearing impairment in this population was 35.5 percent (95% confidence interval [CI] 34.0% -37.1%), and the prevalence of disabling hearing impairment was 5.8 percent (95% CI 5.1% -6.6%). The prevalence of mild hearing impairment was 30.5 percent (95% CI 29.0%-32.0%); of moderate hearing impairment, 3.8 percent (95% CI 3.1% -4.4%); of severe impairment, 0.9 percent (95% CI 0.6% -1.2%); and of profound impairment, 0.4 percent (95% CI 0.2% -0.6%). Individuals at highest risk for hearing loss were men (odds ratio (OR) = 1.24; CI = 1.07-1.40); those 60 years of age and over (OR = 17.07; CI = 16.61-17.53); those working in occupations requiring manual labor (OR = 2.23; CI = 2.01-2.45); those with a history of loud noise exposure (OR = 3.61; CI = 3.14-4.08); and those with a history of trauma (OR = 4.04; CI = 3.62-4.46). The results of this study provide important information regarding hearing impairment in Bolivia which will be used for planning programs for the prevention of deafness in this region, focusing on the populations at highest risk, particularly males working in occupations where they may experience exposure to loud noise or trauma. This study also provides important information for healthcare policy and advocacy work both within the country of Bolivia and internationally.

ACKNOWLEDGEMENTS:

I would like to extend thanks to Dr. Diego Santana-Hernández and all of the individuals at Fundación Totaí for inviting me to participate in this work and for their hospitality while I was in Bolivia; to the Christian Blind Mission (CBM) and donors to Fundación Totaí for funding this study; to Dr. Melinda Pettigrew for her support and guidance as I performed statistical analyses and prepared this thesis; to the individuals in the Yale Social Science Statistical Laboratory for their help with questions about statistical software; to my family for their support and encouragement; and to my fiancée, Candice Corvetti for her love.

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INTRODUCTION:

Overview

Hearing impairment is a significant source of morbidity worldwide. The WHO estimated in 2005 that 278 million people experience moderate to profound bilateral hearing loss. 80% of those individuals live in low and middle income countries.[1] It is estimated that half of all cases of hearing impairment could be prevented, but few resources exist to develop and sustain educational, screening, and treatment programs in developing countries.

Often resources are not allocated to address hearing impairment because it is not a visible or life-threatening disorder, therefore other diseases take priority in resource-poor settings.[2] In fact, while adult onset hearing loss was the sixth highest cause of burden of disease in Disability Adjusted Life Years (DALYs) in high income countries in 2001, it was not even in the top ten causes in low and middle income countries because other causes such as perinatal conditions, lower respiratory infections, ischemic heart disease and HIV/AIDS were more significant.[3] However, hearing impairment has a significant effect on the lives of those suffering with it. Several studies of global disease burden performed by the WHO included hearing impairment. In estimates for 2000, the WHO found that adult onset hearing impairment was the second leading cause of Years Lived with a Disability (YLDs) and accounted for 4.6% of total YLDs.[4] According to 2002 estimates, adult onset hearing loss ranked fourteenth among leading causes of the global burden of disease in females.[5] In the 2004 WHO World Health Report, adult onset hearing loss was estimated to account for 1.7% of the total global burden of disease as determined by Disability-Adjusted Life Years.[6] The social and economic impact of hearing impairment in developing countries continues to increase.

Economics of Hearing Impairment

Communication disorders have tremendous impacts on both society and the individual. In the United States, it is estimated that the cost of communication disorders ranges from $154 billion to $186 billion, representing 2.5% to 3% of the Gross National Product.[7] Severe to profound hearing impairment specifically, is estimated to cost society $297,000 over the lifetime of each individual due to reduced work productivity. If the individual develops hearing impairment prior to acquiring speech, the cost over a lifetime balloons to $1 million.[8] In the UK, individuals with hearing impairment are three times more likely to be unemployed than those without impairment.[7] The sequelae of hearing impairment are significant. Affected individuals may not be able to appropriately interpret words, thus reducing their ability to communicate which leads to a delay in language development. This in turn leads to difficulties in obtaining education or securing employment and leads to isolation and often stigmatization.[4]

Hearing Impairment and Poverty

Most children with hearing impairment in developing countries do not complete primary education and never gain independence from their parents economically, therefore they become trapped in poverty. In most cases, parents are unable to provide support and these individuals live in poverty. Alternatively impoverished conditions, lack of health infrastructure, and lack of resources, such as immunizations against childhood illnesses, may lead to hearing impairment and its associated economic repercussions.[9] In developed countries, the incidence of sensorineural hearing loss is 2-4 per 1,000 live births,[10] and it is estimated that in developing countries that incidence could be greater than 6 per 1,000 live births.[11] Bolivia is the poorest country in South America. According to the World Bank, in 2009, the per capita income was US $1,630 and 37.7% of individuals lived below the poverty line. In 2008, the life expectancy was age 66 and the birth rate was 27 per 1,000 people and the infant mortality rate was 42 per 1,000 live births. In 2007, annual healthcare expenditure per capita was only US $69. [12]

Etiologies of Hearing Impairment

Hearing impairment has many causes, but can be classified into two major groups: conductive and sensorineural. Conductive hearing loss is caused by disorders that affect the outer ear and the middle ear. Examples of outer ear disorders are malformations such as microtia or atresia of the outer ear or ear canal, otitis externa, trauma to the ear or ear canal, tumors such as squamous cell carcinoma, presence of a foreign body, poor eustachian tube function, exostoses, osteomas, psoriasis, and cerumen impaction. Examples of middle ear disorders that cause conductive loss are malformation of the ossicles, otitis media, cholesteatoma, perforation of the tympanic membrane, trauma to the temporal bone, and glomus tumors.[13]

Sensorineural hearing loss is caused by disorders that affect the inner ear and central auditory neural pathways. Examples of disorders that cause sensorineural hearing loss include hereditary conditions, congenital infections, congenital malformations, presbycusis, meningitis, endocrine disorders such as thyrotoxicosis, ototoxicity, Meniere's disease, noise exposure, barotrauma, acoustic neuromas, meningiomas, autoimmune diseases, multiple sclerosis, and stroke.[14]

As mentioned, many of the causes of hearing loss are treatable or preventable. In one study of rural vs. urban school children in Chandigarh, India it was found that the most common cause for hearing loss in schoolchildren was otitis media with effusion,[15] which could be treated if appropriate healthcare infrastructure was available. Another study in Madras, India found that in a school for the deaf, congenital rubella infection was responsible for deafness in 29% of the students,[16] which could be prevented by increased availability of vaccination. It must also be kept in mind that the infectious etiologies in pre-natal, neonatal, childhood and adult infections which cause hearing loss may vary by region. In Saudia Arabia, for example, 21.2% of the cases of hearing loss were caused by *Toxoplasma gondii.* [2] In a study of Nicaraguan school children, the reason for hearing loss was found to be most often associated with ototoxicity (specifically gentamicin exposure), environmental toxin exposure, and neonatal infections.[17] In a study of children in Nigeria, the most common causes of hearing loss were measles, meningitis, viral infections and the use of ototoxic drugs. [18] Other variables such as cardiovascular risk factors like smoke exposure and diabetes have also been associated with hearing impairment.[19,20] Addressing these issues early in life may reduce the incidence and impact of hearing impairment.

WHO Survey and Definitions

To accurately determine the prevalence of hearing impairment in various population groups, the WHO developed a protocol for conducting population based surveys of hearing impairment and ear disease. The protocol is standardized so it may be used in various countries and results may be compared. This protocol will be described in detail in the Methods section as well as additions which were made to this survey during its administration in Beni, Bolivia.

The WHO Working Group on Prevention of Deafness and Hearing Impairment

Planning defined hearing impairment by classifying it into four distinct groups of unaided pure-tone hearing threshold levels for frequencies of 500 Hz, 1 kHz, 2 kHz in the better hearing ear. It was determined that 4 kHz should also be included in epidemiological studies, as 500 Hz, 1 kHz, 2 kHz, and 4 kHz are generally assumed to be part of the speech frequency range. Mild impairment was defined as an average threshold level between 26 and 40 dB, moderate impairment defined as an average threshold level between 41 and 60 dB, severe impairment defined as an average threshold level between 61 and 80 dB, and profound impairment as an average threshold level 81 or greater [21]. In 1997, disabling hearing impairment (DHI) was defined separately for adults and children under the age of 15. For adults, it includes moderate, severe and profound impairment, or an average threshold of 41 dB or greater in the better hearing ear over 500 Hz, 1 kHz, 2 kHz, and 4 kHz. For individuals under the age of 15, DHI was defined as an average threshold of 31 dB or greater in the better hearing ear in those same frequencies. [22]

Data on Hearing Loss Worldwide

Throughout the world, there is limited data available on hearing loss. While the WHO has made a commitment to developing tools and programs to support population-based epidemiological research into the prevalence of this disorder, funding and logistical limitations exist as barriers to obtaining this information. While country-wide data are rare, small scale published studies can be used to gain an overall picture of hearing loss worldwide. The limitation of comparison of these studies is that the statistical power, population demographics, and methods vary from one study to the next.

In Asia, the majority of data comes from India, where approximately 80 million people in the country suffer from some kind of hearing impairment, 35 million of which are below the age of 14 years.[23] Several population based studies have been performed in Asia, some using the WHO protocol. The prevalence of disabling hearing impairment in one study in India was 7%;[24] in Nepal, 3.3%;[25] in Thailand prevalence ranged from 3.9-6%;[26] in China, 1.19% [27] (although unpublished reports have estimated prevalence as high as 6.1%); and in Korea 10.6%. [28]

There are several studies on the prevalence of disabling hearing impairment which have been conducted in Europe and show rates to be relatively lower than many other regions. A prevalence of 0.2% was reported in Denmark,[29] 3.2-4.9% in Finland,[30,31] 4% in Italy, [32] 3.3% in Sweden,[33] and 3.9% in Great Britain.[34]

Three studies provided data for the Middle East including one study in Oman which reported an incidence of disabling hearing impairment of 2.07, [35] another in Pakistan demonstrated a prevalence of 1.5%,[36] and a third study in Saudi Arabia showed the prevalence to be 0.9%. [37]

Several studies describe the statistics for hearing impairment in Africa, however, most focus on child and adolescent populations. It is estimated that there are more than 1.2 million children in sub-Saharan Africa from 5 to 14 years old who have disabling hearing impairment.[38] Published prevalence data is available for several countries in Africa including Angola (2%),[39] Kenya (2.2%),[40] Sierra Leone (1.15%), [41] South Africa (0.5%), [42] Tanzania (0.6-4.24%), [43,44] and Zimbabwe (0.9%).[45] In Uganda, the incidence of disabling hearing impairment was 11.7% in adults and 10.2% in children.[46]

There is also limited data in the Americas. In the United States, several studies have estimated the prevalence of hearing impairment in various populations, but only a few include data about disabling hearing loss. Two studies from various regions in the

United States estimated prevalence ranging from 0.11 to 0.95%. [47,48] A recent review of National Health and Nutrition Examination Survey (NHANES) data revealed that hearing impairment (threshold > 25dB) prevalence in adults is 16.1% and has been increasing from 1999 to 2004.[49] Disabling hearing impairment in the United States is much lower than in Central or South America. In Central America, Nicaragua is the only country where a study providing statistics for disabling hearing impairment was performed. In this study of Nicaraguan school children, a very high 18% of individuals were found to have disabling hearing impairment.[17] In South America, the only study providing such statistics was undertaken in Canoas, Brazil and described a prevalence of 6.8%. [50] Another study performed among school children in Peru showed a prevalence of hearing impairment of 6.9%. [51] However, no disabling hearing impairment data exists for Bolivia or other South American countries.

Preliminary Studies by Fundación Totaí in Trinidad, Bolivia

Fundación Totaí is a non-profit organization in Trindad, Beni, Bolivia, which has been working in the sectors of health, community, education and athletics since its inception in 2004. The foundation provides many health services and includes an active otolaryngology clinic, led by Dr. Santana-Hernández. While no population based data are available in Bolivia, several small studies conducted by Fundación Totaí in Trinidad, the largest population center in Beni, demonstrated the need for more information regarding hearing loss in this region and increased resources for prevention of hearing impairment.

Analysis of 2,936 Fundación Totaí self reported otolaryngology consultations in 2006 demonstrated that 27.1% of patients had normal ears and hearing, 22.8% had otitis media, 4.7% congenital deafness, 2.6% presbycusis, and 42.8% other ear pathology. Almost 14% of ear complaints were due to cerumen impaction, which they assumed is related to a habit in Bolivia of using various instruments to attempt to clean ears (usually impacting the wax rather than removing it). Also surprising was that greater than 10% of ear complaints were related to chronic otitis media which was either suppurative (6.64%), non-suppurative (1.69%), or cholesteatoma (1.69%). Screening of 858 primary school children revealed that over 50% of students either had abnormal otoscopy or audiometry, and over 25% had ear wax impaction.

In the adult population, Fundación Totaí reviewed annual screenings of 210 factory workers exposed to loud noise. In this population, which included workers from a local bottling plant, a power plant, an airport, and a milk processing factory, high levels of noise were recorded at factory sites, and 46.2% of the workers suffered from noise-induced hearing loss.

Two studies were performed in the pediatric population. A retrospective study of 64 children attending the local school for the deaf found that only 7.81% of the cases of congenital disabling hearing impairment were diagnosed before the age of 2 years, with the average age of diagnosis of 9 years and 1 month.[52] Another unpublished study of 593 children under 5 years of age using otoscopy and otoacoustic emissions, showed that 0.7% of the children had congenital deafness, and almost 20% of this population required follow-up testing to determine a definitive diagnosis.

On the whole these preliminary studies demonstrate a clear need in this population for increased awareness regarding hearing impairment and improved infrastructure for diagnosis, treatment and rehabilitation of individuals with deafness.

This information and the absence of prevalence data on hearing impairment in Bolivia were the impetus to undertake a population based survey in the Department of Beni.

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STATEMENT OF PURPOSE:

The purpose of this investigation is to provide the first ever prevalence statistics for hearing impairment in Beni, Bolivia and to determine demographic variables that are associated with higher levels of hearing impairment in this region so that hearing loss prevention programs may be implemented effectively and efficiently.

HYPOTHESIS:

Our hypothesis is that particular demographic variables are associated with an increased prevalence of hearing impairment in the Department of Beni, Bolivia.

SPECIFIC AIMS:

1. To complete a cross-sectional population based study in Beni, Bolivia and collect hearing impairment data and demographic variables.
2. To analyze these data once collected to determine which populations are at most risk for hearing impairment and use this information to direct hearing loss prevention programs in this region of Bolivia.

METHODS:

Overview

This cross-sectional population based household survey was carried out between April 16, 2009 and December 13, 2009 in the Department of Beni, Bolivia. It was designed using the World Health Organization Ear and Hearing Disorders Survey Protocol. [53] This project was approved by the local medical boards in Beni, Bolivia and an application for analysis of these de-identified data (HIC Protocol #1004006599) was approved by the Yale HIC on 4/15/2010.

Survey Population

The population studied in this survey was the citizenry of the Department of Beni, Bolivia. Beni is a large area of northeastern Bolivia covering 213,564 square kilometers with a population of 406,982 individuals based on 2006 estimates from the Instituto Nacional de Estadística de Bolivia (INE). The goal sample size was determined using a crude estimation of the prevalence of hearing loss in Bolivia.

As described in the introduction, there is a paucity of data regarding hearing loss worldwide, and this data is virtually non-existant in Bolivia. The only data available with regard to national prevalence of hearing impairment was found in a study of 16,880 people with disabilities performed by the Japanese International Cooperation Agency (JICA) in 1998. It showed that of all the people with disability studied, 9.13% had significant hearing loss.[54] The World Health Organization estimates that in developing countries like Bolivia, the disabled population is around 10% of the total population, therefore it can be roughly estimated that 0.913% of the population in Beni have a disabling hearing loss, or about 3,716 persons. The data from the JICA study were limited with regard to the sample population (it only included individuals with disability) and the fact that clinical levels of hearing impairment were not described. Therefore this estimate is likely inaccurate. However, it is lower than hearing impairment prevalence statistics from other nations described in the Introduction. We decided to use this likely under-estimation of prevalence to determine sample size, as it would lead us to have more subjects than needed and thus improve the overall power of the study.

To acquire data with a 95% confidence interval with a prevalence of 1% +/- 0.36%, a sample size of 2,933 was necessary.[55] To account for the sample design, intraclass correlation within clusters, and the variability among clusters and strata, it was necessary to multiply this number by a design effect factor. We decided to assume the standard design effect of 2. This brought the total sample size to 5,866.

Survey and Sampling Methods

The type of sampling method we used was a cluster sample design. In a cluster sample design, clusters are designated as groupings or communities within a population that contain sampling units, which in this case were households. The number of clusters required is determined by the sample size and the number of individuals the survey team could screen in 1-2 days. We estimated that we could screen about 100 individuals in that time period and therefore the number of clusters required would be 59 for our sample size. We rounded this value to 60 to account for any losses. As we did not perform a national survey, but rather a survey of one particular region, we did not use multi-stage sampling, but rather simply used probability proportion to size as the sampling method. This method uses census information and determines cluster location based on a sampling interval.

To arrive at a sampling interval, we divided the total population by 60 and arrived at an interval of 6,783 people. The starting number was randomly generated by Microsoft Excel: 3, 106. After obtaining census information from Instituto Nacional de Estadística de Bolivia (INE), we determined which communities would be included and how many clusters each contained. They included Trinidad, San Javier, Riberalta, Guayaramerin, San Borja, Rurrenebaque, Reyes, Santa Rosa, San Ignacio, Santa Ana, Exaltacion, San Pablo, Loreto, San Joaquin, San Ramon, and Magdalena (see Appendices A and B for geographic location). We assumed that there would be about 6 persons per household based on preliminary information and given a cluster size of 100, we needed to survey about 17 households in each cluster. Once the number of clusters in each community was identified, we determined cluster size based on the percentage of the sample size in that community. Our sample size, assuming 60 clusters was 6000, which is about 1.475% of the total population in Beni. Therefore, for each community, we divided 1.475% of the population by the number of clusters designated in that community to arrive at the cluster size. While the average group size was 115 individuals, there was variance in cluster size, which may have detracted from randomization.

Our goal was to have 80% coverage, meaning that while we counted all the individuals who lived in a household, we wanted to be sure that at least 80% of those individuals were examined and included in the survey as some would be absent or refuse to participate. Therefore, to assist in daily goals, we also calculated the number of individuals required to be included to achieve that goal of 80% coverage.

Once we determined the number and size of each cluster, we acquired as detailed maps as available for each community. We determined how many blocks existed in each community and divided them by the number of clusters in that community to determine a block interval. We then used Microsoft Excel to generate a random starting block number. If these maps contained numbered blocks we used the numbers provided. If not, we numbered the blocks in concentric circles starting from the central plaza. We again used Microsoft Excel to randomly choose a direction in which to survey, as well as a corner on which to start, and the survey team would move down that road until the goal number of individuals for that cluster was screened. If the 80% coverage was not obtained, the survey team would return later in the day to survey household members who were absent during the initial visit.

Survey Administration

Survey teams were comprised of 2-4 individuals who included an individual trained in audiology and an otoscopist. The other members of the team participated in collection of administrative data, acquisition of tympanometry and evaluation of children. Members of the team were trained by Dr. Diego Santana- Hernández, a trained otolaryngologist, and Maria del Carmen Fernández-Suárez Guzman, a trained audiologist.

Upon entering a household, the number of individuals living in that household were identified and registered. A member of the household was defined as someone who lived in that location for greater than 6 months out of the year. Next, an information page explaining the study was read with the household members, and informed consent was obtained for each individual. For individuals younger than age 18, a parental signature was obtained for informed consent. In addition to exam codes for group, household, person and date of examination, demographic information including name, date of birth, age, gender, occupation, and household condition were also obtained and recorded on the survey form (Appendix D) which was modified from the original WHO survey form (Appendix C).

The occupation of subjects was determined and coded into one of six groups: agricultural worker, office worker, manual laborer, student, other, or unknown. The condition of each household was also determined and ranked into one of five categories: excellent, good, average, fair and poor. Excellent household condition indicated that the house was constructed of high quality materials, the bathroom was located within the house, and all services were available including running water, lights, telephone, and internet. Good household condition indicated that the house was constructed of average quality materials, the bathroom was located within the house, and only running water and electricity were available. Average household condition indicated that the house was constructed of basic construction materials, the bathroom was located outside of the house, and running water and electricity were available. Fair household condition indicated that the house was constructed with poor quality or temporary material, that the bathroom was located outside of the house and had either running water or electricity, but not both. Poor household condition indicated that the house was constructed of temporary or alternative materials, the bathroom was located outside of the house, and neither running water nor electricity were available.

Otoscopy

The first evaluation to be performed was otoscopy. Examiners were trained by Dr. Santana-Hernández, using photos as well hands-on instruction in the clinical and survey setting to diagnose various ear pathologies. The exam was structured and began with examination of the external ear for both malformation and pain. Next the external ear canal was evaluated for inflammation, cerumen, presence of a foreign body, otorrhea, and fungus. Then, the tympanic membrane was evaluated for perforation, dullness or retraction, redness and protrusion. If a perforation existed, the middle ear was evaluated for the presence or absence of otorrhea. Once otoscopy was completed, tympanometry was also performed and recorded.

Hearing Evaluation

Prior to any evaluation of hearing, the ambient noise in each household was measured and recorded using a Kamplex sound level meter (Interacoustics, Eden Prairie, MN). For individuals younger than 4 years of age, a series of screening implements were administered and were answered either yes or no. These implements included calling the child's name from ½ meter behind the child in a normal conversational voice. The child was then asked in a conversational voice to point to someone in the room known to the subject by name. A positive response was coded if they were successful. The child was then asked a simple question such as "What is your name?" Again, if correct, a positive response was recorded. Lastly, with an observer in front of the child, the examiner made a loud clap behind the child, and a positive response was coded if they reflexively blinked their eyes.

Two additions our group made for evaluation of these children under 4 years of age was the use of an educational hearing game for children over 18 months and evaluation by otoacoustic emissions for cooperative children under the age of four. The educational hearing game was designed by Janusz Nowosielski of Melbourne, Australia. The game is composed of cards with pictures of four different animals on them: a cow, a rooster, birds, and a dog. There is also a sound emitting device. The device produces low frequency cow sounds (500 Hz) which are delivered at around 25 cm from the child's ear, middle frequency rooster sounds (1500 Hz) which are delivered at around 50 cm from the child's ear, and a high frequency bird sound (4000 Hz) which is delivered at 100 cm. The reason for varying distances is that the ambient household noise is more likely to mask the lower frequency sounds, therefore they must be held closer to the subject's ear. The sound is delivered and the child is instructed to match the sound to the appropriate card. Two out of three correct is considered passing. Several devices were used to determine otoacoustic emissions and they were calibrated prior to the start of the study: AudX (Natus Medical, Inc., San Carlos, CA) Otoread (Interacoustics, Eden Prairie, MN) and Audera (Grason-Stadler, Eden Prairie, MN).

For individuals 4 years and older, pure-tone audiometry was performed. Using Kamplex audiometers (Interacoustics, Eden Prairie, MN), subjects were fitted with headphones and instructed to raise their hand each time they heard any sound. Sound at 60 dB was presented first at 1 kHz. If there was no response, it was raised in 10-dB increments until there was a response. After response, the threshold was determined by decreasing the tone by 10-dB increments, then increasing by 5-dB increments until the threshold was established and reproduced on three occasions. This technique was used to determine hearing thresholds at 1 kHz, 2 kHz, 4 kHz, 500 Hz and then the 1 kHz threshold was repeated. If the initial and final 1 kHz thresholds were more than 5-dB different, the data were considered unreliable and the procedure was repeated.

Patients who did experience hearing impairment were asked to describe the duration of that hearing impairment. Individuals were then asked whether they had first degree relatives who experienced hearing loss and questioned regarding possible etiologies of hearing loss which were coded as either infectious (such as malaria, yellow fever, typhoid fever, upper respiratory infection, meningitis, congenital infections, neonatal infections, rubella, varicella zoster, herpes zoster, HSV, syphilis, mumps, measles, tuberculosis, pneumonia, CMV, toxoplasmosis), genetic (such as hereditary hearing loss, microtia, endocrine disorders such as Pendred's Syndrome, Down's syndrome), non-infectious conditions (such as trauma, ototoxicity, presbycusis, hypertension, diabetes, exposure to loud noise, neonatal complications, otosclerosis, dyslipidemia, thyroid disorders, pituitary disorders, exposure to toxic or hazardous chemicals, multiple sclerosis, Parkinson disease, and pregnancy), and others (including ototubaritis, ear canal stenosis, or tympanosclerosis). If the subject had an exam that was abnormal and could benefit from treatment, they were referred to the local hospital or health center where the otolaryngology team and a dedicated audiologist were waiting to provide treatment for various conditions (i.e., provide hearing aids, remove wax impaction, treat otomicosis, and schedule surgery for damaged ears).

Statistical Analysis

Univariate and multivariate analyses were used to determine prevalence and the contribution of various demographic variables to hearing impairment (SPSS version 18.0; SPSS Inc., Chicago, IL). A comparison of proportions was used to determine whether differences between 2001 Beni census data and our survey data were significant ($p<0.05$). Prevalences were obtained by creating CROSSTABS comparing variables and obtaining p-values to determine if differences were significant within groups. Unadjusted odds ratios and confidence intervals for analysis of variables associated with hearing loss were obtained by creating CROSSTABS comparing hearing impairment with the different variables. Variables were selected by comparing hearing impairment with all variables and determining which may be statistically significant. Adjusted odds ratios were obtained by using selected variables and comparing them with hearing impairment using a binary logistic regression model. ANOVA was used to compare differences in background noise with different levels of hearing impairment.

Personal Involvement

The idea for this project began with Dr. Santana-Hernández, who recognized a need for this information as he sought to develop a hearing impairment prevention program in Beni, Bolivia. He worked with individuals at the World Health Organization and CBM to develop a plan for funding and logistics of carrying out this study. I first became involved with this study after being put in touch with Dr. Santana-Hernández, by an organization called Global ENT Outreach, which had collaborated with him in the past. With Dr. Santana-Hernández, and other members of the team, I was involved in the design of the study, particularly the determination of sample size and number of necessary clusters, and assisted with analysis of local maps and determination of starting points prior to data collection trips. I was not involved in the translation of the World Health Organization Ear and Hearing Disorders Protocol into Spanish, nor was I involved in modifications made to that form, including the addition of the educational hearing game and assessment of otoacoustic emissions. On data collection trips, I began by documenting administrative data and conducting tympanometry. After gaining proper experience and increased linguistic skill, I was able to perform otoscopy and take limited histories with the assistance of other team members. Lastly, I was responsible for a large

amount of data entering and all of the statistical analysis included in this thesis. Mrs. Joanne Santana-Hernández, Mrs. KC Rivero, and Mrs. Amanda Cunningham were also instrumental in data entry.

RESULTS:

Overall, from the fifteen municipalities analyzed in this thesis, 4,957 individuals were included in this study. Of these, 4,353 individuals were examined, 56 refused to participate, 518 were absent, and 30 individuals were examined but information was not entered into the database. Therefore, the 4,353 individuals who were examined and coded were included in the following analysis representing 87.8% coverage of the target population. A comparison of age distribution in our study sample with 2001 Beni Census population (Figure 1) shows that our study sample was fairly representative of the overall population. This is also seen when age distribution is compared between the sexes (Figures 2 and 3). There are clear differences in certain age groups, which is expected given the time difference between the census data and our study as well as variance in birth rate from year to year. However, overall, the trend is consistent between these data sets indicating that our sample is representative.

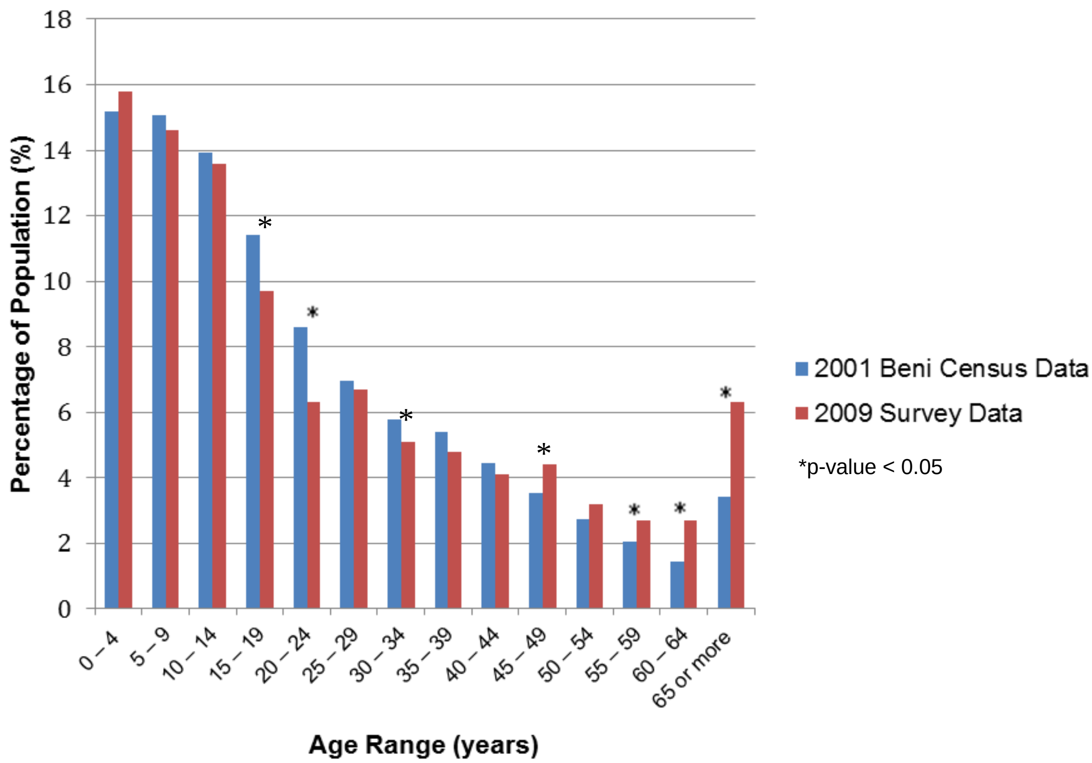

Figure 1: Age distribution (year ranges) for total sample population in this study compared with the age distribution for all individuals registered in the 2001 Beni Census.

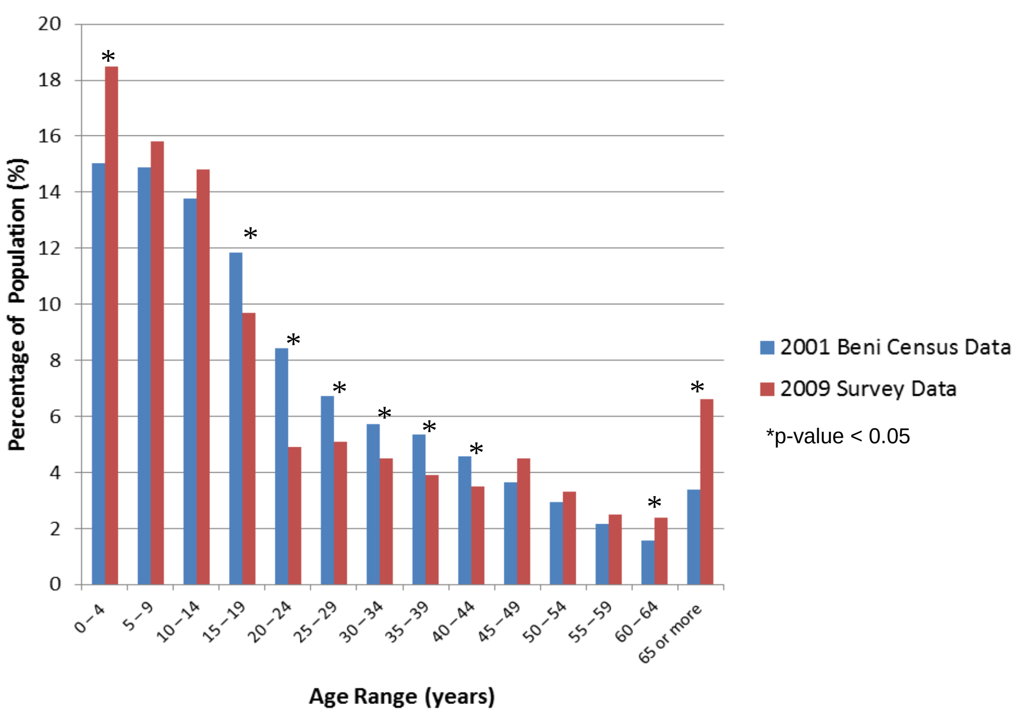

Figure 2: Age distribution (year ranges) for male sample population in this study compared with the age distribution for males registered in the 2001 Beni Census.

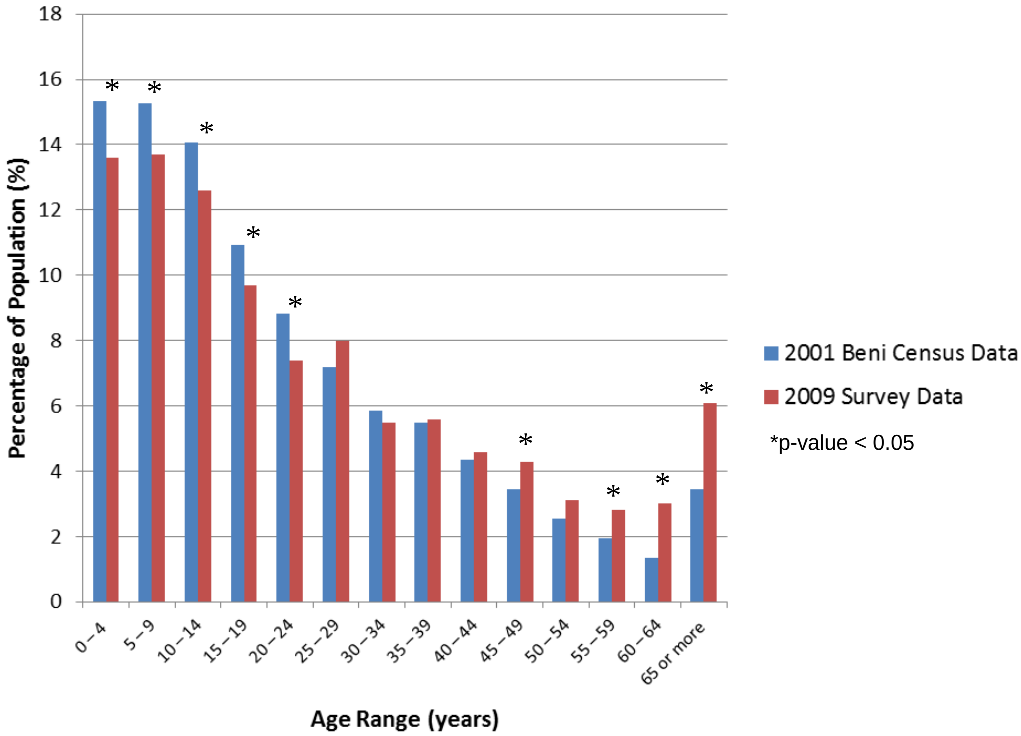

Figure 3: Age distribution (year ranges) for female sample population in this study compared with the age distribution for females registered in the 2001 Beni Census.

Study Population Demographics

The 4,353 individuals examined in the study population ranged in age from one day old to 93 years. The smallest municipality was San Javier, with 47 individuals, and the largest was Riberalta, with 1,041 individuals. The size of households ranged from 1 individual to 24 individuals! The demographic statistics are summarized in Table 1, and are organized by four distinct age groups. The first group is children under the age of four, as this was the cutoff in our study for audiometry. The next cutoff, age fifteen, was identified because, as described in the Methods, the WHO determined different thresholds for disabling hearing impairment for individuals under the age of fifteen. The last cutoff point was determined to be age 59 because at around age 60 presbyacusis, or age-related hearing loss, sets in. These age ranges have been used in the literature, [50] so these were the major age groups used in analysis, which will allow for comparison to results from other WHO studies.

With regard to gender, it is interesting to note that as age increases, the ratio of males to females changes. In the youngest population, 51.9% of the individuals were male and 49.1% were female, this trend reverses in the older age groups. This is likely due to the fact that in the older age groups, during the day, when the survey was performed, men were more often out of the house at their place of work, while females were more frequently involved in childcare and working in the home. Similarly, with regard to age, more than half of the entire study population was younger than age twenty. Again, this is likely due to the fact that as individuals aged, they were more likely to be out of the house at the time of the survey. However, in the overall population (Figure 1) there is a similar trend with the distribution skewed toward younger ages.

The study population lived in impoverished conditions. Over half of the individuals in the survey lived in fair housing conditions, which corresponds to houses built with poor quality or temporary material, where the bathroom was located outside of the house, and which had either running water or electricity, but not both. It is also striking that even though over half of the study population was younger than twenty years, over 40% of the individuals over the age of four worked in agricultural or manual labor jobs, which were often associated with small incomes.

Few individuals reported a family history of hearing impairment, only 1.1%. Similarly, few people had experienced trauma or exposure to loud noises. However, more of these events clearly occur with age, as the percentages increase in each successive age group. This makes sense given increased life experience and opportunity for such accidents, especially in jobs such as agriculture and manual labor. Many accidents described over the course of the survey involved falling from horses or motorcycles, or exposure to loud noises while at work.

Table 1
Demographic Characteristics of Examined Study Population

Characteristic	**Prevalence**									
	Age < 4		**Age 4 to 14**		**Age 15 to 59**		**Age >60**		**All Ages**	
	N	%	N	%	N	%	N	%	N	%
Sex (all differences significant p<0.05 except †)										
Male	289	51.9	658	48.5	809	39.8	173	43.9†	1929	44.3
Female	268	48.1	699	51.5	1235	60.4	221	56.1†	2423	55.7
Age (all differences significant p<0.05)										
0-3	557	100.0							557	12.8
4-14			1357	100.0					1357	31.2
15-19					423	20.7			423	9.7
20-29					567	27.8			567	13.0
30-39					430	21.0			430	9.9
40-49					367	18.0			367	8.4
50-59					256	12.5			256	5.9
60-69							207	52.5	207	4.8
70-79							123	31.2	123	2.8
80+							64	9.1	64	1.5
Region (all differences NOT significant except for *)										
San Javier	4	0.7	25	1.8*	17	0.8	1	0.3	47	1.1
Riberalta	149	26.8	318	23.4*	483	23.6	91	23.1	1041	23.9
Guayaramerin	83	14.9	189	13.9*	309	15.1	62	15.7	643	14.8
San Borja	63	11.3	182	13.4*	285	13.9	44	11.2	574	13.2
Rurrenabaque	25	4.5	82	6.0*	120	5.9	17	4.3	244	5.6
Reyes	22	3.9	76	5.6*	81	4	19	4.8	198	4.5
Santa Rosa	18	3.2	49	3.6*	69	3.4	14	3.6	150	3.4
San Ignacio	53	9.5	117	8.6*	169	8.3	34	8.6	373	8.6
Santa Ana	34	6.1	64	4.7*	148	7.2	36	9.1	282	6.5
Exaltacion	25	4.5	59	4.3*	91	4.4	24	6.1	199	4.6
San Pablo	27	4.8	60	4.4*	83	4.1	7	1.8	177	4.1
Loreto	8	1.4	16	1.2*	32	1.6	4	1	60	1.4
San Joaquin	12	2.2	30	2.2*	43	2.1	9	2.3	94	2.2

San Ramon	13	2.3	35	2.6*	37	1.8	15	3.8	100	2.3
Magdalena	21	3.8	55	4.1*	78	3.8	17	4.3	171	3.9
Household Condition (all differences significant p<0.05)										
Excellent	2	0.4	4	0.3	11	0.5	2	0.5	19	0.4
Good	28	5	61	4.5	168	8.2	28	7.1	285	6.6
Average	129	23.2	381	28.1	678	33.2	143	36.4	1331	30.6
Fair	379	68.2	866	63.9	1132	55.4	205	52.2	2582	59.4
Poor	18	3.2	43	3.2	54	2.6	15	3.8	130	3.0
Occupation (all differences significant p<0.05)										
Agricultural Worker	NA	NA	1	0.1	190	9.3	37	9.4	228	6.0
Office Worker	NA	NA	0	0	143	7	9	2.3	152	4.0
Manual Laborer	NA	NA	13	1	1259	61.6	194	49.4	1466	38.6
Student	NA	NA	1160	85.5	404	19.8	10	2.5	1574	41.5
Other	NA	NA	179	13.2	29	1.4	140	35.6	348	9.2
Unknown	NA	NA	4	0.3	19	0.9	3	0.8	26	0.7
Family History(all differences significant p<0.05 except†)										
Yes	1	0.2	9	0.7†	29	1.4	8	2†	47	1.1
No	555	99.6	1343	99.0†	1999	97.8	382	97.4†	4279	98.4
Uncertain	1	0.2	5	0.4†	15	0.7	2	0.5†	23	0.5
History of Noise Exposure (all differences significant p<0.05)										
Yes	0	0	1	0.1	92	4.5	34	8.6	127	2.9
No	557	100	1356	99.9	1953	95.5	360	91.4	4226	97.1
History of Trauma (all differences significant p<0.05)										
Yes	0	0	14	1.0	94	4.6	59	15.0	167	3.8
No	557	100	1343	99.0	1951	95.4	335	85.0	4186	96.2

Prevalence of Ear Pathology

Tympanic membrane pathology was relatively rare in this population (Table 2). One-hundred-and-twelve individuals were diagnosed with otitis media with effusion. As expected, most of these individuals were children, many of whom will require pressure equalization tubes to improve hearing. Seventy-one of the cases were under the age of four, so it is especially important to address this issue to allow for proper hearing and language development. Forty-five individuals were identified as having chronic otitis media with perforation, representing 1% of the population. Another three individuals had cholesteatoma. All of these disorders also require surgical attention, and it is fortunate that these individuals were identified through this study and will be treated through Fundación Totaí.

There is a significant percentage of the population that was diagnosed with cerumen impaction, which can contribute to conductive hearing impairment. It is interesting that as age increases, the incidence of cerumen impaction decreases and the incidence of foreign bodies increases. This may be explained by the Bolivian custom referenced in the Introduction of using any type of instrument to remove wax from one's ears. Perhaps as individuals age, they are more likely to remove wax, thus decreasing the prevalence of impaction, but increasing the prevalence of foreign bodies due to failed attempts.

Table 2
Prevalence of Ear Pathology

	Prevalence									
Finding	**Age < 4**		**Age 4-14**		**Age 15-59**		**Age >60**		**All Ages**	
Tympanic Membrane Pathology	N	%‡	N	%‡	N	%‡	N	%‡	N	%‡
Acute Otitis Media	3	0.5	3	0.2	1	0.01	0	0	7	0.2
Otitis Media with Effusion	71	12.7	29	2.1	7	0.3	5	1.3	112	2.6
Chronic Otitis Media with Perforation										
Suppurative	4	0.7	5	0.4	15	0.7	3	0.8	27	0.6
Non-Suppurative	0	0	8	0.6	9	0.4	1	0.3	18	0.4
Cholesteatoma	0	0	0	0	3	0.1	0	0	3	0.1
External Ear Malformation	8	1.4	25	1.8	35	1.7	6	1.5	74	1.7
Ear Pain	3	0.5	16	1.2	24	1.2	5	1.3	48	1.1
Foreign Body	3	0.5	21	1.5	91	2.1	17	4.3	132	3.0
Cerumen Impaction	97	17.4	231	17	132	6.5	37	9.4	497	11.4

‡Percentage of total in each age group <4 (557); 4-14 (1357); 15-59 (2045); >60 (394); All ages (4353)

Prevalence of Hearing Impairment

Analysis of hearing impairment levels was performed on the 3,735 individuals age four and older who were evaluated using pure-tone audiometry (61 were not). The overall prevalence of hearing impairment (threshold of 26dB or greater) in this study population was 35.5 percent (95% CI 34.0% -37.1%). Overall prevalence of disabling hearing impairment (31 dB and greater for individuals younger than age 15; 41 dB and greater for individuals age 15 and older) was 5.8 percent (95% CI 5.1% -6.6%). As seen in Table 3, both prevalence and severity of hearing impairment increase with age.

Table 3
Hearing Impairment Demographics

	Prevalence									
Type of Impairment	**Age < 4**		**Age 4-14**		**Age 15-59**		**Age >60**		**All Ages**	
	N	%	N	%	N	%	N	%	N	%
WHO Hearing Classification (all differences significant $p < 0.05$ except [†])										
No Impairment (25 dB or less)	10	83.3[†]	1131	85.7	1237	61	39	10.1	2417	64.4
Mild Impairment (26 dB to 40 dB)	2	16.7[†]	178	13.5	734	36.2	226	58.2	1140	30.5
Moderate Impairment (41 dB to 60 dB)	0	0	7	0.5	43	2.1	90	23.2	140	3.8
Severe Impairment (61 dB to 80 dB)	0	0	0	0	6	0.3	28	7.2	34	0.9
Profound Impairment (81 dB or greater)	0	0	3	0.2	8	0.4	5	1.3	16	0.4
Impairment ‡ (all differences significant $p < 0.05$ except [†])										
Yes	2	16.7[†]	188	14.3	791	39	349	89.9	2417	35.5
*No**	10	83.3[†]	1131	85.7	1237	61	39	10.1	1330	64.5
Disabling Hearing Impairment [0] (all differences significant $p < 0.05$)										
Yes	0	0	37	2.8	57	2.8	123	31.7	217	5.8
*No**	12	100	1282	97.2	1971	97.2	265	68.3	3530	94.2

‡26 dB and greater
* or no audiometry obtained
[0] 31 dB and greater for individuals younger than age 15; 41 dB and greater for individuals age 15 and older

Analysis of Variables Associated with Hearing Impairment

Once overall prevalence of different levels of impairment was obtained, regression analysis was used to determine which variables are associated with hearing impairment (Table 4). Males in our study were more likely to experience hearing impairment than females. Also, confirming the trend developing in Table 3, there is a clear statistical correlation with increased age and hearing loss. With regard to occupation, for this model, individuals who reported as working in either agriculture or manual labor were considered as “working in manual labor” as there are similar hazards in both categories (machinery, loud noises, accidents). These individuals were compared to those who did not work in such jobs, and there is a significant increase in hearing impairment among these individuals.

It was also hypothesized that household condition or household size (number of individuals in each home), would contribute to hearing impairment. Household condition was thought to contribute because decreased sanitation may lead to increased rates of ear infection and resultant hearing impairment. Increased household size was thought to increase exposure to community illnesses and also influence sanitation in the household. However, neither of these variables proved to have a significant correlation with hearing impairment.

The presence of a foreign body was associated with hearing impairment in the univariate analysis, but significance was lost when it was included in our multivariate regression model. Cerumen impaction was not significantly associated with hearing impairment in the univariate analysis, but significance was found when included in the regression model.

Trauma and history of noise exposure were strongly correlated with hearing impairment in both the univariate and multivariate analysis. Family history of hearing impairment was correlated in the univariate but not the multivariate analysis.

Table 4
Variables Associated with Hearing Impairment* in Individuals Older Than Age 4 †

Variable	No of Impaired Individuals	Unadjusted Odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-value
Sex					
Female	726	1.00		1.00	
Male	602	1.15 (1.01-1.32)	0.041	1.24 (1.07-1.40)	0.013
Age					
4 to 14	188	1.00		1.00	
15 to 59	791	3.85 (3.67-4.03)	<0.001	2.01 (1.75-2.26)	<0.001
60+	349	53.84 (53.47-54.20)	<0.001	17.07 (16.61-17.53)	<0.001
Demographics					
Works in Manual Labor	835	4.18 (3.58-4.87)	<0.001	2.23 (2.01-2.45)	<0.001
Household Condition				0.93 (0.81-1.05)	0.93
Household Size				1.00 (0.980-1.02)	0.997
Otoscopy					
Foreign Body	61	1.74 (1.22-2.48)	0.002	1.20 (0.79-1.61)	0.389
Cerumen Impaction	152	1.20 (0.97-1.49)	0.098	1.98 (1.71-2.25)	<0.001
History					
Noise Exposure	99	6.84 (4.47-10.47)	<0.001	3.61 (3.14-4.08)	<0.001
Trauma	128	6.65 (4.60-9.61)	<0.001	4.04 (3.62-4.46)	<0.001
Family History of Hearing Loss	26	2.41 (1.34-4.33)	0.003	1.77 (1.30-2.25)	0.099

*26 dB and greater loss
† All variables were adjusted for each other.

Once variables were identified that were associated with hearing impairment, analysis of the demographics in each of the municipalities was performed (Table 5). Sub group analysis was performed on the three municipalities with the highest prevalence of hearing impairment: Riberalta, Guayaramerin, and Santa Ana. San Ramon was also included because it had a disproportionately high prevalence of disabling hearing loss.

In Riberalta, where the prevalence of hearing impairment was 45.9 percent (95% CI 42.6% -49.2%) and prevalence of disabling hearing impairment was 11.7 percent (95% CI 9.5% -13.8%). While the gender correlation in this subgroup analysis was not significant, age was again highly correlated with impairment. Individuals were 1.3 times (p-value=0.032) and 17.4 times (p-value<0.001) more likely to experience impairment in the 14 to 59 and 60 and over age groups respectively. Individuals in Riberalta who worked in occupations requiring manual labor were 2.9 times (p-value<0.001) more likely to experience impairment, which is consistent with the fact that noise exposure and trauma increased odds of having hearing impairment in this municipality by 6.5 (p-value=0.001) and 19.6 times (p-value=0.004) respectively.

In nearby Guayaramerin, where the prevalence of hearing impairment was 35.1 percent (95% CI 31.1% -39.1%) and prevalence of disabling hearing impairment was 4.9 percent (95% CI 3.1%-6.7%), individuals were 28.1 times (p-value<0.001) more likely to experience impairment in the 60 and over age group. Those who worked in occupations requiring manual labor were 5.8 times (p-value<0.001) more likely to experience impairment, a higher odds ratio than in Riberalta. Noise exposure and trauma increased the odds of having hearing impairment in this municipality as well, by 6.1 times (p-value=0.001) and 7.7 times (p-value=0.004) respectively. In this group presence of a foreign body on otoscopy was also correlated with hearing impairment, increasing odds by 3.2 times (p-value=0.006).

In Santa Ana, where the prevalence of hearing impairment was 43.3 percent (95% CI 37.1% -49.5%) and prevalence of disabling hearing impairment was 4.5 percent (95% CI 1.8%-7.0%), individuals age 60 and older were 14.5 times (p-value<0.001) more likely to experience impairment. Those who worked in occupations requiring manual labor were 3.6 times (p-value<0.001) more likely to experience impairment. In this group trauma was not significantly associated with hearing impairment, but loud noise exposure increased the odds of having hearing impairment by 7.1 times (p-value=0.013).

While the prevalence of hearing impairment in San Ramon was one of the lowest in the study at 20.5 percent (95% CI 11.6% -29.4%) the prevalence of disabling hearing impairment was high at 9.6 percent (95% CI 3.2%-16.1%). In subgroup analysis of this smaller population, it was found that again, age greater than 60 was significantly correlated with hearing impairment. Also noise exposure and trauma increased the odds of hearing impairment by 13.9 times (p-value=0.027) and 9.8 times (p-value=0.013) respectively. The unique finding in this group is that individuals who reported a family history of hearing impairment were 27.1 times (p-value=0.004) more likely to experience hearing impairment. Either high background noise in particular homes or congenital hearing impairment may be contributing to such high levels of disabling hearing impairment in this population.

Table 5: Regional Differences in Prevalence of Variables Associated with Hearing Impairment

Variable	San Javier	Riberalta	Guayaramerin	San Borja	Rurrenabaque	Reyes	Santa Rosa	San Ignacio	Santa Ana	Exaltacion	San Pablo	Loreto	San Joaquin	San Ramon	Magdalena
Sex															
Female	48.8	59.9	56.1	55.8	56.2	54.5	55.3	53.8	58.7	55.7	52.0	63.5	63.4	56.3	55.3
Male	51.2	40.1	43.9	44.2	43.8	45.5	44.7	46.3	41.3	44.3	48.0	36.5	36.6	43.7	44.7
Age															
4 to 14	58.1	35.7	33.8	35.6	37.4	43.2	37.1	36.6	25.8	33.9	40.0	30.8	36.6	40.2	36.7
15 to 59	39.5	54.1	55.2	55.8	54.8	46.0	52.3	52.8	59.7	52.3	55.3	61.5	52.4	42.5	52.0
60+	2.3	10.2	11.1	8.6	7.8	10.8	10.6	10.6	14.5	13.8	4.7	7.7	11.0	17.2	11.3
Average Age (S.D.)	18.96 (16.89)	24.26 (20.95)	25.69 (21.35)	25.54 (20.89)	24.17 (19.89)	23.86 (21.14)	24.08 (20.56)	24.17 (21.29)	27.76 (22.55)	27.57 (23.10)	22.17 (18.76)	23.85 (21.49)	25.18 (20.80)	27.49 (24.16)	27.05 (22.28)
Demographics															
Average Household Condition (S.D.)	3.98 (0.146)	3.46 (0.734)	3.46 (0.646)	3.62 (.813)	3.40 (0.733)	3.56 (0.796)	3.82 (0.386)	3.91 (0.434)	3.24 (0.47)	3.82 (0.38)	4.00 (0.107)	3.78 (0.415)	3.60 (0.66)	3.92 (0.53)	3.40 (0.748)
Average Household Size (S.D.)	8.43 (2.88)	7.07 (3.9)	8.35 (4.44)	7.67 (3.80)	9.27 (5.13)	7.16 (2.44)	10.05 (5.372)	8.73 (4.75)	7.49 (4.20)	7.68 (4.20)	6.94 (2.78)	7.20 (3.68)	11.18 (7.44)	8.37 (3.74)	9.04 (3.74)
Work in Manual Labor	23.8	49.4	54.9	50.2	49.3	44.0	43.5	48.6	47.7	53.2	47.4	46.5	44.9	53.8	51.8
Otoscopy															
Foreign Body	0.0	1.0	4.3	4.9	3.2	6.8	9.1	2.2	2.0	3.4	4.0	1.9	6.1	1.1	6.0
Cerumen Impaction	7.0	16.7	10.2	7.8	11.4	11.4	11.4	12.8	9.7	6.9	1.3	1.9	4.9	2.3	3.3
History															
Noise Exposure	2.3	1.9	5.0	4.1	5.0	1.1	4.5	0.6	4.8	2.9	4.0	3.8	2.4	4.6	5.3
Trauma	0.0	2.8	6.6	3.7	3.7	3.4	3.0	3.1	4.4	8.6	4.7	5.8	7.3	6.9	6.7
Family History of Hearing Loss	0.0	1.7	1.8	0.8	0.5	0.0	3.8	0.0	0.8	0.0	0.0	0.0	3.7	7.0	0.0
Hearing Assessment															
Impairment	18.6	45.9	35.1	34.4	33.6	34.3	30.2	33.4	43.3	30.1	27.7	24.0	15.0	20.5	23.1
DHI	0.0	11.7	4.9	4.3	3.7	4.1	3.1	3.8	4.5	2.3	2.0	4.0	2.5	9.6	3.4

Hearing Evaluation for Children Younger Than Age Four

Of the 4,353 individuals who were examined for this study, 557 were children under the age of four. As described above, three modalities were used to assess hearing in these children: screening questions, otoacoustic emissions, and an educational hearing game. Of these 557 children, 79.2% answered at least one screening question correctly, however 20.8% did not. For otoacoustic emissions testing, the majority of children passed, however 19.9% and 26.8% failed in the right and left ears respectively. Also, over 15% of the children were either uncooperative or the test was not performed. Both the failed tests and the cases where tests were not performed may be related to logistical challenges of performing this test in the field. Some children were crying, distracted, or irritable. Also, at times examiners failed to perform this test because they did not realize the child fell within the appropriate age range. Due to the interactive nature of the educational hearing game, it was only administered to children older than 18 months. Of the 557 children, there were 347 children in this age range. Of these 347 children, the test was administered to 120, most of whom passed. Again, the large number of children who were uncooperative or not tested may have stemmed from logistical difficulties in administering this test. Also, some of the uncooperative children may have been improperly coded as “not done.”

Table 4:
Screening Tests for Children Age < 4

Screening Test	Prevalence n (%)
Screening Questions (answered at least one question correctly)	
Yes	441 (79.2)
No	116 (20.8)
Otoacoustic Emissions	
Right Ear	
Pass	361 (64.8)
Fail	111 (19.9)
Uncooperative	33 (5.9)
Not Done	52 (9.4)
Left Ear	
Pass	320 (57.4)
Fail	149 (26.8)
Uncooperative	35 (6.3)
Not Done	53 (9.5)
Educational Hearing Game (ages 18 months to 4 years)	
Pass	115 (33.1)
Fail	5 (1.4)
Uncooperative	73 (21.1)
Not Done	154 (44.4)

Twelve children under the age of four were able to participate with audiometry. It was thought that there would be sufficient overlap between these data and each of the screening modalities to evaluate their validity (i.e. positive and negative predictive values for these tests, using audiometry as a gold standard). However, the screening tests were not administered to most of these children. Of the twelve, ten had normal audiograms and two showed mild impairment. Of the ten with normal audiograms, only two were asked the screening questions, administered the educational hearing game, and evaluated for otoacoustic emissions. Both children answered the screening questions appropriately. One of the children passed the educational hearing game and had normal otoacoustic emissions. The other passed the educational hearing game but otoacoustic emissions data were not recorded. Neither of the two children who demonstrated mild impairment on audiometry were administered the screening battery. It is not clear why most of these children were not administered the screening tests. It is possible that survey teams independently decided that because audiometry was a superior test, if the child was cooperative, there was no need to evaluate using other modalities.

DISCUSSION:

This study found that the overall prevalence of hearing impairment in this population was 35.5 percent (95% CI 34.0% -37.1%), and the prevalence of disabling hearing impairment was 5.8 percent (95% CI 5.1% -6.6%). While these estimates are still preliminary, as these data do not include information from the city of Trinidad, they are still informative. Extrapolating these numbers to the larger population of the Department of Beni (249,152 in 2001), there are over 88,400 individuals in this region suffering from hearing impairment and over 14,400 individuals with disabling hearing impairment.

In the context of other countries where prevalence studies on hearing impairment have been performed, the prevalence of disabling hearing impairment in this population was relatively high. As described in the introduction, in several developed European nations, prevalence statistics range from 0.2% to 3.9%. [29,34] In the Middle East statistics ranged from 0.9% to 2.07%. [35,37] In many developing countries, including those in different regions in Africa, prevalence was also low ranging from 0.9% to 4.2% with an outlier in Uganda.[43,45,46] The prevalence in this study is more consistent with studies conducted in India (7%), [24] Korea (10.6%), [28] and Brazil (6.8%).[50] With regard to all levels of impairment, this study has one of the highest prevalences recorded. The only population based study that is similar is the one performed in Korea where a prevalence of overall impairment was determined to be 43.4%.[28] The prevalence of impairment in this study is much greater than the study performed in Brazil where the prevalence of overall impairment was 26.1%.[50] While the screening data available in our study for individuals younger than age 4 are not as reliable as audiometry, the high prevalence of failed otoacoustic emissions testing and failure to answer screening questions (both around 20%) is concerning and points to the need for early childhood hearing screening and evaluation to identify problems prior to impairment in speech or language development.

Little data is available for ear pathology in other countries to provide context for statistics gleaned from this study. The prevalence data for ear pathology is mostly limited to the pediatric population. A study of school children in Tanzania, aged five to twenty years, found the prevalence of cerumen impaction to be 15.7% and prevalence of chronic suppurative otitis media to be 2.6%.[44] A separate study performed in a cohort of children ages three to eight in Greenland showed a prevalence of acute otitis media between 1.5% and 0.4%, and of otitis media with effusion between 23.0% and 28.2%.[56] Another study done in school children in Jerusalem between the ages of 8 and 13 found that 1.5% of these children suffered from otitis media with effusion, 0.3% from chronic otitis media, and 0.07% from cholesteatoma.[57] In comparison with these studies, our study found that the prevalence of acute otitis media was somewhat lower at 0.2% in the general population and between 0.2% to 0.5% in children through age 14. The rate of otitis media with effusion was high in the younger population (12.7% in the youngest age group) which is lower than the statistics found in the Greenland study, and the prevalence of 2.1% in the age group from 4 to 14 is higher than found in the Jerusalem study. Suppurative and non-suppurative chronic otitis media were diagnosed in 1.0% of the population, which is lower than the prevalence in Tanzania, but higher than in Jerusalem. Cholesteatoma was diagnosed in 0.1% of the population, which is higher than in the Jerusalem study. Lastly the prevalence range from 17.0% to 17.4% of cerumen impaction in ages 0 to 14 is even greater than the prevalence found in Tanzania in a similarly aged population. This high level of cerumen impaction as well as a prevalence of foreign bodies in 3.0% of the study population presents a clear opportunity for education and prevention.

The regression analysis clearly showed that certain variables are associated with hearing loss. The findings that men had a higher likelihood of experiencing hearing loss and an increasing likelihood of hearing loss with increasing age were found in the population based study performed in Brazil[50] as well as in data from the United States population.[58] The other variables associated with impairment, including working in an occupation requiring manual labor, exposure to loud noise, and history of trauma are likely related. A large proportion of Bolivians work in jobs requiring manual labor and while labor laws providing protection for workers have been passed, there are few resources to enforce them. Also, for either economic or cultural reasons, individuals often do not use ear protective devices. A large number of people travel by motorbike throughout the region, and while accidents are quite common, very few individuals wear helmets.

With regard to regional differences in hearing impairment, the above analysis of the municipalities with the highest prevalence of hearing impairment provides some direction for implementation of hearing impairment prevention programs throughout this region of Bolivia. While all of the population centers would benefit from hearing impairment prevention programs, Riberalta, Santa Ana, and Guayaramerin have the highest prevalence of hearing impairment, and would be good places to focus resources initially. Age, working in manual labor, exposure to loud noise, trauma, and the presence of foreign body on otoscopy were associated with hearing impairment among these communities, it would be helpful to provide education and increased access to screening and treatment services to these individuals.

The World Health Organization has developed a program for the education of individuals in Primary Ear and Hearing Care[59] that may serve as the foundation of such a prevention and intervention initiative. The training resource is divided into beginner, intermediate, and advanced levels. It provides information on the causes, diagnosis, and treatment of many ear diseases. It also provides education about hearing impairment and training on the proper use and maintenance of hearing aids. Prevention is also a major focus of this resource. Included in the curriculum are primary prevention techniques such as education regarding use of ear protection devices, immunization against certain infections, treatment of otitis media and careful use of ototoxic drugs; secondary prevention techniques which focus on the diagnosis and treatment of conditions that may lead to hearing impairment and includes interventions such as hearing screening and early treatment of infections; and tertiary prevention techniques, which focus on rehabilitation of individuals who already have a hearing impairment and include interventions such as providing hearing aids, education, and social integration for these individuals. This curriculum for educating health workers on primary ear and hearing care has been initiated at Fundación Totaí. Training programs will likely be pursued in each of the municipalities to equip individuals there with the proper resources to address the pathology identified in this study. It is recommended that priority be given to the three municipalities mentioned above: Riberalta, Guayaramerin, and Santa Ana. It is also important to further explore the high prevalence of disabling hearing impairment and its connection with reported family history that is present in the community of San Ramon.

There are several limitations of this study. The randomization of the study sample was not entirely consistent from one population center to another, because different information and map resources were available for each location. Also, the goal was for clusters to be of approximately equal sizes. While the average cluster size was 115 individuals, which was close to our goal of 100 individuals, in execution of the survey, average cluster sizes ranged from a minimum of 64 in Loreto to a maximum of 164 in Santa Rosa. These differences may have influenced randomization. Another weakness was that error was likely introduced either when individuals coded responses onto the form manually or when these data were recoded into the computer. In retrospect, it would have been very beneficial to ask more history questions of participants including average household income, health risk factors such as diabetes or history of smoking, and number of years of schooling. These additional data points may have provided more information regarding demographics of hearing impairment. Another confounding factor in our study was the level of ambient noise at the time of audiometry. Background noise interferes with the subject’s ability to discriminate the pure tones emitted from the audiometer. There were statistically significant increases in background noise between the “No Impairment,” “Mild Impairment,” and “Moderate Impairment” groups (Table 6), indicating that there was likely an influence at these lower levels of hearing impairment. However, at more severe levels of loss, there was no correlation on increased background noise with more severe levels of impairment. Therefore, background noise may have caused artificially elevated prevalences of impairment in the mild and moderate impairment categories.

Table 6
Mean Ambient Noise (dB) with 95% confidence intervals according to level of impairment

Level of Impairment	No.	Mean (dB)	95% CI
No Impairment (25 dB or less)	2418	48.41	48.23-48.59
Mild Impairment (26 dB to 40 dB)	1141	49.85	49.53-50.18
Moderate Impairment (41 dB to 60 dB)	141	51.67	50.57-52.77
Severe Impairment (61 dB to 80 dB)	34	49.35	48.01-50.70
Profound Impairment (81 dB or greater)	16	50.63	47.19-54.06

*The analysis of variance technique showed a statistically significant ($p < 0.05$) in the average ambient noise experienced between the first three groups, the difference between the last two groups was not significant.

The completion of this survey and analysis of these data provides useful information on hearing impairment and ear disease which may be used both by local charity organizations such as Fundación Totaí to implement hearing impairment prevention programs as well as by national and international aid organizations such as the World Health Organization as they distribute resources to address the problem of hearing impairment and the many difficulties that accompany it. Through administration of this survey in the various communities, valuable data on prevalance and geographic distribution of disease and impairment was collected, public awareness of hearing loss and ear disease was increased, many individuals were connected with needed treatment from specialists in otolaryngology and audiology, and baseline data have been recorded from which future data may be compared and progress measured.

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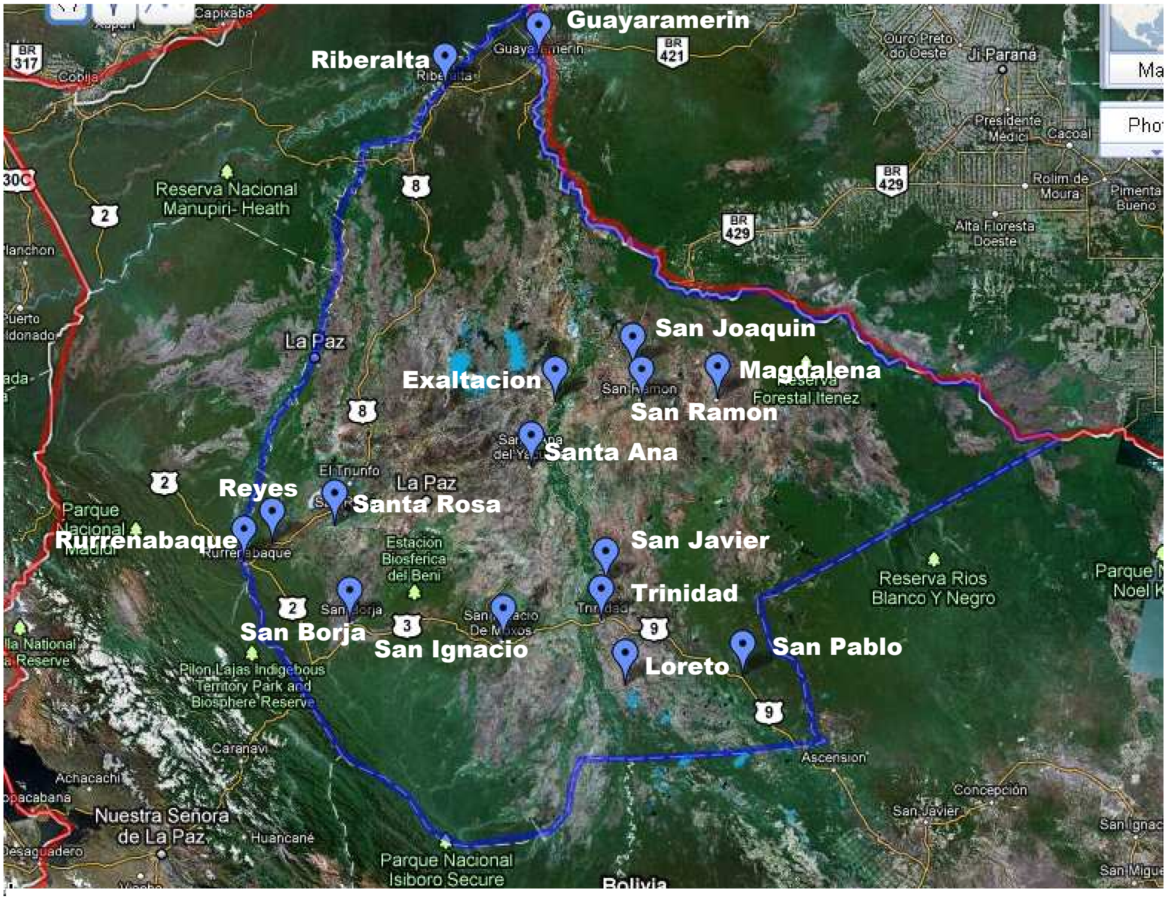
Appendix A: Map of Bolivia (outlined in red) and the Department of Beni (outlined in blue)

Appendix B: Map of Beni, Bolivia (outlined in blue) with each of the population centers labeled with blue tabs



Appendix C: Original WHO Ear and Hearing Disorders Examination Form

WHO/PBD Ear and Hearing Disorders Examination Form **Version 8.3** (use Earform software 6.00d, manual 6v2)

A. CENSUS

Country Number ☐☐☐ Study Number ☐☐ Admin District ☐☐ Cluster Number ☐☐ Household Number ☐☐ Person Number ☐☐ Name ....

1.Date ☐☐☐☐☐☐ (d d m m y y) 2.Exam Status ☐ 3.Age in Years ☐☐ 4.Age in Months ☐☐ 5.Male/ Female ☐ 6.Occupation ☐ 7.Optional ☐☐

B. HEARING EXAMINATION

(I) Hearing Assessment for children *(Age 6m to 3y 11m)* — No / Yes / Not Done

1. A child searches for the sound direction and shows a response such as smile or pause when you call his/her name.......... ☐ ☐ ☐
2. A child can point to a parent or brother & sister when you ask, and speaks simple words such as 'mama' or 'bye bye'..... ☐ ☐ ☐
3. A child can answer your question for his/her name and can repeat sentences which you give.......... ☐ ☐ ☐
4. A child reflexly blinks to loud noise.......... ☐ ☐ ☐

(Pass / Fail / Not done)

5. OAE test Right: ☐ ☐ ☐ Left: ☐ ☐ ☐
6. ABR test Right: ☐ ☐ ☐ Left: ☐ ☐ ☐
7. Tympanometry Right: A: ☐ B: ☐ C: ☐ Not done: ☐ Left: A: ☐ B: ☐ C: ☐ Not done: ☐
8. Equipment number OAE: ☐☐ ABR: ☐☐ Tympanometer: ☐☐

(II) Audiometry *(Age 4 years or over)*

1. Ambient noise .... ☐☐ dBA.
   Equipment number AUDIOMETER.... ☐☐
2. Hearing Thresholds

Right (dBHL)		Left (dBHL)
☐☐	1 KHz	☐☐
☐☐	2 KHz	☐☐
☐☐	4 KHz	☐☐
☐☐	0.5 KHz	☐☐
☐☐	1 KHz	☐☐

EXAMINER NUMBER: ☐☐ REMARKS:-

EXAM COMPLETION Not fully examined: ☐ Fully examined: ☐ Exception: ☐ (exception only allowed for age ≤9y)

C. BASIC EAR ASSESSMENT (← Right → | ← Left →)

I. Ear Pain .... N: ☐ Y: ☐ N/A: ☐ | N: ☐ Y: ☐ N/A: ☐
N=No; Y=yes; N/A=Not asked;

II. Auricle .... N: ☐ M: ☐ N/S: ☐ | N: ☐ M: ☐ N/S: ☐
N=Normal; M=malformation or auricle absent; N/E=not seen

III. External ear canal

1. Normal............ N: ☐ Y: ☐ N/E: ☐ | N: ☐ Y: ☐ N/E: ☐
2. Inflammation .... N: ☐ Y: ☐ N/E: ☐ | N: ☐ Y: ☐ N/E: ☐
3. Wax.................. N: ☐ Y: ☐ N/E: ☐ | N: ☐ Y: ☐ N/E: ☐
   Removed .... Y: ☐ N: ☐ | Y: ☐ N: ☐
4. Foreign body ...... N: ☐ Y: ☐ N/E: ☐ | N: ☐ Y: ☐ N/E: ☐
   Removed .... Y: ☐ N: ☐ | Y: ☐ N: ☐
5. Otorrhoea .... N: ☐ Y: ☐ N/E: ☐ | N: ☐ Y: ☐ N/E: ☐
   Removed .... Y: ☐ N: ☐ | Y: ☐ N: ☐
6. Fungi .... N: ☐ Y: ☐ N/E: ☐ | N: ☐ Y: ☐ N/E: ☐
N=No; Y=Yes; N/E=not examined

IV. Ear drum

1. Perforation ....Y: ☐ | Y: ☐
2. Dullness or Retraction...Y: ☐ | Y: ☐
3. Red and Bulging ....Y: ☐ | Y: ☐
4. Normal ....Y: ☐ | Y: ☐
5. Unsure ....T: ☐ | T: ☐
9. Not examined.................T: ☐ | T: ☐
Y=Yes; T=true

V. Middle Ear

1. Normal..........................Y: ☐ | Y: ☐
2. Otorrhoea.....................Y: ☐ | Y: ☐
3. Not examined................T: ☐ | T: ☐

VI. Others ....N: ☐ Y: ☐ N/E: ☐ | N: ☐ Y: ☐ N/E: ☐
Specify ______________________

VII. Additional Information

1. How long has the subject had difficulty hearing?
   Since infancy/childhood (0-4y) .... ☐
   Since adulthood (15-59y) .... ☐
   Since old age (60y +) .... ☐
   Uncertain .... ☐
   No difficulty.. ☐
   Not asked.. ☐
2. Does any relative of subject have difficulty hearing? (ask all subjects)
   No .... ☐ Brother or sister .....N: ☐ Y: ☐ U: ☐
   Yes .... ☐ ➔➔➔ Child of subject ......N: ☐ Y: ☐ U: ☐
   Uncertain.......... ☐ Parent of subject ....N: ☐ Y: ☐ U: ☐
   Not asked.......... ☐

D.CAUSE OF EAR DISEASE AND/OR HEARING IMPAIRMENT (R L)

Normal ear and normal hearing.......................... ☐ ☐

I. Ear Disease
1. Wax .... ☐ ☐
2. Foreign body .... ☐ ☐
3. Otitis externa .... ☐ ☐
   Otitis media
   4. Acute .... ☐ ☐
   5. Chronic suppurative .... ☐ ☐
   6. Serous (with effusion) .... ☐ ☐
7. Dry perforation of Tympanic Membrane ..... ☐ ☐

II. Infectious Diseases .... ☐ ☐
Specify ______________________

III. Genetic Conditions .... ☐ ☐
Specify ______________________

IV. Non-Infectious Conditions .... ☐ ☐
Specify ______________________

V. Undetermined Cause .... ☐ ☐
Specify ______________________

VI. Other .... ☐ ☐
Specify

E. ACTION NEEDED

T=true; F=false; U=unknown (T F U)

I. No action needed .... ☐ ☐ ☐

N=no; Y=yes; U=unknown (N Y U)

II. Action needed
1. Medication .... ☐ ☐ ☐
2. Hearing aid .... ☐ ☐ ☐
3. Language/speech rehabilitation .... ☐ ☐ ☐
4. Special needs education .... ☐ ☐ ☐
5. Vocational Training .. ☐ ☐ ☐
6. Surgery Referral...... ☐ ☐ ☐
   Urgent .... ☐
   Non-urgent .... ☐
7. Others .... ☐ ☐ ☐
   (Specify) ______________________

SPECIAL EXAMINER'S NUMBER ☐☐

SPECIAL EXAMINER'S REMARKS:-

Date of version: 1.03.09
Date of printing: January 8, 2011

Appendix D: Modified WHO Ear and Hearing Disorders Examination Form in Spanish

Formulario de la OMS/PDH para Trastornos del Oído y la Audición Version 8.0 – Español (Fundación Totaí-Trinidad-Beni)

A. CENSO

Número de país 0 6 8 | Número de estudio 0 1 | División administr. ☐☐ | Número de grupo ☐☐ | Número de vivienda ☐☐ | Número personal ☐☐ | Nombre ....

1.Fecha ☐☐☐☐☐☐ (d d m m a a) | 2. Código examen ☐ (1=examinado; 2=rechaza; 3=ausente) | 3. Edad en años ☐☐ | 4. Edad en meses ☐☐ | 5.Masculino o Femenino ☐ (1 = Masculino 2= Femenino) | 6.Ocupación (código) ☐ | 7.Condición social/vivienda ☐☐ (1=excel; 2=buena; 3=prom; 4=baja; 5=mala)

B. EXAMEN DE LA AUDICIÓN

(I) Evaluación de la Audición en niños (6m a 3a11m)

	No	Sí	No hecho
1. El niño busca la dirección del sonido y muestra una respuesta (sonrisa, pausa, etc.) cuando lo llama por su nombre..(6-12m)...	☐	☐	☐
2. El niño señala a uno de sus familiares cuando se le pide y puede decir una palabra sencilla (mamá, papá, chau, etc)(>18m).	☐	☐	☐
3. El niño responde a preguntas sencillas (¿Cómo te llamas? etc.) y puede repetir frases sencillas que usted le diga...(2-4años)...	☐	☐	☐
4. El niño parpadea como reflejo a un ruido fuerte (0 – 6 meses)...	☐	☐	☐

	Derecho: Pasa	Refiere	No hecho	Izquierdo: Pasa	Refiere	No hecho
5. Test EOA	☐	☐	☐	☐	☐	☐
6. ABR (PEA)	☐	☐	☐	☐	☐	☐

7. Timpanometría Derecho: A ☐ B ☐ C ☐ No hecho ☐ | Izqdo: A ☐ B ☐ C ☐ No hecho ☐

8. Número de equipos EOA: ☐☐ ABR: ☐☐ Timpanómetro: ☐☐ JEA: ☐☐ Sonómetro: ☐☐ Audiómetro: ☐☐

9. JEA (EHG) Juego Educacional Auditivo

Oído Derecho: ☐ D ☐	Pasa	Refiere
Vaca (25 cm)	☐	☐
Gallo (50 cm)	☐	☐
Pájaros (1 m)	☐	☐

Oído Izquierdo: ☐ I ☐	Pasa	Refiere
Vaca (25 cm)	☐	☐
Gallo (50 cm)	☐	☐
Pájaros (1 m)	☐	☐

(II) Audiometría *(Edad: 4 años o más)*

1. Ruido ambiente............. ☐☐ dBA
2. Umbrales auditivos

Derecho (dBHL)		Izquierdo (dBHL)
☐☐	1 KHz	☐☐
☐☐	2 KHz	☐☐
☐☐	4 KHz	☐☐
☐☐	0.5 KHz	☐☐
☐☐	1 KHz	☐☐

NÚMERO DEL EXAMINADOR (B): ☐☐ COMENTARIOS DEL EXAMINADOR:-

EXAMEN COMPLETO Examen no completado: ☐ Examen completado: ☐ Excepción: ☐ las excepciones sólo se permiten para edades <=9a)

C. EVALUACIÓN BÁSICA DEL OÍDO

	Derecho	Izquierdo
I. Otalgia (dolor)	No: ☐ Sí: ☐ N/E: ☐	No ☐ Sí: ☐ N/E: ☐
II. Pabellón auricular	N: ☐ M: ☐ N/E: ☐	N: ☐ M: ☐ N/E: ☐

N=Normal; M=Malformación; N/E=No Examinado

III. Conducto Auditivo Externo

	Derecho	Izquierdo
1. Normal	Sí: ☐ N/E: ☐	Sí: ☐ N/E: ☐
2. Inflamación	☐	☐
3. Cerumen	☐	☐
Extraido	Sí ☐	Sí: ☐
4. Cuerpo extraño	☐	☐
Extraido	Sí ☐	Sí: ☐
5. Otorrea	☐	☐
Extraida	Sí ☐	Sí: ☐
6. Otomicosis	☐	☐
Extraida	Sí ☐	Sí: ☐

IV. Membrana Timpánica

	Derecho	Izquierdo
1. Perforación	☐	☐
2. Opacidad o Retracción	☐	☐
3. Eritema y Protrusión	☐	☐
4. Normal	Sí: ☐	Sí: ☐
5. No visualizado/incierto	V: ☐	V: ☐
6. No examinado	V: ☐	V: ☐

V=verdad

V. Cavidad del Oído Medio

	Derecho	Izquierdo
1. "Normal"(perforación seca)	Sí: ☐	Sí: ☐
2. Otorrea	☐	☐
3. No visualizado	V: ☐	V: ☐

VI. Otros .... V: ☐ .... V: ☐

*Especificar*____________________

VII. Información adicional

1. ¿Edad de presentación? (Esta pregunta debe ser contestada por las personas que presenten sordera o déficit auditivo).
   - Ya presente en el momento del nacimiento...... ☐
   - Presente desde la infancia (0-14años) .... ☐
   - Presentación en edad adulta (15-59a) .... ☐ ➜ 15-17a ☐
   - Presentación en edad avanzada (60a y +) .... ☐
   - Comienzo incierto.. ☐
2. ¿Algún familiar directo tiene dificultad para oír? (Esta pregunta debe ser contestada por todas las personas encuestadas).
   - No........................ ☐
   - Sí......................... ☐ ➜ Hermano o hermana............... ☐ / Hijo/a del encuestado............ ☐ / Padre/madre del encuestado.... ☐
   - Incierto................. ☐

D.CAUSA del TRASTORNO del OÍDO Y/O DÉFICIT AUDITIVO

	D	I
Oído Normal Y Audición Normal	☐	☐
I. Trastorno del Oído		
1. Tapón de cerumen..	☐	☐
2. Cuerpo Extraño	☐	☐
3. Otitis externa	☐	☐
Otitis media		
4. Aguda (menos de 2 semanas)............	☐	☐
5. Supurativa Crónica (activa).................	☐	☐
6. Seromucinosa (serosa o con efusión)...	☐	☐
7. Perforación Seca (OMC Inactiva +1 año)...	☐	☐
8. OMC con Colesteatoma....................	☐	☐
II. Enfermedades Infecciosas sistémicas............	☐	☐
Especificar____________________		
III. Condiciones Genéticas..................................	☐	☐
Especificar____________________		
IV. Condiciones No-Infecciosas.........................	☐	☐
Especificar____________________		
V. Causa indeterminada.....................................	☐	☐
VI. Otra: *Especificar*____________________		

E. ACCIÓN REQUERIDA:

I. No necesita acción alguna.. ☐

II. Acción requerida................ ☐
1. Medicación .... ☐
2. Ayuda Auditiva................ ☐
3. Rehabilitación mediante Logopedia / Fonoterapia. ☐
4. Educación Especial........ ☐
5. Capacitación vocacional.. ☐
6. Derivación a Cirugía
   - Urgente .... ☐
   - No-urgente .... ☐
7. Otra .... ☐

(Especificar)

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NÚMERO DEL EXAMINADOR ESPECIALIZADO: ☐☐

COMENTARIOS DEL EXAMINADOR:-

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