AJA

Research Article

Disposable Hearing Aid Battery Management: Survey Assessment of Providers and Qualitative Interviews of Patients

Torri Ann Woodruff,[a] Jackie DiFrancesco,[a] Michael Kurth,[a] Alison Marinelli,[a,b] and Kathleen M. Cienkowski[a]

Purpose: The purpose of this study was to better understand the behaviors that hearing aid users engage in to manage batteries.
Method: Two arms of research, a survey of audiologists (n = 110) and qualitative interviews with adult hearing aid users (n = 13), were conducted. Surveys were distributed and collected both via paper and online methods. Descriptive analyses of survey results were conducted to report on common threads. Qualitative interviews were conducted with video recording for transcription purposes. These transcripts were then coded thematically to identify shared themes across participants.
Results: Results of this study highlight the variability in behavior between provider-recommended strategies (preemptive battery management) and the reactive/delay strategies that are implemented by users. Patient reports indicate several challenges related to changing their batteries including limited information on hearing aid batteries, physical/sensory challenges to the act, and the social impact of having to change hearing aid batteries. Concurrently, patients express a wide range of strategies to address other challenges including engaging in cost-conscious behaviors when managing batteries (both purchasing and deciding to replace) and maintaining a collection of easily accessible batteries for use.
Conclusions: Hearing aid batteries are a topic that reflect social and economic factors in a patient's life. While providers may report they cover these topics sufficiently, challenges related to batteries may need specific elucidation by the clinician to ensure adherence to recommendations and functioning devices.

By design, hearing aids require a power source to function. The most common solution to this need is disposable batteries in the form of zinc oxide power cells that capitalize on oxygen in the environment to produce the chemical reaction required to power the device (Dillon, 2012). While it is reported that 70% of hearing aid users would prefer rechargeable devices, 89% of users currently have disposable batteries (Copithorne, 2020). As disposable batteries persist and continue to power the overwhelming majority of devices in the marketplace, their implementation and use warrant investigation.

When looking at patient skills with batteries, a majority (88%) of users are satisfied with the process of having to change the battery (Kochkin, 2010). This attitude toward having to change hearing aid batteries when they die has been seen, of note, in hearing aid owners who use and do not use their devices. Kochkin (2000) surveyed individuals who own hearing aids but do not use them and found that 2% of these individuals reported not using their hearing aids because they are dissatisfied with the hearing aid battery life. This dissatisfaction with hearing aid battery life has persisted into Picou's (2020) work on MarkeTrak 10 where it is reported that the surveyed hearing aid owners were "most dissatisfied with the hearing aid's ability to minimize background noise and battery life."

Thirty-six percent of hearing aid users report being between "somewhat dissatisfied" (10%), "dissatisfied" (5%), "very dissatisfied" (3%), or "totally dissatisfied" (18%) with their hearing aid battery life and express concern for the continued investment in batteries over the life of the hearing aid

[a]Department of Speech, Language and Hearing Sciences, University of Connecticut, Storrs, Connecticut
[b]New England Center for Hearing Rehabilitation, Hampton, CT
Correspondence to Torri Ann Woodruff: torri.woodruff@uconn.edu

Editor-in-Chief: Ryan W. McCreery
Editor: Erin M. Picou
Received September 1, 2020
Revision received November 21, 2020
Accepted May 19, 2021
https://doi.org/10.1044/2021_AJA-20-00150

Disclosure: The authors have declared that no competing financial or nonfinancial interests existed at the time of publication.

(Kochkin et al., 2010). When looking at hearing aid features, battery life had the highest negative rating (18%) in terms of satisfaction (Kochkin, 2010). Today, advances in hearing aid technology allow for wireless capability and streaming, along with assistive technologies that augment hearing aids. Yet, the use of such advanced technology further exacerbates battery drain concerns (Woodruff et al., 2018). The use of streaming to devices, and the excessive battery drain associated with it, is another hearing aid battery concern that patients are managing.

It is critical to understand how patients who currently use hearing aids with disposable batteries interact with their batteries. Understanding why patients behave the way they do in terms of battery management opens up topics for discussion and counseling by providers. This information is necessary to understand the nuances of the patient experience and support patient-centered care. While there is work such as Kochkin (2010, 2000) to discuss hearing aid use and satisfaction related to batteries, this study works to address the need for more understanding around how patients interact with their hearing aid batteries. Understanding how patients care for and manage their hearing aid batteries may inform future research questions examining personal factors that impact hearing aid battery dissatisfaction and perceptions. This type of information may support clinicians as they counsel hearing aid users on battery management and adjustment to hearing aid use. This study approaches the need to understand current hearing aid users' behaviors with two arms of research. The first arm concerns itself with providers and their practice with hearing aid batteries. For this assessment, a survey was sent out to audiologists in the United States to collect information on current practices with hearing aid batteries, including the use of disposable and rechargeable batteries by patients, coverage of battery-related topics during the device counseling, and attitudes toward hearing aid batteries. The goal of the survey was to collect information on battery education practices from clinicians. This provided insight into the type of hearing aid battery counseling that may be provided in the clinical setting.

The second arm of this research took a qualitative approach looking at the patients and engaging them in interviews around their thoughts, feelings, and experiences with their hearing aid batteries. Questions in these interviews looked at individual routines for hearing aid use and battery management (purchasing, storing, and changing). Interviews with patients allowed for discussion about the battery-based behaviors they engage in while using their devices. In the field of audiology, most qualitative research aims to investigate hearing disability, help-seeking, and rehabilitation (Knudsen et al., 2012). Knudsen et al. (2010) point out that there is a need for qualitative research with a focus on identifying factors that contribute to hearing aid uptake, use, and satisfaction. Battery management, that is, how a hearing aid user responds to a dying battery, should be considered a component of hearing aid battery education and device utilization facilitation.

Combining these two research arms supports understanding hearing aid users' experience when it comes to powering their devices. These experiences include those driven by clinicians in fitting and follow-up appointments as well as in daily use of hearing aids. In the literature, MarkeTrak research dominates in terms of where information about battery management is found. Approaching this topic from an aural rehabilitation position is an underrepresented component of effective hearing health management plans to support the uptake and use of hearing aids.

Method

Both arms of this study were approved by the institutional review board at the University of Connecticut. All participants provided consent before their participation.

Audiologist Survey

Study Sample and Recruitment Procedure

The study sample included audiologists from around the United States. However, many respondents were located in the New England region of the United States. A version of the survey was made accessible online, and recruitment was conducted through postings to relevant professional organization message boards. Additionally, paper surveys were mailed to a subset of audiologists across the United States. At least two providers from each state were sent paper surveys. Audiologists indexed as local to the University of Connecticut practicing in Connecticut, Rhode Island, and Massachusetts were specifically targeted and sent paper copies of this survey in an effort to leverage university name recognition to encourage participation. Participation was anonymous, and respondents were provided an information sheet on the study before starting the survey.

Provider Participants

A total of 110 responses were collected. Of the 147 paper surveys sent, 81 (55.1%) were returned filled out. Paper responses totaled 73.6% (n = 81) of the sample with the other 26.4% (n = 29) of the sample responding online. Three respondents sent in blank surveys providing no data (10.3%), resulting in 107 surveys to include in analysis. Provider gender and degrees held can be seen in Table 1.

An explicit answer determined the location of each provider. If this question was unanswered on a paper form,

Table 1. Audiologist information.

Gender	
Male	14
Female	93
Did not report	3
Degree held	
AuD	62
PhD	6
AuD and PhD	19
M.S.	20

Note. AuD = doctor of audiology; PhD = doctor of philosophy; M.S. = master of science.

the postmark location was used to determine this. Location information was collected from 107 providers in 29 states. Three (2.7%) online submissions did not include location data. The largest cohort of providers were from the New England Region (*n* = 57, 51.8%) inclusive of Connecticut (*n* = 39, 35.5%), Maine (*n* = 1, .9%), Massachusetts (*n* = 9, 8.2%), and Rhode Island (*n* = 8, 7.3%).

Survey Instrument

The survey was developed with Qualtrics—a secure, online survey application. The survey covered the following general domains: audiologist/clinic demographics (four questions), clinical organization/business model (eight questions), and battery education practices. Ten questions in the survey were about the provision of battery education to patients. Of these 10, five were multiple responses with the option for qualitative comments, two were open-ended, and three were on a Likert scale. Likert scale questions used a 7-point scale from *Not important at all* (scored 1) to *Very important* (scored 7). The survey instrument can be seen in Appendix A.

Data Analysis

Analyses were conducted using SPSS 22 to generate the frequency of responses across all questions and providers. Descriptive statistics were computed for all Likert scale questions.

Patient Interviews

Design

In this arm, qualitative research design, more specifically qualitative content analysis, allowed for an "open-ended approach" using a semistructured interview format to focus on the experiences and opinions of patients with hearing loss (Graneheim & Lundman, 2004; Knudsen et al., 2012; Laplante-Levesque et al., 2012). The questions in the semistructured interviews can be seen in Appendix B. Qualitative research in general serves to amplify the voices and lived experiences of research participants (Creswell & Poth, 2018). By providing patients the opportunity to engage in this type of research, clinicians and researchers can gain systematic information on patients' lived experience. Participants were interviewed one-on-one by the first author. Interviews progressed through a semistructured outline highlighting significant questions, but the interviewer had flexibility as a fully engaged investigator to develop a rapport with the participant and ask follow-up questions and pursue clarifications (Creswell & Poth, 2018). Participants were encouraged to answer every question to the best of their ability if they were comfortable doing so with the interviewer. Participants were compensated for their time.

Data Collection and Participants

Maximum variation sampling was attempted based on four defined levels of battery routine (Sandelowski, 1995). The goal for recruitment was to have at least six participants in each of the four defined levels. Levels were defined as (a) batteries are changed according to a set schedule, (b) batteries are changed after hearing a signal/cue, (c) batteries are changed immediately after the hearing aid(s) stop working, and (d) batteries are not changed immediately after the hearing aid(s) stop working. However, maximum variation sampling was discontinued and replaced with convenience sampling when it was noted that no participants reported engaging exclusively at Level 1 or 2 after 13 interviews were conducted. All participants engaged in some form of Routine 3 or 4, or, when in need of a new battery, changed replacement strategy situationally. This transition to convenience sampling marked a movement away from selecting participants based on their reported behaviors and encouraged enrollment by any individual who reported wearing at least one hearing aid and wanted to participate. All participants were recruited from the University of Connecticut and the surrounding communities by e-mails to university faculty, staff, and student electronic mailing lists, as well as by word of mouth in various hearing loss support groups. By recruiting participants directly, rather than by provider referral based on battery management behaviors, concerns discussed by Knudsen et al. (2012) about selection bias on the part of recruiters, not participants, have mitigated. Participants were able to self-select and volunteer for this study.

In total, 14 individuals enrolled in this study. Interviews were conducted at the University of Connecticut or in the home of the participant using the questions seen in Appendix B. One participant dropped out of the study without taking part in any phase of data collection. Data collection was terminated after 13 interviews when code saturation was reached. Code saturation is a complex idea that is a pillar in qualitative work, yet is elusive in definition. It emphasizes the concept of sample adequacy over size and is the point within the data set where new codes are not being derived from additional participants, or additional participants do not add to the themes derived (Creswell & Poth, 2018; Hennink et al., 2017). The inclusion of 13 participants is roughly consistent with other qualitative investigations on aural rehabilitation topics, including older adults (*n* = 9, Bennion & Forshaw, 2011; *n* = 18, van Leeuwen et al., 2018; *n* = 20, Malmberg et al., 2018) and professionals such as audiologists (*n* = 8, van Leeuwen et al., 2018; *n* = 9, Meyer et al., 2015) and surgeons (*n* = 14, van Leeuwen et al., 2018), as well as Hennink et al. (2017) who looked at saturation as a concept using data on HIV. This study's methods and findings are consistent with previous works suggesting that saturation of individual codes can occur at nine in-depth interviews, and saturation of meaning for those codes can occur between 16 and 24 interviews (Hennick et al., 2017).

Of the 13 interviews conducted, 12 (92.3%) participants utilized spoken English with the interviewer and one (7.7%) participant used both spoken and signed language in the interview. Relevant demographic information for participants and scores on the Hearing Handicap Inventory for Elderly–Screening (HHIE-S) are displayed in Table 2. The HHIE-S is a screening tool to quantify the experience of handicap in adults as a result of their hearing (Weinstein & Ventry, 1983).

Table 2. Patient information.

Participant	Demographic data						Normed measures	
	Age	Gender	Education level	Hearing levels (left/right)	Years of use	Daily use (hours)	HHIE-S	PHAST-R
1	24	Female	Bachelors	Mild/moderate	13	9–11	20	75
2	59	Female	Bachelors	Unknown	40	13–15	30	87.5
3	53	Female	Masters	Mild	.75	14	22	68.8
4	58	Male	Masters	Moderately–severe	54	10	24	78.5
5	20	Female	Associates	Moderate–moderately–severe/profound	12	16–19.5	26	100
6	59	Male	Associate	Profound	56	15.26	8	81.2
7	76	Female	Bachelors	Moderately–severe–severe	60	13–15	28	87.5
8	51	Female	Masters	Moderate/moderately–severe	1	2.16	22	57.1
9	70	Male	Doctorate	Moderate	2	Not reported	14	
10	70	Female	Masters	Moderately–severe	15	Not reported	34	
11	81	Male	Doctorate	Moderately–severe	8	Not reported	24	
12	77	Female	Bachelors	Severe	22	13–15	38	71.4
13	85	Male	Doctorate	Moderately–severe	1.5	Not reported	28	

Note. Hearing Handicap Inventory for the Elderly–Screening (HHIES) version scores are interpreted as 0–8 indicating no need for a referral to rehabilitation services, 10–24 indicating a moderate handicap related to auditory access, and 26–40 being consistent with a referral to rehabilitation services. Practical Hearing Aid Skills Test–Revised (PHAST-R) scores are an observer-assigned score based on a number of skills resulting in a cumulative score ranging from 0% to 100%. Scores are defined as excellent (90%–100%), good (80%–89%), fair (65%–79%), and poor (below 64%; Desjardins & Doherty, 2009).

All but one (92.3%) participant indicated a degree of handicap related to their hearing (n = 13, M = 24.46, SD = 7.88). In this study, the HHIE-S serves to confirm baseline interactions with hearing, hearing aids, and batteries at a logistical usage level and provide more context to each individual participant. Thirteen interviews under 1 hr each were conducted, recorded, transcribed, and utilized in the analysis. Twelve participants were bilateral hearing aid users, and one was a bimodal cochlear implant and hearing aid user. In interviews, participants were only asked about their hearing aid(s) battery usage, not other hearing devices.

All 13 participants were given the opportunity to keep a battery diary to log their hearing aid use and battery changes. Of these, nine of the 13 participants (69.2%) chose to complete and return a battery diary after their interview. In these diaries, participants recorded the day, hours their hearing aids were worn, if they changed their battery, and why they changed their battery for 2–3 weeks. Logs typically included one battery change, except for Participant 1 who had none. These diaries served as a means of cross-checking the consistency of reported battery maintenance behaviors and hearing aid usage in semistructured interviews outside of the research context.

When returning their battery diaries, hearing aid data logs were assessed to confirm the diaries' accuracy for six (46.2%) participants and provide additional insight into the topic of interest, battery change behaviors such as the presence of low battery alerts. Of the participants who completed the battery diaries (n = 9), the hearing aids of three participants (33.3%) could not be connected to programming software to access data logging, and thus this could not be assessed.

Data logging and battery diaries were intended to be implemented as complimentary records. The battery diaries provided participants a space outside of the research setting to reflect on their behaviors and motivators behind battery changes. Accessing the data logging for the six devices provided information about wear time and device setting (such as low battery alerts), yet could not speak to the subjective experience of battery management.

Practical Hearing Aid Skills Test–Revised (PHAST-R) was administered to all who returned with hearing aid battery diaries as this was conducted during follow-up appointments to mitigate participant fatigue following interviews (n = 9; Doherty & Desjardins, 2012). The PHAST-R is an observer rating scale where a participant is asked to perform several hearing aid maintenance tasks, including changing a battery, so their skill at the given task can be assessed. Differing in points that can be assigned on the scale, research highlights there is no significant difference in percentage scores on the PHAST-R (Doherty & Desjardins, 2012). The PHAST-R served to confirm the participants' ability to engage with their batteries and is not treated as an experimental outcome in this study. All but one (88.9%) participant achieved at least "fair" performance with a score of over 65% (n = 9, M = 78.55, SD = 12.49; Desjardins & Doherty, 2009). Please see Table 2 for participant PHAST-R scores. All participants were ultimately able to change their hearing aid battery, with one participant requiring reinstruction on the task.

Analysis

With the semistructured nature of the interviews themselves, the interviewer was able to establish rapport with each participant (Creswell & Poth, 2018). Each interview followed its own format. The order of questions varied based on the conversation. The analysis followed the following steps.

1. All interviews were transcribed in totality.

2. These transcriptions were uploaded into nVivo 9 as text files.
3. The transcribed interviews were read over in their entirety to get a sense of the content.
4. Initial codes to describe the content and ideas expressed by participants were developed. The codes in this study were not generated in isolation. There was consideration and possible influence from previous research or models of hearing aid maintenance. Some initial codes directly correlated with the aims of the study and interview questions, while others, such as social environments being a challenge, rose inductively from the data set.
5. These initial codes were congregated and collapsed across interviews. Decisions around what codes to collapse were discussed until an agreement was reached between the authors.
6. All material from the interviews that fell under a given collapsed code was reviewed in depth by the first author to confirm if it fit within that category.
7. These collapsed and reviewed codes were revised, and two themes in the data were identified. The themes identified included challenges and strategies for battery management. Subthemes exist across these themes to represent the variety of experiences and perceptions of what battery management is to each participant.
8. A random subsection of each interview was recoded by the second author following initial transcription to confirm the robustness of coding decisions.
9. Differences in coding were discussed until consensus was reached.

Results

Audiologist Survey

Of the 110 responses received, 100 providers who reported dispensing hearing aids as a part of their practice (90.9%) provided information about their practice. Those who reported that they did not dispense hearing aids (n = 7, 6.4%) and those who did not respond to this question or mailed back blank surveys (n = 3, 2.7%) were not included in further analysis. For reporting purposes, the responses from the 100 providers engaged in hearing aid dispensing are reported according to their clinic's organization and battery education practices.

Clinical Organization/Business Model

Practice policies and organization. The number of hearing aid fittings and follow-up visits performed by each provider is seen in Figure 1. Across all providers who responded to the question about hearing aid fittings (n = 97), the mean number of visits was 3.96 (SD = 2.43). The average number of follow-up appointments every month by these providers (n = 92) was 11.85 (SD = 9.45). Within each of these appointment types, providers (n = 99) reported how much time they spent counseling patients on battery management (see Figure 2). Providers also responded to questions about policies for bundling hearing aid batteries with the cost of hearing aids (n = 100) where 68% of respondents did not, 31% did, and one provider reported that this was dictated by how the patient paid. The usage of rechargeable batteries in their clinics (n = 85; see Figure 3) was also reported.

Patient demographics. Providers were also asked about the relative age breakdown of their patient base. Responses indicate a participant population that reportedly fits hearing aids to ages 0–75 years. Of note within hearing aid battery management, for providers working with young pediatric patients, the caregivers of children who wear hearing aids are typically those who are being counseled on hearing aid battery care with an emphasis on checking battery life and replacing batteries regularly (Boston Children's Hospital, n.d.; Watermeyer et al., 2017).

Battery Education Practices

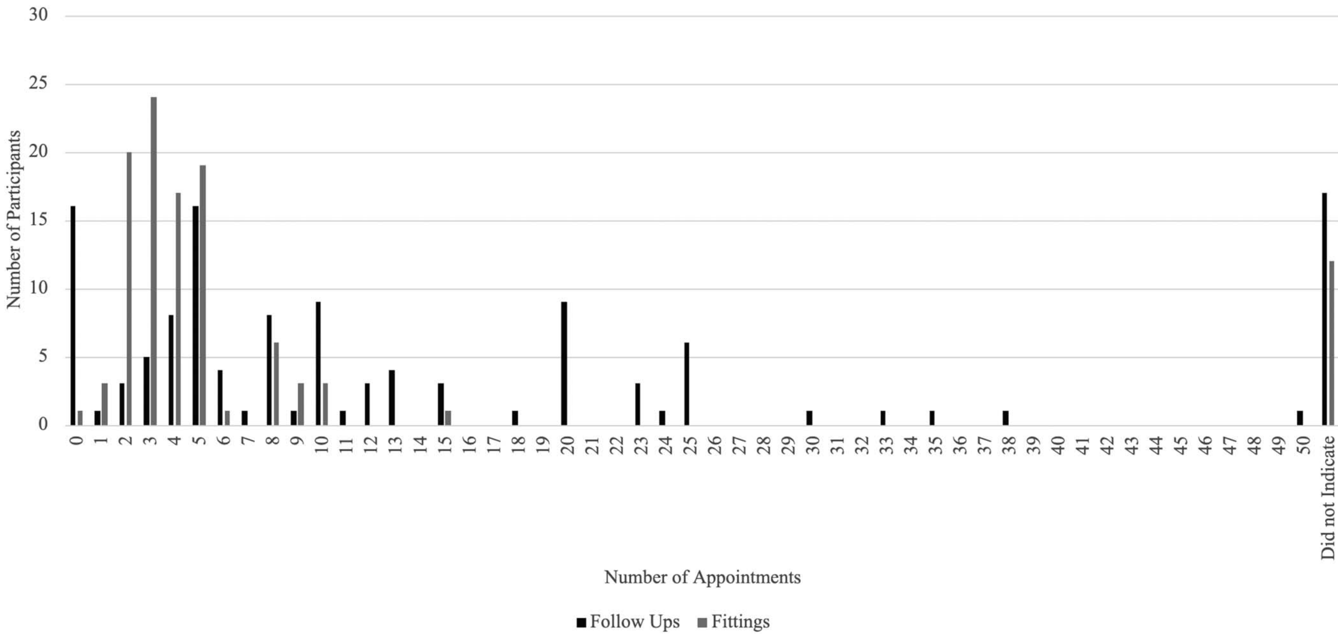
Brand education. All providers included in the analysis (n = 100) reported selling at least one brand of major batteries in their clinics. However, only 54 (54%) reported that they recommend a specific brand of disposable batteries to their patients.

Modes of instruction. Ninety-eight providers indicated the battery education/counseling they engage in with patients. Individually, demonstrating (n = 97, 99%) and having the patient practice battery skills (n = 97, 99%) were the most implemented strategies. The next most common mode of instruction was verbal directions (n = 95, 97.9%), followed by using instructional manuals/booklets (n = 64, 65.3%). The use of all four of these strategies was endorsed by over half (n = 55, 56.1%) of providers. Another strategy implemented included having all battery information in the hearing aid purchase agreement (n = 1, 1%).

Battery alerts. When a hearing aid is being programmed, the provider has the opportunity to select how the user will be alerted to low battery power. In this sample (n = 88), the most common method of having the device alert the user to a low battery level was to use an audible signal (n = 87), followed by lights (n = 24), text message or e-mail (n = 5), or another method (n = 4).

Management strategies. Eighty-nine providers reported what strategies they recommend to patients when determining when they should change their hearing aid batteries. Six respondents to this question provided answers not related to the question, such as "throw it out," "take it out," or "verbal," and were not included in further analysis. This resulted in 83 responses for this question. The majority of providers (n = 68, 81.9%) reported using tones or lights to notify hearing aid users of when to change their battery. Responsive strategies such as changing batteries when the device stops amplifying (n = 18, 21.7%), when testing the battery indicated the batteries had died (n = 4, 4.8%), and changing batteries "as needed" (n = 1, 1.2%) were also noted by respondents. Providers also reported that they encourage patients to engage in anticipatory battery management

Figure 1. Median number of appointments weekly.



strategies. Of all responses to this question, 50 (60.2%) reported encouraging a scheduled time for changes (weekly, every set number of day) and seven (8.4%) providers reported that they have patients put their battery tabs on the calendar to track battery life and determine when to schedule a battery change. Five (6%) providers reported that they instruct patients to change the battery before an event where they want to have their hearing aids, and 12 (14.5%) noted that they encourage changing both batteries in bilateral devices at the same time.

Topics covered. Providers (n = 97) reported the topics that they covered within counseling for patients about batteries. These can be seen in Figure 4. Overall, the majority of providers reported covering all listed battery counseling topics (switching between disposable and rechargeable batteries, how to use a battery charger, where to buy/cost of batteries, battery care, low battery warning signals, battery life, battery safety, battery oxygen, insertion/removal, and battery size/tab color) aside from battery storage. The topic of battery storage was only presented as a prepopulated option to providers taking the online survey and thus is not representative of the entire population.

Perceived importance. At the end of the survey, providers asked to report the perceived importance of battery education to them at the initial fit and follow-up appointments on a 7-point scale scored from *Not important at all* (scored 1) to *Very important* (scored 7). The range of scores can be seen in Figure 5.

In a paired-samples t test, the providers' perceived importance of battery education during the initial fitting (n = 96, M = 6.49, SD = .63) was significantly higher, $t(90)$ = 11.59 $p \leq .05$, than for subsequent follow-up appointments (n = 91, M = 5.26, SD = .99). When asked about their perceptions of patients' perceived importance of battery education (n = 90), the mean score was 5.63 (SD = 1.00).

Figure 2. Self-reported time spent on battery education in appointments by audiologists.

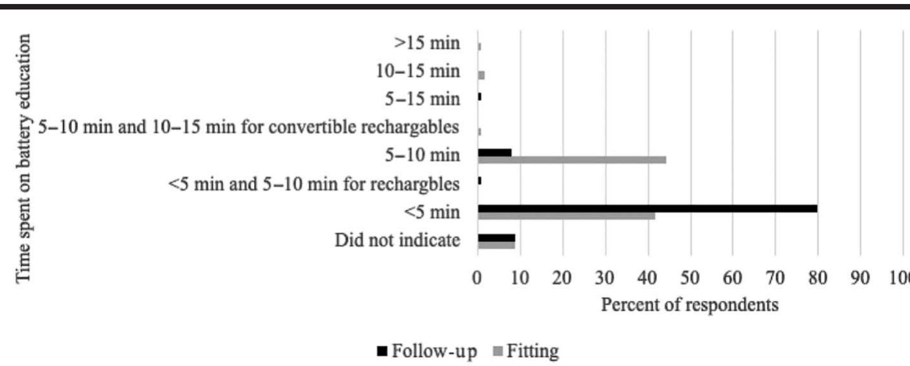
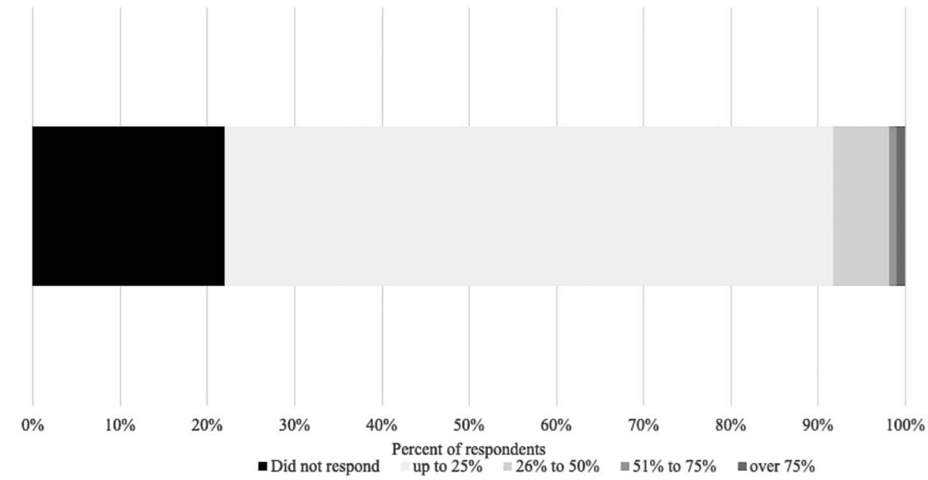


Figure 3. Rechargeable battery usage in reporting audiologists' clinics.



Patient Interviews

Two themes and six subthemes related to battery management were identified in the 13 qualitative interviews. One overarching theme, challenges, included subthemes of social environments, sensory challenges, and inconsistent input from audiologic care providers. A second theme around battery management strategies included subthemes on maintaining battery stashes, delaying replacement of dead batteries, and cost-conscious consumer purchasing behavior.

Challenges

Participants reported challenges around managing their batteries in terms of how to negotiate changing a battery. These challenges were divided into three general themes: social environments, sensory challenges, and inconsistent input from audiologic care providers.

Social environments. Participants noted a conflict with their preferred approach to changing a battery and what they felt comfortable doing in a social situation. When it was time to change batteries, participants indicated they would not change them in front of others or in social situations like meetings or restaurants. Instead, more secluded or private environments were preferred for battery management, such as personal desks or bathrooms. Participant 4 reported.

"I try to change it as quickly as possible, but I'm not going to do it in front of - I don't like to pull my hearing aids out in front of somebody."

However, there was a difference between participants, with one endorsing changing batteries in the privacy of a bathroom and another explicitly noting that they would not change a battery in a place like a bathroom. Participant 11 expressed similar concerns about the conflict with their perceived comfort with the hearing aid battery. Specifically,

Figure 4. Topics in battery education covered in appointments.

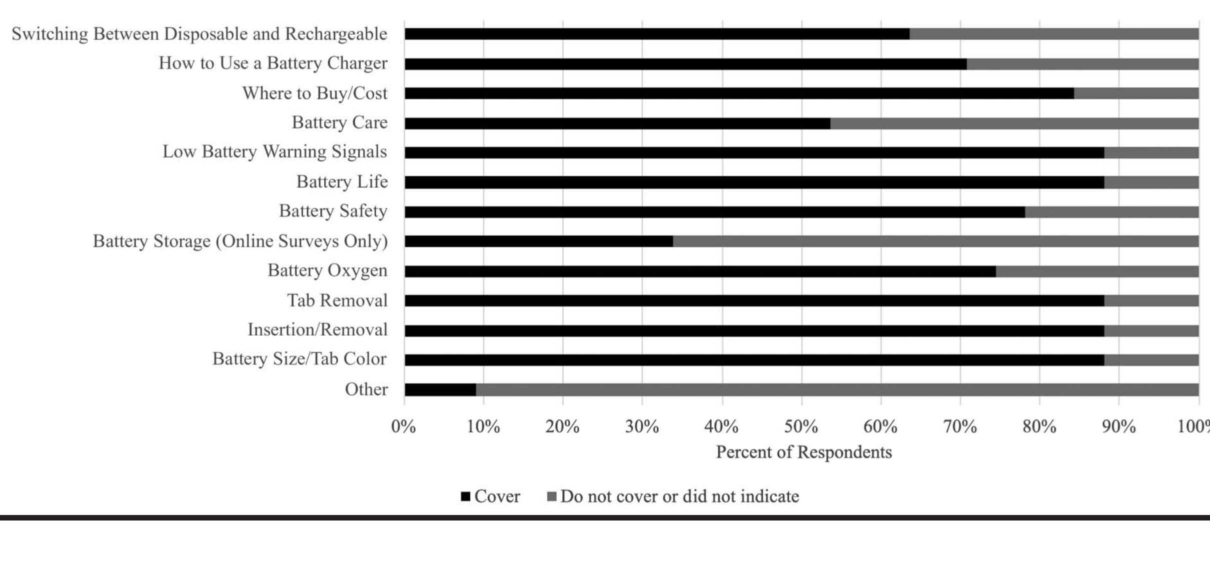
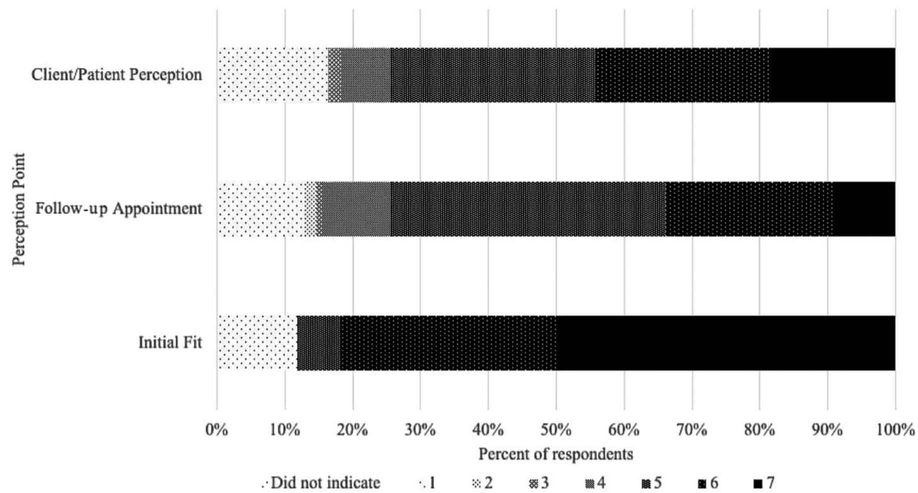


Figure 5. Clinician appraisals of battery education importance across appointments. Questions used a 7-point scale from *Not important at all* (scored 1) to *Very important* (scored 7).



the need to change a battery in front of others and the social implication of self-advocacy was a concern.

"I'm fairly comfortable unless there is a social situation going on, uh, I'm embarrassed to have to say 'Hey everybody, shut up for a minute, I have to change my batteries'."

The presence of another person or the perception of a social setting led to respondents reporting that they would hold off on changing their hearing aid battery longer than they would prefer to.

Sensory challenges. Logistically, participants expressed challenges about physically changing hearing aid batteries due to various sensory differences. These concerns centered around recovering after dropping the small battery. Participant 1 reported.

"...the biggest problem I have is when I drop one."

This challenge compounds with a comment from Participant 13, who highlighted the interaction between hearing loss and other age-related sensation challenges, like feeling in the hands, can compound with one another.

"I have quite difficulty with my sensation of the hands and I have difficulty changing it."

Alternatively, when a hearing aid battery is dropped, Participant 1 reported that it was challenging to locate it without additional cues to its location, such as hearing where it fell. Participants highlighted that while understood as a task, structure-level sensory challenges manifest as activity limitations while trying to manage their batteries.

Inconsistent input from audiologic care providers. Participants indicated a wide range of education on batteries from their hearing health care providers. Two participants indicated that they did not receive any information on hearing aid batteries. Topics participants reported covering included hearing aid battery tab removal (n = 1, 7.7%), low battery warnings (n = 1, 7.7%), how to switch between rechargeable and disposable batteries (n = 1, 7.7%), average battery life (n = 2, 15.4%), hearing aid battery oxygenation/chemistry (n = 2, 15.4%), how to use a hearing aid in general (n = 3, 23.1%), where to purchase batteries and their cost (n = 4, 30.1%), and how to insert and remove batteries (n = 5, 38.5%).

Strategies

Even with these challenges, hearing aid batteries and changing them are necessary for maintaining a functional device and continued auditory access. Participants endorsed three strategies for managing functional devices, including maintaining battery stashes, delaying replacement of batteries, and exhibiting cost-conscious consumer purchasing behaviors.

Maintaining battery stashes. Participants reported that they keep batteries for their devices in several locations that they frequent in their daily lives. While one participant noted challenges with maintaining battery stashes without allowing the batteries to expire, this was not a common concern. More pressing for these participants was ensuring that these locations were accessible. Participant 2 highlighted this variability in locations by saying.

"I generally carry um…extra batteries with me wherever I go. I also have them in my desk at work, and I've got them at home, and I have some in my pocketbook."

While changing batteries in social situations was a challenge for participants, over half (n = 7, 53.8%) of those interviewed reported they had hearing aid batteries in their place of work. Alternatively, locations outside the home included in a backpack (n = 2, 15.4%), specific pouch/pocket on their person (n = 3, 23.1%), or purse (n = 7, 53.8%). Three participants (23.1%) reported storing batteries in their car, and one (7.7%) reported having a battery holder on their keychain.

Delayed replacement of dead batteries. Participants indicated that their primary strategy for deciding when to replace their hearing aid battery was to wait until it was dead or wait until they heard a warning beep. As indicated by Participants 8 and 5 below, the goal of this waiting is related to full lifetime usage and cost concerns.

"I wouldn't change it before I heard the beep. I'm too cheap."

"I try to have the like full long-lasting battery so (laughter) I'll wait until it's completely dead to change it typically."

In the diaries, two participants reported they heard a low battery indicator and then changed their batteries immediately. However, the remaining participants who changed batteries did so once the battery died or when the hearing aid would not turn on. There were no instances of preemptive battery changes. These recordings of actual behaviors indicate a stronger preference for waiting until the hearing aid battery dies before changing it.

Cost-conscious consumer purchasing behaviors. Participants also presented with numerous concerns around the cost of hearing aid batteries. Disposable batteries are a recurring expense. This cost-conscious purchasing strategy is consistent with the reported delayed replacement of dead batteries. When asked about what drives battery purchase decisions, Participant 3 stated, "Price." Participant 4 expanded on this idea when stating

"Ya know, I go I tend to go through hearing aid batteries, so I try to look for the best deal."

Participant 1 was the only individual in this study to report that they did not purchase their hearing aid batteries. This participant's family provided her batteries. All other participants indicated that procuring new batteries was a form of hearing aid maintenance they had to engage in regularly. As a recurring expense for hearing aid users, cost-conscious purchasing behaviors were a common behavioral adaptation discussed by participants. Many participants reported purchasing batteries in bulk or from online discount retailers.

Discussion

This investigation contributes to the small literature base relating to hearing aid batteries, such as the MarkeTrak. It expands this discussion into the qualitative realm to discuss social factors impacting hearing aid battery management. The explicit use of qualitative inquiry to assess patient experiences is unique to the study and supports the small sample. The survey of provider behaviors provides insight into current clinical practices. Survey results provide context for the current consumer climate when purchasing and maintaining hearing aids in terms of battery bundling, rechargeable device purchases, and availability of batteries in the clinic. Taken together, the interviews and surveys in this study paint different pictures of battery education on the part of audiologists and what patients are remembering and implementing in their daily lives. This contrast brings attention to the need for further discussion about hearing aid batteries within clinical interactions specifically around battery change behaviors.

While many providers in the survey endorsed other anticipatory strategies, no patient engaged in this behavior. The preferred method for patient participants in the interviews was to allow the device to die or approach death and then change the battery. This approach is more consistent with the over 80% providers' recommendation to wait for an indicator tone or light. Nevertheless, it is not the implementation of the guidance as intended. This delay in replacing batteries beyond what is encouraged by providers in the survey portion of this study may be related to extending battery life, as this was a noted concern by participants in this study, or challenges changing batteries as desired because of social concerns.

This disconnect between what providers' report recommending and what patients engage in may point to a need for further discussion. In a clinical setting, understanding what drives a specific patient to engage in delayed change behavior might help start a conversation around the recurrent cost of batteries and how that will impact the patient financially. This conversation can serve as a bridge for the patient to consider the limitations of hearing aid batteries and how the cost will be integrated into their lives along with creating a space to address the other challenges hearing aid users in this study presented.

Of the participants who completed the PHAST-R ($n = 9$), all could change their hearing aid battery, with only one participant requiring reinstruction. All participants had the general skills necessary to manage their hearing aid batteries with minimal support. Yet, for individuals who use hearing aid batteries, challenges in terms of sensory information was a subtheme in the qualitative data that was not covered in the audiologist survey. While participants reported that they experience challenges and have concerns related to their hearing aid batteries due to decreased auditory and tactile information, they exhibited the skills necessary to use the hearing aid batteries.

In a clinical setting, the potential sensory and physical challenges experienced by patients should be addressed. Patients may experience dual sensory (hearing and vision) impairments that further complicate battery management, but there is a noted lack of documentation on this topic (Dullard & Saunders, 2014). Most clinical tools like the PHAST-R and HHIE-S do not explicitly cover these issues, so these sensory challenges may not be apparent to a provider unless specific questions about them are integrated into the appointment. Providers may consider implementing questions about vision and dexterity during intake or counseling. This will provide more context for counseling and support individualized battery management education tailored to sensory needs (Dullard & Saunders, 2014). This tailoring of battery management education on the grounds of sensory access also creates a space to counsel on the social challenges that were addressed in qualitative interviews.

In this qualitative analysis, the social impact of hearing aid battery management behaviors has been highlighted. Namely, patient participants tended to delay changing hearing aid batteries in social situations. Clinicians may see this as an opportunity to pursue adjustment counseling with future patients. Adjustment counseling is an approach to patient interaction where the focus is on working to change how the patient feels about their hearing and its consequences (Dillon, 2012). Topics related to adjustment counseling and this recommendation, such as knowledge and awareness of internal/external barriers to rehabilitation, skill in supporting patients to problem solve potential barriers to care, and desire to support the patient in overcoming functional, social, and emotional challenges to care, are present in recent work looking at consensus among experts on counseling competencies (Meibos et al., 2019). This can serve as a means of addressing the disconnect between functional battery skills, as seen in the PHAST-R, and the avoidance of changing batteries in social settings, thus potentially limiting hearing aid benefit in those instances. As seen in the quote from Participant 11 on challenging social environments, self-advocacy skills and a discussion of how to advocate for a break to manage batteries may be a worthwhile use of time in an appointment to address these challenges. One approach to providing this style of education and counseling would be to spread out battery education over multiple appointments post hearing aid fitting. However, this approach is not consistent with audiologists current perceptions of battery education importance.

Clinicians' perceptions of the importance of battery education tended to trend downward in later appointments. Nevertheless, many of the qualitative study patient participants were long-time hearing aid users who did not recall exposure to clinical information, such as battery safety. One participant in particular noted the chemical composition of their hearing aid batteries but did not state this information came from their provider. Another participant noted learning about the importance of the battery tab from the back of the battery packaging and not a care provider. Many topic areas endorsed by clinicians not directly tied to disposable hearing aid battery insertion were not recalled by patients, such as battery storage, battery safety, battery care, battery oxygenation, low battery warnings, battery purchasing, and battery life. Providers reporting they cover more topics of education than patients report exposure to in their interviews is consistent with the estimation of half of the information presented by health care providers are forgotten and the remaining content is distorted in the memory (Margolis, 2004). Clinicians may not perceive continued education on batteries as critical to follow-up care, but currently, patients do not report knowledge of covered topics. Thus, reinstruction on relevant noninsertion and replacement information for disposable hearing aid batteries may have a place in the counseling conducted during hearing aid fitting follow-up care. The decisions that contribute to how patients manage their hearing aid batteries and their success with the devices are dictated by individual interactions with different social environments, sensory challenges, knowledge gaps, access to batteries, and cost-conscious behaviors. Overall, patients tend to be delaying the replacement of these batteries for some or all of these reasons.

Limitations

The qualitative methods implemented created a wealth of data on hearing aid user experiences with hearing aid batteries. A longer span between initial and follow-up sessions where participants were using the hearing aid battery diary would have increased the number of battery change cycles that could be observed. While this would have provided more information about behaviors outside of the research environment, it does not combat concerns around participants biasing their diary entries based on what they reported in their interview and poses a risk in terms of retention to the study.

In the survey of audiologists, while there is a relatively small sample with a concentration in New England, results from the survey indicate battery education practices of respondents are consistent with general practice guidelines to discuss hearing aid battery safety, tab removal, size/color, insertion, removal, purchasing, life, and storage (American Speech-Language-Hearing Association, n.d.; Dillon, 2012; Gelfand, 2009; Johnson, 2012; Mason, 2012; Saunders, 1999). Given that these recommendations are accessible and shared at the national level, there is no noted indication of regional variations in hearing aid battery counseling.

Future Directions

This project is the first mixed-methods approach to systematically evaluate the experiences of audiologists and hearing aid users with disposable hearing aid batteries through the lens of aural rehabilitation. The management of hearing aid batteries is a critical skill for hearing aid users if they are to maintain and use their devices for the long term. Future evaluations should consider how this information, from both patients and providers, relates to device uptake and community engagement.

Information from the qualitative interviews of this study also point out areas of daily living that impact hearing aid battery management (social settings, sensory challenges) and inconsistent input from audiologic care providers. The survey of audiologists highlights that the key components that hearing aid users reported not receiving are reportedly covered by responding audiologists in our survey. This suggests hearing aid users are not remembering the content that is shared with them about batteries by their care providers or not attributing their knowledge to providers (Margolis, 2004). Future works might look to address how to support information transmission from provider to patient, specifically in terms of battery education.

The qualitative comments of hearing aid users in this study also present the unique experience of hearing aid users while managing their batteries. The social and sensory challenges that hearing aid users reported in their interviews are concerns that may be addressed through counseling by providers. Future work should consider the place of battery education as it relates to personal adjustment and acceptance counseling in hearing aid users. Some practical steps to address battery knowledge and management strategies may include providing additional written materials for patients to take home in the form of "tip sheets" or pocket information cards, counseling covering/sale of assistive technology for managing hearing aid batteries such as magnetic tools for picking them up, and including or expanding on battery education at follow-up appointments.

To address the psychosocial concerns expressed by interview participants, providers can prompt the patient to discuss battery use and challenges during appointments and across time points. This could be coupled with dedicated time in appointments to address psychosocial concerns around hearing aid battery management to address self-perception and stigma. Providers could outline practical tips to support inclusion of consistent device utilization and power. A strategy referenced in two interviews and by five survey respondents (10%) was considering preemptive battery changes for social events. Participant 2 reported that the work place was "the most restrictive" in terms of when battery changes can occur. A strategy was to "generally change the batteries just before I go to the meeting." However, this is in direct conflict with cost-conscious delays of battery replacement. The use of anticipatory strategies like this one, as well as self-advocacy in the workplace, are tools that will contribute to better battery management.

Acknowledgments

Funding to support this project was awarded to Kathleen Cienkowski from Proctor & Gamble Duracell Division, Grant 6202340. Thank you to the participants who shared their voices and experiences with us. Thank you to Lauren Benoit, Katherine Chmieleski, and Noelle Wig for their work during data collection and analysis.

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Appendix A (p. 1 of 2)

Audiologist Survey

What is your gender						
Male	Female	Other				
In what state/territory/province/district do you practice?						
Drop down list						
What is the highest degree you have obtained?						
M.A./M.S.	Au.D.	Ph.D.	Au.D./Ph.D.			
Do you dispense hearing aids						
Yes	No					
Please check the approximate client/patient age ranges that you have experience fitting with hearing aids. (Please check all that apply.)						
Birth–3 years	4–12	13–17	18–24	25–34	35–54	55–75
What brand(s) of batteries do you provide within your clinic? (Please check all that apply.)						
Duracell	Rayovac	Energizer	Generic Brand with Clinic Label	ZPower or other interchangeable rechargeable battery	Lithium Ion or other rechargeable battery integrated into the hearing aid (not interchangeable)	Other
What percentage (%) of your clients/patients use rechargeable batteries?						
up to 25%	26% to 50%	51% to 75%	over 75%			
If a client/patient were to ask you, would you recommend a particular brand?						
Yes	No					
Which brand of battery would you recommend?						
Duracell	Rayovac	Energizer	Generic Brand with Clinic Label	ZPower or other interchangeable rechargeable battery	Lithium Ion or other rechargeable battery integrated into the hearing aid (not interchangeable)	Other
Does your clinic bundle batteries with the purchase of hearing aid(s)?						
Yes	No					
Please describe the bundle system you use. (Ex: are specific number of battery packs included annually, are the battery packs distributed through the mail, etc.?)						
Approximately how many hearing aid fittings do you perform weekly?						
During a hearing aid fitting, how many minutes do you spend counseling about battery management?						
< 5 minutes	5–10 minutes	10–15 minutes	> 15 minutes			
Approximately how many clients/patients do you see weekly for hearing aid follow up appointments?						
During a hearing aid follow up, how many minutes do you spend counseling about battery management?						
< 5 minutes	5–10 minutes	10–15 minutes	> 15 minutes			
How do you instruct your clients/patients on batteries and battery related topics? (Please check all that apply.)						
Provide verbal instruction about batteries	Show the client/patient how to manipulate the batteries	Have the client/patient practice with the battery	Provide client/patient with educational materials	Other		

(*table continues*)

Appendix A (p. 2 of 2)

Audiologist Survey

Which topics do you cover when you counsel clients/patients about batteries?						
	Cover	Do not cover	Does not apply	What do you tell the client/patient?		
Battery Size/Tab Color						
Insertion/Removal						
Tab Removal						
Battery Oxygen						
Battery Storage						
Battery Safety						
Battery Life						
Low Battery Warning Signals						
Battery Care						
Where to buy/cost						
How to use a battery charger						
Switching between disposable and rechargeable						
Other						
How do you instruct the client/patient about when to change the battery?						
Do your recommend any advanced battery signal features to your clients/patients? (Please check all that apply.)						
Audible Signals	Lights	Text or email alerts	Other			
On a scale from 1–7 where 1 is not important at all and 7 is very important, how important do you consider client/patient education on batteries to be during the initial fitting?						
Not important at all	Not important	Somewhat not important	Neither important nor not important	Somewhat important	Important	Very important
1	2	3	4	5	6	7
On a scale from 1–7 where 1 is not important at all and 7 is very important, how important do you consider client/patient education on batteries to be at follow up visits?						
Not important at all	Not important	Somewhat not important	Neither important nor not important	Somewhat important	Important	Very important
1	2	3	4	5	6	7
On a scale from 1–7 where 1 is not important at all and 7 is very important, how important do you think clients/patients consider education on batteries to be?						
Not important at all	Not important	Somewhat not important	Neither important nor not important	Somewhat important	Important	Very important
1	2	3	4	5	6	7

Appendix B

Interview Questions

Initial question	Primary probe	Secondary probe	Tertiary probe
How satisfied are you with your hearing aid(s)?			
How many hours do you wear your hearing aid(s) each day?			
How comfortable do you feel with managing your batteries?			
What do/don't you like about hearing aid batteries?			
What do you remember your audiologist telling you about batteries?			
Do you buy a particular brand of batteries?	If so, what influences your battery brand choice?		
How do you store your batteries?			
What do you routinely do with your batteries?	Specific date/time Wait until it dies	Change right away Wait	
Do you hear the battery signal? Reaction to battery signal or another cue	What is the cue?/ What does the signal sound like?	Change right away Wait	How long does it take for the hearing aids to turn off?