A smartphone app to facilitate remote patient-provider communication in hearing healthcare: usability and effect on hearing aid outcomes

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Abstract

Background: Patients often need multiple fine-tuning appointments with their hearing healthcare provider to achieve satisfactory hearing aid outcomes. A smartphone app that enables patients to remotely request and receive new hearing aid settings could improve hearing healthcare access and efficiency.

Introduction: We assessed the usability of ReSound Assist, the remote communication feature of a hearing aid app, and investigated whether hearing aid outcomes are influenced by app-based versus in-person patient-provider communication.

Materials and Methods: Thirty adults were fit bilaterally with hearing aids and randomised to intervention and control groups. During a six-week field trial, participants reported hearing aid problems via ReSound Assist (intervention) or at a scheduled face-to-face follow-up appointment (control). Usability of ReSound Assist was assessed with a questionnaire and interview. Hearing aid performance, benefit, satisfaction, and daily usage were compared for both groups.

Results: ReSound Assist was rated as highly usable. Participants identified specific aspects of effectiveness and efficiency that could be improved. Similar problems were reported by intervention and control participants regardless of communication mode (app-based versus in-person). However, almost half the requests received via ReSound Assist were for problems that required advice from the provider or physical modifications to the hearing aids rather than fine-tuning, highlighting the continued importance of in-person hearing healthcare. There was no significant difference in hearing aid outcomes between intervention and control participants.

Conclusions: Apps enabling remote patient-provider communication are a viable method for hearing aid users to seek and receive help with hearing aid problems that can be addressed through fine-tuning.

Introduction

Hearing loss, a disorder of the ear characterized by a reduction in auditory sensitivity, is the most prevalent sensory impairment[1] and the third leading contributor to years lived with disability worldwide.[2,3] Hearing aids are the most common form of rehabilitation provided to adults with hearing loss and are a cost-effective intervention[4,5] that reduce activity limitations and participation restrictions and improve health-related quality of life.[6,7] Hearing aids are fit to individual patients' needs by applying a prescriptive formula to their hearing thresholds.[8] While the most widely used formulas have been empirically validated, they yield hearing aid settings that address the needs of the average patient, which are not necessarily preferred by the individual.[9] As a result, hearing aids often need to be fine-tuned by the provider to ensure optimal and satisfactory speech understanding, sound quality, and comfort in a range of acoustic environments. Fine-tuning may be undertaken at the time of the initial hearing aid fitting, or, more commonly, after the patient has had the opportunity to wear the hearing aids in daily life. For this reason, several follow-up appointments may be needed in order to meet a patient's individual preferences.

The potential need for multiple face-to-face follow-up appointments poses a number of challenges to hearing healthcare provision. First, patients who have mobility problems, are time-poor, or do not live near an audiology clinic can find it difficult to make repeated in-person visits to a provider.[10] As a result, they may delay or forgo seeking help for their hearing aid problems. Second, patients can struggle to accurately describe listening problems retrospectively.[11] If there is a lengthy delay between their experience of a problem and a visit to their provider, key details about the problem may be forgotten. Third, hearing aids are typically fine-tuned in the clinic, with the patient expected to rapidly assess whether the new, fine-tuned settings have adequately addressed the problem. This may lead to an unsatisfactory result when the patient trials the new settings in daily life, particularly if the original problem was experienced in an acoustic environment that differs markedly from a quiet clinic.[12] Fourth, a recent longitudinal study of a large hearing healthcare provider found that unplanned fine-tuning appointments made up the largest proportion of appointment types, with almost a third of their patients attending four or more fine-tuning appointments after a hearing aid fitting.[13] Together, these challenges suggest that post-fitting care is a logical target for improving hearing healthcare access, effectiveness, and efficiency. Hearing aid manufacturers have recently begun to leverage cloud-based mHealth technologies, such as smartphone applications (apps) that enable remote communication between patients and providers, in an effort to achieve these goals.[14,15]

Before mHealth innovations are implemented into routine clinical practice, they must be rigorously evaluated to ensure they are both usable by, and beneficial for, the target patient population. The concept of usability encompasses three major components: (1) effectiveness, the accuracy and completeness with which the technology can be used to accomplish its goal; (2) efficiency, the resources expended by the user relative to the technology's effectiveness; and (3) satisfaction, the degree to which users are comfortable with, and accepting of, the technology.[16] A recent study found that the usability of several mHealth apps for chronic condition self-management was suboptimal across each of these dimensions, with excessive navigation through multiple screens, complex language, and ambiguous instructions identified as barriers to use.[17] While mHealth technologies are intended to improve healthcare access and efficiency, the authors point out that poor app usability can actually introduce an additional obstacle to achieving this goal. Balancing healthcare efficiency with patient outcomes is another important consideration in the development of mHealth technologies. If an existing element of service delivery is to be augmented or replaced with an app, it is critical to ensure that patient outcomes are at least equivalent to those achieved through standard face-to-face care.

An app enabling remote communication between patients and providers was recently introduced by hearing aid manufacturer GN Hearing. Since the app is the first of its kind, very little is known about its acceptability to patients and its effect on hearing rehabilitation outcomes. An exploratory study was therefore conducted to gather preliminary information about the feasibility of incorporating the app into clinical practice. The aims of the study were to: (1) assess the usability of the remote communication feature of the app; and (2) determine whether hearing aid fitting outcomes are influenced by the mode of patient-provider communication.

Materials and Methods

Participants

Thirty adults (16 male, 14 female) took part in the study. The inclusion criteria were: (1) ≤ 85 years of age; (2) a four-frequency average hearing loss (average of pure-tone thresholds at 0.5, 1, 2, and 4 kHz across both ears) between 25 and 75 dB HL; (3) smartphone ownership, to ensure data were collected on a sample that parallels likely real-world users of a hearing aid app; and (4) ≥ 1 year of bilateral hearing aid experience. The exclusion criteria were: (1) presence of active ear disease; (2) non-English speaking; and (3) additional disabilities, such as severe cognitive impairment, that would preclude participation in the study. The median age of the participants was 67 years (range = 22-83 years). The median four-frequency average hearing loss was 45 dB HL (range = 29-75 dB HL).

Hearing Aids and Smartphone App

The hearing aids used in the study were ReSound LiNX 3D 962 hearing aids, receiver-in-ear devices with four programs, 17 channels, an environmental classifier, and binaural adaptive noise management algorithms. The smartphone app was the ReSound Smart 3D hearing aid app, which communicates with the user's hearing aids via a direct Bluetooth connection between the hearing aids and the user's smartphone. The app feature under test, ReSound Assist, enables hearing aid users to remotely request adjustments to their settings and to receive and upload the new settings from their provider. To use ReSound Assist, users must first have an internet connection. The user is then prompted to answer a series of questions to identify the nature of the problem, the environment(s) in which the problem is occurring, and the perceived severity of the problem. The request is sent to the provider via the cloud and the user receives an automated message indicating the approximate timeframe within which a response can be expected. In response to the request, the provider makes changes to the hearing aid settings within the fitting software and sends the new settings to the user via the cloud. The user is prompted in the app to download the new settings and upload them to the hearing aids.

Usability Outcome Measures

<u>ReSound Assist usability</u>: Usability of ReSound Assist was assessed only in the intervention group with a modified version of the Telehealth Usability Questionnaire.[18] In its original

form, the questionnaire contains 21 items that assess acceptance of and ability to use telehealth services and equipment. In the modified version used in this study, the phrase *the telehealth system* was replaced with *the Assist feature in the ReSound Smart 3D app*. Three items probing ease of real-time communication with the provider (talking to, hearing, and seeing the provider via videoconferencing) were not relevant to ReSound Assist and were therefore removed. Possible scores range from 1-10, with lower ratings indicating greater usability.

<u>Exit interview</u>: Usability was further assessed in the intervention group during a semi-structured exit interview. The first six questions, which required participants to provide a rating on a 5-point Likert scale, probed ease of use, satisfaction with the questions and answer choices provided by the app, satisfaction with the new settings sent by the provider, preference for ReSound Assist versus the type of post-fitting face-to-face consultation they have attended with their own hearing healthcare provider, and preference for a similar feature with their own hearing aids. The other two questions were open-ended and asked participants to describe the problem(s) they reported via ReSound Assist and their overall experience with the feature.

Hearing Aid Outcome Measures

<u>Hearing aid benefit</u>: Hearing aid benefit was assessed with the Abbreviated Profile of Hearing Aid Benefit, a 24-item self-report inventory in which participants rate the degree of difficulty they experience in a variety of quiet, noisy, and reverberant environments.[19]

Hearing aid satisfaction: Hearing aid satisfaction was assessed with the 15-item Satisfaction with Amplification in Daily Life scale.[20] Participants were asked to rate their satisfaction with device performance, effect on self-image, and negative aspects of hearing aid management, with higher ratings representing greater perceived satisfaction.

Speech understanding in noise: The signal-to-noise ratio at which 50% speech recognition in noise is achieved was measured with the Beautifully Efficient Speech Test.[21] Testing was conducted in a circular array of 16 loudspeakers. Speech (subject-verb-object sentences containing 3-8 morphemes) was presented from the loudspeaker at 0° azimuth; a recording of café noise was presented from the other 15 loudspeakers. The level of the speech was varied adaptively according to the participant's response (increased after an incorrect response, decreased after a correct response) and the level of the noise was fixed. Speech was presented adaptively until a minimum of 16 sentences had been presented and a test-retest standard error of 0.8 dB was reached, or a maximum of 32 sentences had been administered.[22]

Hearing aid usage: Hours of use were logged by the hearing aids and read out in the hearing aid fitting software at the end of the study.

Procedure

Participants were assigned to one of two groups (intervention or control) matched for gender, age, and hearing loss severity. All participants attended an initial assessment at the laboratory during which otoscopy and pure tone air- and bone-conduction audiometry were completed and demographic data were recorded. At the second appointment, approximately two weeks later, all participants were fitted bilaterally with the hearing aids and given the ReSound

Smart 3D app. During the following six-week field trial, intervention participants had access to ReSound Assist. Control participants did not have access to ReSound Assist; instead, they attended a face-to-face follow-up appointment two weeks post-fitting. At the end of the field trial, all participants completed the outcome measures; intervention participants additionally completed the measures of ReSound Assist usability. The timing of the study appointments and the use of a six-week field trial parallel real-world clinical practice in audiology, in which patients attend an initial assessment, are fitted with hearing aids approximately two weeks later, and are followed up approximately six weeks post-fitting.

The treatment of participants was approved by the Australian Hearing Human Research Ethics Committee (AHHREC2018-18) and conformed in all respects to the Australian government's National Statement on Ethical Conduct in Human Research.[23]

Results

Usability of ReSound Assist

Twelve of the 15 intervention participants used the ReSound Assist feature at least once during the field trial. Of the participants who used ReSound Assist, 11 were successful, meaning they were able to access the feature, answer the prompt questions, send a request, and upload the new settings to their hearing aids. The one unsuccessful participant attempted to use ReSound Assist several times but received a "service unavailable" message each time. The problem could not be reproduced in the laboratory. Since the usability measures could only be completed by participants who accessed ReSound Assist, there is no Telehealth

Usability Questionnaire[17] data available for this participant, nor could he answer the closed-ended interview questions.

The mean overall score among the 11 participants who accessed ReSound Assist was 1.9 (SD = .83), suggesting they believed that ReSound Assist was simple to use, that they could use it to explain their needs effectively, and that it was an acceptable way to receive hearing healthcare services.

Responses to the closed-ended exit interview questions are shown in Figure 1. Overall, the 11 participants who accessed ReSound Assist rated the feature as highly usable, were satisfied with its question and answer options and the new settings they received from their provider, and reported a preference for app-based versus face-to-face post-fitting patient-provider communication.

Responses to the open-ended questions about participants' experiences using ReSound Assist were classified according to the three components of usability: effectiveness, efficiency, and satisfaction. There were 14 comments about effectiveness (4 positive, 10 negative); 6 about efficiency (2 positive, 4 negative), and 6 about satisfaction (4 positive, 2 negative). Representative comments about each component are shown in Table 1. The preponderance of negative comments about the ReSound Assist's effectiveness and efficiency related primarily to the multiple-choice questions asked by the app to determine the nature and severity of the hearing aid user's problem. Several participants reported that their problem was not adequately covered by the answer choices, leading to concerns they were not clearly communicating the problem to the provider (effectiveness). The majority of participants felt the provider would only understand their problem if they added a written description in the text box in addition to answering the multiple-choice questions (efficiency). Participants were largely positive about the app's appearance and interface (satisfaction).

The problems reported via ReSound Assist are shown in Table 2. Participants reported a total of 23 problems during the six-week field trial. Twelve of the problems could be resolved via remote fine-tuning of the hearing aid settings; the other 11 required that advice be given, either via the app's message box, email, or telephone, or that the participant attend for a face-to-face consultation.

Three participants did not use ReSound Assist. All reported they did not experience any problems with their hearing aids that would warrant contacting their provider.

Hearing Aid Fitting Outcomes

Outcome measure data were assessed to ensure they met the necessary assumptions for performing independent samples t-tests, namely a lack of influential outliers, normality of distribution, and homogeneity of variances.[24] Table 3 shows the mean, standard deviation, and range for each outcome measure and the results of the independent samples t-test comparing the intervention and control groups. One participant in the control group did not complete speech discrimination testing because he lost one of the hearing aids during the trial. Hours of use could not be downloaded from the hearing aids of one participant in the intervention group. There were no significant differences (all $p > .05$) between the intervention and control groups in terms of speech discrimination threshold, hearing aid benefit, hearing aid satisfaction, or hours of daily hearing aid usage.

Discussion

mHealth apps that enable remote patient-provider communication are a potential way to increase the accessibility of hearing healthcare and to facilitate real-time reporting of hearing aid problems. Usability has been identified in previous studies as an important prerequisite to successful integration of mHealth apps into routine clinical practice.[17,25] In the present study, the majority of ReSound Assist users successfully used the feature at least once during the trial and rated their satisfaction with ReSound Assist and its usability very positively.

In line with Sarkar et al.,[17] who advocated for participatory design as a way to improve the usability of apps for chronic condition self-management, the feedback given by the intervention participants provides valuable guidance for further improving the feature's usability. Although 11 of the 12 participants who used ReSound Assist were able to successfully use the feature, they did comment negatively on aspects of the app's effectiveness and efficiency. Specifically, the participants reported that the multiple-choice questions asked by the app – intended to ensure patients fully define the nature, severity, and frequency of their problem – were not always applicable to the problem they were experiencing, thus lessening perceived effectiveness. Several participants reported that as a result, they had to describe their problem in the text box in addition to answering all the questions, thus reducing perceived efficiency. Interestingly, this was most frequently the case when the participant wished to report a problem that could not be addressed through fine-tuning, such as difficulties maintaining a Bluetooth connection or streaming audio input. Together, user feedback and the finding that approximately half of the problems reported via ReSound Assist could not be solved through fine-tuning highlight the possibility of expanding the app's capabilities to increase usability. For example, the app could be programmed to send back automatically generated advice for a range of common problems, such as those related to Bluetooth and audio streaming.

One participant used ReSound Assist to report that her hearing aids were uncomfortable to wear. Such problems almost always require the provider to make physical alterations to the hearing aid, such as changing the ear tip to a different size. This reinforces the important role of face-to-face consultations in hearing healthcare. However, if an app can help to triage patients such that only those truly requiring face-to-face care attend in-person follow-up appointments, this would still contribute toward alleviating the time and resource burden on individual providers.

There were no significant differences in hearing aid fitting outcomes between the intervention and control groups. This finding suggests that replacing the standard post-fitting appointment with an app enabling remote patient-provider communication does not have a detrimental effect on outcomes, at least in the short-term. The current findings are also in agreement with Groth et al.[26], who found that remote versus in-person fine-tuning did not have a significant effect on speech understanding in noise or self-reported aided benefit in a sample of 14 adults. However, our results should be considered in the context of several limitations. First, the sample size of this exploratory study was small because its stated goal was to gather preliminary information about a recently introduced app with novel capabilities. It is possible that significant differences between the intervention and control groups may have been detected on one or more of the outcome measures with a larger sample size. On the basis of the present study's findings, a larger trial is warranted. Second, participants were followed for only the first six weeks after the hearing aid fitting since outcomes are typically measured at this timepoint in real-world clinical practice. However, this also means we cannot be certain of the longer-term impact of app-based patient-provider communication. Third, all study participants were experienced hearing aid users with established listening preferences and well-developed hearing aid management skills; those new to hearing aids may present with qualitatively different problems that may or may not lend themselves to resolution via an app. Future work in this area could focus on longer term usage experiences beyond six weeks and the ways in which mHealth technologies could serve first-time hearing aid users as they acclimatize to amplified sound and acquire the skills necessary to become successful hearing aid users.

Conclusion

Our study found that: (1) ReSound Assist, the remote communication feature in a commercially available hearing aid app, was highly usable based on a validated usability questionnaire and self-report; and (2) replacement of a face-to-face post-fitting follow-up appointment with an app did not have a detrimental effect on hearing aid outcomes, at least in the short term. These findings suggest that while there is still scope for improvement, apps enabling patients to communicate remotely with their hearing healthcare provider are a viable method for experienced hearing aid users to seek and receive help with their hearing aid problems.

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Author Disclosure Statement

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