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Assessment of health-related quality of life 6 years after childhood cochlear implantation

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Abstract

PURPOSE—To examine the impact of cochlear implant (CI) intervention on health-related quality of life (HRQOL) assessed by both self- and parent-reported measures.

METHODS—In this national study of children implanted between ages 6 months and 5 years, HRQOL of 129 children 6-year post-CI was compared to 62 internal study (NH1) and 185 external (NH2) samples of hearing children frequency-matched to the CI group on sociodemographic variables. HRQOL ratings of children and their parents in each group, measured using the Child Health and Illness Profile-Child Edition, were compared, and their associations with the Family Stress Scale were investigated.

RESULTS—CI children reported overall and domain-specific HRQOL that was comparable to both NH1 and NH2 peers. CI parents reported worse child scores than NH1 parents in Achievement, Resilience, and Global score (p 's < 0.01) but similar or better scores than socioeconomically comparable NH2 parents. Higher family stress was negatively associated with

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all parent-reported HRQOL outcomes (p 's < 0.01). Parent-child correlations in HRQOL global scores trended higher in CI recipients ($r = 0.50$) than NH1 ($r = 0.42$) and NH2 ($r = 0.35$) controls.

CONCLUSIONS—CI recipients report HRQOL comparable to NH peers. These results, from both child and parent perspective, lend support to the effectiveness of CI intervention in mitigating the impact of early childhood deafness. Family stress was associated with worse HRQOL, underscoring a potential therapeutic target. Parent-child agreement in HRQOL scores was higher for CI families than NH families, which may reflect higher caregiver insight and involvement related to the CI intervention.

Keywords

cochlear implants; pediatrics; health-related quality of life; family stress

BACKGROUND

Given the large role spoken language plays in overall development, it is not surprising that hearing loss poses a substantial risk for language deficits and concomitant risks to health and well-being[1–8]. Severe-to-profound deafness is associated with measurable deficits in health-related quality of life (HRQOL), reflecting the broad effects of hearing loss and consequent effects on language learning[9], social and emotional functioning[6,7], and academic performance[10,11]. Measures of HRQOL have been used to investigate patients' relative satisfaction with their general health, complementing clinical assessments by emphasizing different aspects of well-being[12–14].

Studies of cochlear implantation typically focus on clinical measures of efficacy related to communication development (e.g., auditory skills, speech, language), which do not represent the intervention's effects on global functioning[11]. HRQOL measures provide a key assessment of the impact of cochlear implants (CIs) on everyday well-being, including physical health, emotional health, academic success, and social functioning. Self-report is central to the concept of HRQOL[15]. Children have been shown to reliably report their HRQOL, and these outcomes are strongly associated with social adjustment[16], engagement in school activities[17], and use of rehabilitative services[18,19].

The importance of HRQOL measurements in efficacy determinations has been emphasized, for example, in FDA assessments of medications and devices[15,20]. However, prior work has often relied on parent proxy results only and/or retrospective data. Using prospective data and refining the application of HRQOL measures to CI recipients provides greater understanding of factors influencing long-term CI outcomes, including overall health.

Standardized, self-report measures offer the best method of assessing HRQOL in children[16,21,22]. Obtaining self-reported HRQOL from children as young as four years old is feasible, for example, as collected in a study of CI recipients using an interview version of the KINDL(R)[22–24]. Child and parent reports of HRQOL correlate moderately in the general pediatric population, particularly in observable domains like physical functioning[25,26], while parent-child agreement is higher for chronically ill children[27]. Parents are limited, however, in their ability to report on unobservable areas of functioning, such as emotional distress and self-esteem[26]. Both self- and parent-reported measures thus provide valuable information about the state of a child's health[28–31].

Self and parent reports of HRQOL for CI recipients have yielded mixed results. A study by Edwards et al. ($n=89$)[32] using parent-reported HRQOL found poorer HRQOL in CI children than normal hearing (NH) peers. A small study ($n=44$) by Huber et al.[4] found lower (worse) child-reported HRQOL for children ages 8–12 years with at least 3 years of

CI experience than for NH peers but no difference for CI and NH adolescents ages 13–16. Parent-reported HRQOL did not differ between CI and NH groups for either age range, and correlations between child and parent reports were weak. In contrast, other investigators[33] found no difference in total HRQOL between CI recipients aged 8–16 years (n=88) and their NH peers, as reported by both children and parents, among participants recruited in a non-generalizable setting (summer camps for CI recipients). Several other groups have investigated HRQOL in children with CIs; however, clinically-meaningful results have been hampered by small sample sizes, lack of controls, inconsistent inclusion criteria, and use of *ad hoc* instruments[12,34]. Inclusion criteria are important design considerations in CI outcome studies, especially when study sample size is small, because heterogeneity across samples in ages at implantation and assessment, years of CI experience, and other child, environmental, and intervention-related confounders may lead to variability in HRQOL scores and difficulty interpreting results, requiring a large sample size for meaningful patterns to emerge[12].

The link between family stress and HRQOL or quality of life (QOL) in chronically-ill pediatric populations is well-established. Family or parenting stress refers to stress associated with parenting tasks, such as discipline, behavior, and finances. High parent-reported, disease-specific stressors were found to correlate with low parent-reported QOL for childhood cancer patients, and maternal depression correlated with low child-reported QOL[35]. Similar associations between high parenting stress and low parent-proxy QOL scores were found in cerebral palsy[36] and sickle cell[37] populations. Furthermore, child-reported family stress was shown to associate negatively with child-reported HRQOL[38]. Family stress may be an important factor affecting HRQOL in children and may be a critical therapeutic target.

We evaluated HRQOL outcomes and assessed the relationship between HRQOL and family stress in the pediatric CI population using the Family Stress Scale (FSS)[39] in conjunction with parent- and child-reported scores on the Child Health and Illness Profile-Child Edition (CHIP-CE). We hypothesized that CI recipients' overall HRQOL at six years post-implantation would fall within the average range and be comparable to that of NH peers, but that CI recipients might experience deficits in areas of HRQOL most related to hearing and language skills, such as social functioning and academic success[3,4,33]. Additionally, we anticipated that higher family stress would be associated with worse HRQOL scores. Paired child and parent reports of HRQOL were expected to correlate moderately, with weaker correlation in unobservable areas of HRQOL and stronger within-group associations for CI vs. NH families[27].

METHODS

Study Population

The Childhood Development after Cochlear Implantation Study (CDaCI) is a diverse, national, longitudinal study following 188 children implanted at six CI centers across the US and 97 NH children (NH1) recruited from two preschools. Participants were enrolled at ages 5 years, with average implantation age of 2.2 years and standard deviation (SD) of 1.2 years, using inclusion and exclusion criteria previously outlined[40]. Children and parents completed a number of assessments at baseline (prior to implantation for CI children; at registration for NH1 children) and annually thereafter to measure children's hearing status, developmental progress, and family environment. The Institutional Review Boards at participating centers approved the protocol, and informed consent was obtained from all parents.

The CDaCI Study's internal control group (NH1) was a convenience sample and, as previously reported[40], had significantly higher socioeconomic status (SES; assessed via family income and maternal education) than the CI group. Given that these variables are associated with HRQOL[41–48], a hearing comparison group external to the CDaCI Study (NH2) was added from the diverse standardization sample used in the CHIP-CE validation studies[23,49]. These NH2 families (n=185) were frequency-matched to the CI group on child age, sex, maternal education, and family income.

The six-year post-implantation visit was chosen for analysis because it was the earliest point at which all CDaCI participants were old enough to complete the self-report HRQOL measure utilized in the study. Questionnaires for this visit were completed by 129 of 188 CI recipients (69%) enrolled in the CDaCI Study and 135 of their parents (72%) for 126 complete child-parent dyads, as well as 62 of 97 NH1 controls (64%) and 60 of their parents (62%) (56 dyads). For the CI group, some non-responders were lost to follow-up, moved, or declined further participation prior to the six-year post-implantation visit (n=27), some were unable to schedule that visit (n=20), and the rest did not complete questionnaires. Non-responders did not significantly differ from those who completed the questionnaire on any sociodemographic variables used as covariates in these analyses or on age at CDaCI entry. At six years post-implantation, 87% of respondents were using speech emphasis or oral language to communicate and 80% were enrolled in mainstreamed classrooms.

Outcome Measures and Procedures

The CHIP-CE was selected for use in the CDaCI Study because it is a well-validated instrument with good internal consistency and test-retest reliability, and includes an extensive battery of questions covering a wide range of functioning domains. It has corresponding child- and parent-report forms for comparison across reporters[50] and is valid for children ages 6–11[23]. The instrument assesses five domains: Satisfaction (well-being, self-esteem); Comfort (physical and emotional symptoms, activity limitations); Resilience (states and behaviors likely to enhance health); Risk Avoidance (behaviors likely to reduce health); and Achievement (academic performance, peer relationships). Additional information about these domains, as well as sample items, can be found in Table 1 (p.222) of Riley et al[23]. Each domain is standardized with a mean of 50 (SD=10) representing average health, with higher scores indicating better HRQOL. A reliable and valid Global Score for HRQOL can be calculated from individual domain scores[51].

CHIP-CE Child Report Form (CHIP-CE/CRF)—The Child Report Form allows children to report on their perceived health, activities, and well-being in the five principal domains on a 45-item questionnaire using a five-point Likert rating scale. The CHIP-CE includes illustrations and uses graduated-size response options to facilitate comprehension[13].

CHIP-CE Parent Report Form (CHIP-CE/PRF)—The Parent Report Form-76 consists of the 45 items from the CHIP-CE/CRF, allowing comparisons of domain scores between children and parents, plus 31 additional items distributed across the domains. The larger number of questions (76 total) allows the same five principal domains to be further broken into 12 subdomains of health and functioning (see Riley et al. Table 2, p.212, for additional details about the subdomains)[49]. The CHIP-CE/PRF also uses a five-point Likert scale and is written at a fifth-grade level. Additionally, it includes family sociodemographic and child disorders modules. The disorders module assesses acute minor (e.g. scrape), acute major (e.g. broken bone), recurrent (e.g. asthma), long-term medical (e.g. diabetes), long-term surgical (e.g. physical disabilities), and psychosocial (e.g. stuttering) disorder subdomains.

The CHIP-CE/PRF has been validated based on expected differences in health by child age, sex, SES, and disorder status[49].

As part of the CDaCI Study, CI and NH1 children ages six and older and their parents complete the CHIP-CE at scheduled annual visits. Children are instructed to complete the questionnaire without assistance from parents, and when necessary, they receive assistance from the study coordinator. Parents complete the questionnaire separately at home and either bring the form to the follow-up visit or mail it to the clinic. NH2 participants completed the measure in their school settings, and parents completed the form at home[23,49].

Main predictors—In addition to examining the effects of CI intervention on HRQOL and comparing child and parent scores, family stress was measured by administering the FSS to parents of CI recipients and NH1 peers in the CDaCI study, with instructions to “think of stress as meaning something that taxes your resources or is more than you can handle comfortably”[39]. The FSS is a parent-report questionnaire with 13 items for all respondents, covering parenting stressors like marital relationship and educational concerns, with three additional disease-specific items for CI families (e.g., keeping the CIs on); it has demonstrated good internal consistency[52]. Items are rated on a 5-point Likert scale ranging from “not at all stressful” to “extremely stressful.” Ratings were averaged across the items to calculate a mean FSS score. Because the questionnaire was administered as part of the CDaCI Study to CI and NH1 parents, FSS data were not available for the NH2 group.

Covariates—Child age and sex, family income, and maternal education were collected from demographic items on the CHIP-CE/PRF. Annual family income was grouped into three categories: <\$39,999, \$40,000–\$79,999, and \$80,000. Maternal education was divided into two categories, split at completion of college.

Statistical Analyses

Sociodemographic characteristics and outcome measures were summarized as frequency distributions for categorical variables and as means and SDs for continuous variables. Per the CHIP-CE scoring instructions, negative items were reverse-scored and relevant domain scores were calculated only when 70% of component items were answered. Paired t-tests and correlations were used to compare domain-specific scores and Global Scores within parent-child dyads. Multivariable linear regression was performed for each domain (and subdomain, for CHIP-CE/PRF scores) to estimate effects of CIs on HRQOL, adjusting for SES, sex, and age (since patient-reported health tends to worsen as children age). The average CI participant profile for these variables was applied to all three groups to derive the adjusted mean scores and associated 95% confidence intervals. Further multivariable modeling was performed for the CI and NH1 groups, adjusting CHIP-CE/PRF scores for mean FSS scores, in addition to covariates from the previous model. Stata 11 (StataCorp, College Station, TX) was used for analyses, and all tests were two-sided with $\alpha=0.05$. No adjustments were made for multiple comparisons.

RESULTS

Demographic characteristics are presented in Table 1. Age, sex, and racial/ethnic distributions were comparable for all groups. As anticipated, the NH1 group had significantly higher family income and maternal education ($p<0.001$) than the CI group. The NH2 group did not differ significantly from CI recipients in any variables.

Unadjusted CHIP-CE/CRF and CHIP-CE/PRF scores for each group are shown in Table 2. Less than 5% of respondents had unscored domains due to answering <70% of relevant items[23,49]. On average, CI children had scores 50 across all domains for both child- and

parent-reported measures after six years of CI use, which is the average level of HRQOL established for the CHIP-CE[23,49]. The CHIP-CE/PRF disorders mean scores showed no significant differences between CI recipients and NH1 or NH2 peers in any subdomain except long-term surgical disorders.

Comparisons between child- and parent-reported HRQOL

The CI families' unadjusted CHIP-CE scores showed that parents and children reported similar scores, only statistically differing in Global Score ($p<0.05$). On average, NH1 child-reported scores were *lower* (worse) than parent-reported scores across all five domains and the Global Score, with the largest differences noted in Achievement, Resilience, and Global Score ($p's<0.001$). In contrast, NH2 child-reported scores were *higher* (better) on average than parent-reported scores across all five domains, but the within-family differences were only significant for Resilience ($p<0.01$). Paired correlations between self- and parent-reported CHIP-CE scores were generally moderate, ranging from $r=0.16$ to $r=0.56$ (Table 3), such that children who reported better HRQOL tended to have parents who reported their HRQOL as more positive too. CI families showed the strongest correlations of the three groups in Achievement ($r=0.53$; $p<0.001$), Resilience ($r=0.28$; $p<0.01$), and Satisfaction ($r=0.32$; $p<0.001$), as well as in Global Score ($r=0.50$; $p<0.001$), although differences between groups were generally not significant.

Comparisons between CI recipients and NH controls

CHIP-CE domain and subdomain mean scores, after adjustment for covariates known to affect HRQOL (age, sex, maternal education, and income), for both child and parent reporters are shown in Table 4. NH1 children's self-reported domain-specific scores and Global Score did not differ significantly from CI recipients' self-reports. NH1 parents reported higher scores (better HRQOL) for their children than did CI parents in Achievement ($p<0.001$), Resilience ($p<0.001$), and Global Score ($p<0.01$). The Resilience difference was driven largely by its social problem solving and physical activity subdomains ($p's<0.001$).

NH2 controls' self-reported scores were lower (worse) than CI children's self-ratings in Satisfaction ($p<0.05$). NH2 parents reported lower scores than CI parents in Comfort ($p<0.001$), Risk Avoidance ($p<0.05$), Satisfaction ($p<0.01$), and Global Score ($p<0.05$). The Comfort difference was driven largely by the emotional comfort subdomain ($p<0.001$), with no significant differences in the physical comfort or restricted activity subdomains.

Effects of family stress on HRQOL

Table 5 shows correlations between FSS and CHIP-CE/PRF scores and FSS regression coefficients in a model adjusting for age, sex, and SES. Correlations between FSS mean scores and CHIP-CE/PRF scores in the CI group were moderate, ranging from -0.25 for Satisfaction to -0.50 for Global Score, such that higher levels of stress were correlated with worse HRQOL scores. These correlations were highly significant for the Global Score and across all domains ($p's<0.01$). For NH1 parents, correlations between FSS mean scores and CHIP-CE/PRF scores varied by domain. Moderate, significant correlations were observed for Comfort ($r=-0.44$; $p<0.001$), Risk Avoidance ($r=-0.30$; $p<0.05$), Satisfaction ($r=-0.32$; $p<0.05$), and Global Score ($r=-0.31$; $p<0.05$); no correlations were observed with Achievement and Resilience.

Higher FSS scores (more stress), as reported by parents, were associated with significantly lower CHIP-CE/PRF Global Scores and domain scores ($p's<0.001$), ranging from a 4-point lower Satisfaction score to a 7.7-point lower Global Score for each 1-point increase on the FSS. After inclusion of FSS scores in the model, the Achievement and Resilience

differences observed between the CI and NH1 parent reports in Table 4 remained, but the two groups no longer statistically differed in Global Score. FSS scores accounted for 23% of the variance in Global Score. Overall, FSS scores had inverse correlations and negative associations with CHIP-CE scores, and adjusting for FSS attenuated differences between CI and NH1 parent reports.

DISCUSSION

The results of this study using a comprehensive, reliable, well-validated generic HRQOL instrument indicated children who have undergone cochlear implantation experience HRQOL comparable to their NH peers after six years of device use. Average CHIP-CE scores of both children with CIs and their parents were above the established population mean of 50, demonstrating that both the children and their parents evaluate the child's health favorably. Children themselves reported high scores in Comfort, reflecting low levels of physical and emotional symptoms, consistent with parental ratings of disorders, where only the long-term surgical disorders subdomain was rated worse for the CI group; this can be explained by the CI alone, since that subdomain includes a question about hearing difficulties. Otherwise, CI children had no more disorders than NH peers. Importantly, in contrast to findings from a prior investigation[4], CI recipients also report high Satisfaction, indicating good levels of well-being and self-esteem, as well as above average scores in Achievement, demonstrating success in academic functioning and peer relationships. Overall, the CI recipients' self-reports did not differ from either NH group, demonstrating they do not view themselves as "less healthy" than their NH peers.

Within families, CI parent-child pairs reported similar results, while NH dyads' scores differed. NH1 children reported significantly lower HRQOL than parents' proxy ratings, an incompletely understood finding often observed in community samples[27,53]. It is possible that high SES parents have a different standard for these behaviors than do children. NH2 children rated themselves significantly higher in Resilience than parents did. Resilience is a composite scale comprising health-promoting behaviors, including family involvement, physical activity, and nutrition. This finding was not seen in the full CHIP-CE cohort[23,49] and could be due to chance in the NH2 sampling. It is notable that the parent-child difference in Resilience scores is small and likely not clinically meaningful.[54]

Correlations within dyads, though not significant, lent support to higher agreement for CI families than for either control group. In our sample, this finding may be explained by parents' involvement in the treatment, needs, and progress of their children with CIs, leading to a shared understanding of the child's experience of health. Correlations were highest for Achievement and Risk Avoidance for all three parent-child groups, which is consistent with literature showing better agreement for observable aspects of functioning[27,53]. Achievement scores are commonly reported by the child's school, and risk avoidance is based on actual behavior which is observable by parents.

Although parents of children with CIs reported at least average health for their children, there were significant differences between parent groups. NH1 parents rated their children *higher* in Achievement, Resilience, and Global Score than parents of CI recipients, even after controlling for SES, with scores on all domains above the CHIP-CE standardized average score. It is notable that CI parents report lower scores for their children than NH1 parents in the Resilience subdomains physical activity and social problem solving, as well as in the Achievement domain, consistent with prior reports[3,4]. In the latter two areas of functioning, language competency drives successful development. Moreover, children in the more affluent families may experience conditions such as academic support that favorably influence their health status across domains.

Concerns about SES differences between CI and NH1 families led to inclusion of the NH2 group, which was obtained from the CHIP standardization sample and matched to CI participants as described above. In contrast to the NH1 group, NH2 parents generally reported *worse* HRQOL than CI parents, as seen in Comfort, Risk Avoidance, Satisfaction, and Global Score.

Our analyses showed that family stress plays an important role in HRQOL. Parent-reported family stress was negatively associated with all parent-reported domains and the global score. A unit increase in FSS score was associated with a decrease in parent-reported HRQOL that is likely to be clinically meaningful[54]. Adjustment for family stress decreased the disparity in Achievement and Resilience subdomain scores and removed the Global Score discrepancy between CI and NH1 parent reports, indicating family stress explains part of these differences. Several studies have shown higher levels of reported family stress in parents of CI recipients than parents of NH children[52,55], and level of family stress may be a factor underlying perceptions of QOL. Further studies are necessary to identify additional factors, such as parental depression, that may result in parents reporting both higher family stress and worse HRQOL for their children. In any case, it may be important to identify and provide additional support to families with elevated family stress to further improve HRQOL in pediatric CI recipients.

In sum, once sociodemographic and family stress factors were controlled, HRQOL for these 6–11 year old children with CIs vs. hearing children was observed to be lower only in academic achievement and social problem solving, and these differences were reported by parents but not by children themselves. These are important areas of functioning, but it is remarkable that in most aspects of health, six years after cochlear implantation, these children were rated by themselves and their parents as being as healthy as hearing peers.

Our findings in this study support those of Loy et al.[33], who found no significant difference in total HRQOL between CI children and NH peers. However, they did find that younger CI recipients (8–11 years of age) reported lower family scores on the KINDL(R), which is roughly analogous to the family involvement subdomain within Resilience, a difference we did not observe. Our findings contradict Huber et al.'s[4], who reported worse global HRQOL for CI recipients than normative scores. They found lower CI recipient than NH peer child-reported scores in areas of HRQOL relating to self-esteem, family, friends, and physical and psychological symptoms, similar to subdomains within Satisfaction, Resilience, Achievement, and Comfort, respectively, and low parent-child score correlations. Here, we evaluated a large, representative cohort[56] with narrow range of age at implantation (0–5 years) and years of CI experience, to yield results generalizable to the US pediatric CI population. By using this group of participants and two NH groups, we believe our study's comprehensive, accurate assessment of HRQOL in CI recipients was less prone to limitations plaguing previous studies.

This work provides further insight into the impact of childhood cochlear implantation on patients with early-onset deafness, characterized as onset during infancy or toddlerhood. We chose an outcome measure that explores children's everyday well-being to complement prior investigations using clinical tests of speech, hearing, or language. Examining HRQOL also acknowledges the recent interest and importance placed on such contextually-specific measures, a trend seen in the literature and supported by the FDA[15,20,57,58]. HRQOL can provide clinicians with a broader view of CI outcomes, offering potential insights into the role of modifying factors surrounding the specific intervention (CI). Measured HRQOL outcomes may be used to guide supporting therapies and interventions, such as those targeting family stress, rehabilitation and education strategies, and social support networks.

Limitations

The NH1 group differed from the CI group in important participant characteristics, most notably family income and maternal education. The NH2 group was introduced as a second control that matched the CI group more closely in demographic characteristics, but this sample did not follow the same protocol as the CI children, including different method of CHIP-CE administration and lack of FSS administration. Differences in demographics and data collection between NH1 and NH2 groups, respectively, may have affected group comparisons. Additionally, while the heterogeneity of CI participants allows for greater generalizability, it could result in greater outcome variability, making identification of factors associated with HRQOL more difficult.

While only two children were eliminated from analyses for completing <70% of CHIP-CE items, it is possible that some participants had difficulty understanding questions due to language or cognitive deficits. Although there were no differences in responders and non-responders, exclusion of 30% of the original CI group due to loss to follow-up and failure to complete questionnaires could lead to undetected biases. Additionally, use of a generic HRQOL measure, rather than a disease-specific measure, was necessary for comparison of HRQOL of CI children to NH peers, but this measure may have been less sensitive to the specific challenges faced by CI recipients.

CONCLUSION

This investigation found that six years after implantation, CI recipients enjoy HRQOL as good as NH peers, according to both child and parent reports. CI recipients' parents reported their children's HRQOL as intermediate between parent-reported HRQOL scores from two NH control groups. Parent-reported family stress was associated with worse parent-reported HRQOL for CI recipients, suggesting stress reduction as a potential therapeutic target for CI families. Additionally, we found higher agreement in child HRQOL between CI children and their parents than between NH parent-child dyads, indicating CI parents may have greater awareness of their children's HRQOL due to increased participation in their children's health care. These results suggest that CIs can effectively minimize the impact of early childhood deafness on HRQOL, consistent with the positive effects of CI on other reported performance outcomes[59–62]. Our findings also offer insight into the link between family stress and children's HRQOL that could lead to further improvements in cochlear implantation outcomes.

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Table 1

Participant characteristics for CI recipients, internal CDaCI NH controls, and external sociodemographically-matched NH controls

	CDaCI CI Recipients [n=129 unless otherwise noted] N (%)	CDaCI NH1 Controls [n=62 unless otherwise noted] N (%)	External NH2 Controls [n=185 unless otherwise noted] N (%)
Mean Age at Assessment in Years (SD)	8.0 (1.3)	7.8 (1.0)	8.1 (1.4)
Sex			
Male	52 (40%)	25 (40%)	81 (44%)
Female	77 (60%)	37 (60%)	104 (56%)
Race			
White	[n=123] 93 (76%)	[n=53] 42 (79%)	[n=89] 72 (81%)
Black/African-American	8 (7%)	6 (11%)	8 (9%)
Asian/Pacific Islander	7 (6%)	1 (2%)	3 (3%)
Mixed	7 (6%)	3 (6%)	4 (4%)
Other	8 (7%)	1 (2%)	2 (2%)
Annual Family Income		***	
<\$40,000	[n=121] 18 (15%)	[n=53] 4 (8%)	[n=169] 31 (18%)
\$40,000–\$79,999	42 (35%)	4 (8%)	62 (37%)
\$80,000	61 (50%)	45 (85%)	76 (45%)
Maternal Education		***	
College graduate or higher	[n=128] 72 (56%)	[n=54] 47 (87%)	112 (61%)
Mean Family Stress Scale Score (SD)		***	
	[n=132] 1.8 (0.7)	[n=57] 1.5 (0.4)	Not Available

Abbreviations: CI = cochlear implant; CDaCI = Childhood Development after Cochlear Implantation; NH = normal hearing; SD = standard deviation

p-value for comparison with CI group

*
<0.05;

**
<0.01;

***
<0.001

Table 2

Comparisons between child- and parent-reported mean CHIP-CE scores (SD) for CI recipients and NH control groups

	CDaCI CI Recipients	CDaCI NH1 Controls	External NH2 Controls
Child Report	[n=127][†]	[n=62]	[n=185]
Achievement	50.7 (9.0)	52.9 (6.9)***	51.2 (8.9)
Comfort	54.2 (8.6)	54.0 (6.9)*	52.9 (9.0)
Resilience	51.4 (8.0)	51.6 (8.4)***	51.8 (8.4)**
Risk Avoidance	51.6 (8.2)	50.3 (8.9)	49.9 (9.9)
Satisfaction	53.4 (8.0)	53.1 (7.2)**	50.8 (9.8)
Global Score	52.0 (11.5)*	52.3 (10.9)***	49.9 (13.2)
Parent Report	[n=135]	[n=60]	[n=185]
Achievement	50.6 (10.6)	57.3 (8.1)	50.9 (9.2)
Comfort	55.3 (9.0)	56.2 (8.8)	51.7 (9.0)
Resilience	50.1 (10.9)	58.2 (8.6)	49.4 (10.2)
Risk Avoidance	51.6 (8.4)	51.7 (8.2)	49.8 (8.2)
Satisfaction	54.4 (9.1)	56.3 (8.4)	50.5 (8.9)
Global Score	53.2 (10.1)	58.1 (8.5)	50.6 (9.3)

Abbreviations: CHIP-CE = Child Health and Illness Profile-Child Edition; SD = standard deviation; CI = cochlear implant; NH = normal hearing; CDaCI = Childhood Development after Cochlear Implantation

Standardized CHIP score mean = 50, SD = 10, where higher scores indicate better health.

[†] Of the 129 child respondents, two children returned questionnaires that could not be scored for any domains because <70% of items in each domain were completed.

p-value for pair-wise comparison with parent-reported score of same domain

* <0.05;

** <0.01;

*** <0.001

Table 3

Pair-wise correlations between child- and parent-reported CHIP-CE scores by domain

	CDaCI CI Recipients	CDaCI NH1 Controls	External NH2 Controls
Achievement			*
<i>r</i>	0.53	0.40	0.32
<i>p-value</i>	<0.0001	0.0024	<0.0001
<i># of pairs</i>	124	55	184
Comfort			
<i>r</i>	0.29	0.36	0.29
<i>p-value</i>	0.0011	0.0067	0.0001
<i># of pairs</i>	126	56	184
Resilience			
<i>r</i>	0.28	0.17	0.19
<i>p-value</i>	0.0017	0.22	0.0091
<i># of pairs</i>	125	55	185
Risk Avoidance			
<i>r</i>	0.50	0.56	0.31
<i>p-value</i>	<0.0001	<0.0001	<0.0001
<i># of pairs</i>	124	54	185
Satisfaction			
<i>r</i>	0.32	0.16	0.21
<i>p-value</i>	0.0003	0.23	0.0049
<i># of pairs</i>	125	56	184
Global Score			
<i>r</i>	0.50	0.42	0.35
<i>p-value</i>	<0.0001	0.0015	<0.0001
<i># of pairs</i>	121	54	182

Abbreviations: CHIP-CE = Child Health and Illness Profile – Child Edition; CI = cochlear implant; NH = normal hearing

p-value for test of differences in correlation coefficients from CI group:

*
<0.05

Table 4

Comparisons of adjusted^a mean child- and parent-reported CHIP-CE scores (95% C.I.) between CI recipients and two NH control groups

	CDaCI CI Recipients	CDaCI NH1 Controls^b	External NH2 Controls[‡]
Child Report	[n=117–119]	[n=51–52]	[n=168–169]
Achievement	51.0 (49.4–52.5)	53.1 (50.6–55.5)	51.8 (50.5–53.1)
Comfort	54.0 (52.5–55.6)	53.5 (51.1–55.9)	53.1 (51.8–54.4)
Resilience	51.6 (50.1–53.1)	52.3 (50.0–54.7)	52.1 (50.8–53.3)
Risk Avoidance	51.5 (50.0–53.0)	49.2 (46.7–51.7)	50.3 (49.0–51.6)
Satisfaction	53.6 (52.0–55.1)	53.6 (51.1–56.1)	51.0 (49.7–52.3)*
Global Score	52.1 (49.8–54.3)	52.3 (48.7–55.8)	50.6 (48.8–52.5)
Parent Report	[n=122–128]	[n=53–55]	[n=167–169]
Achievement	50.3 (48.7–52.0)	56.6 (54.0–59.2)***	51.2 (49.8–52.6)
<i>Academic Performance</i>	51.0 (49.5–52.5)	55.8 (53.4–58.2)**	51.0 (49.6–52.3)
<i>Peer Relations</i>	49.2 (47.5–51.0)	55.0 (52.1–57.8)**	51.0 (49.4–52.5)
Comfort	55.3 (53.8–56.8)	55.7 (53.2–58.2)	51.4 (50.1–52.8)***
<i>Physical Comfort</i>	54.8 (53.3–56.3)	54.4 (52.0–56.8)	52.8 (51.6–54.1)
<i>Emotional Comfort</i>	54.8 (53.3–56.4)	55.6 (53.1–58.1)	49.2 (47.8–50.5)***
<i>Restricted Activity</i>	51.4 (49.9–52.9)	52.5 (50.2–54.9)	52.7 (51.5–54.0)
Resilience	50.0 (48.3–51.8)	57.3 (54.5–60.1)***	49.8 (48.3–51.3)
<i>Family Involvement</i>	51.9 (50.3–53.6)	54.2 (51.5–56.8)	49.7 (48.3–51.2)*
<i>Social Problem Solving</i>	46.7 (45.0–48.5)	54.2 (51.4–57.1)***	49.2 (47.7–50.8)*
<i>Physical Activity</i>	51.5 (49.9–53.1)	57.0 (54.4–59.7)***	50.7 (49.3–52.2)
Risk Avoidance	51.7 (50.2–53.1)	51.4 (49.1–53.6)	49.5 (48.3–50.7)*
<i>Individual Risk Avoidance</i>	49.7 (48.0–51.3)	51.4 (48.8–54.0)	47.9 (46.5–49.4)
<i>Threats to Achievement</i>	52.4 (51.1–53.7)	51.1 (49.0–53.2)	50.3 (49.2–51.5)*
Satisfaction	54.4 (52.9–55.9)	55.7 (53.3–58.2)	50.8 (49.5–52.1)**
<i>Satisfaction with Health</i>	54.0 (52.3–55.6)	55.6 (52.9–58.3)	51.3 (49.8–52.8)*
<i>Satisfaction with Self</i>	53.6 (52.3–54.9)	54.2 (52.0–56.3)	50.0 (48.8–51.1)***
Global Score	53.1 (51.5–54.7)	57.2 (54.7–59.8)**	50.7 (49.3–52.1)*

Abbreviations: CHIP = Child Health and Illness Profile-Child Edition; C.I. = confidence interval; CI = cochlear implant; NH = normal hearing

Standardized CHIP score mean = 50, SD = 10, where higher scores indicate better health.

p-value for comparison with CI group

* <0.05;

** <0.01;

*** <0.001

^a Adjusted for group (CI, NH1, and NH2), test age, sex, maternal education, and family income

^b Adjusted mean scores based on the average CI group sociodemographic profile on test age, sex, maternal education, and family income

Table 5 Associations^a and correlations^b of FSS mean scores with CHIP-CE/PRF scores

	FSS Beta Coefficient (CDaCI participants)	FSS-CHIP Correlation Coefficient (CDaCI CI Recipients)	FSS-CHIP Correlation Coefficient (CDaCI NH1 Controls)
Achievement ^{††}	-6.21 ***	-0.44 ***	-0.04
Comfort	-5.85 ***	-0.37 ***	-0.44 ***
Resilience	-5.08 ***	-0.32 ***	-0.09
Risk Avoidance	-6.50 ***	-0.48 ***	-0.30 *
Satisfaction	-4.00 ***	-0.25 **	-0.32 *
Global Score	-7.66 ***	-0.50 ***	-0.31 *

Abbreviations: FSS = Family Stress Scale; CHIP-CE/PRF = Child Health and Illness Profile – Child Edition Parent Report Form; CI = cochlear implant; NH = normal hearing

p-values:

*
<0.05;

**
<0.01;

***
<0.001;

p-values for test of differences in correlation coefficients:

^{††}
<0.01

^a Associations of FSS (completed only by parents, and where higher FSS scores indicate higher stress levels) with CHIP-CE scores (higher scores indicate better health), adjusting for group (cochlear implant [CI] or internal CDaCI controls [NH1]), test age, sex, maternal education, and family income

^b Pair-wise correlations between FSS mean score and CHIP-CE score