Predictors of health-related quality of life in adult cochlear implant recipients in South Africa

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Abbreviations: CI, cochlear implant; HRQoL, health-related quality of life; HL, hearing loss; NCIQ, Nijmegen Cochlear Implant Questionnaire; QoL, Quality of Life

ABSTRACT

Objective: To identify and describe predictors of health-related quality of life (HRQoL) outcomes for adult cochlear implant (CI) recipients in South Africa.

Design: A retrospective study of adult CI recipients was conducted and cross-sectional HRQoL outcome data were added at the time of data-collection, using the Nijmegen Cochlear Implant Questionnaire (NCIQ). Twenty-two potential predictive factors were identified from the retrospective dataset, including demographic, hearing loss, CI and risk related factors. Multiple regression analyses were performed to identify predictor variables that influence HRQoL outcomes.

Study sample: The study sample included 100 adult CI recipients from four CI programs, implanted for at least 12 months.

Results*:* History of no tinnitus prior to CI, bilateral implantation and mainstream schooling were strongly predictive of better overall HRQoL outcomes. Factors such as age, age at implant, gender, onset of hearing loss, duration of CI use and presence of risk factors did not predict HRQoL scores.

Conclusion: A range of significant prognostic indicators were identified for HRQoL outcomes in adult CI recipients. These predictors of HRQoL outcomes can guide intervention services' informational counselling.

INTRODUCTION

Cochlear implantation is a well-established intervention for individuals with severe-profound sensorineural hearing loss who obtain no or insufficient benefit from acoustic amplification. With the broadening of implantation criteria, increased numbers of adult patients are being implanted at advanced ages and with less severe hearing losses (Olze et al, 2011). Cochlear implantation does not only affect the hearing, speech perception and speech production abilities of a patient, but it also has a broader impact on social functioning, daily activities and self-esteem (Hinderink et al, 2000; Hirschfelder et al, 2008). In recognizing the need to measure and objectify the benefits or limitations of medical interventions on an individuals' social, emotional and physical well-being, the term quality of life (QoL) has been defined (Loeffler et al, 2010). QoL is a broad ranging concept, referring to an individual's perception of his/her position in life, affected in a multifaceted way by psychological state, level of independence, social relationships, personal beliefs and physical health (World Health Organization, 1998). More specifically, this general health status of patients, often referred to as health-related quality of life (HRQoL), has been recognized as a more comprehensive measure of medical intervention outcomes (Mo et al, 2005).

In order to capture cochlear implant (CI) patient outcomes more holistically, the functional impact of permanent hearing loss and consequent treatment on personal well-being should be assessed through HRQoL measures (Capretta & Moberly, 2015; Zaidman-zait, 2010). In recent years, in addition to standard speech perception testing, HRQoL has become a widespread outcome measure to quantify and monitor cochlear implant outcomes. Significant improvement between pre- and post-implantation HRQoL scores was documented for unilaterally implanted postlingually (Chung et al, 2012; Damen et al, 2007; Hinderink et al, 2000; Hirschfelder et al, 2008; Klop et al, 2008; Mo et al, 2005; Olze et al, 2011), as well as prelingually (Klop et al, 2007; Straatman et al, 2014) deafened adult CI recipients. Similarly,

HRQoL measures revealed a positive effect of implantation for unilaterally implanted postlingually deafened elderly patients (Orabi et al, 2006; Sanchez-Cuadrado et al, 2013; Vermeire et al, 2005) and also adult patients implanted for unilateral deafness (Arndt et al, 2011; Vermeire & Van De Heyning, 2009). Recent studies also demonstrate improved HRQoL for bilateral sequential cochlear implantation compared to unilateral implantation (Härkönen et al, 2015; King et al, 2014; Olze et al, 2012).

Various factors have been identified as predictors of improved outcomes in adult CI recipients in terms of speech recognition performance, including better pre-operative speech recognition, shorter duration of deafness, higher educational level, oral mode of communication during childhood, progressive hearing loss, earlier age at implantation and positioning of electrode arrays closer to the modiolar wall (Caposecco et al, 2012; Friedland et al, 2010; Hirschfelder et al, 2008; Klop et al, 2008; Holden et al, 2013; Leung et al, 2005). Yet, these factors do not necessarily contribute to broader HRQoL outcomes (Capretta & Moberly, 2015) and as a result, identifying patient factors that predict outcomes in terms of HRQoL is of specific interest. This prognostic information is not only required for the planning of post-implantation intervention, but also to counsel potential CI recipients pre-operatively about the range of possible outcomes (Black et al, 2011).

A significant association between speech perception testing outcomes and HRQoL scores have been indicated in several studies (Cohen et al, 2004; Damen et al, 2007; Francis et al, 2002; Hirschfelder et al, 2008; Vermeire et al, 2005). However, this association could not be replicated by a number of studies (Capretta & Moberly, 2015; Hinderink et al, 2000; Maillet et al, 1995; Mo et al, 2005; Straatman et al, 2014), arguably due to the fact that subjective perceptions of benefit from a CI could not be linked directly to the objective performance level on speech perception testing (Hinderink et al, 2000). It is therefore possible that the

effect of cochlear implantation on HRQoL may outweigh the improvements in hearing as measured during speech perception testing (Loeffler et al, 2010).

Various other factors having an influence on HRQoL outcomes in adult CI recipients have been investigated, with some factors being inconclusive among studies. While no correlation was found between duration of deafness and HRQoL scores by a number of studies (Capretta & Moberly, 2015; Cohen et al, 2004; Hawthorne et al, 2004; Hirschfelder et al, 2008; Mo et al, 2005; Olze et al, 2011), Maillet et al. (Maillet et al, 1995) indicated that the longer the duration of deafness, the less improvement in HRQoL is perceived. An association between younger age and better HRQoL scores was found by Chung et al. (Chung et al, 2012) and Klop et al. (Klop et al, 2008), whereas numerous other studies could not confirm this association (Capretta & Moberly, 2015; Hirschfelder et al, 2008; Vermeire et al, 2005). Hawthorne et al. (Hawthorne et al, 2004) indicated that HRQoL outcomes depend on socio-economic status, with CI recipients in the top socio-economic tertile obtaining greater gains in HRQoL scores. Study results from Hirschfelder et al. (Hirschfelder et al, 2008) showed a significant positive correlation between duration of CI use and HRQoL scores, while Capretta and Moberly (Capretta & Moberly, 2015) found that duration of CI use, socio-economic status, reading ability, vocabulary size and cognitive status did not consistently predict HRQoL scores. The findings of Olze et al. (Olze et al, 2011) revealed that a high level of tinnitus impairment is associated with lower HRQoL scores before and after CI and confirmed negative correlations between HRQoL and stress, depression and anxiety.

CI performance and HRQoL outcomes vary among adult patients and are influenced by a wide variety of multifactorial predictors. Accurate pre-operative predictions of these outcomes would enable clinicians to counsel patients to such an extent that they will be able to make informed judgements of the personal benefits they might receive from implantation (Summerfield & Marshall, 1995). However, in spite of the recent focus to assess the broader

personal impact of permanent hearing loss and cochlear implantation in patients, the multifaceted nature of HRQoL as an outcome measure requires further study to explore relative significance of different interacting factors (Klop et al, 2008). Given the current paucity of proven prognostic factors for HRQoL in CI recipients, this study aimed to identify predictors of HRQoL and to investigate the prognostic significance of these factors in an unselected caseload of adult CI recipients in South Africa.

METHOD

Institutional ethics committee approval was obtained prior to the commencement of data collection.

Study population

Four CI programs participated in this multicentre study. Three programs are situated in the Gauteng Province (University of Pretoria Cochlear Implant Unit, Johannesburg Cochlear Implant Program, Chris Hani Baragwanath Academic Hospital Cochlear Implant Program), and the remaining program is situated in the Free State Province (Bloemfontein Cochlear Implant Program). Patient files of 334 adult (>18 years) CI recipients were reviewed retrospectively at these four participating programs as part of a larger national outcomes study. During the eight month data collection period, the Nijmegen Cochlear Implant Questionnaire (NCIQ) was distributed by e-mail or handed to adult CI recipients who were seen for consultation at the participating CI programs. Only adult CI recipients who were proficient in English were requested to complete the questionnaire. A third (113/344; 33%) of the adult CI recipients returned the questionnaires. Experience with a CI of at least 12 months was specified as the only inclusion criteria. Returned questionaires were then inspected to confirm completeness of answers and CI experience of at least 12 months. Thirteen of the

113 subjects who completed the NCIQ were excluded: five subjects' questionnaires could not be used for data-analysis due to incomplete answers and a further eight subjects completed the NCIQ questionnaire, but did not have at least 12 months experience with a CI. The final study sample consisted of 100 adult CI recipients who were implanted with multichannel CIs between 1991 and 2013. All subjects were implanted for at least 12 months and were active users of their CIs.

Demographic and clinical characteristics of the study population are presented in Table 1. Most subjects (70%) were implanted unilaterally, while 30 (30%) were implanted bilaterally at the time of data collection (n=100). All bilateral implants were performed sequentially, with the interval between first and second implant ranging from 0.1 to 15.5 years (mean= 5.3 years; 4.3 SD; n=30). With the exception of five subjects (5.5%, 5/91), all subjects had a fully inserted electrode array in at least one cochlea. Explant/re-implant procedures of their 1st/only implant were necessary for four (4%) subjects (n=100). Most of the subjects implanted unilaterally (81.2%, 56/69) used bimodal amplification and only 18 (18.6%, 18/97) made use of assistive listening devices. The study sample were primarily oral communicators (93%), with the exception of seven subjects (7%) who used total (mixed oral and manual) communication (n=100).

Table 1. Characteristics of study population

Demographic characteristics	***% (n)***	**Clinical characteristics**	***% (n)***
Gender		**Onset of hearing loss**	
Male	58 (58/100)	Pre-lingual onset	35.0
Female	42 (42/100)	Post-lingual onset	(35/100)
		Unknown	62.0
			(62/100)
			3.0
			(3/100)
Age at study (years) (n=100)		**Rapidity of onset of hearing loss**	
Mean (SD)	44.7 (16.7)	Congenital/ early onset	30.9 (30/97)
Range	19.4–83.4	Progressive	56.7 (55/97)
		Sudden	12.4 (12/97)
Employment status		**Age at diagnosis of hearing loss**	
Employed	67.4 (64/95)	Pre-lingual onset hearing loss (in months) (n=23)	
Retired	14.7 (14/95)	Mean (SD)	18.0 (8.1)
Unemployed/ not working	7.4 (7/95)	Range	3-35
Current educational/ training setting	8.4 (8/95)	Post-lingual onset hearing loss (in years) (n=55)	
		Mean (SD)	21.6 (17.6)
		Range	3-65
Highest educational qualification		**Age at implantation (years)**	
Secondary education (Grade 12)	47.3 (43/91)	Total sample (n=100)	
completed	29.7 (27/91)	Mean (SD)	36.9 (18.6)
Tertiary qualification (University)	18.7 (17/91)	Range	3.3–74.9
Tertiary qualification (other)	4.4 (4/91)	Pre-lingual onset hearing loss (n=35)	
Primary/ high school (< Grade 12)		Mean (SD)	25.9 (15.6)
		Range	3.3–67.6
		Post-lingual onset hearing loss (n=62)	
		Mean (SD)	43.1 (44.5)
		Range	4.4–74.9
Mode of communication		**Duration of CI use (years)** (n=100)	
Oral	93.0 (93/100)	Mean (SD)	7.7 (5.0)
Total communication (mixed)	7.0 (7/100)	Range	1.0–21.9
South African citizen		**Duration of hearing loss prior to CI (years)** (n=78)	
Yes	96 (96/100)	Mean (SD)	22.9 (16.8)
No	4 (4/100)	Range	0.3 –66.0
Health sector		**CI device**	
Private	96 (96/100)	Cochlear©	87 (87/100)
Public	4 (4/100)	Med-el©	10 (10/100)
		Advanced Bionics©	3 (3/100)

Description of variables

Outcome variables

The Nijmegen Cochlear Implant Questionnaire (NCIQ) was completed by adult CI recipients as a measurement of HRQoL. The NCIQ is a disease-specific, self-report questionnaire developed specifically for CI recipients (Hinderink et al, 2000). Three general domains are addressed in the NCIQ, namely: physical functioning (with "basic sound perception", "advanced sound perception" and "speech production" subdomains); psychological functioning (with "self-esteem" sub-domain) and social functioning (with "activity limitations" and "social interactions" subdomains). Each sub-domain consists of 10 questions, with answers depicted on a 5-point Likert scale, ranging from "never" to "always" (55 questions) or from "no" to "quite well" (5 questions). Should a question not apply to a CI recipient, a sixth answer ("not applicable") can be given. The subdomain scores range from 0 (never/ very poor) to 100 (always/ optimal). The NCIQ has become a standard outcome measure in evaluating the HRQoL in adult CI recipients (Loeffler et al, 2010). Validity, reliability and sensitivity to clinical changes have been confirmed for the NCIQ (Cohen et al, 2004; Damen et al, 2006; Damen et al, 2007; Hinderink et al, 2000; Hirschfelder et al, 2008; Krabbe et al, 2000). For the data analysis, overall HRQoL (total NCIQ score), together with each of the six NCIQ subdomains (basic sound perception, advanced sound perception, speech production, self-esteem, activity limitations and social interactions) were considered as continuous outcome variables.

Explanatory variables

Data on demographic and clinical characteristics (Table 1), as well as risk, family, educational and employment factors (Appendix A, Table A1) of the study sample were collected retrospectively. Twenty-two potential predictive factors were identified from this

retrospective dataset and defined as either continuous or categorical variables. These predictors are presented in Appendix A, Table A2 in terms of demographic and related factors (gender, marital status, age at study, highest educational qualification, school type attended, employment status); hearing loss factors (onset of hearing loss, rapidity of onset of hearing loss, duration of hearing loss prior to CI, use of assistive listening device); CI factors (choice of ear for first/only implant, age at implantation, duration of CI use, bilateral implantation) and risk factors (additional disabilities, diagnosed ear disease, ear surgery prior to CI, tinnitus prior to CI, dizziness prior to CI, family history of permanent childhood hearing loss, pre-natal risk factors, post-natal risk factors). Supplementary Tables A1 and A2 are available in the online version of the journal.

Data collection

An electronic database was developed to capture retrospective data from the clinical files of eligible adult CI recipients amongst the participating CI programs. At the time of data collection, the NCIQ was distributed to all adult CI recipients at the participating CI programs by email. Only CI recipients proficient in English were requested to complete the questionnaire. In order to increase the response rate of completed questionnaires, the NCIQ was also handed to adult CI recipients who were seen for consultations during the eight months data collection period at the respective CI programs. The NCIQ was completed electronically or in hard copy as a self-assessment of HRQoL by individual CI recipients themselves at home or during consultations at the various CI programs. This cross-sectional HRQoL data were then added to the electronic database.

Statistical analysis

Descriptive statistics was utilized to define the study population in terms of demographic and clinical characteristics (Table 1), as well as risk, family, educational and employment profiles

(Appendix A, Table A1). Twenty-two suspected predictive factors were identified from these characteristics (Appendix A, Table A2).

The criterion used to differentiate between a prelingual and postlingual onset of hearing loss in CI recipients was age of diagnosis of hearing loss before and after their third birthday, henceforth called prelingual and postlingual onset respectively (De Graaf & Bijl, 2002). For three subjects the onset of hearing loss was unknown and they were omitted from the analyses. For bilateral implantation, only the subjects who had at least six months experience with their bilateral implant at the time of data collection (completion of NCIQ) were considered as bilateral implant users (80%, 24/30).

Answers to the 60 questions of the NCIQ were scored by transforming answer categories (1-5) as follows: 1=0, 2=25, 3=50, 4=75, and 5=100. Scores for each of the six subdomains of the NCIQ were computed by adding together the 10-item scores of each subdomain and dividing it by the number of completed questions (Hinderink et al, 2000). The response category "not applicable" as well as missing values were treated as not completed. Subjects exceeding the maximum number of three incomplete answers for each specific subdomain were excluded (Hinderink et al, 2000). An overall HRQoL average percentage score was then also calculated for the six subdomains together.

Multiple linear regression analysis was used for the prediction of HRQoL outcomes in adult CI recipients. Regression models were constructed to investigate the influence of categorical and continuous predictors on HRQoL percentage scores.

RESULTS

HRQoL outcome profile

Comprehensive post-operative NCIQ scores were obtained for 100 adult CI recipients. Table 2 presents the descriptive statistics for overall HRQoL and the six sub-domains of the NCIQ. Highest mean scores were obtained for the "advanced sound perception" (77%) and the "activity limitations" (71.5%) sub-domains. Lowest mean score was obtained for the "self-esteem" (57.9%) sub-domain.

Table 2. HRQoL scores depicted from NCIQ results (n=100)

Nijmegen Cochlear Implant Questionnaire	*Mean (SD)*	*Median*	*Range*
Total HRQoL score	66.1 (12.6)	65.7	30.4 – 90.4
NCIQ sub-domain			
Physical: Basic sound perception	64.1 (17.1)	67.5	19.4 – 97.5
Physical: Advanced sound perception	77.0 (15.9)	80.3	38.9 – 100
Physical: Speech production	59.6 (18.7)	60.0	12.5 – 100
Psychological: Self-esteem	57.9 (17.2)	60.0	12.5 – 85.0
Social: Activity limitations	71.5 (18.5)	75.0	25.0 – 100
Social: Social interactions	66.5 (11.4)	67.5	30.6 – 90.0

Multiple linear regression analysis: HRQoL

A multiple linear regression model was constructed for overall HRQoL outcomes. Twenty-two predictor variables (Appendix A, Table A2) were randomly fed into the model and the best predictors for overall HRQoL were then identified during the model building process. A similar analysis was then done for each of the six sub-domains of the NCIQ, but only revealed significant associations with the "advanced sound perception" sub-domain. Table 3 presents the multiple linear regression analysis results, showing the best predictors of outcomes in terms of overall HRQoL and advanced sound perception. The simultaneous

effect of the identified predictors was measured for these two outcomes and therefore the influence of a predictor is significant on the outcome in the presence of the other predictors.

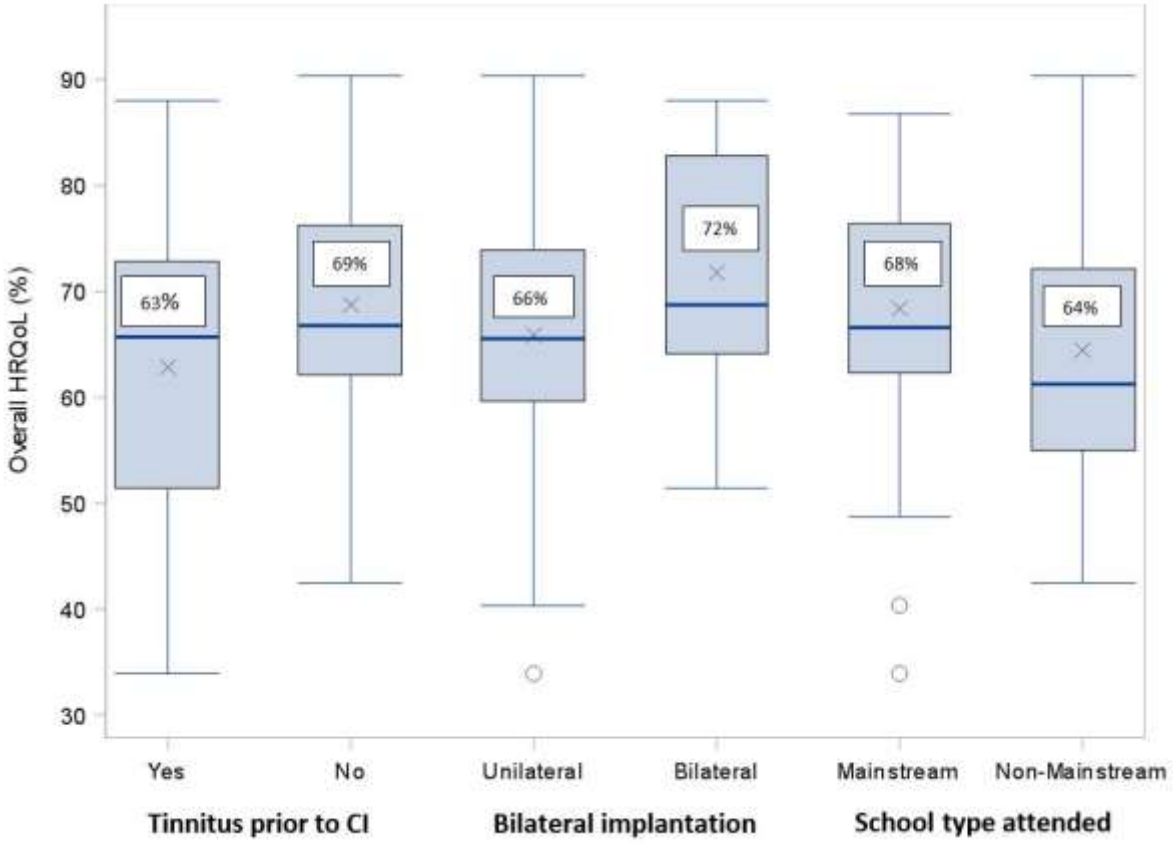

Figure 1: Tinnitus prior to CI, bilateral implantation and mainstream schooling as predictors of overall HRQoL n=66 The box plots represent the smallest observation, lower quartile, median (bold line), mean (x) with percentage indicated in textbox, upper quartile, largest observation, and outliers (>1.5 times interquartile range) (○)

Multiple linear regression results identified tinnitus, bilateral implantation, school type attended and additional disabilities as categorical predictors for the overall HRQoL outcome (Table 3). The boxplots in Figure 1 illustrate that patients with a history of tinnitus prior to CI have a significantly lower mean HRQoL score of 63% compared to the mean score of 69% of patients without a history of tinnitus (p=0.0301). The same results are observed for the

bilateral implantation and school type attended factors, where on average patients with unilateral implants scored 6% lower than patients implanted bilaterally (p=0.0433), and patients who did not attend mainstream schools scored 4% lower than those who attended mainstream schools (p=0.0485). Furthermore, this analysis indicates a suggestive, but not significant association between the additional disability factor and overall HRQoL outcomes. Patients without additional disabilities have a significant lower average HRQoL score (67%) compared to an average score of 75% for patients with additional disabilities (p=0.0544). Also, a regression coefficient of 0.17 was noted for the duration of hearing loss prior to CI continuous predictor (p=0.0408).

Table 3. Multiple linear regression analysis results

Outcome variables	**Predictors**	**p-value**	**df****	**Sum of Squares**	**F Value**	**Pr > F*** (p value)**	**R^2******
Overall HRQoL (n=66)	Tinnitus prior to CI Duration of hearing loss prior to CI* Bilateral implantation School type attended Additional disabilities	0.0301 0.0408 0.0433 0.0485 0.0544	5	2084.52	3.40	0.0090	0.22
Advanced sound perception (n=70)	School type attended Additional disabilities Employment status Duration of hearing loss prior to CI*	0.0142 0.0228 0.0571 0.0922	4	2673.16	3.87	0.0070	0.19

continuous variables; **df: Degrees of freedom; ***Pr>F: p-value of the F-test (with F-test testing the significance of the model); **R^2: determination coefficient*

In a similar regression analysis, school type attended and additional disabilities were identified as categorical predictors for the advanced sound perception outcome, together with employment status (Table 3). Patients who attended mainstream schools have a significant higher average score for the advanced sound perception sub-domain of 80%, compared to a lower average score of 72% for patients who attended non-mainstream schools (p=0.0142). Patients without additional disabilities have a significant lower average score for advanced sound perception (77%) when compared to the average score of 86% for patients with additional disabilities (p=0.0228). This analysis shows marginal evidence to suggest that patients who are unemployed obtain a significant lower score of 72% for the advanced sound perception sub-domain when compared to patients who are employed with an average score of 79% (p=0.0571). Duration of hearing loss prior to CI was indicated as a continuous predictor for advanced sound perception, but with negligible significance (regression coefficient of 0.16; p=0.0992).

Linear regression models for both the overall HRQoL and advanced sound perception outcomes were highly significant ($p<0.01$) and present with determination coefficients (R^2) of 22% and 19% respectively. These determination coefficients indicate that less than 25% of the variation in the HRQoL outcomes observed in the data was accounted for by the specified models.

DISCUSSION

The HRQoL outcomes in the unselected group of adult CI recipients in this study were significantly predicted by history of tinnitus prior to CI, bilateral implantation and school type attended. A history of tinnitus prior to CI was a strong predictor of poorer HRQoL outcomes overall. In spite of the dearth of available data on the HRQoL of patients with

tinnitus before and after implantation (Olze et al, 2011), some evidence suggest that tinnitus is an important factor that significantly affects the HRQoL of CI patients. Using the *Glasgow Benefit Inventory* and the *Specific Questionnaire* as HRQoL measures, Ramos et al. (Ramos et al, 2013) found that better HRQoL scores were obtained by adult (>60 years) CI recipients that have never had tinnitus, with 88% of these adults being "remarkably satisfied" with their CI intervention. Olze et al. (Olze et al, 2011) also utilized the NCIQ to evaluate HRQoL pre- and post-operatively in post-lingually deafened adults, showing that patients with high-level tinnitus had significantly lower NCIQ scores before and after CI. Additionally, in a study exploring the benefits of sequential implantation, positive changes in HRQoL were associated with improvements in hearing, but were counterbalanced by negative changes associated with worsening of tinnitus (Summerfield et al, 2006). Even though data on the severity of tinnitus pre and post CI were not collected and could not be reported on, this study provides evidence that the presence of tinnitus prior to CI influences HRQoL outcomes with implications for the rehabilitation process.

Bilateral implantation was also strongly associated with better HRQoL outcomes. This finding confirms results from the prospective study of Härkönen et al. (Härkönen et al, 2015) in which generic HRQoL questionnaires (the *Glascow Benefit Inventory* and the *15D* questionnaire) were used to indicate that sequential bilateral cochlear implantation improved HRQoL. Similarly, in a study where the additional benefit of a second CI was evaluated, Olze et al. (Olze et al, 2012) indicated that HRQoL assessed with the NCIQ further increased after the second CI. With their novel HRQoL questionnaire that assesses physical and psychosocial benefits of sequential bilateral implantation, King et al. (King et al, 2014) also demonstrated subjective improvement in all measured domains after receiving a second CI. However, it should be noted that not all patients in this dataset had the opportunity to access a second CI, since financial resources currently remains a decisive factor for bilateral

implantation in South Africa. It is therefore possible that the association between bilateral implantation and increased HRQoL outcomes could be related to socioeconomic factors as well. Irrespective, results from this study suggest that perceived improvements in hearing resulting from the addition of a second CI could be associated with better HRQoL outcomes.

Mainstream schooling, implying a normal hearing or oral communication educational setting, was strongly predictive of better HRQoL outcomes overall and in the advanced sound perception sub-domain. Evidence suggest that deaf children perform better on measures of speech perception, receptive and expressive language when oral communication predominate their educational environment, potentially by placement in a mainstream classroom setting (Cosetti & Waltzman, 2012). This study provides preliminary evidence that a mainstream educational setting also predicts better overall HRQoL outcomes for adult CI recipients, possibly as a result of former integration in oral communication educational environments. Yet again, due to socioeconomic and geographical constraints it is possible that not all CI recipients from this dataset had equal access to supportive mainstream education. Nevertheless, better subjective ratings in terms of perceived advanced sound perception could still be expected from adult CI recipients who attended mainstream schools. In support of these results, Van Deun et al. (Van Deun et al, 2009) indicated that in a group of sequentially implanted children, localization abilities were greatest in children who attended mainstream schools versus schools for the deaf.

Contrary to expectations, additional disabilities and duration of hearing loss prior to CI also yielded statistical significance as predictive factors in the regression analyses. Firstly, additional disabilities were associated with better scores for overall HRQoL and for the advanced sound perception sub-domain. With only 10% of the total study sample presenting with one or more additional disability, the results obtained for this association could not be generalized. However, it could be that these few cases with additional disabilities perceive

the restorative effect of cochlear implantation and the consequent lessening of the total disability burden to be more significant than patients who only have deafness as an isolated disability. Secondly, longer duration of hearing loss prior to CI predicted better scores for overall HRQoL. Duration of deafness / severe-to-profound hearing loss is generally considered as a more robust predictive factor in CI outcomes, since it implies the duration of auditory deprivation, which is known to be a critical predictor of implantation success. However, CI performance remains highly variable, even among patients with identical duration of deafness, signifying that clinical and HRQoL outcomes are determined by various other interacting factors (Giraud & Lee, 2007). Similar to the contradictory tendency observed in this study, Klop et al. (Klop et al, 2008) and Ramos et al. (Ramos et al, 2013) also found a significant association between longer duration of deafness and better HRQoL outcomes, which accentuate the complex nature of HRQoL as an outcome measure.

Since this current study aimed to provide a broad overview of HRQoL outcomes, the range for duration of CI use in this diverse study sample was rather broad. However, this was accounted for by including duration of CI use as an explanatory variable in the regression analysis. In agreement with the study results of Capretta and Moberly (Capretta & Moberly, 2015), duration of CI use did not influence HRQoL scores for this study sample. Furthermore, the factors identified to be predictive of HRQoL outcomes within this dataset accounted for less than 25% of the variation in HRQoL outcomes. This underscores the intricate and multifactorial influence of predictors on HRQoL outcomes.

CONCLUSION

History of no tinnitus prior to CI, bilateral implantation and mainstream schooling were strong predictors of better HRQoL outcomes in adult CI recipients. Other factors such as age, age at implant, gender, onset of hearing loss, duration of CI use and presence of risk factors did not consistently predict HRQoL scores. The importance of appropriate pre-operative counselling and post-implantation support and rehabilitation services for patients with tinnitus is underscored by the findings from this study. This work also contributes to a better understanding of factors influencing HRQoL outcomes enabling clinicians to provide evidence-based information counselling to adult CI patients and their families.

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Appendix A

Table A1: Risk, family, education and employment factor prevalence

Syndromes and additional developmental conditions identified	% (n)	Risk factors identified	% (n)	Family, educational and employment factors identified	% (n)
Syndromes		**Prenatal risk factor**		**Family factors**	
Any syndrome diagnosed (including syndromes listed below)	5.1 (5/89)	1 or more prenatal risk factor present	20.6 (20/97)		
Ushers Syndrome	3.1 (3/89)	Family history of permanent childhood hearing loss	17.0 (16/94)	Marital status	
Osteogenesis Imperfecta	1.0 (1/89)	Rubella	3.2 (3/94)	Married	47.5 (47/99)
Leopard Syndrome	1.0 (1/89)	Twin/triplet	1.1 (1/94)	Single	47.5 (47/99)
				Divorced	2.0 (2/99)
Additional disabilities		**Natal risk factor**		Partner, not married	3.0 (3/99)
1 or more condition present	10.4 (10/96)	1 or more natal risk factor present	6.5 (6/92)		
Visual impairment	5.2 (5/96)	Birth trauma	3.3 (3/92)	**Educational and employment factors**	
Cerebral palsy	2.1 (2/96)	Rh incompatibility	2.2 (2/92)		
Learning disability	2.1 (2/96)	Prematurity	2.2 (2/92)	Highest educational qualification	
Emotional/ behavioural disability	1.0 (1/96)	Anoxia	1.1 (1/92)	Secondary education (Grade 12) completed	47.3 (43/91)
Epilepsy	1.0 (1/96)			Tertiary qualification (University)	29.7 (27/91)
		Postnatal risk factor		Tertiary qualification (other)	18.7 (17/91)
		1 or more postnatal risk factor present	33.7 (31/92)	Primary/ high school (< Grade 12)	4.4 (4/91)
		Meningitis	8.7 (8/92)		
		Noise exposure	7.6 (7/92)	Employment status	
		Trauma	5.4 (5/92)	Employed	67.4 (64/95)
		Viral infection (unspecified)	3.3 (3/92)	Retired	14.7 (14/95)
		Neonatal jaundice/ hyperbilirubinemia	3.3 (3/92)	Unemployed/ not working	7.4 (7/95)
		Measles	2.1 (2/92)	Current educational/ training setting	8.4 (8/95)
		Mumps	2.1 (2/92)		
		Neonatal jaundice with blood transfusion	1.1 (1/92)	School type attended	
		Neonatal jaundice Kernicterus	1.1 (1/92)	Mainstream school	73.0 (65/89)
		Ototoxic drugs: aminoglycosides	1.1 (1/92)	School for the Deaf (Sign Language mode of communication)	11.2 (10/89)
		Ototoxic drugs: cerebral malaria treatment	1.1 (1/92)	School for the hard-of-hearing (oral mode of communication)	11.2 (10/89)
				Special school (mainstream syllabus)	3.4 (3/89)
		General otological risk factor		Alternative education: technical or apprentice	1.1 (1/89)
		History of tinnitus prior to CI	22.5 (20/89)		
		Chronic middle-ear infection	15.7 (14/89)		
		History of dizziness prior to CI	15.7 (14/89)		
		History of ear surgery prior to CI	13.5 (12/89)		
		Meniere's disease	2.3 (2/89)		
		Otosclerosis	1.1 (1/89)		

Table A2: Suspected predictive factors

Explanatory variables	Categorical/ continuous description	% (n)
Demographic and related factors		
Gender	Male	58.0 (58/100)
	Female	42.0 (42/100)
Marital status	Married	47.5 (47/99)
	Single/ divorced/ partner, not married	52.5 (52/99)
Age at study (years)*	Mean (SD)	44.7 (16.7)
(n=100)	Range	19.4 – 83.4
Highest educational qualification	High school	51.6 (47/91)
	Tertiary qualification	48.4 (44/91)
School type attended	Mainstream	73.0 (65/89)
	Non-mainstream	27.0 (24/89)
Employment status	Employed	67.4 (64/95)
	Not employed	32.6 (31/95)
Hearing loss factors		
Rapidity of onset of hearing loss	Congenital/ early onset	30.9 (30/97)
	Post-natal (sudden and progressive)	69.1 (67/97)
Onset of hearing loss	Prelingual	36.1 (35/97)
	Postlingual	63.9 (62/97)
Duration of hearing loss prior to CI* (n=78)	Mean (SD)	22.9 (16.8)
(time from diagnosis of hearing loss to cochlear implantation)	Range	0.3 – 66.0
Use of assistive listening device	Yes	18.2 (18/99)
	No	81.8 (81/99)
Cochlear Implant factors		
Choice of ear for 1st/ only implant	Left	41.0 (41/100)
	Right	59.0 (59/100)
Age at implantation (years)*	Mean (SD)	36.9 (18.6)
(n=100)	Range	3.3 – 74.9
Duration of CI use (years)*	Mean (SD)	7.7 (5.0)
(n=100)	Range	1.0 – 21.9
Bilateral implantation *(including only cases with at least 6 month experience with bilateral implant)*	Yes (bilateral)	24.0 (24/100)
	No (unilateral)	76.0 (76/100)
Risk factors		
Additional disabilities	Yes (1 or more)	10.4 (10/96)
	None	89.6 (86/96)
Diagnosed ear disease	Yes	20.2 (18/89)
(e.g. Meniere's disease, otosclerosis, chronic middle-ear infection)	No	79.8 (71/89)
History of ear surgery prior to CI	Yes	13.5 (12/89)
	No	86.5 (77/89)
History of tinnitus prior to CI	Yes	22.5 (20/89)
	No	77.5 (69/89)
History of dizziness prior to CI	Yes	15.7 (14/89)
	No	84.3 (75/89)
Family history of permanent childhood hearing loss	Yes	17.0 (16/94)
	No/ uncertain	83.0 (78/94)
Presence of 1 or more pre-natal risk factor	Yes (1 or more)	20.6 (20/97)
	None	79.4 (77/97)
Presence of 1 or more post-natal risk factor	Yes (1 or more)	33.7 (31/92)
	None	66.3 (61/92)

**continuous variables*