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DEVELOPMENT OF A HIGH-FREQUENCY HEARING LOSS QUESTIONNAIRE FOR CHILDREN

by

Jamie M. Baum

A Capstone Project
submitted in partial fulfillment of the
requirements for the degree of:

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Approved by:
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Abstract: The "Pediatric Assessment of Hearing" questionnaire was developed to evaluate how children with high-frequency hearing loss perform in various listening conditions.

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Abstract

Ototoxicity from cisplatin and carboplatin is characterized by a bilateral sensorineural hearing loss, initially affecting the high frequencies. This type of hearing loss is often unreported by children and underestimated by parents and teachers. Children with high-frequency hearing loss are at risk for academic failure and social-emotional problems. The "Pediatric Assessment of Hearing" questionnaire was developed to evaluate how children with high-frequency hearing loss perform in various listening conditions. Participants included children with high-frequency hearing loss due to treatment with cisplatin or carboplatin and children with normal hearing. Sixteen participants completed the study, 15 with normal hearing (control group) and 1 with high-frequency hearing loss (experimental group). Normal hearing children scored relatively low on the questionnaire, indicating no difficulties to occasional difficulties hearing in various listening situations. The one experimental participant scored similar to the control group. Because only one participant was enrolled in the experimental group, statistical analysis comparing the groups could not be performed. Due to the small sample size, conclusions regarding the sensitivity of the questionnaire and use as a counseling tool can not be made. Further research is needed to accrue more participants in both the control and experimental groups.

Introduction

Ototoxicity occurs when a specific medication causes functional impairment and structural degeneration of the inner ear (Waters, Ahmad, Katsarkas, Stanimir & McKay, 1991). A drug or substance can be considered potentially ototoxic when treatment with the agent results in symptoms such as hearing loss, tinnitus, imbalance, or vertigo. There are several classes of medications that have ototoxic side effects, including specific types of aminoglycosides, salicylates, diuretics, and quinine (Pappas & Pappas, Jr., 1997). This study focuses on cisplatin and carboplatin, which are both chemotherapeutic agents that are potentially ototoxic.

Cisplatin and carboplatin are used to treat several childhood malignancies, including cancers of the head and neck, esophagus, lungs, and other primary sites (Bertolini et al., 2004; Nagy et al., 1999). Cisplatin and its derivatives are the most ototoxic chemotherapeutic agents currently in use (Bellman, 1996). Ototoxicity caused by cisplatin and carboplatin is characterized by a permanent bilateral sensorineural hearing loss (Bellman, 1996; Blakely & Myers, 1993; Melamed, Selim & Schuchman, 1985; Nagy et al., 1999; Schaefer, Post, Close & Wright, 1985; Waters et al., 1991). The loss is most often symmetrical; however, asymmetric or unilateral losses have been reported (Waters et al., 1991).

Initially, the ototoxicity occurs in the high-frequency range above 8000 Hz, but can spread to affect the audiometric frequencies, including those important for understanding conversational speech, such as 500, 1000, 2000, and 4000 Hz (Bertolini et al., 2004; Blakely & Myers, 1993; Melamed et al., 1985; Nagy et al., 1999; Weatherly, Owens, Catlin & Mahoney, 1991). The onset of hearing loss varies for each individual and may begin soon after the first dose, or may gradually develop after repeated drug exposure (Blakely & Myers, 1993; Nagy et

al., 1999; Waters et al., 1991). The ototoxic effects can continue to develop and worsen for several months to several years after the treatment has ended (Bertolini et al., 2004).

Several factors affect the severity of the hearing loss caused by cisplatin and carboplatin. Children are more susceptible to ototoxic effects, particularly those younger than five years of age (Berg, Spitzer & Garvin, 1999; Bertolini et al., 1994; Li, Womer & Silber, 2004; Pappas & Pappas, Jr., 1997; Sexauer et al., 1985). Researchers have also found that continued exposure and higher cumulative dose can cause a more severe hearing loss which affects additional frequencies (Berg et al., 1999; Li et al., 2004; Pappas & Pappas, Jr., 1997; Schell et al., 1989; Skinner, Pearson, Amineddine, Mathias & Craft, 1990; Waters et al., 1991). Treatment with ototoxic medications in combination with cranial irradiation (Berg et al., 1999; Schell et al., 1989; Weatherly et al., 1991) or other ototoxic medications (Knoll, Smith, Shores & Blatt, 2006) also increases the incidence and severity of hearing loss, especially in children.

The incidence of cisplatin and carboplatin ototoxicity in children ranges from 10% to 100% (Blakely & Myers, 1993; Li et al., 2004; Melamed et al., 1985; Moroso & Blair, 1983; Nagy et al., 1999; Ruiz, Gilden, Jaffe, Robertson & Wang, 1989; Schaefer et al., 1985; Schell et al., 1989; Skinner et al., 1990). The variation can be attributed to treatment and patient-related factors, as well as different criteria used to define hearing loss. For example, Blakely & Myers (1993) defined a loss as a shift from baseline greater than 15 dB at one frequency or greater than 10 dB at three or more frequencies; whereas, Li et al. (2004) used a Brock grade of 2 (thresholds in the better ear > 40 dB at 4000 Hz and higher) to define a significant hearing loss. Although some researchers rely solely on audiometric data, others accept subjective complaints of hearing difficulty, creating even more variation in the incidence reports (Blakely & Myers, 1993).

Effects of Minimal Sensorineural Hearing Loss

Children do not normally report symptoms, and the initial effects of hearing loss are often underestimated by parents, teachers, and clinicians. It is not until communication is significantly impaired that parents realize there is a problem with their child's hearing abilities (Bellman, 1996; Knight, Kraemer & Neuwelt, 2005; Konrad-Martin et al., 2005).

Research has shown that minimal hearing loss can have a significant impact on language development, psychosocial development, and academic success in children (Barr et al., 2000; Bertolini et al., 2004; Bess, Dodd-Murphy & Parker, 1998; Davis, Elfenbein, Schum & Bentler, 1986; Konrad-Martin et al., 2005). Bess et al. (1998) evaluated the educational performance and social-emotional functioning of 1,218 children with minimal sensorineural hearing loss (MSHL). MSHL was defined to include mild degrees of unilateral (pure-tone average ≥ 20 dB HL in the poor ear), bilateral (pure-tone thresholds between 20 and 40 dB HL bilaterally at 1000, 2000, and 4000 Hz), and high-frequency (> 25 dB HL at two or more frequencies above 2000 Hz in one or both ears) sensorineural hearing loss. The researchers found that 37% of children with MSHL failed at least one grade in school, compared to only 3% in the normal hearing population. The children with MSHL also experienced more behavior problems, increased stress, and lowered self-esteem (Bess et al., 1998). Other researchers have reached similar conclusions. Davis et al. (1986) stated that "…children with any degree of hearing loss appear to be at risk for delayed development of verbal skills and reduced academic achievement."

Although there is research evaluating the effects of hearing loss on academic and social success, there is minimal research evaluating high-frequency hearing loss specifically. Knight et al. (2005) argue that even a mild hearing loss at frequencies above 2000 Hz can significantly impact a child, both socially and academically. Individuals with high-frequency hearing loss

have a built in acoustic filter, which causes the high-frequency speech cues to be inaudible (Suter, 1985). The specific speech sounds most affected, i.e. "s, f, th, sh, h, k", and "t", contribute greatly to the intelligibility of speech (Bellman, 1996; Knight et al., 2005). A reduction in the audibility of these sounds can result in errors in noun-verb morphology and plural forms of words (Stelmachowicz, Pittman, Hoover & Lewis, 2001; Stelmachowicz, Pittman, Hoover, Lewis & Moeller, 2004). In addition, children with high-frequency hearing loss have more difficulty understanding female voices than male voices because they are typically higher in pitch (Stelmachowicz et al., 2004). This can create difficulties in the classroom because most elementary school teachers are female. Noisy environments, such as traditional classrooms, further decrease understanding abilities for children with high-frequency hearing loss by reducing the redundancies that are inherent to speech (Berg et al., 1999; Crandell, 1993; Nelson, 1997; Suter, 1985).

The importance of high-frequency sound cues can be explored objectively by using the speech intelligibility index (SII). The SII is "a method for computing a physical measure that is highly correlated with the intelligibility of speech under a variety of adverse listening conditions, such as noise, filtering, and reverberation" (ANSI, S3.5-1997, p.ii). SII scores range from 0.0 to 1.0 and represent the percent of speech cues that are audible and usable in a specific setting, but are not a direct measure of intelligibility (ANSI, S3.5-1997). SII scores can be used to predict speech recognition scores by means of different transfer functions, depending on which speech materials were used during testing (Hornsby, 2004). Determining the SII of children with hearing loss due to cisplatin or carboplatin treatment may predict their performance in difficult listening situations.

Ototoxic Monitoring Programs

In an attempt to track the effects of cisplatin and carboplatin on hearing, ototoxic monitoring programs have been established in most medical facilities. There are many different guidelines for the timing and battery of auditory tests. The manufacturer of cisplatin recommends that a baseline audiogram be obtained prior to the first dose and additional audiograms before each subsequent dose (Nagy et al., 1999). The American Speech-Language-Hearing Association (ASHA) recommends that baseline data be obtained no later than 24 hours after the administration of the first treatment with cisplatin or carboplatin. Similar to the cisplatin manufacturer, ASHA also recommends that subsequent tests be obtained prior to each additional treatment (Konrad-Martin et al., 2005). For most programs, these guidelines are impractical and generally not followed (Nagy et al., 1999). Others have suggested baseline audiograms with follow-up tests only after the total cumulative dose has been reached, additional risks factors are noted, or ototoxic symptoms have developed (Schaefer et al., 1985). Bertolini et al. (2004) recommend that follow-up continue for at least two years after the end of treatment due to the late effects of the cisplatin and carboplatin.

Pure-tone testing typically includes all octaves 250 through 8000 Hz for cooperative and attentive patients. High-frequency audiometry (> 8000 Hz) is recommended because cisplatin initially affects the higher frequencies. Monitoring frequencies above 8000 Hz can help identify ototoxicity before the speech frequencies are affected (Bellman, 1996; Fausti et al., 1994). It should be noted that high-frequency testing in very young children has higher variability and is considered less reliable than in adults (Konrad-Martin et al., 2005).

Serial examination of behavioral auditory thresholds is currently the most reliable method for detecting hearing changes during treatment with these medications (Fausti et al., 1994). This

includes visual reinforcement audiometry (approximately 6 months to 2 years of age), conditioned play audiometry (approximately 2 years to 5 years of age), and conventional audiometry (5 years of age and older). Young infants or children unable to cooperate may require physiologic types of audiometric testing, such as otoacoustic emissions (OAEs) and/or auditory brainstem response tests (ABRs) (Konrad-Martin et al., 2005; Stavroulaki, Apostolopoulos, Segas, Tsakanikos & Adamopoulos, 2001).

Criteria to define a significant change in hearing varies among programs; however, a >20 dB shift from baseline at any single test frequency is generally considered significant. ASHA recommends that a >10 dB shift at two consecutive test frequencies or threshold responses shifting to "no response" at three consecutive test frequencies also be considered significant. In addition, ASHA recommends that all significant changes be confirmed by retest (Konrad-Martin et al., 2005). The ototoxic monitoring program at our facility uses the following criteria to define a significant change in hearing: 15 dB shift at one frequency or 10 dB shift at two or more frequencies; retesting of significant changes is not required. Early identification provides information that can be used to adjust the medication treatment program, if possible, and to assist in counseling and appropriate rehabilitation.

Subjective Measures

In contrast to the rich literature in audiometric assessment of hearing loss caused by ototoxic medications, there are no published reports of questionnaires or parent reports aimed at identifying this particular type of hearing loss. However, subjective measures, such as self-reports and questionnaires, have been used to detect and counsel for hearing loss for several decades. Research has shown that these types of measures are reliable and can be a quick and inexpensive way to detect hearing loss (Bess et al., 1998; Gleason & Blood, 1982). Gleason &

Blood (1982) administered a questionnaire to parents of preschool-aged children and determined that parents' perceptions of their child's auditory abilities are most often accurate and may aid in diagnosing disorders. Bess et al. (1998) provided a questionnaire to teachers focusing on behavior problems in the classroom. The results showed significant differences between children with minimal sensorineural hearing loss and those with normal hearing. This suggests that subjective measures may be sensitive enough to detect minimal losses, such as high-frequency hearing loss caused by cisplatin and carboplatin.

The purpose of this study is to develop and implement a questionnaire to assess the hearing abilities of children with high-frequency hearing loss due to treatment with cisplatin or carboplatin. In addition to acquiring normative data for the questionnaire with the control group, results will be used to determine if a difference in hearing abilities is noticed for children with high-frequency hearing loss. If the questionnaire is sensitive to high-frequency hearing loss, the utility as a counseling tool will also be examined.

Methods

Development of the "Pediatric Assessment of Hearing" Questionnaire

Several existing questionnaires were reviewed to determine if one could be used for this particular study. It was determined that no single questionnaire covered the specific problems associated with high-frequency hearing loss; therefore, it was necessary to develop a new questionnaire using the existing questionnaires as guides. The "Self-Assessment of Communication" screening test was the major contributor for design and content of our questionnaire (Schow & Nerbonne, 1982). The audiologists at St. Louis Children's Hospital edited the questionnaire and the final questionnaire was titled "Pediatric Assessment of Hearing" (see appendix A).

The "Pediatric Assessment of Hearing" consists of 13 questions. The questions address how the child hears in specific listening situations, as well as social-emotional aspects of hearing difficulties. Questions were answered with a five point rating scale, with 1 representing almost no difficulties and 5 representing significant hearing difficulties. Total scores ranged from a minimum of 13 points to a maximum of 65 points. Because the questionnaire could be completed in approximately 5 minutes, it did not significantly increase the amount of time needed for the test session. For study purposes only, demographic questions are listed at the end of the questionnaire.

The questionnaire addresses problems associated with hearing loss in general, including difficulties listening in small groups, changes in speech abilities, and asking for repetition. Questions 5, 6, and 8 are aimed specifically at high-frequency hearing loss, and address difficulties in background noise and reverberant settings, listening in large groups, and understanding female voices. Including questions specific to high-frequency problems was important because this type of hearing loss may initially have minimal effects. If significant hearing difficulties are noted on questions 5, 6, and 8, it may be an indicator that high-frequency hearing loss is developing.

Participants

All patients were recruited through the outpatient offices of the physicians in the Department of Otolaryngology of Washington University School of Medicine and from the outpatient/inpatient services of the Audiology Department at St. Louis Children's Hospital. Entry criteria for all participants included: (a) age five to twelve years at the time of testing; (b) able to participate in an audiologic evaluation; (c) no history of hearing loss other than that

associated with cisplatin or carboplatin treatment. Participants were excluded if it was determined that they had any of the following:

- attention deficit hyperactivity disorder
- auditory processing disorder
- learning disability
- confirmed or suspected syndrome associated with hearing loss or cognitive delays
- speech or language deficiency
- other cognitive deficits
- use of any type of amplification or hearing assistive technology, including but not limited to, hearing aids, cochlear implants, or FM system.

The purpose of the exclusion criteria was to limit any factors, other than peripheral hearing loss, that might affect answers on the questionnaire.

Participants were divided into two groups: (1) the control group consisted of children with normal hearing, bilaterally (air conduction thresholds ≤ 20 dB HL 500 through 4000 Hz); (2) the experimental group consisted of children with high-frequency hearing loss (any air conduction thresholds > 20 dB HL 500 through 4000 Hz with a sloping configuration) who were receiving or had received cisplatin or carboplatin. The purpose of the control group was to normalize the questionnaire; therefore, all children with normal hearing were included, regardless of cisplatin or carboplatin treatment.

Twenty-five participants were enrolled into the study, 14 females and 11 males with a mean age of 7.6 (standard deviation 2.0 years; range 5-12 years). Sixteen participants completed the study; the other nine were removed based on the exclusion criteria (see Table 1). The mean age of the remaining participants was 7.8 (standard deviation 1.9 years; range 5-12 years). See Table 2 for complete demographic information. Of the 16 participants who completed the study, 15 had normal hearing (control group) and 1 had significant hearing loss (experimental group).

Within the control group, 2 participants had received cisplatin/carboplatin but still had normal hearing.

Procedures

The audiologist previewed the patient's chart to determine eligibility based on the inclusion and exclusion criteria listed above. If the patient was determined to be eligible for the study by chart preview, the audiologist provided and reviewed the informed consent with the parent(s). If both parental consent and assent from the child were obtained, the audiologist administered a screening questionnaire (see Appendix B) to confirm eligibility. The intent of the screening questionnaire was to retrieve information not included in the chart that may have excluded the participant. In addition, demographic information (age, gender, and Medicaid benefits) was obtained on the screening questionnaire, and was reviewed weekly to determine if enrollment was well distributed.

If the participant was determined not eligible by the screening questionnaire, it was explained to the parent(s) that their child no longer met the criteria for the study and the audiologic examination continued as planned. If the participant was determined eligible, the parent(s) was given the "Pediatric Assessment of Hearing" and instructed to complete all questions during their child's hearing test. The questionnaire was completed before the parent(s) knew the results of the hearing test in order to avoid bias.

All participants underwent an audiologic examination to determine hearing status by a licensed audiologist. Standard audiology evaluation procedures, including conditioned play audiometry and conventional audiometry, were administered. Thresholds were obtained for all octaves 250 through 8000 Hz. If air-conduction thresholds were between 0 and 15 dB HL, bone conduction was not required. For thresholds greater than 15 dB HL, bone conduction was

required at those specific frequencies to determine if a conductive component was present. Tympanograms were not required for this study, and abnormal results did not exclude the subject from the study. The participants' SII scores were calculated using the AudioScan Verifit system. This system uses air conduction thresholds 250 through 6000 Hz to estimate an SII percent for each ear.

A complete audiogram with reliability judged as good or fair and validity as acceptable was required for participation in the study. Any participant who was not able to complete their hearing test, or had poor reliability and/or questionable validity was removed from the study. Participants were also removed if the audiogram revealed the presence of a hearing loss not typically associated with cisplatin or carboplatin, or a conductive component. A conductive component was defined as an air-bone gap of 10 dB for at least 3 frequencies or 15 dB at 2 frequencies 500 through 4000 Hz. It should be noted that patients identified with significant hearing loss were referred for follow-up evaluations, regardless of study participation.

Upon completion of the audiology appointment, the audiologist attached a copy of the participant's hearing test to the signed informed consent, screening questionnaire, and the "Pediatric Assessment of Hearing." For participants determined ineligible by the screening questionnaire, only the signed informed consent and screening questionnaire were collected. All documents were placed in a collection envelope kept in a locked office of a locked department. Participation in the study ended at the completion of the questionnaire and audiologic exam. Data collected included audiometric thresholds, "Pediatric Assessment of Hearing" score (per question and composite), demographic information, and SII score.

Results

The data reported below are for the control group. Only one participant was enrolled in the experimental group; therefore, statistical analysis comparing the groups was not performed. The results for the experimental participant will be discussed as a case study.

Normal audiometric thresholds (≤ 20 dB HL, 500 through 4000 Hz) were obtained for all 15 participants in the control group (see Appendix C). The SII score for children with normal hearing is 1.0 meaning he/she can hear all available speech cues at an average conversation level (60 dB SPL). The mean composite score for the "Pediatric Assessment of Hearing" was 18.8 (standard deviation = 5.2) out of a possible 65 points. This score reflects a rating of no difficulty to occasional difficulty for all questions. See Appendix D for complete questionnaire data. An unpaired t-test showed no statistically significant difference between the mean composite scores for females 18.4 (standard deviation = 6.0) and males 19.5 (standard deviation = 3.7), $p = 0.715$. The correlation coefficient between age and composite score was 0.432. This value was not significantly different from 0, $p = 0.108$. Visual inspection of the data suggests that questions 3, 7, and 8 were rated higher than others based on the mean values (see Figure 1). This observation is not based on statistical analysis, but rather a trend in the data. It should be noted that the means are reflective of the sample population's responses. There were no age effects for questions 3, 7, and 8 (see Figure 2).

Case Study

Only one participant met the audiometric criteria for the experimental group. The participant was an 8-year-old male with history of hearing loss caused by treatment with cisplatin for a stage III neuroblastoma. Audiometric testing showed normal hearing sloping to a severe hearing loss (see Figure 3). The protocol for this study did not require a threshold for 6000 Hz to

be measured; however, the audiologist did obtain this threshold due to the precipitous slope of the hearing loss. Bone conduction was not performed during this test session due to attention abilities; however, previous testing confirmed the hearing loss was sensorineural. The participant scored 18.0 on the "Pediatric Assessment of Hearing." This score is very similar to the mean of the control group. Using the audiogram in Figure 3, the SII was calculated to be 0.87 for both the right and left ears.

Discussion

The purpose of this study was to develop and implement a questionnaire to assess the hearing abilities of children with high-frequency hearing loss due to treatment with cisplatin or carboplatin. Children with normal hearing were included in the study to collect normative data for the questionnaire. As hypothesized, children with normal hearing scored relatively low on the questionnaire with a mean score of 18.8 out of 65 points. A low score represents no difficulties to occasional hearing difficulties in all listening situations discussed in the questionnaire.

Evaluation of the scores for the control group revealed three questions (numbers 3, 7, and 8) were consistently rated higher than the other questions. Question 3 inquires if the child asks for repetitions or says "what" or "huh." A higher rating on this question by the control group may be a reflection of attention abilities due to age rather than actual hearing difficulties. Question 7 asks about excessive television and radio volume. It is possible that a higher rating on this question is related to the trend that children and adolescents are listening to music at very loud levels, regardless of hearing abilities (Williams, 2005). Question 8 asks how the child hears in loud environments such as parties, gymnasiums, and sporting events. Research has shown that noise and reverberation can deteriorate speech perception for children with normal hearing,

especially those younger than 15 years of age (Crandell & Smaldino, 2000). There were no age effects noted for questions 3, 7, or 8.

During the duration of the study, only one participant was enrolled in the experimental group and no conclusions can be made regarding the sensitivity of the questionnaire for high-frequency hearing loss. The one experimental participant had a score similar to the composite score on the questionnaire from the control group. There are several possible reasons why his score does not reflect more than occasional difficulties. First, his hearing loss is so mild at 4000 Hz, the effects of high-frequency hearing loss are still very minimal and may be unnoticed by his parents. Second, the duration of the loss could affect the severity of his difficulties; if the loss occurred more recently, the effects of the loss may not be noticed at this time. The duration of this participant's loss is unknown, as this information was not obtained as part of the study. Finally, the "Pediatric Assessment of Hearing" may not be sensitive enough to detect the effects of this type of hearing loss. No conclusions can be made based on one participant.

The experimental participant had an SII score of 0.87. This means that for average conversation (level of 60 dB SPL), this child is receiving 87% of the available speech cues. Although this number seems acceptable, for a school-aged child, missing 13% of what is said can be detrimental to learning. Without a larger experimental group, it is difficult to determine if the SII score can be correlated with the "Pediatric Assessment of Hearing" score.

Future Research

This study completed the first two steps for evaluating HFHL using a questionnaire; developing the questionnaire and collecting normative data. Further research is needed to accrue more participants in both the control and experimental groups. With larger groups, statistical analysis can be performed to determine if a significant difference in composite score on the

"Pediatric Assessment of Hearing" questionnaire is present. If a difference exists, the questionnaire can be implemented in ototoxic monitoring programs as both a screening and counseling tool for high-frequency hearing loss. If a difference is not present, the feasibility of modifying the questionnaire will need to be examined, so that questions and rating scale are more sensitive to this type of hearing loss.

Further examination of the relationship between the SII score and the "Pediatric Assessment of Hearing" score also needs to be completed. With a larger experimental group, a correlation can be calculated for SII and questionnaire scores to determine if a change in one score will cause a change in the other. If there is a strong correlation between the SII and questionnaire scores, a higher score on the questionnaire may indicate a decrease in auditory thresholds.

Weaknesses of the Study

Due to time constraints, an insufficient number of participants were enrolled into the experimental group, which prevented statistical analysis comparing the groups. Therefore, at this time, no conclusions can be made regarding the usefulness of the questionnaire for counseling hematology/oncology patients.

Conclusions

Communication ability is very important to the quality of life (Barr et al, 2000; Bertolini et al, 2004; Konrad-Martin et al, 2005). Identification and intervention for significant high-frequency hearing loss is necessary for academic success and social-emotional development in children. The "Pediatric Assessment of Hearing" questionnaire is an attempt to develop a tool to both screen and counsel for this type of hearing loss so that the effects of high-frequency hearing loss are minimized for children.

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Table 1

Demographic information and exclusion criteria for participants removed from the study.

Subject #	Gender	Age	Medicaid	Reason for Removal
3	F	6	N	Incomplete questionnaire
4	M	6	N	Unilateral conductive hearing loss
5	M	12	N	Bilateral conductive hearing loss
11	M	9	N	Attention Deficit Hyperactivity Disorder
13	F	7	Y	Unilateral conductive hearing loss
14	F	5	N	Incomplete questionnaire
21	F	5	Y	Attention Deficit Hyperactivity Disorder
24	M	7	Y	Unable to obtain complete audiogram
25	M	7	N	Attention Deficit Hyperactivity Disorder

Table 2

Demographic information for participants who completed the study.

Subject #	**Gender**		**Age**	**Ethnicity**			**Medicaid**	
	Male	*Female*		*Afr. Am.*	*Caucasian*	*Other*	*Yes*	*No*
1		X	8			X	X	
2		X	5		X			X
6		X	8		X		X	
7		X	9	X			X	
8		X	8	X			X	
9	X		6		X			X
10	X		11		X		X	
12	X		6		X			X
15		X	12	X			X	
16	X		9		X			X
17		X	8		X			X
18		X	6	X			X	
19	X		9	X			X	
20		X	6		X			X
22		X	6		X			X
23	X		8			X	X	
Totals	**6**	**10**	**7.8**	**5**	**9**	**2**	**9**	**7**

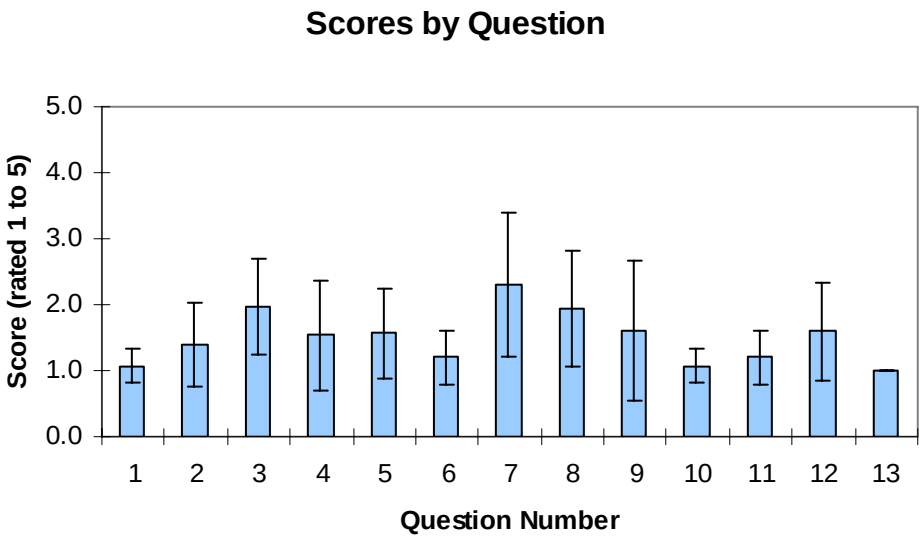

Figure 1: Mean scores and standard deviations for all questions on the "Pediatric Assessment of Hearing" questionnaire. All participants had a score of 1 on question 13; therefore, there is no variability.

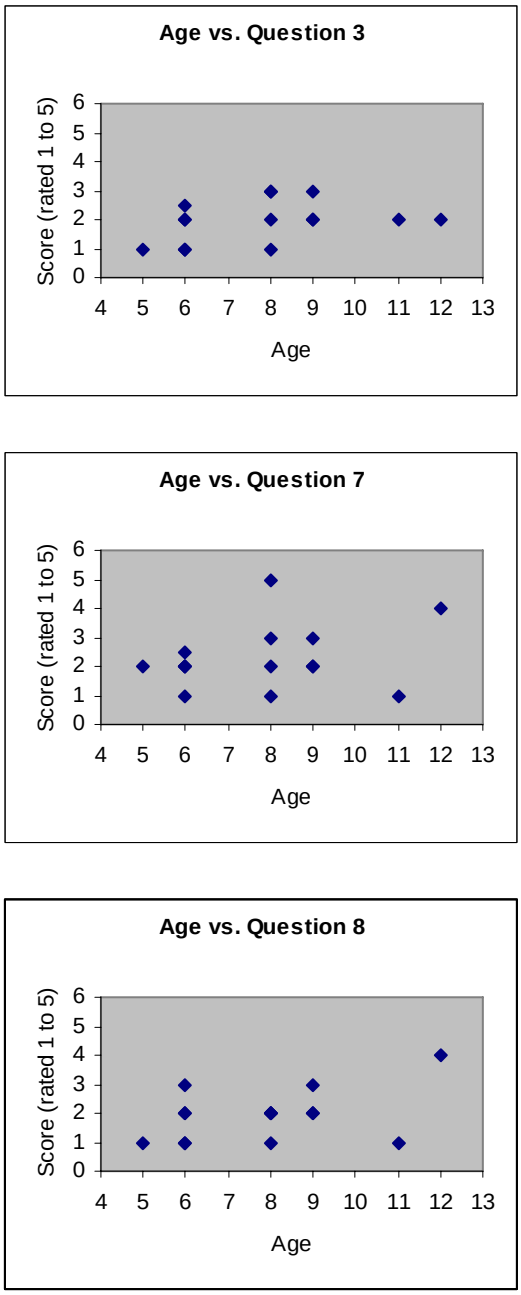

Figure 2: Age versus score on questions 3, 7, and 8.

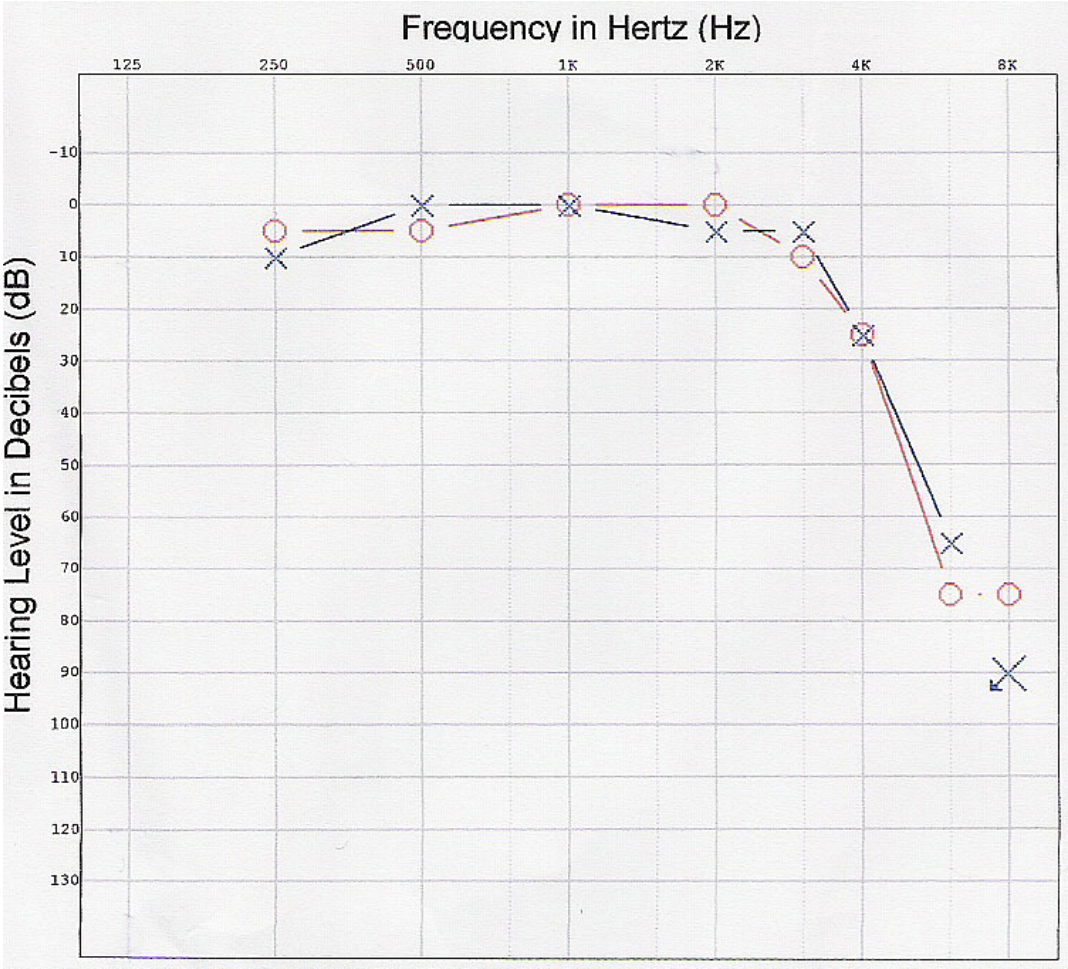

Figure 3: Audiogram for subject #23 showing a bilateral sensorineural hearing loss starting at 4000 Hz.

Appendix A

Pediatric Assessment of Hearing: Parent Version

Please select the appropriate number ranging from 1 to 5 for the following questions. Circle only one number for each question.

1. Does your child have difficulty communicating his/her needs to you?
(1) almost never (2) occasionally (3) about half the time (4) frequently (5) practically always

2. Does your child have difficulty hearing one-on-one with another person? (for example, at home, at school with a teacher, playing with a friend, etc.)
(1) almost never (2) occasionally (3) about half the time (4) frequently (5) practically always

3. Does your child say "what" or "huh" or ask for things to be repeated?
(1) almost never (2) occasionally (3) about half the time (4) frequently (5) practically always

4. Does your child have difficulty hearing when in a small group? (for example, a small play group, dinner table with more than two other people, etc.)
(1) almost never (2) occasionally (3) about half the time (4) frequently (5) practically always

5. Does your child have difficulty hearing when he/she is in a large group? (for example, teacher's voice in class, etc.)
(1) almost never (2) occasionally (3) about half the time (4) frequently (5) practically always

6. Does your child have more difficulty hearing female voices than male voices?
(1) almost never (2) occasionally (3) about half the time (4) frequently (5) practically always

7. Does your child turn the television or radio up louder than you think they need?
(1) almost never (2) occasionally (3) about half the time (4) frequently (5) practically always

8. Does your child have difficulties hearing when in a busy or loud environment? (for example, at a birthday party, at the park, gym class, eating in the cafeteria, at sporting events, etc.)
(1) almost never (2) occasionally (3) about half the time (4) frequently (5) practically always

9. Does your child have difficulty hearing when using the telephone?
(1) almost never (2) occasionally (3) about half the time (4) frequently (5) practically always

10. Do you feel that any hearing difficulties limit your child's ability to socialize or play?
(1) almost never (2) occasionally (3) about half the time (4) frequently (5) practically always

11. Do you feel that your child is frustrated because he/she has trouble hearing?
(1) almost never (2) occasionally (3) about half the time (4) frequently (5) practically always

12. Has anyone else ever suggested that your child might have trouble hearing?
(1) almost never (2) occasionally (3) about half the time (4) frequently (5) practically always

13. Have you noticed a change in your child's speech within the last 6 months?
(1) no change (2) a little worse (3) noticeably worse (4) significantly worse (5) I can barely understand my child

Other comments you would like to tell us regarding your child's hearing and/or communication abilities

_____

_____

_____

_____

_____

What is your relation to the child? **mother father other_____**

What is your child's gender? **girl boy**

What is your child's date of birth? **_____/_____/_____**

What is your child's ethnicity? **African American Asian Caucasian Hispanic/Latino Native American Pacific Islander Other**

What is your date of birth? **_____/_____/_____**

What is your ethnicity? **African American Asian Caucasian Hispanic/Latino Native American Pacific Islander Other**

What is your highest level of education? **grade school high school some college college graduate post graduate**

Does your child receive Medicaid benefits? **Yes No**

Appendix B

Screening Questionnaire

(To be filled out by the audiologist before the hearing test)

Patient's Name:_____

Please mark "yes" or "no"

1. Has your child been diagnosed with any of the following?

Attention deficit hyperactivity disorder	_____
Auditory processing disorder	_____
Confirmed/suspected syndrome	_____
Learning disability	_____
Cognitive deficits	_____
Confirmed speech/language deficits	_____

2. Does your child currently use hearing aids or any other type of hearing assistive devices (i.e. F.M. system)? _____

If "yes" was marked for any of these questions, the child is not eligible for the study

To Be Completed by the Audiologist Only		
Age	5 6 7 8 9 10 11 12	
Gender	male	female
Medicaid	yes	no

Appendix C

Threshold Data for the Control Group

	Right Ear							Left Ear						
Subject #	**PTA**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**PTA**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
1	6.25	10	10	10	5	0	5	3.75	5	5	5	5	0	0
2	2.5	5	5	5	0	0	20	2.5	5	5	5	0	0	20
6	5	10	10	5	0	5	15	11.25	15	15	10	10	10	20
7	10	15	15	10	5	10	10	10	10	10	10	10	10	10
8	8.75	10	10	5	10	10	10	6.25	10	10	5	5	5	5
9	6.25	10	10	10	0	5	20	6.25	10	10	5	5	5	20
10	10	DNT	10	15	10	5	5	7.5	DNT	10	5	5	10	5
12	7.5	10	15	10	5	0	5	7.5	20	15	10	5	0	5
15	17.5	10	15	20	15	20	20	17.5	10	15	15	20	20	20
16	5	15	5	10	5	0	0	2.5	10	5	5	0	0	0
17	5	10	10	5	0	5	10	6.25	15	15	5	5	0	15
18	12.5	15	15	10	15	10	15	12.5	15	15	10	15	10	20
19	11.25	10	10	10	15	10	35	13.75	10	10	10	20	15	20
20	10	20	15	15	5	5	35	13.75	20	15	15	10	15	20
22	1.25	5	0	5	0	0	0	1.25	10	5	0	0	0	5

Note: PTA = pure-tone average (500, 1000, 2000, and 4000 Hz); DNT = did not test; numbers across the top represent test frequency in Hz; thresholds are given in dB HL

Appendix D

"Pediatric Assessment of Hearing" Data for the Control Group

Subject #	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Composite
1	1	2	3	2	2	2	3	2	2	1	2	1	1	14
2	1	1	1	1	1	1	2	1	1	1	1	1	1	14
6	2	2	3	2	2	1	2	2	2	1	1	3	1	24
7	1	1	3	1	2	1	3	3	5	1	1	3	1	26
8	1	1	2	1	1	1	5	2	1	1	1	2	1	20
9	1	1	2.5	2	2.5	2	2.5	2	2	1	2	2	1	23.5
10	1	1	2	1	1	1	1	1	1	1	1	1	1	14
12	1	2	2	2	1	1	2	3	1	1	2	1	1	20
15	1	3	2	4	2	1	4	4	2	2	1	2	1	29
16	1	2	2	2	3	2	2	2	1	1	1	2	1	22
17	1	1	1	1	1	1	1	1	1	1	1	1	1	13
18	1	1	2	1	1	1	2	2	2	1	1	1	1	17
19	1	1	2	1	2	1	2	2	1	1	1	2	1	18
20	1	1	1	1	1	1	1	1	1	1	1	1	1	13
22	1	1	1	1	1	1	2	1	1	1	1	1	1	14
Mean	1.1	1.4	2.0	1.5	1.6	1.2	2.3	1.9	1.6	1.1	1.2	1.6	1.0	18.8

Note: Q = question