

# Self-reported cochlear implant management skills: development and validation of the self-administered Cochlear Implant Management Skills (CIMS-self) survey

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**Key Words:** cochlear implant, handling skills, management skills, survey, validation, patient outcomes.

**Abbreviations:** CI: cochlear implant; CIMS: Cochlear Implant Management Skills; CIMS-self: self-administered Cochlear Implant Management Skills; ICC: intraclass correlation.

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## ABSTRACT

**Objective:** A self-administered device management survey was developed and validated to investigate the ability of cochlear implant recipients to self-report physical handling and care for their hearing implant device(s) and to identify factors that may influence self-reported management skills.

**Design:** Survey development and validation. A prospective convenience cohort design study.

**Setting:** Specialist hearing implant clinic.

**Participants:** Forty-nine postlingually deafened, adult cochlear implant recipients, at least 12 months post-operative.

**Main Outcome Measures:** Survey test-retest reliability, responsiveness, criterion validity and sensitivity and specificity compared to clinician evaluation of device management skills. Correlations between self-reported management skills and participant demographic, audiometric, cognitive function, clinical outcomes and device factors.

**Results:** The self-administered Cochlear Implant Management Skills survey was developed, demonstrating high test-retest reliability (ICC = 0.884,  $p < 0.001$ ; CI 95%: 0.721 to 0.952), responsiveness to intervention (management skills training) [ $t(20) = -3.245$ ,  $p = 0.004$ ], criterion validity (ICC = 0.765,  $p < 0.001$ ; CI 95%: 0.584 to 0.868) and sensitivity (0.89). No associations were found between self-reported management skills and participant factors.

**Conclusions:** This study demonstrated that a self-report survey is an effective method for the evaluation of skills required for cochlear implant device management.

## INTRODUCTION

Information and training on the daily care and maintenance of the external components of the hearing implant system (including the speech processor, battery compartment, transmitter coil and associated accessories(1, 2) and described hereafter as the “CI device”) is a vital part of the cochlear implant (CI) rehabilitation program, as evidenced by their positive association with rehabilitation outcomes, such as self-report satisfaction with the CI device(3). However, a recent study by Bennett et al(3) demonstrated variability in CI device management skills of cochlear implant recipients, putting to question the effectiveness of current clinical techniques utilised for skills training in populations of CI device users.

The Cochlear Implant Management Skills (CIMS) survey was developed as a clinician administered tool to systematically evaluate device management skills and identify those skills that require retraining(3). In a cohort of 49 experienced CI device users, 89.80% (n=44) were identified as demonstrating difficulty with at least one item on the CIMS, most commonly cleaning, volume and program control, and hearing on the telephone(3).

The clinical utility of the CIMS is limited in that in its current form it requires face-to-face delivery and thus can only be administered as part of the clinical consultation. The development of a self-administered survey evaluating CI device management skills may reduce the clinical load in that patients can complete the survey outside of clinical time (such as at home or in the waiting room), freeing up valuable consultation time for additional counselling and training. Additionally, a self-administered survey may facilitate more frequent use than face-to-face consultations allow. For example, completing a self-report survey on CI device management skills in the few months following switch-on may

identify gaps in skills that were not previously recognised. Furthermore, completing a self-report survey on management skills at intervals over an extended period of time following cochlear implantation may identify age-related changes in management skills, such as those arising from reduced cognitive function(4), vision(5), or finger dexterity(6, 7). Although a self-administered survey for CI device management may provide a more efficient medium for ongoing patient care, there is currently no evidence to support whether CI recipients can accurately self-report management skills.

This study therefore developed the self-administered Cochlear Implant Management Skills (CIMS-self) survey, based on the CIMS(3). The primary aim of this study was to determine if CI recipients were able to accurately identify and self-report CI device management difficulties when provided with an itemised list of management tasks, and to compare the sensitivity of the self-report survey to a face-to-face evaluation of skills by a clinician. A secondary aim of this study was to investigate association between self-report management skills and participant demographic, audiometric, cognitive, clinical outcomes and device factors. Cognitive ability (as evaluated using a cognitive screening test) was evaluated to determine whether cognitive performance contributed to self-reported CI device management skills or changes in self-reported management skills following intervention.

## **METHODS**

### **Ethical Considerations**

Ethics clearance for this study was granted by the Human Research Ethics Office of The University of Western Australia, and all participants provided informed consent to participate.

## Materials

A short clinical history form was used to collect participant demographic and device data, including: age, gender, CI device use (hours per day) and a question regarding overall satisfaction with the CI device(s) (evaluated on a five-point Likert scale, where 1 indicated very satisfied and 5 indicated very dissatisfied).

***Clinician assessing CI device management skills.*** This was recorded using the CIMS survey(3), a clinician-administered survey evaluating ten aspects of CI device management skills in order to identify those that may require additional training. The CIMS score represents percentage of competency, with 100% indicating full competency, i.e. no management difficulties.

***Self-report management skills: Survey development.*** The self-administered Cochlear Implant Management Skills (CIMS-self) survey was developed for this study (Appendix 1) based on the CIMS survey(3). Minor variations to the language and scoring between the CIMS and the CIMS-self were required. Whilst all survey items remained essentially the same, where the wording of each question in the CIMS survey commenced with “Please show me how you...”, the wording in the self-administered version was changed to “Are you confident with your ability to...”. Furthermore, where the CIMS used a three-point Likert scale graded as ‘Performs inaccurately or unable to perform’, ‘Performs task with some difficulty or would benefit from some additional training regarding technique’, or ‘Performs task accurately and with no difficulty’, the CIMS-self used a four-point Likert scale for participants to self-rate their ability to perform each task graded as ‘Never/Unsure’, ‘Sometimes’, ‘Most of the time’, and ‘Always’. A ‘Not applicable’ option was available. An additional option was included the self-administered version as pilot testing of an earlier

version using a three-point Likert scale resulted in participants reporting that they were unsure whether to select sometimes or always as their experiences lay somewhere in between. The scores are summed, subtracted from 51 and divided by 0.51 to produce the final score representing percentage of competency, increasing to 100% as competency increases.

***Cognitive status.*** The original English version of the MoCA (MoCA Version 7.1)(8) was used to evaluate cognitive function. The MoCA has 13 items evaluating cognitive abilities including attention, memory, language, and visuospatial functions and is scored out of 30, with a score  $\geq 26$  indicating cognitive functions similar to normal controls(8).

Participant audiometric results, device data, and rehabilitation outcomes were extracted from patients' files with their consent. Data collected included aided four frequency average hearing loss (4FAHL, including 500Hz, 1kHz, 2kHz and 4kHz) for the implanted ear (at least 12 months post implantation); post implantation (at least 12 months) aided binaural City University of New York (CUNY) sentence perception test(9) scores and Abbreviated Profile of Hearing Aid Benefit (APHAB)(10) survey scores; model of CI device; number of years since implantation; and number of years since most recent processor upgrade.

## **Participants**

Participants were recruited via purposive sampling from the Ear Science Clinic in Perth, Western Australia. This study forms the second part of an earlier study ~~CI recipients~~ on clinician evaluation of CI device management(3), and thus uses the same cohort of CI recipients. See Bennett et al.(3) for further details on participant recruitment. All

participants were adult cochlear implant recipients implanted with a Cochlear® device at least twelve months prior to data collection.

Participants were randomly assigned to two groups: Group One, the intervention group, to evaluate responsiveness of the survey; and Group Two, the delayed intervention group, to evaluate test-retest reliability of the survey.

### **Data collection**

Participants attended two, 30-minute data collection sessions, two to five weeks apart. During data collection participants were instructed to wear their CI device(s), and contra-lateral hearing aid if applicable, in their normal (everyday) settings. Participants were also advised to make use of nonverbal cues, such as lip reading, when required.

The methodology used is the same as that used previously to validate the CIMS(3). In brief, participants completed a short clinical history form (Session One and Session Two), the CIMS-self (Session One and Session Two), the MoCA Version 7.1 (Session One only), and the CIMS survey (Session One and Session Two). During both sessions, the participants completed the CIMS-self without clinician involvement and before completing the CIMS survey. The clinicians were blinded to the CIMS-self survey responses. Following Session One, participants in Group One (intervention group) received retraining on CI device management skills listed in the CIMS survey, while participants in Group Two (delayed intervention) did not receive training during Session One. During Session Two, all participants completed the CIMS-self and the CIMS surveys, then all participants received retraining on CI device management skills, if indicated by the survey responses. While the training delivered at this stage was not necessary for the study, it was provided as a service

to the participants. Training provided (to the intervention group and after completion of the data collection in Session Two) was based on the areas of difficulty identified by the CIMS survey and conducted in line with recommendations outlined in the user manual that accompanied their cochlear implant processor, and delivered by the two clinical audiologists administering the surveys.

### **Data Analysis**

When completing the CIMS survey each participant was scored independently by two clinicians and thus received two CIMS survey scores at each appointment. These were averaged, justifiable on the basis that the validation study on the CIMS showed a high inter-observer reliability(3).

Data were normally distributed, and no outliers were indicated by z-score calculations. Sampling distribution was investigated using independent sample t-tests and Chi-Square tests for between group differences (intervention versus delayed intervention).

***CIMS-self survey validity.*** Construct validity was assessed using Pearson's correlation coefficient and ANOVA for the following hypotheses: 1. CIMS-self survey scores will be positively correlated with CIMS survey scores; 2. CIMS-self survey scores will be positively correlated with overall satisfaction with CI device; 3. CIMS-self survey scores will not be associated with age; 4. CIMS-self survey scores will not be associated with gender; and 5. CIMS-self survey scores will not be associated with hearing sensitivity (aided 4FAHL).

Test-retest reliability was assessed using intraclass correlation (ICC) for individuals CIMS-self survey scores in the delayed intervention group (Group Two), with a minimum of two and a maximum of three weeks between test and retest.



Responsiveness, the instruments ability to detect clinically important changes over time(11), was evaluated using paired sample t-test to compare mean CIMS-self survey scores pre and post intervention for the intervention group (Group One), excluding the five participants who did not attend the second session.

Criterion validity, the extent to which scores on a survey relate to a gold standard (12) was evaluated using intraclass correlation (ICC) between CIMS-self and CIMS survey scores at Session 1.

Sensitivity and specificity analyses were performed comparing CIMS-self survey pass/fail rates to clinician evaluation of management skills (CIMS pass/fail rates) from Session 1.

***Factors associated with CI device management.*** Associations between CIMS-self survey scores and participant demographic, audiometric, clinical outcomes and CI device factors were investigated using Pearson's correlation coefficient or ANOVA. Association between cognitive ability (MoCA scores) and self-report management skills (CIMS-self scores) as well as ability to learn management skills (change in CIMS-self scores following retraining; intervention group) was evaluated using Pearson's correlations coefficient.

## RESULTS

Participants ranged in age from 27.3 to 87.7 years (mean 65.0; SD 16.9), 44.9% were male and 55.1% were female, and the mean number of years since implantation was 5.0 years (range 0.7 to 21.3; SD 3.9). Overall, participants were satisfied with their CI devices, with 93.9% reporting being Satisfied or Very Satisfied. Generally CI device management skills were good; CIMS survey scores range from 54.7% to 100% (mean: 83.5%; SD: 12.5)(3).

There were no significant differences between demographic factors, audiometric results, cognitive ability or actual CI device management skills (CIMS scores at Session 1) between the groups (intervention and delayed intervention), with the exception of length of time since implantation [ $t(37.15) = 3.058, p = 0.004$ ]; however, this was found not to be associated with other variables in this study (Table 1).

**Table 1.** Cohort description

	Group One (intervention) (n = 26)	Group Two (delayed intervention) (n = 23)
Age (mean years $\pm$ SD)	65.49 $\pm$ 17.21	64.34 $\pm$ 16.85
Gender	Male (n=12), Female (n=14)	Male (n=10), Female (n=13)
Aetiology	Congenital (n=8), Meniere's (n=6), Hereditary (n=4), Otosclerosis (n=3), Noise exposure (n=1), Meningitis (n=1), Unknown (n=4)	Congenital (n=1), Meniere's disease (n=1), Hereditary (n=9), Otosclerosis (n=3), Noise exposure (n=2), Neurofibromatosis (n=1), Nerve Damage (n=1), Osteogenesis Imperfecta (n=1), Unknown (n=4)
Implant models	N22 (n=1), CI24RE(CA) (n=25), CI24RE(ST) (n=1), CI24R(CS) (n=4), CI24R(ST) (n=3), CI422 (n=1), CI512 (n=2)	CI24RE (CA) (n=17), CI24RE (ST) (n=1), CI422 (n=5), CI512 (n=7), CI513 (n=1)
Processor Models	ESPrIt3G (n=1), Freedom (n=4), CP810 (n=25), CP910 (n=6)	Freedom (n=8), CP810 (n=23), CP910 (n=4)
Time since initial implantation (mean years $\pm$ SD)	6.47 $\pm$ 4.52	3.42 $\pm$ 2.20
Time since most recent processor upgrade (mean years $\pm$ SD)	2.71 $\pm$ 2.47	2.39 $\pm$ 1.82
Aided 4FAHL (for the implanted ear) (mean decibels $\pm$ SD)	28.27 $\pm$ 4.51	26.56 $\pm$ 6.96
Bilateral CUNY speech scores (mean $\pm$ SD)	93.25 $\pm$ 2.47	94.17 $\pm$ 10.05
Post-op APHAB scores (mean $\pm$ SD)	37.96 $\pm$ 16.07	35.42 $\pm$ 13.49
MoCA scores	23.95 $\pm$ 3.17	23.86 $\pm$ 3.10

## Survey validation

Four of the five hypotheses tested for construct validity were met (Table 2). The test-retest reliability of the CIMS-self survey was “almost perfect” (ICC = 0.884,  $p < 0.001$ ; CI 95%: 0.721 to 0.952). Evaluation of the responsiveness of the CIMS-self survey demonstrated a significant improvement when comparing pre-intervention ( $78.43 \pm 18.66$ ) to post-intervention ( $88.42 \pm 9.68$ ) scores [ $t(20) = -3.245$ ,  $p = 0.004$ ]. Criterion validity was “almost perfect” (ICC = 0.765,  $p < 0.001$ ; CI 95%: 0.584 to 0.868) when CIMS-self scores were compared to CIMS survey scores (clinician evaluation of skills).

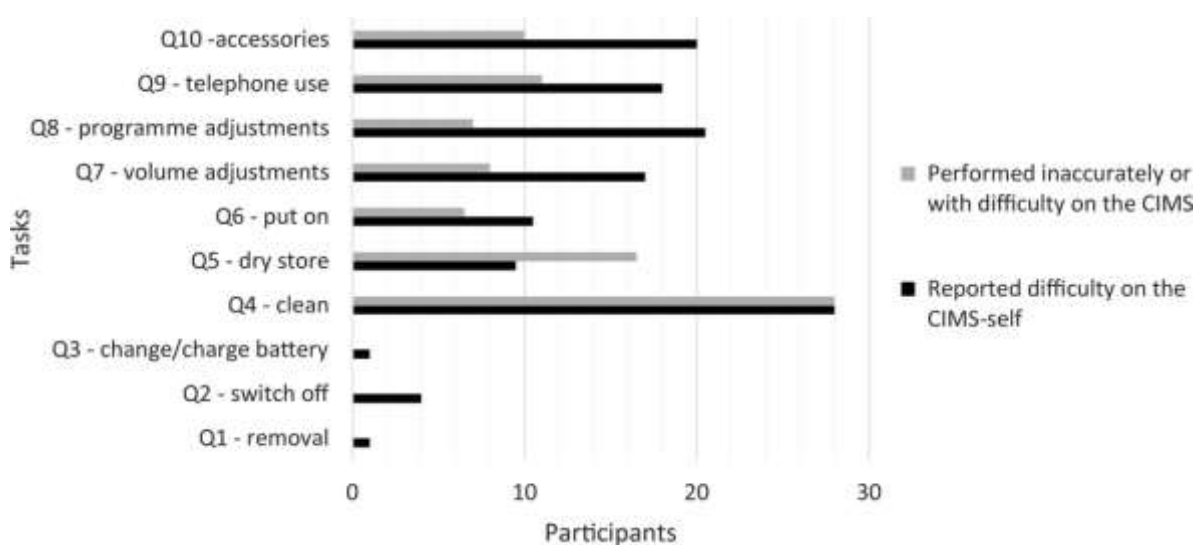
Sensitivity of the CIMS-self survey was high (0.89) when compared to clinician evaluation of management skills (CIMS pass/fail rates); however, specificity could not be calculated due to the lack of true negatives; that is, none of the participants that passed the CIMS survey self-reported full competence on the CIMS-self.

**Table 2.** Associations between CIMS-self survey scores and participant demographic and self-report outcome factors to establish construct validity of the CIMS-self survey

	Pearson's Correlation analysis			ANOVA		
	df	P	$\rho$	df	F	$p$
1. CIMS survey scores (clinician evaluation of skill)	48	0.630	<0.001**			
2. Overall satisfaction with CI device(s)	48	-0.141	0.333			
3. Age	48	-0.079	0.591			
4. Gender				1	1.997	0.164
5. 4FAHL for the implanted ear	48	-0.114	0.442			

\*\*Correlation is significant at the 0.001 level

The mean CIMS-self survey score (pre intervention) was 81.19% (SD 14.91, Range 31.37% to 100%). 95.92% (n=47) of participants scored below 100%, demonstrating difficulty with at least one aspect of CI device management. Participants had the most difficulty with the questions on the CIMS-self survey relating to cleaning, program adjustments and use of accessories (Figure 1). Participants tended to overstate their difficulties of management tasks, with the exception of use of the dry store unit (Figure 1).



**Figure 1.** Percentage of participants that indicated (CIMS-self) or demonstrated (CIMS) difficulty or inability to perform tasks.

### Factors associated with self-report CI device management

No associations were found between self-report management skills (CIMS-self survey scores) and participant demographic, audiometric, CI device factors and clinical outcomes (Table 3). No associations were found between MoCA scores and CIMS-self scores ( $r = -0.100$ ,  $p = 0.495$ ) or change in CIMS-self scores ( $r = -0.067$ ,  $p = 0.772$ ).

**Table 3.** Associations between self-reported CI device management skills (CIMS-self survey scores) and participant demographic, audiometric, clinical outcomes and device factors.

	Pearson's Correlation analysis			ANOVA		
	df	P	<i>p</i>	df	F	<i>p</i>
Age	48	-0.079	0.591			
Gender				1	1.997	0.164
Processor Models				3	0.694	0.561
Time since initial implantation (years)	48	-0.162	0.266			
Time since most recent processor upgrade (years)	48	-0.240	0.096			
Aided 4FAHL (for the implanted ear)	48	-0.114	0.266			
CUNY speech scores (bilateral; at least 12 months post implantation)	46	0.118	0.429			
Post-op APHAB scores (at least 12 months post implantation)	39	-0.189	0.242			
Raw MoCA score	48	-0.100	0.495			
MoCA pass/fail (with < 26 indicating a fail)				2	2.443	0.098
Self-report satisfaction with CI device(s)	48	-0.141	0.333			

## DISCUSSION

In order to determine whether CI recipients are able to accurately identify and self-report CI device management difficulties, this study compared self-perceived ability, measured using the CIMS-self survey, with demonstrated ability, measured using the CIMS survey. The high sensitivity and criterion validity achieved for the CIMS-self survey suggests that CI recipients are able to accurately identify and self-report management skills using an itemised list of management tasks. However, participants generally scored lower on the

CIMS-self than the CIMS, indicating that participants reported more difficulty than was observed by the two clinicians. It is possible that participants' tendency to overstate their difficulties may be influenced by self-efficacy (people's judgement of their capabilities to perform tasks), as competent functioning requires both possession of skills and self-efficacy(13-16). It is then possible that clinical use of the CIMS-self could result in an increase of seemingly unnecessary appointments. However, it could be argued that a client who self-reports difficulty may still benefit from consultation if it helps to improve their confidence in CI device management(14). Our clinical experience indicates that many concerns are relatively easy to explain or remedy and that alternative education tools may include development of online education or problem solving guides. This is a potential source of future analysis and assessment with the CIMS-self.

Participants showed a significant improvement in CIMS-self survey scores following intervention, demonstrating that the CIMS-self survey is sensitive enough to detect changes in CI device management following retraining(11) and that recipients are able to recognise improvement in themselves. However, despite receiving retraining and demonstrating full competency only two weeks prior, 61.5% of participants (Group One) still reported difficulty with at least one task on the CIMS-self survey when reassessed at the second data collection session. The difficulties most often self-reported following intervention included not knowing what volume to set the CI device at in different situations (52.63% self-reported ongoing difficulties following intervention), not knowing what program to select in different situations (50%), not being able to use the remote control competently (46.15%) and the device being uncomfortable when in use (42.86%).

Although the authors suspected that cognitive status may be a contributing factor, no associations were found between MoCA scores and CIMS-self survey scores or change in CIMS-self survey scores following intervention. It is possible that the cognitive screening tool used in this study was not sensitive enough to detect association between cognitive performance and skill acquisition, or that confounding factors masked this relationship, such as self-efficacy. It is possible that current methods of CI device training are insufficient for more complex tasks and that the ongoing difficulties reported reflect the integral role of self-efficacy in skill acquisition. Thus the role of the clinician should not be to simply provide instructions for CI device management, but to establish whether CI recipients have learned the skills and developed sufficient self-efficacy for optimal CI device use.

With respect to the task evaluating comfort, discomfort may be due to magnet strength, incorrect placement on the ear, or hook size, all of which are rectifiable through modifications to the CI device or patient training. However, less commonly, discomfort may be due to irritation of the skin caused by wearing the CI device for long periods of time, which may not be rectifiable. Hence, in some cases patients may fail the CIMS-self despite being able to competently complete the management tasks necessary for daily use. Despite this, the authors recommend to retain the question assessing comfort as in 80% of cases (four of the five participants in the treatment group who self-reported comfort issues) clinicians were able to relieve the discomfort through modifications to the CI device and provision of patient training.

### **Factors associated with CI device management**

Although one may assume that CI device management skills might be affected by factors such as participant age, years of experience with CI devices or processor model, this

study found no such associations. These findings suggest that clinicians should not assume that younger or experienced CI recipients already have the skills necessary to use and manage their CI devices appropriately(3). Instead, training and evaluation of management skills should be part of the rehabilitation process for all CI recipients(3).

### **Clinical considerations**

While the CIMS survey(3) is available to assist clinicians in systematically evaluating CI recipients' level of skill with regard to CI device management in the clinical setting, the CIMS-self is the first self-administered tool available enabling CI recipients to self-identify and report CI device management skills. Both forms of the survey have a place in clinical practice. The CIMS, being a clinician-administered tool, is for use during clinical consultations. The clinician may use it as a checklist when providing initial CI device management training, and as a mean of evaluating the patients' level of skill following training to ensure that the information has in fact been learned. In contrast, the CIMS-self, being self-administered, is to be used when making contact with the patient in their home. The CIMS-self could be posted out to the patients, allowing them to self-evaluate any aspects of CI device management that were not learned during the initial training sessions, or that may have been forgotten since. The use of self-report survey evaluating management skills allows clinicians to evaluate and re-evaluate client's skills at regular intervals and with reduced burden on clinical time than currently available clinician-administered measures. Development of education tools in line with the CIMS-self, such as a management skills training tool or problem solving guide, may further increase patient CI device management skills, reducing clinician load and potentially enhancing patient satisfaction(3).



### **Limitations and future research**

A limitation of this study was that although the CIMS-self survey was developed for use with all CI devices, to date it has only been validated with participants with a CI device from one manufacturer. Furthermore, validation was performed on a cohort recruited from a single clinic. As such, a multicentre study is needed to include participants with a wider range of clinical experience, and CI device brands/models to further validate the CIMS-self survey.

### **CONCLUSION**

This study has demonstrated that self-report survey is a viable method for the evaluation of CI device management skills where the survey itemises tasks required for daily CI device management. The CIMS-self survey demonstrated high test-retest reliability, responsiveness to retraining, criterion validity and sensitivity when compared to clinician evaluation of CI device management skills. The CIMS-self survey could be used to evaluate and re-evaluate CI device management skills at regular intervals and with reduced burden on clinical time than currently available clinician-administered measures.

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## Declaration of interest

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**Appendix 1. Items from the CIMS-self survey**

- Q1. Are you confident with your ability to remove your hearing implant device (speech processor)?
- Q2. Are you confident with your ability to turn your device off and on? (disconnecting the battery, muting the device or switching off at the device are all acceptable methods)
- Q3. Are you confident with your ability to charge your rechargeable batteries and/or change your disposable batteries?
- Q4 a) Are you confident with your ability to clean your hearing implant device? (includes wiping down processor, coil and magnet)  
b) Are you confident with your ability to change the microphone cover? (not applicable to all devices)
- Q5 a) Are you confident with your ability to use your dry store unit?  
b) How often do you change your dry store unit tablet?
- Q6 a) Are you confident with your ability to put your hearing implant device on?  
b) Is your device comfortable and not causing pressure sores?
- Q7 a) Is your hearing implant device set up with a volume control?  
b) Are you confident with your ability to adjust the volume of your device? (using the processor or remote control to do this are both acceptable methods)  
c) Are you confident in knowing what volume level to set your device in different situations?
- Q8 a) Is your hearing implant device set up with multiple programs?  
b) Are you able to adjust the program setting of your device? (using the processor or remote control to do this are both acceptable methods)  
c) Are you confident in knowing what program to select in different situations?
- Q9 a) Is your hearing implant device set up with a telecoil (use for the telephone and loop systems)?  
b) Are you able to access your telecoil? (using the processor or remote control to do this are both acceptable methods)  
c) Do you know how to hold the phone in the optimal position when using the telecoil?
- Q10. Are you confident with your ability to use your remote control?
- Q11. Would you like us to arrange an appointment for you to see your audiologist to review any of the above items?