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The HEAR-QL: Quality of Life Questionnaire for Children with Hearing Loss

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Abstract

Background—Few quality of life (QOL) assessment tools are available for children with specific chronic conditions, and none have been designed specifically for children with hearing loss (HL). A validated hearing-related QOL questionnaire could help clinicians determine whether an intervention is beneficial and whether one intervention is better than another.

Purpose—To examine QOL in children with HL and assess the validity, reliability, and factor structure of a new measure, the Hearing Environments and Reflection on Quality of Life (HEAR-QL) questionnaire.

Research Design—A descriptive and correlational study of a convenience sample of children.

Study Sample—Participants included 35 children with unilateral HL, 45 with bilateral HL, and 35 siblings with normal hearing.

Data Collection and Analysis—Children 7-12 years old were recruited by mail from a tertiary-care pediatric otolaryngology practice and the local county's Special School District. With parent consent, children completed the validated Pediatric Quality of Life InventoryTM (PedsQLTM) 4.0 and a 35-item HEAR-QL questionnaire. The factor structure of the HEAR-QL was determined through principal components analysis (PCA), and mean scores were computed for each subscale and the total HEAR-QL. Three weeks following return of the initial questionnaires, a second HEAR-QL questionnaire was sent to participants to assess test-retest reliability. Both PedsQL and HEAR-QL scores were compared between children with and without HL, between children with unilateral and bilateral HL, and between children who used and did not use a hearing device using analysis of variance. Sensitivity and specificity were calculated for both the HEAR-QL and PedsQL. A multivariable, hierarchical linear regression analysis was conducted with independent variables associated with HEAR-QL in unadjusted tests.

Results—Using exploratory PCA, the 35-item HEAR-QL was reduced to 26 items (Cronbach's $\alpha=0.97$; sensitivity 91% and specificity 92% at cut-off score of 93.5) loading on 3 factors: difficulty hearing in certain environments/situations (Environments $\alpha=0.97$), impact of HL on social/sports activities (Activities $\alpha=0.92$), and impact of HL on child's feelings (Feelings $\alpha=0.88$). Sensitivity 78.8% and specificity 30.9% at a cut-off score of 69.6 on the PedsQL ((at-risk for impaired QOL) were lower than for the HEAR-QL. Participants with HL reported significantly

lower mean total HEAR-QL scores (71 [SD 18] versus 98 [SD 5]; $p < 0.001$), but not mean total PedsQL scores (77 [SD 14] versus 83 [SD 15]; $p = 0.47$), than participants with normal hearing. Among children with bilateral HL, children who used a hearing device reported lower mean total HEAR-QL scores ($p = 0.01$), but not mean total PedsQL scores ($p = 0.55$), than children who did not use a hearing device. The intraclass correlation (ICC) for test-retest reliability for the 26-item HEAR-QL total score was .83. Hearing status and use of a device were independently associated with the HEAR-QL, and the variables in the model accounted for 46% of the HEAR-QL total score variance.

Conclusion—The HEAR-QL appears to be a valid, reliable, and sensitive questionnaire for children with HL. The HEAR-QL was better able than the PedsQL to distinguish between children with and without HL and can help evaluate interventions for children with HL.

Keywords

Hearing loss; Children; Quality of life; Questionnaire

Introduction

Approximately 5000 infants are born with moderate, severe, or profound bilateral sensorineural hearing loss (HL) each year in the U.S. (Force, 2000), and many more have mild, unilateral, or progressive HL that will be identified in childhood. However, the degree of HL alone cannot predict a child's language or educational performance (Davis et al, 1986). Furthermore, no one treatment is applicable to all children with HL (Carney, 1998). It is therefore advantageous to evaluate the child's overall well-being in a meaningful way.

Assessing quality of life (QOL) in clinical practice quantifies the relationship between traditional clinical indicators (i.e. functional assessment) and the child's subjective experience (Bjornson and McLaughlin, 2001). There are limited numbers of QOL assessment tools available for children with specific chronic conditions, and none designed specifically for children with HL (Lin and Niparko, 2006). A validated hearing-related QOL questionnaire could aid a clinician in determining when an intervention should be tried to improve the child's overall well-being, whether an intervention is beneficial, and whether one intervention is better than another. Following literature reviews addressing quality of life in children with HL and focus groups using children with HL (Streufert, 2010) a questionnaire, Hearing Environments and Reflection on Quality of Life (HEAR-QL), was developed. The HEAR-QL questionnaire is a condition-specific QOL measure designed to determine how a child perceives the social and emotional effects of their HL, especially in environments in which HL might have a great impact on children's QOL.

The objectives of this study were to examine the QOL in children with HL using a general pediatric QOL questionnaire and the newly developed HEAR-QL and to assess the validity, reliability, and factor analysis of the HEAR-QL. We hypothesized that children with unilateral HL and bilateral HL would perceive poorer QOL than their normal hearing peers, and that children with bilateral HL would perceive poorer QOL than children with unilateral HL.

Methods

Participants

The study population included children 7-12 years old who were seen in the pediatric otolaryngology clinic at Washington University Medical Center (WUMC) and from the St. Louis County Special School District who were documented to have HL either in their

medical record (using ICD-9 codes for HL) or school record. Controls with normal hearing were recruited from among the siblings of the children with HL to reduce demographic variability. This age group was selected based on the expectation that children in this age group can read independently and on the literature regarding development of a generic pediatric QOL questionnaire, the Pediatric Quality of Life Inventory (PedsQL™) (Varni et al, 2001; Varni et al, 2006). The PedsQL was developed using child self-report as well as parent proxy reports for children 18 years of age and younger. In addition to the reliability and validity of this measure (Varni et al, 2001; Varni et al, 2006), it has been shown in several studies that children have similar understanding of items on the PedsQL items based on invariance in the PedsQL factor structure regardless of race/ethnicity (Limbers et al, 2009), socioeconomic background (Limbers et al, 2008b), age group (Limbers et al, 2008a), and mode of administration (Varni et al, 2009).

This study was approved by the WUMC Human Research Protection Office. Written consent was obtained from parents of participants, and written or verbal assent was obtained from all child participants. Parents completed a demographic form, and the children completed the HEAR-QL and PedsQL questionnaires. Three weeks following return of the initial questionnaires, a second HEAR-QL questionnaire was sent to participants to assess test-retest reliability.

Questionnaires

The PedsQL™ 4.0 Child Report is a validated, generic, 23-item health-related QOL questionnaire (Varni et al, 2001; Varni et al, 2006) with 4 subscales (Physical, Emotional, Social, and School). The version for children 8-12 years of age was used in this study. Children were asked to rate how frequently each item was a problem for them in the past month using the following response choices: “never” (1), “almost never” (2), “sometimes” (3), “often” (4), or “always” (5). Scores are transformed with 1=100, 2=75, 3=50, 4=25, and 5=0 points. A mean total PedsQL score and mean scores for items in each subscale were computed. Higher scores indicate higher perceived QOL. We developed 35 items for the HEAR-QL questionnaire for children ages 7-12 years based on focus groups with children with HL and their parents (Streufert, 2010). The items focused on situations affecting interactions with family and friends (e.g., “Is it hard to hear your friends when playing outside?”), participation in social and school activities (e.g., “Do you play fewer sports or participate in fewer activities than your friends because of your hearing?”), and impact of HL on the child's emotional well being (e.g., “Do you feel shy when meeting new people because of your hearing?”), using the same response choices and scoring as used for the PedsQL items. Children with HL were instructed to answer the questions as if they were wearing their hearing aid(s) or cochlear implant(s), if applicable.

On the demographic form, parents reported the child's age, sex, race/ethnicity, maternal educational level, medical insurance status, household income, and parental marital status. Parents also reported information about the child's HL, including laterality (unilateral and bilateral HL) and severity (normal hearing, mild to profound HL). The children reported whether they had cochlear implants, wore hearing aids, or used frequency modulation (FM) assistive listening systems.

Statistical Analysis

Exploratory principal components analysis (PCA) with varimax rotation and Lautenschlager's parallel analysis criteria (Lautenschlager, 1989) were used to determine the factor structure of the HEAR-QL. Rather than determining the number of factors based solely on eigenvalues > 1.000 in PCA, Lautenschlager's method, based on the work of Velicer (Velicer, 1976), uses partial correlation matrices, which consider the number of

items tested and the sample size to determine the minimum eigenvalue needed to retain a given number of factors. Due to the sample size, we retained items with factor loadings ≥ 0.650 (Stevens, 1992) and eliminated items with factor loadings ≥ 0.400 on more than one factor. The internal consistency of items on a factor was assessed using Cronbach's alpha coefficient (Hays and Morales, 2001); items were further eliminated if alpha could be increased by eliminating those items. Intraclass correlation coefficients (ICC) were used to assess test-retest reliability.

Between-groups differences in demographic and clinical characteristics were evaluated with chi-square tests for categorical variables and analysis of variance (ANOVA) for continuous variables. Differences in PedsQL and HEAR-QL overall and subscale scores between children with and without HL were performed using Student's t-test and ANOVA. The scores of children with HL who did or did not use a hearing device were examined using Kolmogorov-Smirnov Z (due to sample size <25 per group (Field, 2005)).

The PedsQL was used to assess the construct validity of the HEAR-QL. We used Pearson's r to measure the association between PedsQL and HEAR-QL scores and hypothesized that the correlation between the two measures would be moderate (i.e., 0.3-0.5 (Cohen, 1988)). Sensitivity and specificity were calculated for the HEAR-QL and PedsQL scores to determine how well each would discriminate between those with and without HL, and were plotted as receiver-operating-characteristics (ROC) curves.

A multivariable, hierarchical linear regression analysis was conducted with independent variables associated with HEAR-QL total scores at $p < 0.20$ in bivariate tests. The demographic variables age, gender and maternal education level were entered first, followed by hearing status and use of assistive devices. Children with missing data for variables included in the regression model were excluded from the analysis.

SPSS for Windows, Version 15.0 (SPSS, Inc., Chicago, IL) was used for analysis. Two-sided p values < 0.05 were considered statistically significant.

Results

Participants

A total of 334 letters of invitation were mailed, and 120 parents allowed their children to participate. Since student names from St. Louis County Special School District were not supplied directly to the researchers (the school district sent invitations directly to students with documented HL), some students may have been invited through both the Special School District and WUMC, and the actual number of individuals asked to participate may be lower than the number of invitations sent. Therefore, the response rate was between 36% (no duplicate invitations) and 52% (all invitations were sent twice). Five questionnaires returned without the informed consent were not included in the analysis. Of the 115 who consented and completed questionnaires, 80 (70%) had HL – 35 unilateral and 45 bilateral – and 35 reported normal hearing (controls).

Demographic characteristics of the study participants are shown in Table 1. There were no significant differences in age, sex, race/ethnicity, income, maternal education, insurance, or marital status between participants with and without HL or those with bilateral and unilateral HL.

Table 2 summarizes the frequency of various hearing devices used by children with unilateral and bilateral HL. More children with bilateral HL used a hearing device than children with unilateral HL ($p = 0.03$).

Factor Analysis

Using an iterative process of PCA, 9 of the original 35 HEAR-QL items were eliminated because they loaded on more than one factor. Three factors emerged: measuring the child's perceived difficulty hearing in certain environments or situations (Environments), the impact of HL on social/sports activities (Activities), and the impact of HL on the child's feelings (Feelings). The internal-consistency reliabilities were high for each subscale (13-item Environments scale, $\alpha = 0.97$; 6-item Activities scale, $\alpha = 0.92$; and 7-item Feelings scale, $\alpha = 0.88$) and for the 26-item HEAR-QL ($\alpha = 0.97$).

Sixty-percent of participants completed the HEAR-QL a second time after three weeks (retest $\alpha = 0.97$). The ICC for the first and second assessments of the 26-item HEAR-QL total score was .83 (95% CI, 0.73- 0.90). The ICC for the first and second assessments of the HEAR-QL subscales were 0.82 (95% CI, 0.72- 0.89) for Environments, 0.81 (95% CI, 0.71- 0.88) for Activities, and 0.64 (95% CI, 0.47- 0.77) for Feelings.

Discriminant Validity

Scores for the HEAR-QL and the PedsQL for children with and without HL are shown in Table 3. The HEAR-QL total and subscale scores for children with normal hearing were all higher than the scores for children with HL. Differences in the total PedsQL and Physical, Emotional, and Social subscale scores between children with and without HL were not statistically significant. Children with bilateral HL reported lower PedsQL School subscale scores than children with normal hearing.

The HEAR-QL scores for children with normal hearing, unilateral and bilateral HL are illustrated in Figure 1. In post-hoc pairwise comparisons, HEAR-QL scores were poorer for children with either unilateral or bilateral HL compared with children with normal hearing ($p < 0.001$). The HEAR-QL scores for children with bilateral and unilateral HL did not differ significantly in total score ($p = 0.15$), Environments ($p = 0.30$) or Feelings ($p = 0.12$) subscales. However, children with bilateral HL had worse Activities subscale scores than children with unilateral HL ($p = 0.02$).

The PedsQL scores for children with normal hearing, unilateral and bilateral HL are shown in Figure 2. In post-hoc pairwise comparisons, PedsQL total and subscale scores were not different for children with either unilateral or bilateral HL compared with children with normal hearing, except for lower School subscale scores for the bilateral HL group ($p = 0.03$). The total and subscale PedsQL scores were similar for children with bilateral and unilateral HL. Seventy-nine percent of children with normal hearing scored above the total PedsQL cut-off score of 69.7 (defined as >1 standard deviation below the population sample mean of total PedsQL scores and reflecting an at-risk status for impaired QOL)(Varni et al, 2003)) compared with 69% of children with HL ($p = 0.46$); 65% with unilateral HL and 72% with bilateral HL scored above the cutoff score of 69.7 for the PedsQL ($p = 0.70$).

Neither total HEAR-QL nor total PedsQL scores differed by use/non-use of a hearing device among children with unilateral HL (Table 4). Children with bilateral HL who used a device reported lower total and subscale HEAR-QL scores, but not lower PedsQL scores, than children who did not use a device.

Construct Validity

The HEAR-QL and PedsQL scores correlated moderately ($r = .428$, $p < 0.001$) across all participants as well as when using data only for the children with HL ($r = .510$, $p < 0.001$), but were not significantly correlated when using data for children with normal hearing only ($r = 0.311$, $p = 0.07$). In Figure 3, the area under the curve (AUC) was 0.959 for the HEAR-

QL and 0.625 for the PedsQL, showing better discrimination between children with and without HL on the HEAR-QL than on the PedsQL. The HEAR-QL had a sensitivity of 91.2% and specificity of 92.3% at a cutoff score of 93.5. The PedsQL had a sensitivity of 78.8% and specificity of 30.9% at a cutoff score of 69.6, which was nearest to the cutoff score of 69.7 for children at risk of impaired health-related QOL (Varni et al, 2003).

Table 5 shows mean HEAR-QL scores by demographic, hearing status, and use of hearing device variables. Age and HEAR-QL scores were not significantly correlated ($r = -0.049$, $p = 0.630$). Age, sex, and maternal education were included as covariates in the multiple regression models to discern whether they were independently associated with children's HEAR-QL scores; race/ethnicity and income, which were highly correlated with maternal education (data not shown), were excluded to avoid multicollinearity. Since relatively few children in our sample had severe or profound bilateral HL (Table 1), "hearing status" was coded as normal hearing=1, unilateral and mild bilateral HL=2, and moderate-to-profound bilateral HL=3 for the multivariable regression analysis. Hearing status and use of a device were independently associated with HEAR-QL (Table 6). Variables in the model accounted for 46% of the HEAR-QL total score variance.

Discussion

In our study, children with HL reported significantly poorer QOL than their peers with normal hearing on the newly developed HEAR-QL, which is the first hearing-specific QOL measure for children with HL. Poorer QOL for children with HL on the School subscale of the PedsQL also was significant. These findings demonstrate that a true difference in QOL likely exists between children with and without HL, particularly in environments where the impact of HL on children might be particularly keen, e.g., school and social settings.

Excellent internal-consistency reliabilities were observed for each of the three factors that emerged in the PCA (Environments, Activities, and Feelings) as well as for the total HEAR-QL. A high internal-consistency also can indicate possible redundancy of items on a measure, and it is common practice to examine different measures of reliability of a new measure (Light et al, 1990). Cronbach's alphas for and the ICC between the first and second assessments of the 26-item HEAR-QL were high, indicating acceptable internal consistency and test-retest reliability for the HEAR-QL. Future work on the measure might include shortening the HEAR-QL further, if items are found to be redundant or otherwise unnecessary to maintain excellent reliability and validity.

We hypothesized that children with unilateral HL and bilateral HL would report poorer QOL than children with normal hearing. This was true for all the subscales and total HEAR-QL scores. However this was only the case for those with bilateral HL in the School subscale for the PedsQL. Our second hypothesis that children with bilateral HL would report poorer QOL than children with unilateral HL was supported only with the Activities subscale of the HEAR-QL; we observed only small, non-statistically significant differences between these two groups in the Environments and Feelings subscales. Thus, the HEAR-QL items on these two subscales might not be sensitive to small differences between children with unilateral and bilateral HL, and/or our sample size might not have been sufficiently large to give us the power needed to show significance. A larger study would help us determine whether lack of significant differences in these two subscales between children with unilateral and bilateral HL is due to insufficient sample size.

Based on adult literature, we expected children who used a hearing device to be more engaged socially (Kent, 2006; Tsakiroulou, 2007; Lotfi, 2009). Instead, we observed that children with bilateral HL who used a device reported poorer QOL on the HEAR-QL than

children who did not use a hearing device. These results appear to explain why older children and adolescents may be more resistant to wearing devices, even though they functionally hear better with the devices (Kent, 2006). Due to the small numbers of children in our sample, confirmation of our findings in larger studies is warranted.

The minimally clinically important difference (MCID) refers to the smallest difference in a score that is considered to be important (Hays, 2001). Some widely used measures of QOL in adults have reported MCID as small as 3-5 points in cancer survivors and as large as 10 points in the general population, based on standardized QOL scores ranging from 0 to 100 (Samsa, 1999). Further research is necessary to assess the MCID in QOL using the HEAR-QL; however the large differences in mean HEAR-QL scores among children with normal hearing, unilateral HL, and bilateral HL (98, 75, and 69, respectively) enable us to discriminate between children with milder and more severe HL.

Our findings are in agreement with previous studies which found hearing loss to be associated with diminished health-related QOL (Davis et al, 1986; Wake and Poulakis, 2004; Petrou et al, 2007; Legood et al, 2009) and psychosocial well-being (Wake et al, 2004). However, a Swedish study found that children with HL reported similar scores on generic mental health and self-image questionnaires as children with normal hearing (Mejstad, 2009). Although it is promising that children with HL demonstrate similar levels of self-esteem and mental health as children with normal hearing, it is important as well to understand the effects of HL on specific aspects of these children's QOL (e.g., personal relationships with other people and environmental/situational factors that are challenging to them), which have not previously been described.

A literature review by Lin and Niparko (2006) found that there were no well-validated, deafness-specific or hearing-related QOL instruments available for assessment of children with HL. We developed the HEAR-QL to fill this assessment gap and identify QOL challenges for children with HL that require intervention.

In addition, further validation of the HEAR-QL should be conducted with other validated measures of aspects of QOL, such as anxiety and depressed mood, as well as with measures of social desirability response bias and more objective functional measures of HL. It would be important to know the magnitude and direction of correlations between the HEAR-QL and other previously validated measures to further assess the construct and discriminant validity of this new QOL measure for children with HL.

We hypothesized that the PedsQL and the HEAR-QL would be moderately correlated. Although there was a moderate correlation between the two QOL questionnaires for children with HL, the differences between children with and without HL were greater using the hearing-specific HEAR-QL than the more generic PedsQL. Because the PedsQL cut-off score of 69.7 is near the mean for children with severe chronic health conditions, such as newly diagnosed cancer on treatment or juvenile rheumatoid arthritis (Varni et al, 2003), it is not surprising that children with HL in the present study did not have statistically different scores on the PedsQL than children with normal hearing. Our findings also showed that the HEAR-QL was better suited than the PedsQL to determine how HL, severity of HL, and use of hearing devices might affect the QOL of children.

Participants in this study tended to be from middle- to upper-middle-class families with higher maternal education, which may limit the generalizability of the findings of this study. QOL may vary with race/ethnicity and indicators of socioeconomic status (e.g., health care access) (Varni et al., 2003). Since we included sibling controls, there were no significant differences in demographic variables between participants with and without HL. Children with siblings who have severe chronic conditions (e.g., cancer) may report lower QOL than

their peers; however, other siblings have shown some chronic conditions do not have this impact (e.g., Down Syndrome) and may report similar levels of QOL as their peers who do not have siblings with chronic conditions (O'Brien et al, 2009). Thus, having chronic conditions may or may not equally affect the QOL of a child's siblings. In this initial study, we included siblings with normal hearing as our comparison group. Further study of the HEAR-QL comparing a larger, more heterogeneous population of children with HL and their non-related peers with normal hearing would add to the generalizability of our findings.

Other limitations of our study exist. For example, the small percentage of children with HL who participated may have introduced a selection bias. It is possible that only the children who were the most unhappy or most bothered by HL agreed to participate. However, the PedsQL total score or subscales showed no differences between children with and without HL that would indicate such bias. Participants with bilateral HL may have been more likely to have received amplification or other intervention that may have improved their QOL over other children with HL. If so, however, we would expect to see smaller gaps in scores between children with HL and children with normal hearing. Validation of the HEAR-QL in a larger population with greater variability in socioeconomic status and race/ethnicity would increase the generalizability of our findings and reinforce our conclusions.

Another limitation of our study includes the hearing status of the participants was based on parent reports. Audiograms were not available to confirm the presence and severity of HL. However, the group comparisons between children with and without HL did not seem to depend on the severity of HL and appear robust to small degrees of inaccuracy in hearing severity.

This study chose to assess the child's self-report and did not collect reports from parents or teachers. While parent and teacher reports are important during functional assessments of children with HL, we were most interested in understanding how children perceived their own QOL. Moreover, research has shown that parents are not necessarily accurate reporters of their child's QOL (Le Coq, 2000; Eiser and Morse, 2001; Jovokic, 2004; Goldbeck and Melches, 2005; Cremeens et al, 2006, Uzark et al, 2008). In addition, self-report is considered the standard for assessing perceived HRQOL, and only if a child is too young, too ill, or cognitively unable to answer the questions should parental proxy be substituted (Varni et al, 2005).

Summary

The HEAR-QL appears to be a valid and reliable hearing-specific QOL questionnaire for children with HL and had greater sensitivity than the PedsQL. When used in conjunction with other, more generic measures of QOL, the HEAR-QL can yield important information about QOL of children with HL. Future research will be directed toward further validation of the HEAR-QL on larger, more representative samples, assessment of its sensitivity to change over time, to differences in the environment, and to use/non-use of hearing devices.

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References

- Bjornson KF, McLaughlin JF. The measurement of health-related quality of life (HRQL) in children with cerebral palsy. *Eur J Neurol*. 2001; 5 8:183–93. [PubMed: 11851747]
- Carney AE, Moeller MP. Treatment Efficacy Hearing Loss in Children. *J Speech Lang Hear Res*. 1998; 41(1):S61–S84. [PubMed: 9493747]
- Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*. New Jersey: Lawrence Erlbaum Associates; 1988.
- Cremeens J, Eiser C, Blades M. Factors influencing agreement between child self-report and parent proxy-reports on the Pediatric Quality of Life Inventory 4.0 (PedsQL) generic core scales. *Health Qual Life Outcomes*. 2006; 4:58. [PubMed: 16942613]
- Davis J, Elfenbein J, Schum R, Bentler R. Effects of mild and moderate hearing impairments on language, educational, and psychosocial behavior of children. *J Speech Hear Disord*. 1986; 51(1): 53–62. [PubMed: 3945060]
- Eiser C, Morse R. The measurement of quality of life in children: past and future perspectives. *J Dev Behav Pediatr*. 2001; 22(4):248–56. [PubMed: 11530898]
- Field, A. *Discovering Statistics Using SPSS*. Thousand Oaks: SAGE; 2005.
- Goldbeck L, Melches J. Quality of life in families of children with congenital heart disease. *Qual Life Res*. 2005; 14(8):1915–24. [PubMed: 16155778]
- Hays RD, Morales LS. The RAND-36 measure of health-related quality of life. *Ann Med*. 2001; 33(5): 350–7. [PubMed: 11491194]
- Jovovic A, Locker D, Guyatt G. How well do parents know their children? Implications for proxy reporting of child health-related quality of life. *Qual Life Res*. 2004; 13:1297–1307. [PubMed: 15473508]
- Kent B, Smith S. They Only See It When the Sun Shines in My Ears: Exploring Perceptions of Adolescent Hearing Aid Users. *J Deaf Stud Deaf Educ*. 2006; 11(4):461–476. [PubMed: 16699063]
- Lautenschlager GJ. A Comparison of Alternatives to Conducting Monte Carlo Analyses for Determining Parallel Analysis Criteria. *Multivariate Behav Res*. 1989; 24(3):65–395.
- Le Coq EM, Boeke AJP, Bezemer PD, Colland VT, van Eijk JT. Which source should we use to measure quality of life in children with asthma: The children themselves or their parents? *Qual Life Res*. 2000; 9(6):625–636. [PubMed: 11236853]
- Light, R.; Singeris, J.; Willett, J. *By Design: Planning Research on Higher Education*. Harvard University Press; 1990.
- Limbers CA, Newman DA, Varni JW. Factorial invariance of child self-report across age subgroups: a multigroup confirmatory factor analysis utilizing the PedsQL 4.0 Generic Core Scales. *Value Health*. 2008a; 11(4):659–68. [PubMed: 18179671]
- Limbers CA, Newman DA, Varni JW. Factorial invariance of child self-report across socioeconomic status groups: a multigroup confirmatory factor analysis utilizing the PedsQL 4.0 Generic Core Scales. *J Behav Med*. 2008b; 31(5):401–11. [PubMed: 18607710]
- Limbers CA, Newman DA, Varni JW. Factorial invariance of child self-report across race/ethnicity groups: a multigroup confirmatory factor analysis utilizing the PedsQL 4.0 Generic Core Scales. *Ann Epidemiol*. 2009; 19(8):575–81. [PubMed: 19576538]
- Lin FR, Niparko K. Measuring health-related quality of life after pediatric cochlear implantation: A systematic review. *Int J Pediatr Otorhinolaryngol*. 2006; 70:1695–1706. [PubMed: 16806501]
- Lotfi Y, Mehrkian S, Moossavi A, Faghih-Zadeh S. Quality of life improvement in hearing-impaired elderly people after wearing a hearing aid. *Arch Iran Med*. 2009; 12(4):365–370. [PubMed: 19566353]
- Mejstad L, Heiling K, Goran Svedin C. Mental Health and Self-Image Among Deaf and Hard of Hearing Children. *Am Ann Deaf*. 2009; 153(5):504–515. [PubMed: 19350957]
- Samsa G, Edelman D, Rothman ML, Williams GR, Lipscomb J, Matchar D. Determining clinically important differences in health status measures: a general approach with illustration to the Health Utilities Index Mark II. *Pharmacoeconomics*. 1999; 15(2):141–55. [PubMed: 10351188]
- Stevens, JP. *Applied multivariate statistics for the social sciences*. Hillsdale, NJ: Erlbaum; 1992.

- Streufert, AM. Quality of Life Measure for Adolescents and Children with Hearing Loss. Doctor of Audiology Capstone Washington University School of Medicine; 2010.
- Tsakiropoulou E, Konstantinidis I, Vital I, Konstantinidou S, Kotsani A. Hearing aids: Quality of life and socio-economic aspects. *Hippokratia*. 2007; 11(4):183–186. [PubMed: 19582191]
- U.S. Preventative Services Task Force. Guide to Clinical Preventive Services. Alexandria, VA: International Medical Publishing; 2000. Screening for hearing impairment.
- Uzark K, Jones K, Slusher J, Limbers CA, Burwinkle TM, Varni JW. Quality of Life in Children With Heart Disease as Perceived by Children and Parents. *Pediatrics*. 2008; 121(5):e1060–e1067. [PubMed: 18450848]
- Varni JW, Burwinkle TM, Lane MM. Health-related quality of life measurement in pediatric clinical practice: An appraisal and precept for future research and application. *Health and Quality of Life Outcomes*. 2005; 3:1–9. [PubMed: 15634354]
- Varni JW, Burwinkle TM, Seid M, Skarr D. The PedsQL 4.0 as a pediatric population health measure: feasibility, reliability, and validity. *Ambul Pediatr*. 2003; 3:329–341. [PubMed: 14616041]
- Varni JW, Burwinkle TM, Seid M. The PedsQL 4.0 as a school population health measure: feasibility, reliability, and validity. *Qual Life Res*. 2006; 15(2):203–15. [PubMed: 16468077]
- Varni JW, Limbers CA, Newman DA. Using factor analysis to confirm the validity of children's self-reported health-related quality of life across different modes of administration. *Clinical Trials*. 2009; 6(2):185–95. [PubMed: 19342471]
- Varni JW, Seid M, Kurtin PS. PedsQL 4.0: reliability and validity of the Pediatric Quality of Life Inventory version 4.0 generic core scales in healthy and patient populations. *Medical Care*. 2001; 39(8):800–12. [PubMed: 11468499]
- Velicer WF. Determining the number of components form the matrix of partial correlations. *Psychometrika*. 1976; 41(3):321.
- Wake M, Poulakis Z. Slight and mild hearing loss in primary school children. *J Paediatr Child Health*. 2004; 40(1-2):11–3. [PubMed: 14717996]

Abbreviations

AUC	area under the curve
FM	frequency modulation
HEAR-QL	Hearing Environments and Reflection on Quality of Life
HL	Hearing Loss
MCID	minimally clinically important difference
PCA	principal components analysis
PedsQL	Pediatric Quality of Life Inventory™
QOL	Quality of life
ROC	receiver-operating-characteristics curves

Figure 1.

Differences in Hearing Environments and Reflection on Quality of Life (HEAR-QL) mean scores among children with unilateral HL ($n = 35$), bilateral HL ($n = 45$), and normal hearing ($n = 35$). *Note:* HL = hearing loss. * $p < 0.05$. ** $p < 0.001$.

Figure 2. Differences in Pediatric Quality of Life Inventory™ (PedsQL™) mean scores among children with unilateral HL (n = 35), bilateral HL (n = 45), and normal hearing (n = 35). Note: HL = hearing loss. *p < 0.05

Figure 3. Receiver operating curves for (a) the 26-item HEAR-QL questionnaire (AUC=0.959) and (b) the PedsQL questionnaire (AUC=0.625).

Table 1
Demographic characteristics of 115 child participants, age 7-12 years

	Normal Hearing (n=35)	Unilateral HL (n=35)	Bilateral HL (n=45)
Age, mean (SD)	9.4 (1.8)	9.6 (0.5)	9.8 (1.4)
Female sex, n (%)	17 (49)	19 (56)	26 (58)
Race/ethnicity, n (%)			
White	29 (83)	25 (74)	35 (78)
African American	4 (11)	5 (15)	2 (4)
Asian or Pacific Islander	0	2 (6)	1 (2)
Latino or Hispanic	0	0	3 (7)
Mixed or "other"	2 (6)	1 (5)	4 (9)
No response	0	1 (5)	0
Income, n (%)			
<\$10,000	1 (3)	1 (3)	3 (7)
\$10,000-\$25,000	2 (6)	3 (9)	4 (9)
\$25,001-\$40,000	4 (11)	4 (12)	6 (13)
\$40,001-\$60,000	5 (14)	5 (15)	8 (18)
\$60,001-\$80,000	7 (20)	5 (15)	5 (11)
\$80,001-\$100,000	4 (11)	3 (9)	4 (9)
Over \$100,000	12 (34)	12 (35)	13 (29)
No response	0	1 (3)	2 (4)
Maternal Education level, n (%)			
< High school diploma	1 (3)	2 (6)	4 (9)
Completed high school/GED	3 (9)	4 (12)	7 (16)
Some college/Associate	11 (31)	9 (27)	13 (29)
College/Bachelor's degree	10 (29)	7 (21)	9 (20)
Post-graduate/Advanced degree	10 (28)	11 (31)	11 (24)
No response	0 (0)	1 (3)	1 (2)
Severity of HL, n (%)			
Mild	--	7 (20)	16 (36)
Moderate	--	7 (20)	15 (33)
Severe	--	7 (20)	8 (18)
Profound	--	14 (40)	6 (13)
Insurance status, n(%)			
Private	28 (80)	23 (66)	32 (71)
Public/Medicaid	6 (17)	7 (20)	7 (16)
Both private and public	--	3 (9)	1 (2)
None/unknown	1 (3)	1 (3)	5 (11)
Parent's marital status, n (%)			
Never married	2 (6)	3 (9)	3 (7)
Married	28 (80)	23 (66)	33 (73)
Divorced/separated	4 (11)	5 (14)	7 (16)

	Normal Hearing (n=35)	Unilateral HL (n=35)	Bilateral HL (n=45)
Re-married	1 (3)	3 (9)	2 (4)

HL, hearing loss.

Table 2

Frequency of use of hearing devices used by children with unilateral hearing loss (HL) and bilateral hearing loss.

Hearing device	Unilateral HL (n=35)	Mild-to-moderate Bilateral HL (n=20)	Severe-to-profound Bilateral HL (n=25)
None	6	2	1
FM system	9	7	9
Hearing aid—one	4	5	3
Hearing aid—two	0	2	8
Baha® system	1	0	1
Cochlear implant—one	0	5	2
Cochlear implant—two	0	0	1
Unknown	19	8	8
Any hearing device, n (%) ^a	13 (37)	12 (60)	16 (64)

FM, frequency-modulated assistive listening device.

^a 18 children with HL used an FM system with their hearing aid or cochlear implant, and one child used a hearing aid and cochlear implant.

Table 3

Comparisons of the HEAR-QL and the PedsQL scores for children with normal hearing, any hearing loss (HL), unilateral HL, and bilateral HL. P values refer to the comparisons between normal hearing and any HL.

	Normal hearing (n=35)	Any HL (n=80)	p	Unilateral HL (n=35)	Bilateral HL (n=45)
PedsQL, mean (SD), [range]					
Physical	89 (13) [50-100]	86 (16) [22-100]	0.41	86 (17) [22-100]	86 (15) [38-100]
Emotional	79 (22) [25-100]	72 (19) [20-100]	0.13	73 (19) [40-100]	73 (19) [20-100]
Social	86 (16) [45-100]	79 (19) [20-100]	0.08	79 (20) [30-100]	79 (19) [20-100]
School	78 (21) [30-100]	70 (17) [30-100]	0.047	71 (15) [45-100]	69 (18) [30-100]
Total	83 (15) [44-100]	77 (14) [36-100]	0.06	78 (15) [41-100]	77 (14) [36-100]
HEAR-QL, mean (SD), [range]					
Environments	97 (7) [73-100]	65 (23) [2-100]	<0.001	69 (18) [33-98]	63 (26) [2-100]
Activities	100 (1) [96-100]	89 (20) [8-100]	<0.001	94 (9) [63-100]	85 (26) [8-100]
Feelings	98 (6) [75-100]	73 (21) [0-100]	<0.001	78 (18) [46-100]	70 (22) [0-100]
Total	98 (5) [80-100]	71 (18) [23-100]	<0.001	75 (14) [44-98]	69 (21) [23-100]

SD, standard deviation

Table 4

Differences in mean (SD) PedsQL and HEAR-QL scores between children with hearing loss (HL) who did and did not use a hearing device.

	Unilateral HL			Bilateral HL		
	Used a device (n=13)	No device (n=22)	p	Used a device (n=28)	No device (n=17)	p
PedsQL						
Physical	85 (15)	86 (19)	0.91	84 (16)	91 (10)	0.13
Emotional	65 (15)	75 (21)	0.15	73 (18)	73 (21)	0.99
Social	74 (13)	82 (23)	0.21	77 (21)	83 (13)	0.24
School	65 (10)	74 (17)	0.05	69 (18)	67 (18)	0.69
Total	72 (9)	79 (17)	0.11	76 (15)	79 (11)	0.55
HEAR-QL						
Environments	68 (21)	68 (16)	0.93	57 (28)	73 (19)	0.03
Activities	92 (11)	95 (7)	0.25	78 (30)	95 (9)	0.01
Feelings	80 (18)	75 (20)	0.59	64 (24)	81 (14)	0.02
Total	74 (17)	75 (12)	0.75	64 (23)	78 (13)	0.01

SD, standard deviation

Table 5
HEAR-QL scores by demographic and clinical variables

Variable	HEAR-QL score Mean (SD)	<i>p</i>
Sex		0.21
Male	83 (18)	
Female	78 (20)	
Race/ethnicity		0.86
White	80 (20)	
Black	79 (22)	
Asian/Pacific Islander	84 (3)	
Latino/Hispanic	81 (15)	
Mixed	87 (12)	
Other	100	
Unknown	98	
Hearing level		
Normal	96 (9)	<0.001
Unilateral	75 (14)	
Mild Bilateral	78 (14)	
Moderate bilateral	66 (22)	
Severe bilateral	57 (27)	
Profound bilateral	74 (9)	
Use of hearing device		<0.001
No	88 (14)	
Yes	66 (21)	
Household income		0.77
<\$10,000	67 (22)	
\$10,000-\$25,000	78 (28)	
\$25,001-\$40,000	83 (20)	
\$40,001-\$60,000	78 (23)	
\$60,001-\$80,000	80 (18)	
\$80,001-\$100,000	86 (15)	
Over \$100,000	80 (18)	
No response	95 (5)	
Maternal Education level		0.46
< High school diploma	86 (17)	
Completed high school/GED	72 (24)	
Some college/Associate	80 (22)	
College/Bachelor's degree	84 (16)	
Post-graduate/Advanced degree	80 (18)	
No response	98 (0)	

Table 6
Hierarchical multivariable linear regression of HEAR-QL scores on demographic variables, hearing status, and use of a hearing device

Variables	R ²	Non-standardized β	SE	Standardized β coefficient	t value	p
Step 1	.027					
Intercept		90.06	12.42		7.25	<0.001
Age		-1.11	1.27	-0.09	-0.87	0.39
Gender		0.16	0.20	0.08	0.77	0.44
Maternal education		0.21	0.20	0.11	1.04	0.30
Step 2	.439					
Intercept		117.59	10.05		11.70	<0.001
Age		-0.75	0.97	-0.06	-0.774	0.44
Gender		0.02	0.16	0.008	0.10	0.92
Maternal education		0.20	0.16	0.10	1.29	0.20
Hearing Status		-16.10	1.95	-0.65	-8.26	<0.001
Step 3	.464					
Intercept		111.03	10.38		10.70	<.001
Age		-0.43	0.97	-0.04	-0.44	0.66
Gender		0.02	0.15	0.01	0.15	0.88
Maternal education		0.25	0.15	0.13	1.63	0.11
Hearing Status		-12.83	2.48	-0.52	-5.16	<0.001
Use any hearing device		-8.56	4.15	-0.21	-2.06	0.04

Coding of Hearing status: normal hearing=0, unilateral and mild bilateral HL=1, moderate-to-profound bilateral HL=3. Coding of Use of any hearing device: no device used=0, used device(s)=1.