

# Factors Influencing Postoperative Experiences in Adult Cochlear Implant Recipients: A Multistakeholder Perspective

Ebrahimi-Madiseh, Azadeh<sup>\*,†,‡</sup>; Eikelboom, Robert H.<sup>‡,§,¶</sup>; Bennett, Rebecca J.<sup>‡,§</sup>; Upson, Gemma S.<sup>¶</sup>; Friedland, Peter<sup>\*\*††</sup>; Swanepoel, De Wet<sup>‡,¶</sup>; Atlas, Marcus D.<sup>‡,§</sup>

\*UWA Medical School, The University of Western Australia, Perth

†Telethon Speech and Hearing, Wembley

‡Ear Science Institute Australia, Subiaco

§Center for Ear Sciences, The University of Western Australia, Nedlands

¶Telethon Kids Institute, Nedlands, Australia

¶Department of Speech Language Pathology and Audiology, University of Pretoria, Pretoria, South Africa

\*\*University of Notre Dame Australia, Fremantle, Australia

††Dept Otolaryngology, Sir Charles Gairdner Hospital.

\*Address correspondence and reprint requests to Azadeh Ebrahimi-Madiseh, Telethon Speech and Hearing, 36 Dodd Street Wembley, Western Australia 6014, Australia. Tel: +61-415994314, Email: Azadeh.ebrahimimadiseh@research.uwa.edu.au.

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## ABSTRACT

**Objective:** To explore factors influencing postoperative experiences of adult cochlear implant (CI) recipients, determine the impact of each factor, and conceptualize recipients' postoperative journey.

**Study Design:** Participatory mixed methods; concept mapping.

**Setting:** Tertiary care (private and public).

**Patients:** Ninety-three participated in the brainstorming activity. Eighty-nine completed the sorting tasks (96% retention rate): CI recipients (n = 44), significant others (n = 13), CI audiologists (n = 14) and surgeons (n = 5), CI clinics' administration staff (n = 5) and managers (n = 3), and CI manufactures' clinical support staff (n = 5).

**Intervention(s):** Rehabilitative (CIs).

**Main Outcome Measure(s):** Statements were generated and rated by participants. Similarity of grouping of the statements informed the matrices used for cluster analysis to form concepts.

**Results:** Eighty-seven unique statements described the factors influencing adapting to, use, and maintenance of CIs after implantation. These were grouped, and five concepts were identified: financial considerations, complications, device usability and durability, device programming and adaptation, and patient motivation and supports. Although statements within the concepts financial considerations and complications were negatively rated, statements within the concepts device programming and adaptation, and patient motivation and supports were mostly rated as having positive influence in patients' postoperative journey. The concept device usability and durability contained both negatively and positively rated statements.

**Conclusions:** Postoperative experience of adult CI recipients is a multifaceted journey with several challenges to address to improve services. Although support from and connection with family and clinicians, and simplicity of using a CI device facilitated the experience, medical and surgical complications, durability, and cost of maintaining the device challenged the postoperative experience.

**Keywords:** Acute care; Barrier; Cochlear implant; Concept mapping; Maintenance; Service delivery; Value-based healthcare

## INTRODUCTION

Evaluating the complete care cycle for any health condition is imperative in gauging success in healthcare interventions <sup>1</sup>. Postoperative care for recipients of cochlear implants (CIs) is a multiphase process, from immediate postoperative medical care to long-term rehabilitative care delivery for the lifetime of the implant. The care process can be described in two phases, acute and long-term, both involving medical and audiological management with several stakeholders playing various roles, including the clinical team (mainly ear, nose, and throat (ENT) surgeons and audiologists), the administrators, recipients, and their family <sup>2</sup>.

The acute phase of medical care for CI recipients usually occurs within the first 30 days after implantation <sup>3</sup> and includes postoperative care of the wound, recipients' recovery from surgery, and management of any potential complications <sup>4</sup>. This is followed by activating the internal electrode and audiological rehabilitation, once the wound is sufficiently healed <sup>5</sup>.

As part of postoperative auditory rehabilitation requirements, audiologists spend time with recipients and families providing counseling regarding gradual adaptation to sounds and goal setting <sup>6,7</sup>, programming and adjustment <sup>8</sup>, handling and management of the external processor <sup>9,10</sup>, and addressing problems and concerns that may arise. Recipients are transitioned to the long-term phase of care once devices' settings (map) are stabilized; that is, a map is considered stable when changes made in the loudness settings are less than 10 current levels <sup>11</sup>, and potential complications that may arise are appropriately managed, for example, management of potential late onset balance disturbance.

The success of all phases of care delivery to CI recipients is historically measured by the health status of patients and a range of subjective psychoacoustic and perceptual measures,

mainly audiometric and speech perception outcomes<sup>12</sup>. Despite the focus on outcome measures evaluating health status they do not provide any information about recipients' broader experience with the care process, such as continuity of care, information provision, autonomy, time to receive care, and communication between the professionals<sup>13</sup>. Therefore, whether we are measuring “what matters” to recipients after cochlear implantation remains a valid query, as there are no studies that indicate the underlying factors impacting the postoperative experience from recipients and their families' perspectives. These factors and their impact should be better understood, incorporated, and measured as part of a comprehensive outcome measure of care delivery<sup>14</sup>. Improving the outcomes that “matter to patients” is the fundamental goal of value-based healthcare to improve efficiency and create value aligned with patients' needs<sup>1,15</sup>.

To better understand what matters to CI recipients postoperatively and how these factors impact postoperative care, this study explored stakeholders' perceptions on underlying factors influencing acute and long-term experiences with CIs in adapting to, using, and maintaining CIs; determined the impact of each factor (negative or positive); and conceptualized CI recipients' postoperative journey.

## **MATERIALS AND METHODS**

This study received ethics approval from the Human Research Ethics Committee of The University of Western Australia.

A participatory mixed-method approach, concept mapping, was used to integrate the experiences and expertise contributed from multiple stakeholder groups<sup>16</sup>. Concept mapping uses a qualitative approach to data collection wherein participants put forward thoughts, ideas, and experiences to describe their perceptions of a particular topic (in this case, adaptation to, use, and maintenance of CIs) and give meaning to the data through grouping and ranking tasks. These data are quantitatively analyzed, resulting in a visual representation of the ideas in the form of conceptual maps<sup>17</sup>. This study is part 2 of a three-part study and followed the same protocol as those described in Ebrahimi-Madiseh et al<sup>18</sup>.

### **Participants**

Two stakeholder groups were identified and purposefully recruited in this study: the client cohort (comprising CI potential candidates, recipients, and recipient's family members/significant others) and the professional cohort (comprising hearing implant audiologists, surgeons, administration staff, managers, and manufacturer clinical support staff).

The client cohort was recruited from two of the largest CI clinics in Australia<sup>18</sup>. All professionals from large CI units across Australia, their affiliated ENT surgeons who conducted their CI operations, and all four hearing implant companies operating in Australia were invited to participate. Professional participants were eligible to take part if they had 2 or more years of CI experience and were in direct contact with clients or in decision-making roles for services delivered. Professional participants came from six implant units and three manufactures in Australia.

## **Procedures**

Data collection occurred across three tasks: brainstorming (the generation of ideas in relation to the topic of interest), sorting (the grouping of brainstormed ideas), and rating (the ranking of ideas, using Likert scales). These tasks were completed using a combination of face-to-face and online modes<sup>19</sup>. Participants completed the three tasks within two sessions in the face-to-face mode or within 2 weeks if they selected the online mode. The details of each task are described hereinafter.

### ***Brainstorming***

The brainstorming tasks were completed in person, either individually or in focus groups of no more than 20 people, according to the participants' availability and preferences and specific to the participants' stakeholder group allowing them to freely share their experiences. In total, nine group and four individual brainstorming sessions were held, in which participants were asked to share their thoughts, feelings, or experiences in response to the question, "What influences adapting to, use and maintenance of a cochlear implant?" The question was carefully worded to be broad encompassing the acute and long-term postoperative care, neutral, simple, and involving all participants. Adapting to CIs was defined as getting used to the new device and sound environment. The statements generated by participants were projected on a screen visible to everyone. Participants were prompted with a focus prompt of "Adapting to, using and maintaining a cochlear implant is influenced by...." where there was a moment of lull. The sessions were ended when all participants had the opportunity to share their experiences, and there were no new statements generated.

The statements from all sessions were compiled and reviewed by the research team before the sorting session. The statements were edited according to the concept mapping guidelines<sup>20</sup>. Peer debriefing was used to improve the rigor of the statement reduction process<sup>18</sup>.

### ***Sorting and Rating***

Sorting and rating tasks were completed individually online<sup>21</sup> or in person (paper-based) at a time convenient to the participants. All participants were given verbal and/or written instructions on how to complete the tasks. They first grouped the statements into piles according to their meaning and named each pile. Second, they completed the rating task wherein they rated each statement for (i) its impact on adapting to, use and maintenance of CIs (1 = "Hinder" through to 5 = "Help"), and (ii) the extent to which the situation described by each statement needed to be changed or improved (1 = "No need" to 5 = "High need" for change/improvement).

## **Data Analysis**

### ***Multidimensional Scaling and Hierarchical Cluster Analysis***

Data were analyzed using the concept mapping software<sup>21</sup> and SPSS v27<sup>22</sup>. Multivariate analysis of similarity matrices (multidimensional scaling) was used to provide a geographical

map of ideas as points in two dimensions<sup>16</sup>. Each point represented a statement generated during the brainstorming. The closer the points were to one another, the more often they were grouped together by the participants.

Hierarchical cluster analysis, using the coordinate input from multidimensional scaling and Ward's algorithm<sup>23</sup>, partitions the points to form nonoverlapping clusters based on their proximity<sup>24</sup>. There is no simple mathematical solution for the final number of clusters, and it is determined by the needs of a project<sup>16</sup>. The procedure that is typically followed is to examine an initial cluster solution, usually the maximum desirable for interpretation in the context, followed by lowering the cluster solutions, with the research team making a judgment at each level about whether the merger seems reasonable by reviewing and discussing the contents<sup>24</sup>. This process is assisted with a mean proximity index of the points in the cluster configuration calculated in concept map software, the bridging value. Naming of each cluster was informed by the sorting piles titles given by the participants and the statements contained within each cluster, performed by the research team.

A bivariate scatterplot-type graph, go zone, was plotted for average rating scores for each statement for their perceived impact (hinder/help) against the need to change/improve (lowest/highest) to better understand how each statements' impact was ranked against their need for change or improvement. The mean rating scores of clusters were also compared for the two cohorts to determine any differences in their viewpoints using *t* test.

### ***Validity and Reliability***

Validity of the produced concept map refers to the degree to which the conceptualized model (map) reflects the judgments made by participants in information provided through the sorting task to produce the map<sup>25</sup>. This was measured using a stress index, indicative of how the point maps fit the similarity matrices, with a value lower than 0.35 considered acceptable<sup>20</sup>.

A split-half reliability analysis was conducted using Spearman-Brown correlation<sup>25</sup> to evaluate the reliability of the final concept map, and for professional and client cohorts' data to decide on producing separate maps for each cohort or to combine the data to generate one point map.

Internal consistency of the rating items was measured using Cronbach  $\alpha$  calculating the average correlation among items based on the cluster configuration selected and for each rating question separately<sup>25</sup>.

## **RESULTS**

In total, 93 adults participated in the brainstorming activity, 89 completed the sorting tasks (96% retention rate), and 74 completed the rating task (84% retention rate), above the minimum requirement of 30 participants for concept mapping studies<sup>19,25</sup>. No CI candidates participated in the sorting or rating tasks. Noncompleters reported time and travel constraints. Details of the demographic data are provided in Tables 1 and 2.

**TABLE 1 - Demographic characteristics of the participants in client cohort**

	N
<b>No. participants</b>	60
<b>Subcohorts</b>	
<b>CI recipients</b>	44
<b>Unilateral</b>	28
<b>Bilateral</b>	16
<b>Family members</b>	13
<b>CI candidates</b>	3
<b>Age, mean (SD; range), yr</b>	66.61 (13.39; 26–84)
<b>CI use duration, mean (SD; range), yr</b>	
<b>Unilateral</b>	6.64 (5.46; 0.8–24.4)
<b>Bilateral (second side)</b>	5.40 (4.61; 0.2–13.4)
<b>Onset</b>	
<b>Prelingual, n</b>	12
<b>Postlingual, n</b>	35
<b>Sex, n</b>	
<b>Female</b>	35
<b>Male</b>	25
<b>Remoteness, n</b>	
<b>R1 = metropolitan area</b>	38
<b>R2 = inner regional</b>	15
<b>R3 = outer regional</b>	6
<b>R4 = remote</b>	1
<b>R5 = very remote</b>	0

Remoteness was classified using the Australian Standard Geographical Classification <sup>(26)</sup>. CI indicates cochlear implant; SD, standard deviation.

**TABLE 2 - Demographic characteristics of the participants in professional cohort**

	N
<b>No. participants (total)</b>	33
<b>Subcohorts</b>	
<b>Implant audiologists</b>	14
<b>Surgeons</b>	6
<b>Administration staff</b>	5
<b>Managers</b>	3
<b>Manufacturers' clinical support staff</b>	5
<b>Age, mean (SD; range), yr</b>	45.24 (9.61; 26–65)
<b>Professional experience, mean (SD; range), yr</b>	11.1 (5.56; 2–25)
<b>Sex, n</b>	
<b>Female</b>	26
<b>Male</b>	7
<b>Remoteness, n</b>	
<b>R1 = metropolitan area</b>	31
<b>R2 = inner regional</b>	2
<b>R3 = outer regional</b>	0
<b>R4 = remote</b>	0
<b>R5 = very remote</b>	0

Remoteness was classified using the Australian Standard Geographical Classification <sup>(26)</sup>. SD indicates standard deviation.

In total, 541 statements were generated across the sessions. Duplicate (n = 274) and statements irrelevant to the question (n = 69; e.g. "Teenagers are very cruel" or

“Newspapers are better than the news on TV”) were deleted. Statements containing multiple aspects were split. Statements conveying the same matters were merged into single statements. For example, “I developed dizziness after surgery,” “I had balance issues after CI,” “I had tinnitus after surgery,” and “Facial nerve issues” were merged into a single statement “Post surgery complications including balance problem, tinnitus and facial nerve damage #1.” This editing resulted in 87 unique statements describing underlying factors influencing adaptation to, use, and maintenance of CIs (Supplementary File 1, <https://links.lww.com/MAO/B446>).

A five-cluster structure was selected as best representing the data (Fig. 1). Spearman-Brown correlation test showed a high reliability of the final concept map ( $r = 0.96$ ). Comparison between the professional and client cohorts' similarity matrices showed a high internal consistency ( $r = 0.94$ ) indicative of a high agreement between the sorted statements of the two cohorts. Therefore, data from the two cohorts were combined to generate one point map. Stress index ( $SI = 0.26$ ) showed a high validity of visual representation of participants' ideas on the two-dimensional point map.

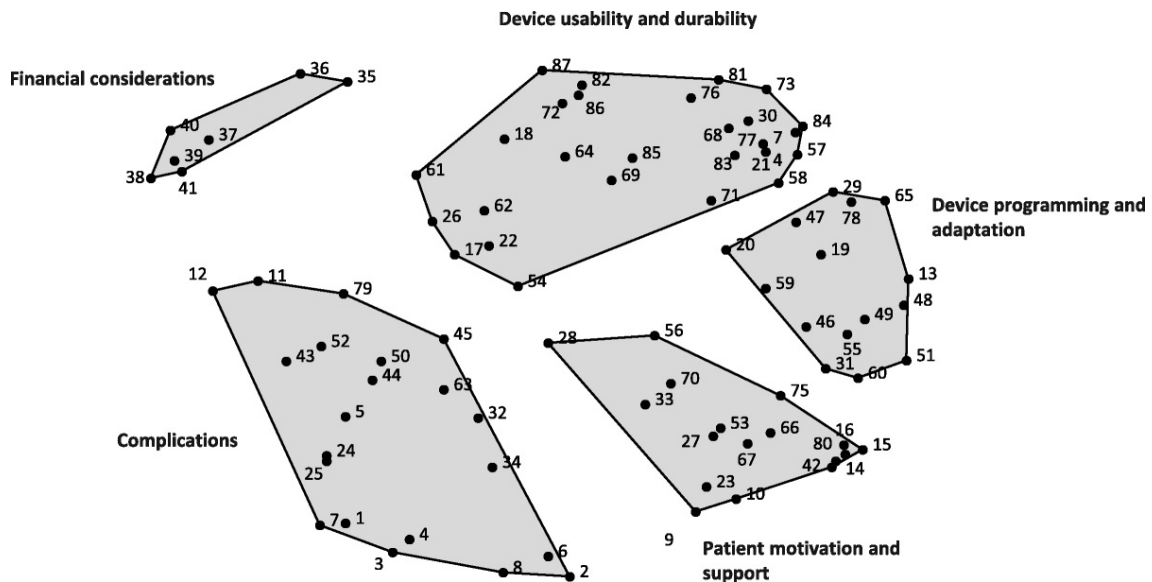


FIG. 1: Concept map showing the 87 statements or underlying factors influencing adaption to, use, and maintenance of a CI clustered into five concepts. Each point and the adjacent number indicate a brainstormed statement (by statement number; see Supplementary File 1, <https://links.lww.com/MAO/B446>).

All five clusters were distinctly depicted on the concept map, with the cluster financial considerations situated a further distance from the others. This indicates that the concepts of statements in this cluster are very tightly related and were less frequently grouped with the statements in other clusters. The description of each cluster is summarized in Table 3.

Rating scores were calculated for each statement and clusters using the rating data to determine whether participants viewed each statement as having a negative (Hinder) or positive (Help) impact on CI adaptation, use, and maintenance. The statement “Poor after-surgery care #3” was rated as having the lowest mean (mean [standard deviation {SD}], 1.51 [0.81]), whereas the statement “Support of friends and family after surgery and through

**TABLE 3** - Clusters of underlying factors to adaptation to, use, and maintenance of CIs; description; corresponding statements' numbers in each cluster; average rating scores for each cluster; and internal consistency of rating scores within each cluster for impact and need for change/improvement rating scores (measured by Cronbach  $\alpha$ )

Cluster (No. Statements in the Cluster)	Description	Average Rating Scores of Clusters; Impact, Need for Change, Mean (SD)	Internal Consistency of Cluster Ratings (Impact, Need for Change)
<b>Financial considerations (n = 7)</b>	Costs associated with maintenance of a CI device (repairs, insurance, consumables); distance and travel	2.44 (0.61),	$\alpha = 0.81, \alpha = 0.98$
		3.47 (0.81)	
<b>Complications (n = 21)</b>	Surgery (complications, recovery, surgical staff attitude and management); comorbidities and mental health; complications related to the external device (wearing, programming, stigma); unawareness of public regarding the limitation of CIs; organization of postoperative appointments (frequency, location, administration)	2.55 (0.49),	$\alpha = 0.83, \alpha = 0.97$
		3.41 (0.70)	
<b>Device usability and durability (n = 27)</b>	Durability of the external device; maintenance (large number of items to maintain and charge, impact of age and dependence on others, other commitments); comfort and cosmetics; upgrades and repairs	3.34 (0.45),	$\alpha = 0.86, \alpha = 0.99$
		3.10 (0.76)	
<b>Device programming and adaptation (n = 15)</b>	Progress with CIs (improvements on the phone, localization, adaptation); sound quality; mapping (changes made to the map, frequency, quality); access to resources	4.10 (0.50),	$\alpha = 0.54, \alpha = 0.98$
		3.09 (0.79)	
<b>Patient motivation and supports (n = 17)</b>	Knowledge and attitude of implant audiologists; support network (friends, family, social media); recipients' attitude (motivation, commitment, resilient, expectation); access to help and appointments	4.24 (0.59),	$\alpha = 0.66, \alpha = 0.99$
		2.94 (0.90)	

Statements are reported in full in Supplementary File 1, <https://links.lww.com/MAO/B446>.

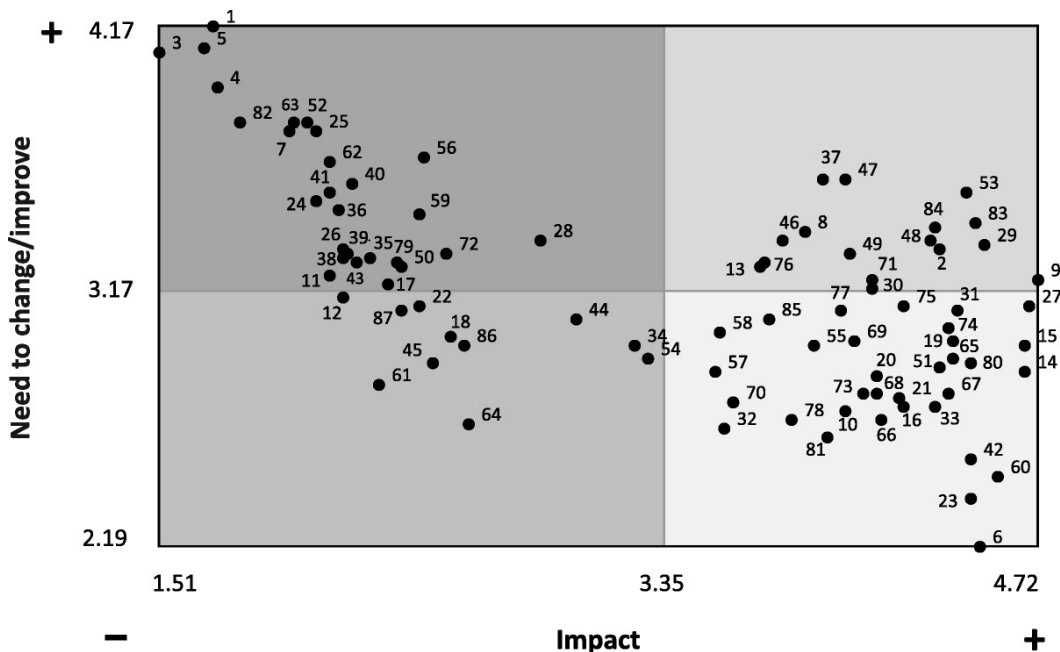
CI indicates cochlear implant; SD, standard deviation.



therapy #9” had the largest mean (mean [SD], 4.73 [0.62]). There was a low variability between the ratings of each statement between participants. The average rating scores were also computed for each cluster by averaging the rating scores of the corresponding statements. The mean (SD) rating scores of the clusters ranged from 2.44 (0.61) for cluster financial considerations to 4.24 (0.59) for cluster patient motivation and supports (Table 3). These scores were significantly different from one another ( $F_{4,350} = 148.74, p = 0.001$ ).

Cronbach  $\alpha$  showed moderate to high internal consistency for ratings<sup>27</sup> of impact, ranging from  $\alpha = 0.54$  to 0.89. The ratings of need to change/improve within the clusters showed high internal consistency for all clusters ranging from  $\alpha = 0.97$  to 0.99 (Table 3).

The go zone graph (Fig. 2) shows the mean impact score against the mean score for change/improvement for each statement. It illustrates statements with a relatively negative impact with higher priority for change (top left,  $n = 27$ ), a relatively negative impact with lower priority for change (bottom left,  $n = 11$ ), a relatively positive impact and higher priority for change (top right,  $n = 16$ ), and a relatively positive impact with lower priority for change (bottom right,  $n = 33$ ). The top-left quadrant contains the second largest number of the statements (27 of 87), a majority of which were grouped in the two clusters of complications (13 of 27) and financial considerations (6 of 27) followed by the device usability and durability (5 of 27). The 11 statements in the bottom-left quadrant are from the clusters device usability and durability (7 of 11) and complications (4 of 11). A majority of the 16 statements in the top-right quadrant were originated from the clusters device programming and adaptation (6 of 16) and device usability and durability (5 of 16). The bottom-right quadrant contained the largest number of statements (33 of 87), a majority of which were from the clusters patient motivation and supports (13 of 33), device usability and durability (10 of 33), and device programming and adaptation (8 of 33).



**FIG. 2:** Go zone graph: a scatterplot graph of statements ratings of impact against need to change/improve. The plot is nominally divided into four quadrants separated by lines indicating the mean value of the average rating scores. Each dot with the adjacent number represents a statement.

Comparison of the mean rating scores of the impact and need for change/improvement of each cluster for the client and professional cohorts showed statistically significant differences between the two cohorts for three cluster (Table 4).

**TABLE 4** - Comparison of mean rating scores of impact and need for change/improvement of each cluster for the client and professional cohorts

Cluster Name	Impact			Need for Change/Improvement		
	Client, Mean (SD)	Professional, Mean (SD)	<i>p</i>	Client, Mean (SD)	Professional, Mean (SD)	<i>p</i>
<b>Financial considerations</b>	2.52 (0.69)	2.34 (0.43)	0.23	3.37 (0.90)	3.64 (0.57)	0.16
<b>Complications</b>	2.61 (0.56)	2.45 (0.31)	0.18	3.33 (0.77)	3.55 (0.52)	0.18
<b>Device usability and durability</b>	3.47 (0.53)	3.16 (0.18)	0.006*	2.94 (0.82)	3.37 (0.52)	0.02*
<b>Device programming and adaptation</b>	4.22 (0.68)	3.87 (0.28)	0.01*	2.91 (0.85)	3.34 (0.56)	0.01*
<b>Patient motivation and supports</b>	4.36 (0.78)	3.98 (0.29)	0.01*	2.65 (0.92)	3.44 (0.61)	<0.001*

\*Indicates significant difference ( $p < 0.05$ ) between the cluster ratings of the two cohorts.

## DISCUSSION

This study aimed to gain understanding of factors influencing the acute and long-term postoperative experiences of CI recipients. Identified factors incorporated aspects related to the device, associated costs, logistics and governance of ongoing care, and recipients. Knowledge gained can inform improvements in service delivery and future development of outcome measures evaluating CI services that align with the needs of recipients, their families, and clinicians involved. The concepts demonstrate the complexity and interrelation of various phases of CI service delivery, viewing service delivery on a continuum rather than a series of independent steps. Similarly, evaluating the outcome of the intervention should reflect the multifaceted experience.

The concept complications incorporated several problems experienced by the participants because of surgery, surgical after care, and wearing the CI devices that negatively impact various steps in the postoperative journey. Some of these problems were collectively rated as having a relative negative impact on recipients' experience. Although the length of stay in hospitals as a result of an intervention is an indicator for measuring outcomes of healthcare<sup>28</sup>, the experience during the stay and their impact on patients and their families are not measured as a health outcome. According to value-based healthcare, functional outcomes are multidimensional<sup>26</sup> and should not only measure changes in before-after care capabilities but also lessen the pain, discomfort, disutility of care, and success in reducing stress of treatment<sup>1</sup>. Statements generated in this study (e.g., statements 63, 5, or 26) are supportive of a multifaceted experience for CI recipients beyond improving speech understanding. These statements were ranked as relatively negative factors that should be changed/improved with high priority (go zone, top-left quarter; Fig. 2).

The statements grouped in the concept financial considerations have demonstrated the burden of ongoing costs of maintaining CI external devices experienced by recipients and may require consideration by providers including implant companies. Six of the seven statements in this concept were ranked as having high priority for change or improvement. In Australia, there is partial support for the ongoing maintenance and consumables of the external devices through the federal government for eligible adults<sup>29</sup> and through private insurance if recipients elect and are able to afford the cost.

The statements grouped in the concept device usability and durability that are more centrally located on the concept map (toward the concepts complications and financial considerations) are all representative of the negative impact of CI devices' durability and usability on recipients' experiences that have financial implications. These statements were ranked to be improved with high priority (e.g., statements 82 or 17), consistent with previous findings on recipients' poor skills in cleaning and ongoing care of the devices<sup>30</sup>. Simplicity of use (e.g., turning on and off) and provision of accessories and rechargeable batteries were, however, ranked positively, consistent with literature reporting ease of daily use of CI devices<sup>10,31</sup>. Recipients rated statements in this concept higher than the professional cohort for impact on their experiences, aligned with previous literature on use and maintenance of hearing devices<sup>10</sup>.

Statements grouped in the two concepts of patient motivation and supports, and device programming and acclimatization were almost all positively ranked, reflecting the literature describing the vital role of audiological support in a recipient's journey<sup>2,8</sup>. Although relationship and support from family and clinical team were previously identified as positive factors influencing adoption of hearing devices<sup>18,32</sup> and promoting person-centered care<sup>33</sup>, this study also demonstrates their significance in the postoperative experience of CI recipients. Some statements in these two concepts were among those with a highly negative impact (e.g., statements 56 or 46) or were ranked to require a high need for change/improvement (e.g., statements 13 or 47). This may be indicative of shortcomings of the current CI technology to meet the goals and expectations of recipients and their families<sup>34,35</sup> and the need for more targeted postoperative rehabilitation<sup>36,37</sup>.

Lastly, participants in this study expressed their concern about the disruption to their daily lives attending appointments and committing to the expectations of rehabilitation (e.g., statements 11 or 44). A CI recipient, on average, attends eight appointments in the first year after implantation<sup>5</sup>. Patient-led appointment system and provision of remote care to reduce the number of postimplantation appointments and burden of travel were previously recommended<sup>38-40</sup>. However, there is a gap in knowledge regarding the different factors and aspects of attending appointments influencing recipients' experiences and their impact. Incorporating all aspects of recipients' interactions with the system assists with better understanding of their human needs and designing more human-centered, efficient, and effective interventions and services<sup>15,41</sup>.

## **LIMITATIONS AND FUTURE RESEARCH**

This study explored an Australian setting. Concepts and statements may have different weightings in other countries with different infrastructure and financial systems.

Nevertheless, commonalities in human behavior have application in all settings. Further research is required to determine factors influencing the ongoing interaction of recipients with the system attending several appointments after implantation and the impact of these factors on their journey.

## **CONCLUSIONS**

Postoperative experience of adult CI recipients is a multifaceted journey with several challenges that can be addressed to improve services. Although support from and connection with family and clinicians, and simplicity of using a CI device facilitated the experience, medical and surgical complications, durability, and cost of maintaining the device challenged the experience. None of these factors are currently measured as an outcome or success for CIs.

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