

# Introducing TeleHear: An Evolution in Synchronous Remote Programming



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## Introduction

The way hearing aids are fit has evolved. The prevalence of telehealth has increased, and the appeal of remote healthcare during a global pandemic are growing. Hearing professionals have more flexibility than ever before to fit hearing aids, adjust hearing aid parameters, and counsel patients without seeing the patient in the office (Wolfgang, 2019). Outside the context of a global pandemic, telehealth appointments with a hearing professional, or teleaudiology, have potential applications for patients who have difficulty commuting to the clinic. In the context of hearing aids, inconvenience is often cited by patients as a barrier to pursuing hearing health care (Morla, 2011). Further, a systematic review of thirty, peer-reviewed articles investigating key factors involved in access and utilization of hearing healthcare identified “appointment convenience” as one of the top non-audiological motivators to seek healthcare services (Barnett et al., 2017). Related, inconvenience was cited as one of the top barriers to seeking healthcare services (Barnett et al., 2017). Patients may even delay receiving hearing aids after discovering they are hearing aid candidates, with some data indicating this delay may be as long as 8.9 years (Simpson et al., 2019).

Starkey’s improved synchronous remote programming feature, TeleHear, is designed to connect patients efficiently and remotely with their hearing professional. Hearing professionals

can initiate an appointment from the TeleHear Dashboard using the Inspire X fitting software, and connect with patients who are using the Thrive Hearing Control app. TeleHear offers the tools needed to support a high-quality, efficacious hearing aid fitting while the hearing aid user is in the comfort of his or her own home. TeleHear allows the hearing professional to run feedback initialization, utilize Starkey’s Best Fit tool to ensure the hearing aids are programmed to an acceptable level, confirm that soft sounds are audible and loud sounds are comfortable using Verify Comfort, and confirm thresholds with the current acoustic coupling of the hearing aids using in-situ audiometry. Hearing professionals can also add memories, manipulate user controls, and completely personalize the fitting to a specific patient’s needs and preferences. Hearing professionals are able to see patients through the live video stream, which allows for visual confirmation that the hearing aids are inserted in the patients’ ears properly.

While there are several convenient and efficacious applications for the virtual patient, TeleHear is not meant to entirely replace in-person appointments with the patient. It is still recommended that patients visit the office for regular comprehensive hearing evaluations and consult their hearing professional with concerns of physical discomfort, sudden onset of tinnitus, or worsening hearing loss. However, TeleHear does provide a full suite of capabilities and tools to support the fitting and fine-tuning of hearing aids, while removing some of the major barriers individuals face in pursuing hearing health care.

A clinical validation was completed by Starkey to investigate the capabilities of TeleHear and the subjective impressions of TeleHear by actual hearing aid users. Specifically, the main objective of the clinical validation was to assess the in-situ audiometry feature within TeleHear. An accurate assessment of hearing thresholds, and a resultant fitting that is audiologically equivalent to an in-person hearing aid fitting, are essential elements of a remote fitting tool that hearing professionals can feel comfortable using. A secondary objective of the clinical validation was to understand the perception of hearing aid users and their confidence in using TeleHear for first-fittings and fine-tuning appointments. Participants completed subjective assessments of usability aspects, as well as overall confidence in their hearing aid fittings completed through TeleHear.

## Participants

Thirty participants (mean age = 69.41 years, ranging 40 to 84.9 years; 21 males, 9 females) participated in this study. All participants had sensorineural hearing loss and were experienced hearing aid users, as defined by six months or more of full-time hearing aid use. Fifteen participants had mild to moderately severe hearing losses and were fitted with Completely-In-the-Canal (CIC) hearing aids. Fifteen participants had severe to profound hearing loss and were fitted with Power Plus Behind-The-Ear 13 (PP BTE 13) devices. See Figure 1 below for the average audiogram for right and left ears across all participants in the study.

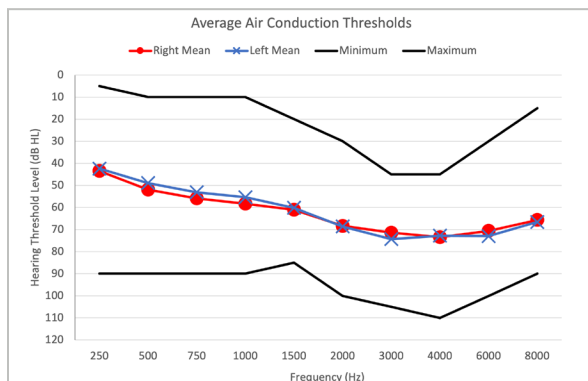


Figure 1: Pure-tone air conduction thresholds, averaged across participants (n=30).

## Coupling and Venting

The PP BTE 13 hearing aids were either coupled to a thin tube and occluded dome (n=4) or were coupled with standard tubing and silicone earmold (n=11). Fittings for both the PP BTE 13 and CIC groups utilized Starkey's recommended venting as noted in the Inspire X fitting software.

## Methods

The study investigators first downloaded the Thrive app on either the participant's phone (if compatible\*), or a lab smartphone. Hearing aids were paired to the smartphone and participants were counseled on use of the Thrive app and use of TeleHear. Participants were then situated in a lab, separate from the experimenter. This was done to simulate the participant being seated in their "home" for the TeleHear appointment.

A TeleHear appointment was initiated by the researcher using the Inspire X TeleHear Dashboard, and participants joined the appointment from their "home" environment. Participants were provided instructions during the video call, prior to completing in-situ audiometry. Initially, the hearing aids were Best Fit to e-STAT, Starkey's proprietary fitting formula, using the thresholds obtained from traditional audiometry. After in-situ thresholds were obtained, the hearing aids were Best Fit to e-STAT using in-situ thresholds. Participants provided subjective ratings of overall sound quality and own voice sound quality for both fitting methods. Additionally, Verify Comfort, a verification of audibility of soft sounds and comfort of loud sounds was completed. Adjustments were made to ensure audibility and comfort, per participant preference. This step was included, as it is an additional feature available to hearing professionals, recently made accessible through TeleHear, to ensure the comfort of a fitting.

\*For a full list of compatible smartphones, please visit: <https://www.starkey.com/hearing-aids/apps/thrive-hearing-control/compatibility>

The final part of the study session involved participant ratings of their overall confidence in using TeleHear and the ease of use of the TeleHear feature within the Thrive app. They were also asked to assess the convenience of a virtual appointment, in comparison to a traditional office visit.

## Results

### In-Situ Audiometry vs. Traditional Booth Thresholds

Audiometric results were analyzed by comparing TeleHear in-situ thresholds with audiometric thresholds obtained traditionally in a sound booth (referred to as, “traditional”). All sound booth thresholds were obtained with ER1 Insert earphones, and hearing tests all occurred within six months of the clinical validation.

The difference between air conduction thresholds obtained through traditional audiometry and in-situ audiometry through TeleHear were calculated for each frequency. Because air conduction thresholds were similar between ears, with a difference of less than 5 dB across all frequencies tested (for both conditions), results were averaged across the two ears. See Figure 2 for the mean difference in average thresholds between the two audiogram methods, across frequency. Values falling below zero indicate a greater threshold for in-situ audiometry than traditional booth audiometry at that frequency.

The mean difference between audiogram methods was calculated, and the absolute values were averaged from 250-8000 Hz. The average difference was 2.19 dB for the CIC group, sufficiently below 5-10 dB test-retest reliability of traditional audiometry (Schlauch & Nelson, 2014). The mean difference between audiogram methods from 500-8000 Hz was 3.35 dB for the PP BTE 13 group, with the mean difference at 250 Hz falling just outside this 5-10 dB range (-13.33 dB). The thresholds captured through in-situ audiometry at 250 Hz were greater than the thresholds captured in the sound booth. This is most likely due to the presence of venting in the earmolds for the PP BTE 13 group, which would not have been present during traditional audiometry in the sound booth.

Finally, TeleHear in-situ thresholds and traditional audiometric thresholds were also analyzed by comparing the four-frequency pure-tone averages for each method. A four-frequency pure-tone average (500, 1000, 2000, and 4000 Hz) was obtained for right and left ears, for each participant. A paired t-test was calculated to determine if the difference in four frequency pure-tone average (500, 1000, 2000, and 4000 Hz) between the traditional and in-situ audiograms was statistically significant. The mean difference in PTAs between traditional and in-situ audiometry was -0.58 dB for the right ear (SD = 3.5 dB) and -1.42 dB for the left ear (SD = 3.84 dB). The t-test revealed a non-significant difference between these differences in PTA for right ear ( $p = 0.38$ ) and left ear ( $p = 0.053$ ).

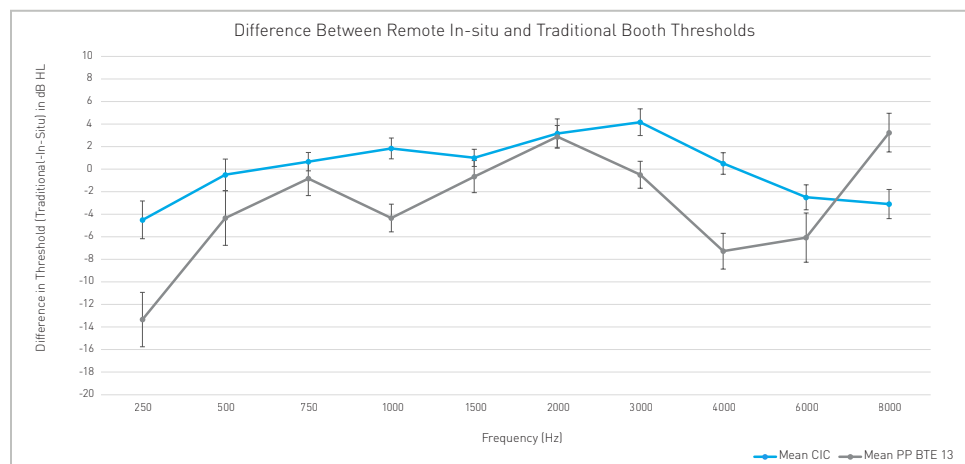


Figure 2: Mean difference in air conduction thresholds plotted by frequency. Thresholds were averaged between right and left ears and averaged across participants (n=30). Error bars represent standard error of the mean at each frequency. Symbols falling above zero suggest the average traditional audiometry air conduction threshold was greater than the TeleHear in-situ threshold at that frequency. Symbols falling below zero suggest the in-situ threshold was greater than the average traditional booth threshold at that frequency.

Results indicate that the PTAs obtained using traditional and TeleHear in-situ audiometry were not statistically different.

### Resultant Hearing Aid Fittings and Prescribed Gain based on TeleHear In-Situ Thresholds

The resultant hearing aid fittings based on both traditional booth thresholds and TeleHear in-situ thresholds were compared. It was of particular interest if the combination of in-situ thresholds and the Verify Comfort adjustments within TeleHear yield a similar final fitting and prescribed gain as compared to a fitting based on the traditional booth audiogram. However, very few participants required any adjustment to achieve a desirable volume or comfort level following the completion of Verify Comfort.

Prescribed gain based on the TeleHear session, including in-situ thresholds and any adjustments made using Verify Comfort, was subtracted from the traditional audiometry prescribed gain.

The mean difference in prescribed gain is plotted by frequency (Figure 3). Bars falling below zero indicate the in-situ thresholds resulted in more prescribed gain compared to the traditional threshold's prescribed gain.

These results indicate that TeleHear, with in-situ audiometry and Verify Comfort, resulted in prescribed gain values within 5 dB of what would be prescribed through a hearing aid fitting based on traditional booth thresholds. While only the prescribed gain for moderate input levels is visualized in Figure 3, the differences in the final fitting, between the traditional thresholds and in-situ thresholds with Verify Comfort, for soft and loud input levels showed a similar degree of difference as moderate sounds (shown in Figure 3). Feedback related to comfort was not obtained in the "traditional booth threshold" condition, but the degree to which these methods agree give a high level of confidence that even some adjustments based on comfort would result in a similar audiologic fitting between these two methods.

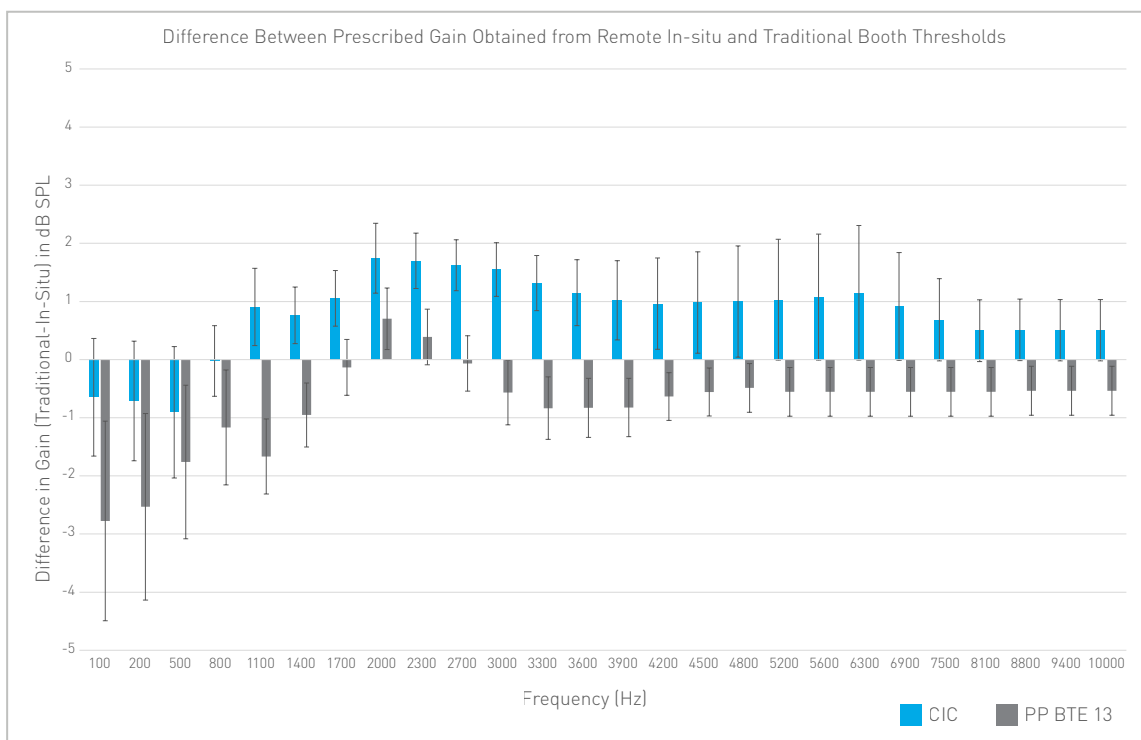


Figure 3: Mean differences in prescribed gain are plotted by frequency, for the moderate input curves (n=28; CIC n=14; PP BTE 13 n=14). Error bars represent standard error of the mean at each frequency. Two TeleHear Inspire X sessions were unable to be recovered. Bars falling below zero indicate that more gain was prescribed in the fitting based on the TeleHear fitting, including in-situ thresholds and Verify Comfort, as compared to the fitting based on traditional booth thresholds.

## Subjective Impressions of TeleHear

Participants were asked for subjective impressions of hearing aid sound quality for the fitting that resulted from the TeleHear fitting session and the fitting resulting from traditional booth thresholds. Subjective ratings of overall sound quality and own voice sound quality were obtained using a 7-point Likert scale (1 representing “very poor” and 7 representing “very good”). Average responses can be visualized in Figures 4 and 5.

Overall sound quality was rated as somewhat good to very good for 85% and 95% of participants for the fitting based on traditional and in-situ thresholds, respectively. Own voice sound quality was rated as somewhat good to very good for 85% and 80% of participants for the fitting based on traditional and in-situ thresholds, respectively. Note that all of these ratings of sound quality were based on first impressions of the Best Fit settings, prior to making adjustments that are typical of any fitting, including minor increases or decreases in loudness or adjustments for occlusion.

Participants also completed a questionnaire to provide subjective feedback on their experience using TeleHear, including measures of ease of use and convenience. Ease of use was rated on a 7-point Likert scale (1 representing “very difficult to use” and 7 representing “very easy to use”). Overall, 80% of participants rated TeleHear as somewhat easy to use to very easy to use (Figure 6). One participant reported rating TeleHear as somewhat difficult to use and specified that he/she “couldn’t understand what the audiologist was saying at times”. The convenience of TeleHear was rated on a 7-point Likert scale (1 representing “very inconvenient” and 7 representing “very convenient”). Eighty-seven percent of participants rated TeleHear as somewhat convenient to very convenient (Figure 7 on next page).

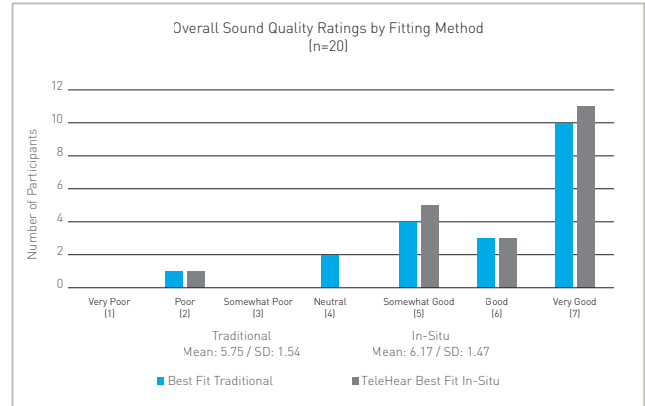


Figure 4: Subjective ratings of overall sound quality for the Best Fit using traditional audiometric thresholds, and for the TeleHear Best Fit using in-situ thresholds (n=20). Several participants’ data were excluded due to missing/incomplete responses.

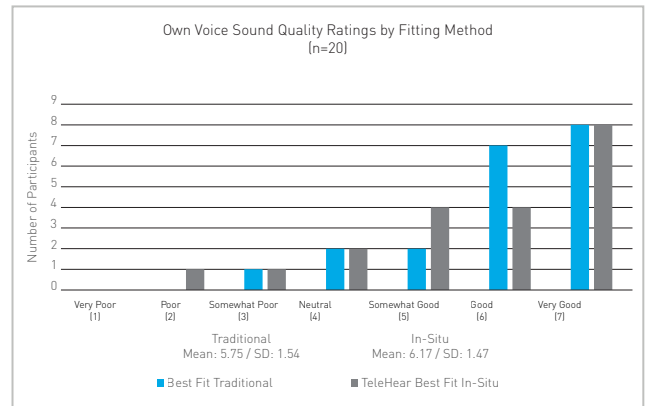


Figure 5: Subjective ratings of own voice sound quality for the Best Fit using traditional audiometric thresholds, and for the TeleHear Best Fit using in-situ thresholds (n=20). Several participants’ data were excluded due to missing/incomplete responses.

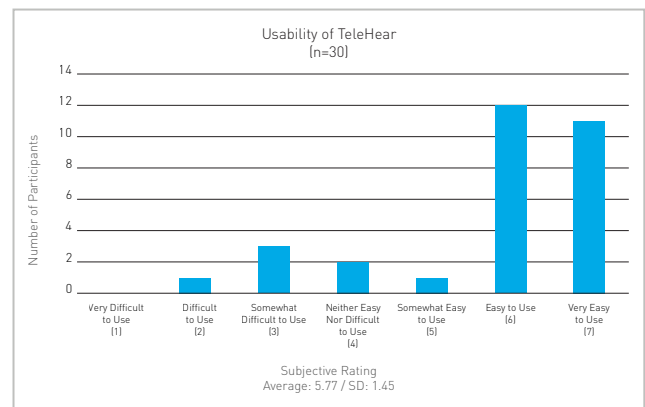


Figure 6: Subjective ratings for the usability of TeleHear (n=30). Bars indicate the number of participants providing that rating.

Importantly, participants rated their level of confidence in completing their hearing evaluation and hearing aid programming remotely with TeleHear. Fifty-three percent of participants agreed that a remote first-fit of the hearing aids would be a suitable replacement for a first-fit in the office (Figure 8). The overwhelming majority, 90%, agreed that completing a follow-up fine-tuning appointment remotely would be a suitable replacement for an in-person programming session (Figure 9).

### Timing of Pursuing Hearing Healthcare

One particularly important question asked to the participants in this study was if the availability of this remote programming capability would have encouraged him/her to pursue hearing health care sooner. Due to the implications on health and well-being in the delay of pursuing hearing healthcare, this was of high interest. It was hypothesized that perhaps removing barriers of travel to and from a hearing professional's office may encourage earlier intervention. Although this question was asked in interview form, and this group of participants represent experienced hearing aid users, over 1 in 3 did affirm the idea that remote appointments would have encouraged him/her to pursue hearing health care sooner than they did. A more systematic investigation with new hearing aid users in a clinical setting would need to be done to confirm this finding, but the evidence provided in the current study does provide extremely encouraging results about the impact of this technology on individuals who may be hesitant to pursue amplification.

### Conclusion

The results of this study indicate that TeleHear is a robust and efficacious tool for the virtual patient. The results indicate that TeleHear in-situ audiometry yields statistically equivalent thresholds to traditional booth thresholds, allowing for hearing professionals to feel confident in this capability through TeleHear. While a difference was noted in thresholds at 250Hz in the PP BTE 13 group, it is likely due to leakage or vent effects from the earmold.

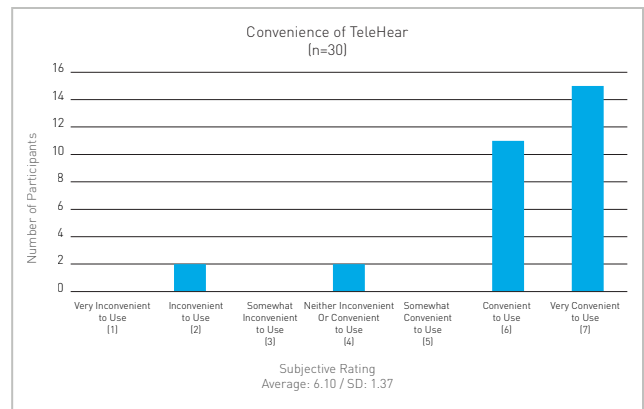


Figure 7: Subjective ratings for the convenience of using TeleHear (n=30), compared to a traditional office visit.

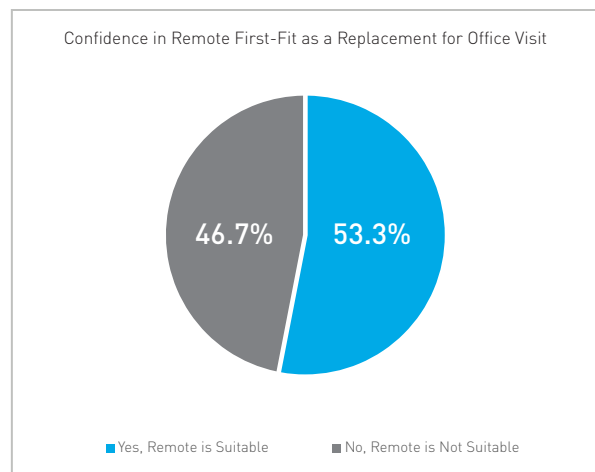


Figure 8: Percentage of participants who felt a remote first-fit would be a suitable replacement for an in-person first-fit appointment (n = 30).

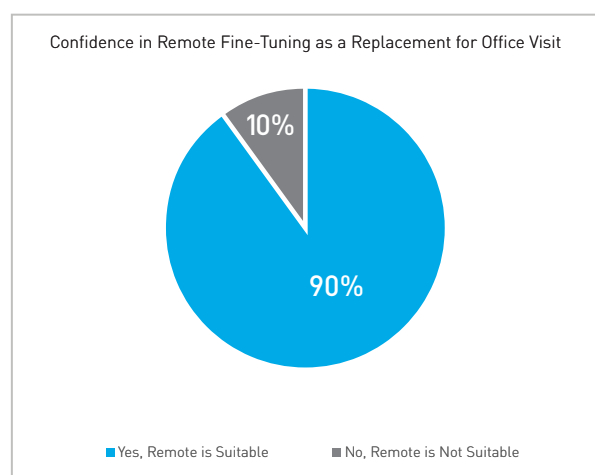


Figure 9: Percentage of participants who felt a remote first-fit would be a suitable replacement for an in-person fine-tuning appointment (n=30).

While most participants reported satisfaction with the swept pure tones for both soft and loud levels and did not request any adjustments, the ability to perform Verify Comfort from the patient's home provides an extra level of security in ensuring a safe, comfortable hearing aid fitting. Verify Comfort has potential applications for identifying and adjusting frequencies the patient perceives to be too soft or inaudible, as well as accounting for loudness discomfort.

Despite any small changes made through Verify Comfort, the resultant fitting through TeleHear was, on average, within 5 dB of a fitting based on booth thresholds.

Overall, participants reported satisfaction with the usability and convenience of TeleHear and reported confidence in the hearing evaluation and fitting compared to a traditional office visit. Specifically, participants indicate comfort with both a remote first-fitting appointment and overwhelming confidence with remote follow-up fine tuning appointments. One of the most powerful findings from this study is the suggestion that hearing aid users would be motivated to pursue hearing healthcare sooner if they had access to the TeleHear system. Given the barriers to hearing health care and the number of years individuals with hearing loss wait before pursuing amplification, any removal of barriers is a step in the right direction towards helping more people with hearing loss.

In an evolving healthcare climate, TeleHear remote services provides hearing professionals with the tools to completely personalize the hearing aid fitting experience to best suit the patient's needs and preferences.

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