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Research Article

Digital Proficiency Is Not a Significant Barrier for Taking Up Hearing Services With a Hybrid Online and Face-to-Face Model

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Purpose: The aim of this study was to determine the effect of self-perceived digital proficiency on the uptake of hearing services through a hybrid online and face-to-face hearing health care model.
Method: Adults were recruited via online methods to complete an online hearing screening test within the greater Durban area in South Africa. On submission of contact details after failing the screening, contact was made via telephone to assess readiness for further hearing care. If motivated and willing to continue, a face-to-face appointment for diagnostic hearing testing was confirmed, at which time an e-mail with an online mobile device and computer proficiency survey was sent. Hearing services were offered using combined online and face-to-face methods.
Results: Within 2 years (June 2017 to June 2019), 1,259 people from the target location submitted their details for the clinic audiologist to contact, of whom 931 participants (73.95%) failed the screening test. Of these participants, 5.69% (53/931, 57.41% men) attended a face-to-face diagnostic hearing evaluation. Mobile device and computer proficiency scores were not a predictor of acquiring hearing services. Age was the only significant predictor (p = .018) for those continuing with hearing care. Patients who continued with hearing care by acquiring hearing aids and support services were older (M = 73.63 years, SD = 11.62) and on average aware of their hearing loss for a longer time (M = 14.71 years, SD = 15.77), as compared to those who discontinued hearing health care who were younger (M = 59.21 years, SD = 14.42) and on average aware of their hearing loss for a shorter time (M = 6.37 years, SD = 9.26).
Conclusions: Digital proficiency is not a predictor for acquiring hearing services through a hybrid online and face-to-face hearing care model. Hybrid services could allow professionals to assist patients in a combination of face-to-face and online services tailored to meet individual needs, including convenience and personalized care.

Mobile devices and computers have become an integrated component of daily life. Most people over the age of 65 years use information and communication technology to maintain family and social connections and to access information related to health and routine activities (Vroman et al., 2015). Approximately 90% of people aged between 50 and 91 years use Internet services such as Facebook and Twitter to find and share health information (Tennant et al., 2015). Adults who were younger, more educated, and used more electronic devices were significantly associated with higher online health literacy (Tennant et al., 2015). Several descriptive Internet and computer research studies have been conducted within audiology (see Table 1 for a summary). There is lack of consistency regarding the terms and concepts used, for example, skills, competency, and proficiency mentioned. Only one study utilized a validated measure to assess computer literacy in adults with hearing loss (Moore et al., 2015). To date, no study has considered mobile proficiency, which is increasingly becoming the mode of choice to access information.

Technology use by adults with and without hearing loss and between those who take up hearing aids differ. Generally, older adults with hearing loss use technology or the Internet more than their normal-hearing counterparts (Gonsalves & Pichora-Fuller, 2008; Thorén et al., 2013). People with hearing loss who do not use hearing

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Table 1. Summary of computer and Internet research on adults with hearing loss.

Author (year)	Country	*n*	Age range (years)	Validated questionnaire	Focus area			Method	Main findings
					Computer skills/ competence	Internet use/ competence	Other technology		
Gonsalves & Pichora-Fuller (2008)	Canada	135	65–87	Nonvalidated			Ability to use a broad variety of common communication technologies	Study conducted in 2006 Random selection from pool of healthy older adults who volunteer to participate in university laboratory research	Participants with hearing loss (*n* = 52, 38.5%) Used hearing aids (*n* = 28, 20.7%) Full study sample participated in leisure activities, which were more communication-demanding and used technology to a greater extent than the average senior
Henshaw et al. (2012)	United Kingdom	1,235	50–74	Nonvalidated 16-item postal questionnaire	Computer skill: i. Never used a computer ii. Beginner iii. Competent Computer confidence: i. Not competent at all ii. I usually need help, it takes me a while but I can manage iii. Confident	Internet use		Year in which study was conducted is not stated	Computer and Internet use was greater in younger (50–62 years) than older (63–74 years) adults. Older adults with slight hearing loss had greater odds of computer use than adults with no hearing loss. Those with moderate and greater hearing loss had lower odds of computer use than adults with no hearing loss. 84 people reported, with those who reported greater computer skills also reported greater computer confidence.

(*table continues*)

Table 1. *(Continued).*

Author (year)	Country	*n*	Age range (years)	Validated questionnaire	Focus area: Computer skills/ competence	Focus area: Internet use/ competence	Focus area: Other technology	Method	Main findings
Thorén et al. (2013)	Sweden	158	20–98	Nonvalidated multiple-choice questionnaires		Internet and e-mail use		Study conducted in 2009 Patients from an audiology clinic Purposive sampling	60% of adults with hearing loss used computers and Internet. Age, gender, and education explained the level of Internet use and not degree of hearing loss ($p < .000$). Internet use was higher in the younger age group (25–64 years) compared to the older age group (75–96 years). Higher usage of Internet in adults with hearing loss compared to general population ($OR = 1.74$, 95% CI [1.23, 3.17], $p = .04$)
Moore et al. (2015)	United States	26		Validated i. Patient–Technology Acceptance Questionnaire (Or, 2008) ii. Northstar Digital Literacy Assessment to access computer literacy (Cytron-Hysom et al., 2012)	Computer literacy Computer anxiety Computer self-efficacy	Acceptance of Internet-based hearing health care		Year in which study was conducted is not stated Failed hearing screening	Anxiety Older adults with hearing loss had poorer computer literacy scores than those just a few years younger. Computer literacy and computer self-efficacy were negatively correlated with age, with additional negative relationships between computer literacy and computer anxiety and computer self-efficacy and computer anxiety.

(*table continues*)

Table 1. *(Continued).*

Author (year)	Country	*n*	Age range (years)	Validated questionnaire	Focus area			Method	Main findings
					Computer skills/ competence	Internet use/ competence	Other technology		
									Computer self-efficacy was positively correlated with perceived ease of use. An indirect relationship was observed between age and computer self-efficacy and between age and computer anxiety.
Ferguson & Henshaw (2015)	United Kingdom	231	50–74	Nonvalidated questionnaires	Computer competence: i. Never used ii. Beginner iii. Competent	Adherence to computerized and online interventions		Studies conducted between 2009 and 2014 Four intervention studies: – Two auditory training studies – One working memory – One study of multimedia educational support	Approximately 15% of participants never used a computer. Computer competence was not associated with use or adherence of the intervention (auditory training, working memory training, and multimedia educational support) delivered by DVD for TV or computer or via the Internet. Computer skills and Internet access influenced adults' preference of the delivery method of multimedia educational support program.

(*table continues*)

Table 1. *(Continued).*

Author (year)	Country	*n*	Age range (years)	Validated questionnaire	Focus area			Method	Main findings
					Computer skills/ competence	Internet use/ competence	Other technology		
Maidment et al. (2016)	United Kingdom	203	42–95, first time hearing aid users	Nonvalidated questionnaires		Self-reported Internet competency: i. Never used ii. Beginner iii. Competent Assess whether Internet competency predicts practical hearing aid knowledge		Year in which study was conducted is not stated. Prospective, randomized controlled trial Multimedia educational intervention (interactive video tutorial) Delivered through DVD for TV or computer and online	20% reported never used the Internet and 29% were beginner in the intervention group vs. 22% never used the Internet and 32% were beginners in the control group Self-reported competent Internet users of 51% in the intervention group vs. 46% in the control group Internet competency did not differ significantly between the intervention and control groups. In the intervention group, higher Internet competency was associated with more knowledge of practical hearing aid challenges. Better Internet competency was associated with better practical hearing aid handling skills at the follow-up appointment. Higher Internet competency was significantly associated with watching the multimedia videos less amount of time.

(*table continues*)

Table 1. *(Continued).*

Author (year)	Country	*n*	Age range (years)	Validated questionnaire	Focus area			Method	Main findings
					Computer skills/ competence	Internet use/ competence	Other technology		
									Internet competency was the only significant factor in predicting practical hearing aid knowledge, with variance of 12%. Internet competency also significantly predicted practical hearing aid handling skills. Internet competency was a significant predictor of hearing aid knowledge and skills after controlling for demographic attributes (age, hearing threshold, educational status, and gender).

aids are less likely to use other technologies (computers, automated teller machines, e-mail, and Internet) than their peers with normal hearing and those using hearing aids (Gonsalves & Pichora-Fuller, 2008). The extent of use and ability to use technology in this study were associated with education, occupation, method of transportation, and language (Gonsalves & Pichora-Fuller, 2008). In another study, age, gender, and education were associated with the extent of Internet use and not the degree of hearing loss (Thorén et al., 2013).

Reports also show that younger (50–62 years) adults with hearing loss had greater usage of computers and Internet than their older (63–74 years) counterparts, and those who reported greater computer skills also reported greater computer confidence (Henshaw et al., 2012). Similarly, another study reported Internet use was higher in the youngest age group (25–64 years) compared to the oldest age group (75–96 years, $p \leq .001$), with the highest Internet usage reported by younger men with higher levels of education (Thorén et al., 2013). The same is evident from another study where higher self-reported Internet competency was associated with younger age, better hearing thresholds, higher educational status, and being male (Maidment et al., 2016). In a study of 26 older adults aged between 55 and 95 years with hearing loss using a validated computer literacy questionnaire, a significant negative correlation was found between computer literacy and age (Moore et al., 2015). Computer literacy and computer self-efficacy were also negatively correlated with age, with additional negative relationships between computer literacy and computer anxiety, and computer self-efficacy and computer anxiety (Moore et al., 2015). Computer self-efficacy was positively correlated with perceived ease of use (Moore et al., 2015).

In summary, the main factors associated with people who have hearing loss and the ability to use technology, or the Internet, or self-reported Internet competency are as follows: younger in age (Gonsalves & Pichora-Fuller, 2008; Henshaw et al., 2012; Maidment et al., 2016; Thorén et al., 2013), having higher levels of education (Gonsalves & Pichora-Fuller, 2008; Maidment et al., 2016; Thorén et al., 2013), and being male (Maidment et al., 2016; Thorén et al., 2013).

Interestingly, computer skill/competency was not associated with use or adherence to the intervention (auditory training, working memory training, and multimedia educational support) delivered by DVD for TV or computer or via the Internet (Ferguson & Henshaw 2015). Computer skills and Internet access influenced participant preference for the delivery method of multimedia educational support program, whereas all those who never used a computer and majority of the beginners chose the DVD for TV use (Ferguson & Henshaw 2015). In an intervention group of patients who watched educational video segments, patients with higher Internet competency scores also viewed the video segments less number of times, which could indicate the ease of knowledge/skills transfer (Maidment et al., 2016). Internet competency was the only statistically significant predictor of practical hearing aid knowledge and practical hearing aid skills in those who received an intervention, which may indicate they are better equipped to put new knowledge into practice (Maidment et al., 2016).

Individuals with hearing loss often delay seeking help. On average, people wait for 7–10 years before taking action to address their hearing concerns (Davis et al., 2007; Simpson et al., 2019), with the typical age for first hearing aid fitting reported to be around 74 years of age (Henshaw et al., 2012). Multiple nonaudiological and audiological factors influence the uptake of hearing aids. Examples of nonaudiological factors include self-efficacy in the use of hearing aids, readiness to improve hearing, stages of change, expectations of hearing aids, self-perceived hearing loss and hearing aid benefit, demographics, support from significant others, social pressure, and the level of health literacy needed to understand hearing aid materials (Ferguson et al., 2016; Klyn et al., 2020; Ng & Loke, 2015; Pronk et al., 2017). Examples of audiological factors include severity of hearing loss, onset and duration of hearing loss, type of hearing loss, insertion gain, and acceptance of background noise (Knudsen et al., 2010; Ng & Loke, 2015; Pronk et al., 2017).

In a recent study, age was not a significant predictor of hearing aid uptake (Simpson et al., 2019). However, age and readiness were predictors and modifiers in a study of 377 adults who either continued or discontinued a hearing aid trial (Pronk et al., 2017). The duration of hearing loss is an important factor during the prefitting stage of patients seeking hearing health care (HHC; Knudsen et al., 2010). Hearing loss duration significantly impacts adjustment to hearing aids: Patients who experience hearing loss for a longer time may have had more time to prepare themselves for wearing and using hearing aids (Meyer et al., 2014). Advanced stages of change are also associated with longer hearing loss duration (Laplante-Lévesque et al., 2015, 2013). To the authors' knowledge, no research is available regarding the digital proficiency of patients with hearing loss and their uptake of hearing aids.

The uptake of hearing aids is also influenced by the beliefs and attitude of the person with hearing loss. A health behavior change model assesses the person's beliefs and attitude to help predict hearing aid outcomes (Saunders et al., 2016). One behavior change model used in HHC is the transtheoretical model of health behavior change or the stages of change model. According to this model, people move along a continuum of stages toward behavior change from precontemplation to contemplation, preparation, and action. The staging algorithm asks patients to select one of four statements, where each statement characterizes a stage of change (Milstein & Weinstein, 2002).

Computer and Internet-delivered hearing information, hearing screening, and intervention could be feasible for people who do not typically present themselves to an audiologist (Henshaw et al., 2012). Increasing digital competence in older adults is making online HHC interventions a viable option (Ferguson & Henshaw, 2015). Published online interventions for hearing loss include online hearing rehabilitation programs using videos of real persons with

functional tasks for completion and testimonials of persons who have experienced similar hearing challenges and their advice for new hearing aid users (Ferguson & Henshaw 2015; Greenwell et al., 2015; Thorén et al., 2015). To date, however, the translation of such programs into sustainable clinical practice beyond research projects has been limited.

The advent of mobile technology provides the opportunity to use mobile device applications, enabling HHC interventions to be personalized and on-demand when delivered via mobile devices to patients as well as their families and significant others (Paglialonga et al., 2018). Hearing aids are increasingly controlled by mobile applications enabling remote fine-tuning, sound environment monitoring, and enhancements (Paglialonga et al., 2018). There is a preference and a move toward application-based and online eHealth studies (Paglialonga et al., 2018). In our previous study, we reported that 87.10% of individuals completed online hearing screening testing from a mobile device and only 12.90% from a computer (Ratanjee-Vanmali et al., 2020).

In this study, standardized self-report questionnaires were used to measure self-perceived digital proficiency and, more specifically, mobile device and computer proficiency. Digital proficiency measures must reflect currently used digital solutions. Available measures include the Mobile Device Proficiency Questionnaire (MDPQ-16) and the Computer Proficiency Questionnaire (CPQ-12; Boot et al., 2015; Roque & Boot, 2018). The terms *proficiency* and *skills* are often used synonymously. In this study, "proficiency" describes an individual's ability to perform a particular task or skill. Proficiency can be measured through self-report or behavioral observation. This study describes the self-perceived digital proficiency (i.e., mobile device and computer proficiency) of a group of adults who took up hearing services through a hybrid online and face-to-face HHC model. Furthermore, it assesses whether the mobile device and computer proficiency were associated with the uptake of such services. We hypothesize that lower digital proficiency is associated with lower uptake of hybrid HHC services.

Method and Materials

Setting / Recruitment

A nonprofit entity, the Hearing Research Clinic Non-Profit Company, was established in June 2017 in Durban, KwaZulu-Natal, South Africa. A free online hearing screening test (Potgieter et al., 2016, 2018) was placed on the clinic's website, and online methods (Google and Facebook) were used to recruit adults above the age of 18 years within the target location. The online screening test result was displayed at the end of the test (pass or refer), and an option to submit contact details for the clinic audiologist (first author) to make contact with was made available to each test taker. The clinic audiologist then made contact with the potential patients to assess their readiness to complete diagnostic hearing testing and then became patients of the clinic. Patients paid for the hearing health services, which removed volunteer biases. Five steps made up the patient journey from the completion of the online hearing screening test to the fitting of hearing aids. Full details of the clinic and process can be found in Figure 1 and elsewhere (Ratanjee-Vanmali et al., 2019).

Participants

All patients who provided consent to be contacted after failing the online screening test were contacted. Telephonic readiness measurements and motivational engagement were assessed (the clinic audiologist conducted these telephone calls solely for the first 12 months after which a layperson was trained intensively and is coached regularly), and then a face-to-face diagnostic hearing test was scheduled with the clinic audiologist. All the participants who failed the online test, submitted their details, reached by the clinic on their provided telephone number, and completed the face-to-face diagnostic hearing test were included in this study, therefore indicating a purposive sampling method was used.

Materials

Online Hearing Screening Test

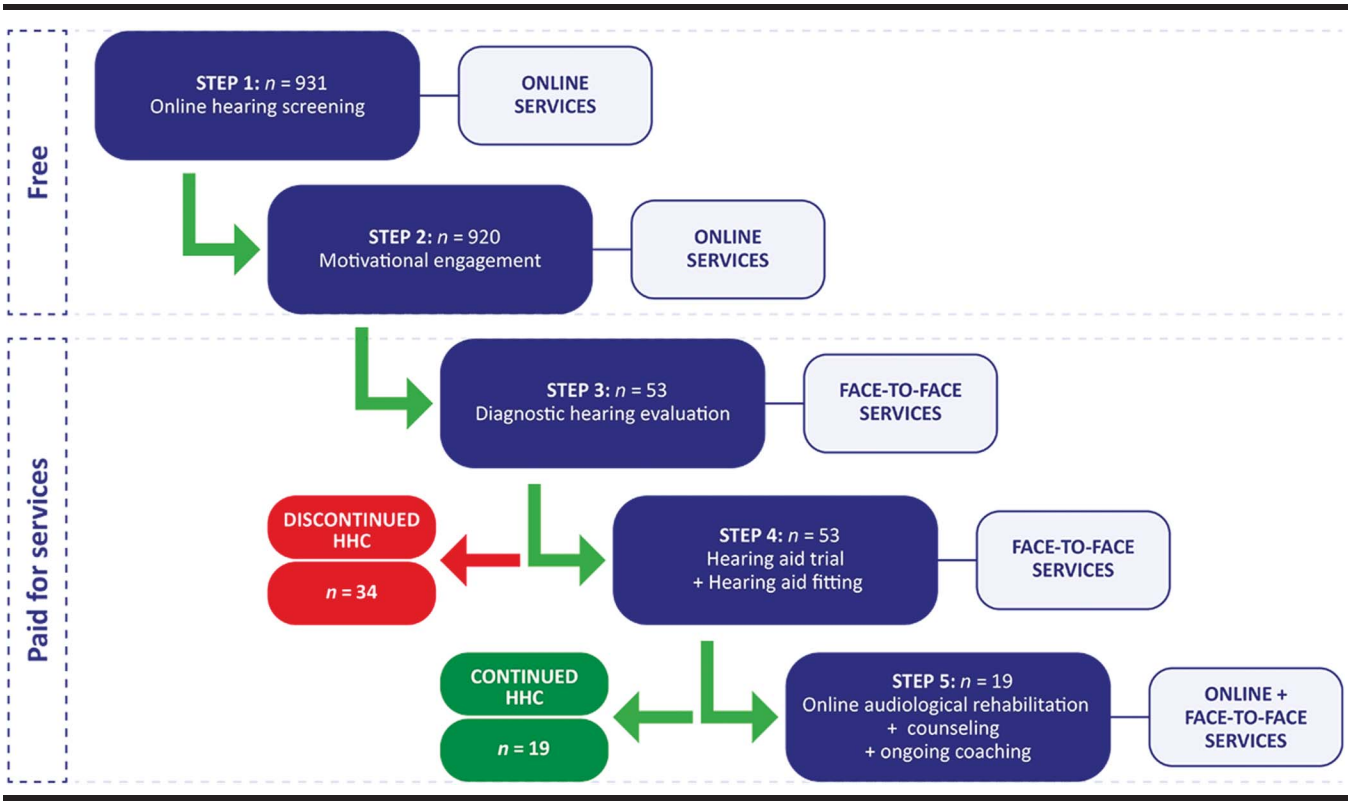
The online hearing screening test is an adaptive triple digit-in-noise (DIN) test developed and validated for South African English (Potgieter et al., 2016, 2018). The DIN test was provided as a web widget (hearX Group, 2020), which was hosted on the clinic's website. Each individual began the test by inserting their date of birth and then continued with the 23 user tries of the triple-digit test (Potgieter et al., 2016, 2018). Each DIN test completed resulted in a speech reception threshold (SRT; the level at which 50% correct was achieved) recording. Only at the end of the online hearing screening test, after the participant viewed the result, if interested, they could submit their details to be contacted by the clinic.

Measures of Readiness and Stages of Change

A one-item measure of readiness, sometimes called "The Line," was used (Rollnick et al., 1999; Tønnesen 2012). The question asks: How important is it for you to improve your hearing right now? Responses were recorded on a Likert scale from 0 to 10, where 0 indicates *not at all* and 10 indicates *very much*. Scores were dichotomized into two groups describing low readiness (≤ 5) or high readiness (> 6).

A one-item measure of stages of change, sometimes called "staging algorithm," was used (Milstein & Weinstein 2002). Respondents are asked to pick one of four statements that best describe their situation. Each statement corresponds to a stage of change: (a) I do not think I have a hearing problem, and therefore, nothing should be done about it (Stage 1: Precontemplation). (b) I think I have a hearing problem. However, I am not yet ready to take any action to solve the problem, but I might do so in the future (Stage 2: Contemplation). (c) I know I have a hearing problem,

Figure 1. Five steps of a combined online and face-to-face hybrid hearing health care model. HHC = hearing health care.



and I intend to take action to solve it soon (Stage 3: Preparation). (d) I know I have a hearing problem, and I am here to take action to solve it now (Stage 4: Action). Scores were dichotomized into two groups, describing early stages of change (the stages precontemplation, contemplation, and preparation) or the late stage of change (action stage). The binary grouping was necessary based on the uneven distribution of the small sample size across the four categories. The action stage was considered the most overt behavioral change, as it entailed considerable commitment of time and energy and requires the person to modify behavior, experiences, and the environment to overcome their challenges (Prochaska et al., 1992).

Mobile Device and Computer Proficiency Questionnaires

The two questionnaires included in this study were the abbreviated versions of the MDPQ-16 (see Appendix A; Roque & Boot, 2018) and the CPQ-12 (see Appendix B; Boot et al., 2015). The MDPQ-16 consisted of 16 questions with eight domains, and the CPQ-12 consisted of 12 questions with six domains. The MDPQ-16 and CPQ-12 share the following assessment domains: basics, communication, Internet, calendar, and entertainment. However, the abilities queried are different and are generally more complex for the MDPQ-16 than the CPQ-12. For example, the questions for the CPQ-12 basics domain examine the ability to use a computer keyboard to type and the ability to use a mouse. In contrast, the questions for the MDPQ-16 basics domain examine the ability to navigate onscreen menus using the touchscreen and the ability to use the onscreen keyboard to type. For the entertainment domain, the CPQ-12 assesses the ability to watch movies and videos and listen to music on the computer, whereas the same domain on the MDPQ-16 assesses the ability to use the device online store to find games and other entertainment and listen to music. The questionnaires differ further in that the CPQ-12 includes a printer domain and the MDPQ-16 includes the domains privacy and troubleshooting, as well as software management.

The first page of the MDPQ-16 included images of the devices and information that educated patients on the type of devices of interest included on both questionnaires: mobile devices (tablets and smartphones) and computers. Scoring of the questionnaire was from a minimum of 1 to a maximum of 5: 1 = *never tried,* 2 = *not at all,* 3 = *not very easily,* 4 = *somewhat easily,* and 5 = *very easily.* The final score was calculated by adding the average response of each to produce a total MDPQ-16 and CPQ-12 score. The higher the score indicated, the better digital proficiency.

Pure-Tone Average—Better Ear

A pure-tone average (PTA) was calculated by taking the calculated hearing threshold across four frequencies (500, 1000, 2000, and 4000 Hz) conducted during diagnostic

hearing testing using equipment by Interacoustics A/S, Callisto Suite AC 440 (Version 1.8.0), in a quiet environment (Interacoustics A/S, 2019). A better ear PTA was recorded for each patient.

Procedure

This study was conducted under the ethical approval of the University of Pretoria Faculty of Humanities Research Ethics Committee (GW20170409HS). All participants provided online and written consent to be contacted and to participate in this study.

Patients who sought help from the clinic within the target location between the periods of June 2017 and June 2019 were included in this study (see Figure 1). Of the 53 patients who took up HHC services through a hybrid model, 34 patients discontinued HHC (after trialing hearing aids in Step 4), and 19 patients continued with HHC by trialing and then obtaining their own hearing aids (continued to Step 5). Of the 53 patients, 22 (41.51%) were women and 31 (58.49%) were men, with an age range of 33–101 years (SD = 15.09). In this article, patient groups are described as follows: those who took up hearing services by completing a face-to-face diagnostic hearing evaluation (Step 3), those who discontinued HHC (Step 4), and those who continued with HHC (Step 5).

Information Collected Before the Consultation

Participants who submitted their details on failing the online hearing screening test (Step 1) were contacted by e-mail and telephone. Readiness measures, The Line, and stages of change were completed with the participants over the phone to assess their motivation and readiness to move ahead with HHC (Step 2). A face-to-face appointment for diagnostic hearing testing was then confirmed if the participants scored ≥ 5 on The Line and Stage 3 or 4 on the stages of change.

After this, an appointment confirmation e-mail was sent to patients, which included information regarding the date and time of appointment, address of the clinic, preparation, bringing a significant other to the appointment, and expectations of the appointment. A link to the MDPQ-16 and CPQ-12 was included in the e-mail, hosted and administrated by Qualtrics (2020). The responses were password protected and only accessible to the clinic audiologist. Patients who did not complete the questionnaires before their appointment were requested to complete the questionnaires before the consultation began or if assistance was required; the clinic audiologist read out the questions for the patient to complete it immediately. This e-mail appointment confirmation was sent to 53 patients.

Information Collected During the Consultation

The clinic audiologist reviewed the results of the MDPQ-16 and the CPQ-12 before the patient attended the face-to-face appointment. When the MDPQ-16 and CPQ-12 scores indicated that digital proficiency was rather limited, additional support was offered to patients. Additional support offered to patients included downloading of a mobile application to the patient's mobile phone, pairing mobile phone with the patient's hearing aids, and instructing on the use of the mobile application to adjust volume and change programs.

This face-to-face appointment was conducted with the clinic audiologist where the following information was gathered: in-depth case history, needs assessment, medical history, the length of time the patient was aware of their hearing difficulty/challenges/loss, and a full audiological diagnostic evaluation (Step 3). Results of the audiological assessment were presented to the patient, and then treatment options, together with counseling, were discussed with the patient. If no red flags were observed (sudden onset of hearing loss, middle ear pathology, asymmetrical hearing loss, sudden onset of tinnitus, aural fullness, and vertigo), needing referral to an otolaryngologist (ear, nose, throat specialist), the patient was fitted with a trial set of hearing aids and were counseled based on their needs (Step 4). After trialing the set of hearing aids, patients had the option to purchase their own set of hearing aids, were offered an online audiological rehabilitation program, and were offered ongoing coaching and counseling when needed (Step 5).

Data Analysis

Data were analyzed using SPSS Version 25 (2015) and SAS Version 9.4 (2020). The Shapiro–Wilk test was used to check the distribution of the following variables: MDPQ-16, CPQ-12, SRT, age, years aware of hearing loss, and better ear PTA. None of these variables were normally distributed, and therefore, nonparametric tests were used. Statistical significance was set at $p < .05$. The Mann–Whitney U test (nonparametric test) was used to compare the differences between the two patient groups: discontinued HHC (Step 4) and continued HHC (Step 5). Point biserial correlations were used to examine associations between continuous and binary variables, and Spearman correlations were used to examine associations between Likert-type (ordinal) and continuous variables.

To determine which factors were associated with who continued with HHC, an exact logistic regression analysis was conducted using SAS software (Version 9.4, 2020). Exact logistic regression models a binary outcome variable (whether or not a patient would acquire hearing aids and support services through a hybrid online and face-to-face model) with one or more predictor variables (SRT, MDPQ-16, CPQ-12, gender, years aware of hearing loss, age, readiness, stages of change, and better ear PTA). The following potential predictors were omitted from the exact logistic regression, as they were highly correlated (point-biserial or Spearman correlations) with other variables included in the model: CPQ-12, readiness, years aware of hearing loss, and better ear PTA.

The categories of the stages of change were collapsed into two groups: The first three stages were compared to the fourth stage. Exact logistic regression was used as it is more robust to limited samples: The analysis was completed

on data from 53 participants. The small sample size provided sufficient power to include numerous independent variables in an exact logistic regression model.

Results

Description of Participants

Over 2 years (June 23, 2017, to June 22, 2019), 8,118 participants completed the online hearing screening test. Of those, 7,898 were from South Africa, and 6,982 (86.01%) were from the target location of greater Durban, South Africa. Within this period, 1,259 people from the target location submitted their details for the clinic audiologist to contact; 931 (73.95%) failed the online hearing screening test, and 328 (26.05%) passed it. Of the 931 participants who failed and submitted their details, 53 (5.69%) participants became patients (57.41% male) of the clinic and took up hearing services with a hybrid online and face-to-face model by attending a face-to-face diagnostic hearing evaluation (see Table 2).

The majority (84.91%) of the 53 patients accessed the online hearing screening test through a mobile device using either Android (60.38%) or iOS (24.53%), with a small minority using a Windows PC (15.09%). Most patients who completed Step 3 (84.91%) were in the preparation or action stages of readiness to take up HHC (see Table 2). After the diagnostic hearing evaluation, 35.85% of patients continued with HHC by purchasing hearing aids (see Table 2).

The mean better ear PTA score was 38.48 dB HL (SD = 19.50) for the total group who trialed hearing aids (n = 53). People who continued with HHC (n = 19) had a mean better ear PTA of 46.11 dB HL (SD = 23.14), and people who discontinued with HHC (n = 34) had a mean better ear PTA of 34.15 dB HL (SD = 15.95). When looking closer at the patient groups who discontinued HHC versus those who continued HHC, the following differences were noted. Compared to patients who continued HHC, patients who discontinued HHC were younger, had higher SRT and better ear PTA scores, and were aware of their hearing loss for a shorter time (see Table 2 for comparisons). Regarding the stages of change scores, patients who discontinued HHC were equally divided between stages precontemplation, contemplation, and preparation (n = 17) and action (n = 17), as compared to patients who continued HHC; 63.2% of patients reported stage action (n = 12; see Table 2).

Mobile Device and Computer Proficiency in Adults Who Sought HHC Online

The mobile proficiency (MDPQ-16) and computer proficiency (CPQ-12) mean scores and ranges are reported in Tables 3 and 4. With regard to the domains on each of the proficiency questionnaires, lower scores were found on more complex tasks such as data and file storage, calendar use, entertainment, and privacy settings (see Tables 3 and 4). Statistically significant differences were found on the Mann–Whitney U test between patients in Step 4 (discontinued HHC) and Step 5 (continued HHC) on the following domains of the MDPQ-16: basics (p = .037), data file and storage (p = .026), calendar (p = .013), privacy (p = .022), and troubleshooting and software management (p = .024; see Table 3). Only two statistically significant differences were found on the CPQ-12 between the groups in Steps 4 and 5 on the following domains: calendar (p = .025) and entertainment (p = .040; see Table 4).

The reliability of the MDPQ-16 (see Table 3) and CPQ-12 (see Table 4) was assessed with Cronbach's alpha, where alpha of above .70 was considered acceptable (Field, 2018). The overall reliability of the MDPQ-16 was excellent (Cronbach's α = .90), with the reliability of the eight domains ranging from .66 to .99. The overall reliability of

Table 2. Description of patient characteristics and readiness in seeking hearing health care (HHC).

Variable	Step 3 Total group (n = 53)	Step 4 Discontinued HHC (n = 34)	Step 5 Continued HHC (n = 19)
Age			
M (*SD*)	64.38 (15.09)	59.21 (14.42)	73.63 (11.62)
Range	33–101 years	33–86 years	52–101 years
Speech-in-noise recognition threshold			
M (*SD*)	−4.68 (6.51)	−6.51 (3.96)	−1.41 (8.72)
Range	−10.80 to 16.0 dB	−10.80 to 5.60 dB	−10.80 to 16.00 dB
Pure-tone average (better ear)			
M (*SD*)	38.43 (19.50)	34.15 (15.95)	46.11 (23.14)
Range	9–88 dB HL	9–79 dB HL	9–88 dB HL
Years aware of hearing loss			
M (*SD*)	9.36 (12.52)	6.37 (9.26)	14.71 (15.77)
Range	0.1–60 years	0.1–40 years	0.5–60 years
Readiness stage on staging algorithm, % (*n*)			
Stage 1: Precontemplation	3.8 (2)	5.9 (2)	0.0 (0)
Stage 2: Contemplation	11.3 (6)	14.7 (5)	5.3 (1)
Stage 3: Preparation	30.2 (16)	29.4 (10)	31.6 (6)
Stage 4: Action	54.7 (29)	50.0 (17)	63.2 (12)

Table 3. Mean and standard deviation for mobile proficiency measurement using the Mobile Device Proficiency Questionnaire (MDPQ-16) of all patients who completed Steps 3, 4, and 5.

MDPQ-16 (*n* = 53)	Step 3 Total group, *n* = 53 (*M*; *SD*)	Range (min–max)	Step 4 Discontinued HHC, *n* = 34 (*M*; *SD*)	Step 5 Continued HHC, *n* = 19 (*M*; *SD*)	Mann–Whitney (*p* value)
MDPQ-16 total:	28.83; 9.63	8.50–40.00	31.28; 11.35	25.58; 12.39	190.00 (.013*)
1. Mobile device basics	4.40; 1.15	1.00–5.00	4.65; 0.85	3.95; 1.47	230.50 (.037*)
2. Communication	4.07; 1.45	1.00–5.00	4.24; 1.30	3.76; 1.67	275.50 (.322)
3. Data and file storage	3.04; 1.81	1.00–5.00	3.41; 1.78	2.37; 1.71	210.00 (.026*)
4. Internet	4.10; 1.45	1.00–5.00	4.25; 1.34	3.84; 1.64	283.50 (.396)
5. Calendar	3.44; 1.79	1.00–5.00	3.93; 1.59	2.58; 1.84	197.50 (.013*)
6. Entertainment	3.44; 1.30	1.00–5.00	3.38; 1.39	3.55; 1.14	305.50 (.740)
7. Privacy	3.41; 1.49	1.50–5.00	3.75; 1.45	2.79; 1.40	203.50 (.022*)
8. Troubleshooting and software management	3.34; 1.66	1.00–5.00	3.68; 1.67	2.74; 1.52	206.50 (.024*)

Note. HHC = hearing health care.

*$p < .05$.

the CPQ-12 was also excellent (Cronbach's $\alpha = .93$), with the reliability of the six domains ranging from .84 to .97. Correlation analyses between uptake of HHC services and potential predictor variables were conducted to inform the inclusion of independent variables for the exact logistic regression to determine possible predictors for persons who continued with HHC.

The following statistically significant correlations were found between CPQ-12 and MDPQ-16 (corr = .74, $p < .001$), between readiness and stages of change (corr = .60, $p < .001$), and between better ear PTA and SRT (corr = .75, $p < .001$). Thus, CPQ-12, readiness, and better ear PTA were excluded from the model since the correlations were moderate to strong (corr = .6 and higher; Akoglu, 2018). It should be noted that the correlation between years aware of hearing loss and the stages of change was statistically significant, albeit only moderate (corr = .33, $p < .001$). Years aware of hearing loss was initially included in the model; however, since it did not contribute significantly to the model ($p = .053$), it was excluded from the final model.

MDPQ-16 was chosen for the regression model as the majority of patients (84.91%) completed the online hearing screening test from a mobile phone rather than a computer. The exact logistic regression included the MDPQ-16, SRT, gender, age, and stages of change as predictor variables. Only age was a significant predictor for those continuing with a hybrid HHC model, $\beta = 0.072$ (parameter estimate) with 95% CI [0.01, 0.144] and $OR = 1.075$ with 95% CI [1.011, 1.155], both with $p = .018$. Older people were more likely to continue with HHC. The odds ratios for age were 1.075, indicating that for every year a person gets older, they are 1.08 times more likely to continue with a hybrid HHC model, with $R^2 = .275$, accounting for 27.5% variance (see Table 5).

A positive, strong ($r^2 = .69$) correlation between age and the MDPQ-16 indicated that patients who continued with HHC are older and scored poorer (see Figure 2a). Whereas between CPQ-12 and age, a positive moderate ($r^2 = .40$) correlation is reported for the group who continued with HHC (see Figure 2b). Total group scores indicate a positive moderate ($r^2 = .40$, $p < .001$) correlation

Table 4. Mean and standard deviation for computer proficiency measurement using the Computer Proficiency Questionnaire (CPQ-12) of all patients who completed Steps 3, 4, and 5.

CPQ-12	Step 3 Total group, *n* = 53 (*M*; SD)	Range (min–max)	Step 4 Discontinued HHC, *n* = 34 (*M*; *SD*)	Step 5 Continued HHC, *n* = 19 (*M*; *SD*)	Mann–Whitney (*p* value)
CPQ-12 total:	23.86; 7.30	6.00–30.00	25.31; 7.73	21.90; 9.60	230.50 (.085)
1. Computer basics	4.55; 1.10	1.00–5.00	4.62; 0.99	4.42; 1.31	316.00 (.793)
2. Printer	4.00; 1.54	1.00–5.00	4.18; 1.42	3.68; 1.73	287.50 (.445)
3. Communication	4.47; 1.25	1.00–5.00	4.62; 1.02	4.21; 1.59	305.00 (.574)
4. Internet	4.21; 1.29	1.00–5.00	4.32; 1.12	4.00; 1.56	304.50 (.714)
5. Calendar	3.36; 1.81	1.00–5.00	3.77; 1.69	2.63; 1.83	209.50 (.025*)
6. Entertainment	3.50; 1.57	1.00–5.00	3.81; 1.5	2.95; 1.59	217.00 (.040*)

Note. HHC = hearing health care.

*$p < .05$.

Table 5. Results of exact logistic regression identifying predictors of taking up hearing health care services with a hybrid online and face-to-face model (n = 53).

Factor	Exact parameter estimates	*OR* (95% CI)	Two-sided *p* value
MDPQ-16	0.013	1.01 [0.94, 1.10]	.769
SRT	0.09	1.09 [0.98, 1.24]	.109
Gender (male benchmarked against female)	0.068	1.07 [0.24, 5.48]	1
Age	0.072	1.08 [1.01, 1.16]	.018*
Stages of change (action benchmarked against precontemplation, contemplation and preparation)	0.357	1.43 [0.32, 6.48]	.827

Note. CI = confidence interval; MDPQ-16 = Mobile Device Proficiency Questionnaire; SRT = speech reception threshold; CPQ-12 = Computer Proficiency Questionnaire.

*$p < .05$.

between age and MDPQ-16 and a positive weak correlation (r^2 = .22, p = .009) between age and CPQ-12.

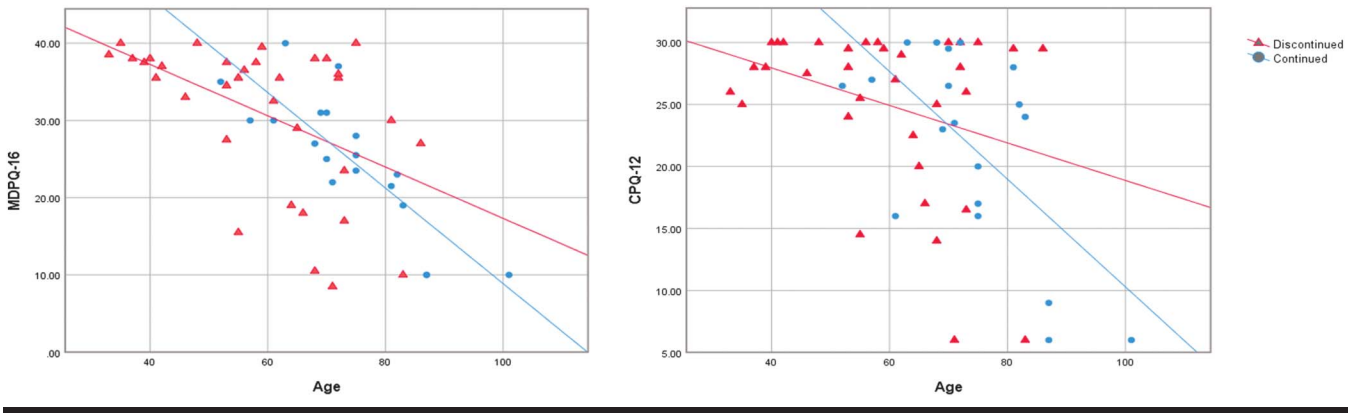
Discussion

This study characterized self-perceived mobile device and computer proficiency of 53 adults with hearing loss who took up hearing services through an online and face-to-face model. In this study, average proficiency scores for mobile device and computer use were 28.83 (*SD* = 9.63) out of 40 (MDPQ-16) and 23.86 (*SD* = 7.30) out of 30 (CPQ-12), respectively. Only age was significantly associated with uptake of hearing services, with older subjects being more likely, using a hybrid online and face-to-face service.

There is a dearth of research on mobile proficiency with summarized results (see Table 1) in adults with hearing loss showing that, apart from one study, all computer skills and Internet research used nonvalidated measures. Younger people typically score higher on digital proficiency measures. Our study showed higher mobile proficiency compared to other studies of adults without hearing impairment (Moret-Tatay et al., 2019; Roque & Boot, 2018). However, computer literacy in this study is slightly lower than for adults with significant computer experience, where older adults were less computer proficient (Boot et al., 2015). Computer proficiency scores in this study (CPQ-12 = 23.86, *SD* = 7.30) compared well with a group of persons with significant computer experience (CPQ-12 = 25.67, *SD* = 3.84) from the general public (Boot et al., 2015). Although people might not be proficient with complex tasks, they may be able to access online health care by completing the online hearing screening test without difficulty or asked for assistance. People with hearing loss may have a better computer and mobile device proficiency than the general population (Gonsalves & Pichora-Fuller, 2008; Thorén et al., 2013) due to the visual nature of online communication being less reliant on hearing. However, since this study used purposive sampling, which targeted adults with hearing loss who were accessing information online, comparison with studies that used random sampling should be made with caution, as the respondents were all Internet users.

Gonsalves and Pichora-Fuller (2008) reported that people with hearing impairment without a hearing aid used the Internet and e-mail significantly less than those with hearing aids. The non–hearing aid users also appeared to use the computer, fax, and ATM less than those with

Figure 2. Relationship between (a) age and the Mobile Device Proficiency Questionnaire (MDPQ-16) and (b) age and the Computer Proficiency Questionnaire (CPQ-12) for patients who discontinued and continued hearing health care.



normal hearing and those using hearing aids. In comparison, a more recent study reported that technology use did not vary from people who did not own or wear their hearing aids versus those who did after controlling for age, gender, and living arrangement (Ham et al., 2014). Results from this study further support that the findings that digital proficiency does not affect the uptake of HHC services when combining online and face-to-face services. This study is the first to assess digital proficiency of patients in a combined online and face-to-face HHC model as compared to previous studies that used a traditional face-to-face model. A large percentage of patients (67.39%) in the hybrid model presented here took up hearing services by completing a diagnostic hearing evaluation but then discontinued care by not opting for hearing aids and support services (Ratanjee-Vanmali et al., 2020).

Even though in this study, self-perceived digital proficiency decreased as the age of respondents increased, mobile device and computer proficiency were not associated with the uptake of hearing services through a hybrid of online and face-to-face services. However, age was associated with the uptake of hybrid HHC services, with older patients more likely to continue with HHC. A previous study (Ham et al., 2014) reported that older adults and being female were associated with decreased technology use.

Even though the patients initiated HHC by completing the first step of the online hearing screening test, the majority (84.91%) from a mobile device, this patient group was already aware of their hearing difficulties and capable of using the Internet from their mobile devices. Therefore, providers need to be cognizant when developing their online content to ensure that it employs a responsive design for positive mobile phone user experiences (Ratanjee-Vanmali et al., 2019).

The rapid increase in connectivity and mobile device usage has made online hearing screening very accessible (De Sousa et al., 2018). This study suggests that the older the patient, the more likely they will continue with HHC, even though their self-perceived digital skills (mobile and computer proficiency) may be lower. Lower proficiency did not prevent older adults from seeking and continuing HHC in a hybrid hearing care service, in which the first step entailed an online hearing screening test. Digital literacy is, therefore, not necessarily a hindrance to the uptake of online services. Providing good design and usability can go a long way toward increasing the accessibility of mobile HHC services (Covery et al., 2019). Since patients in this sample sought HHC with the first step of an online hearing screening test, their level of digital proficiency was not associated with the uptake of hearing services, which suggest that online options for HHC may be important avenues for adults with hearing loss.

This study is the first report on self-perceived mobile device proficiency in people with hearing loss. Logistic regression was used to control for the effect of covariates on the relationship between digital proficiency and the uptake of hearing services using a hybrid model of online and face-to-face methods. The small sample size provided less statistical power to the analyses, but an exact regression model was utilized to account for confounding variables.

The sample is not representative of the general population as it sampled patients who used online methods to access HHC. However, digital proficiency levels in this group did not influence the uptake of hearing services through a combination of online and face-to-face methods. Adult patients with lower mobile and computer proficiency may have had the support/assistance from a significant other to acquire hearing aids and support services from a hybrid service delivery model. The exact regression model could have been strengthened by including other factors associated with hearing aid adoption, such as severity of hearing loss (measured or perceived), self-reported activity limitations or participation restrictions, perceived benefits and barriers to hearing aid adoption, and support from significant others (Meyer & Hickson, 2012).

Conclusions

Self-perceived digital proficiency, or the ability to use mobile devices and computers, was not a predictor for acquiring hearing aids and support through an online and face-to-face (hybrid) HHC model. Age was the only factor predicting uptake of online and face-to-face HHC services, with older patients being more likely to continue with HHC. With the availability of carefully designed eHealth tools to supplement current service delivery models, digital proficiency may not be vital for the uptake of such services. Hybrid services encourage hearing care professionals to assist patients in face-to-face modalities in combination with online services. Treatment plans can be tailored to meet the individual needs of the patient, thereby delivering convenient, personalized, and patient-centered care by utilizing a hybrid service delivery offering.

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References

Akoglu, H. (2018). User's guide to correlation coefficients. *Turkish Journal of Emergency Medicine, 18*(3), 91–93. https://doi.org/10.1016/j.tjem.2018.08.001

Boot, W. R., Charness, N., Czaja, S. J., Sharit, J., Rogers, W. A., Fisk, A. D., Mitzner, T., Lee, C., & Nair, S. (2015). Computer Proficiency Questionnaire: Assessing low and high computer proficient seniors. *The Gerontologist, 55*(3), 404–411. https://doi.org/10.1093/geront/gnt117

Covery, E., Keidser, G., McLelland, M., & Groth, G. (2019). A smartphone app to facilitate remote patient–provider communication in hearing health care: Usability and effect on hearing aid outcomes. *Telemedicine and e-Health*. https://doi.org/10.1089/tmj.2019.0109

Cytron-Hysom, T., Hadley, K., Vanek, J., Graif, M., & Asp, J. (2012, March 14). *Assessing and building digital literacy skills for low-skilled adults: A practical approach* [Online presentation]. Retrieved from https://digitalcommons.macalester.edu/libtech_conf/2012/sessions/75/

Davis, A., Smith, P., Ferguson, M., Stephens, D., & Gianopoulos, I. (2007). Acceptability, benefit and costs of early screening for hearing disability: A study of potential screening tests and models. *Health Technology Assessment, 11*(42), 1–294. https://doi.org/10.3310/hta11420

De Sousa, K. C., Swanepoel, D. W., Moore, D. R., & Smits, C. (2018). A smartphone national hearing test: Performance and characteristics of users. *American Journal of Audiology, 27*(3S), 448–454. https://doi.org/10.1044/2018_AJA-IMIA3-18-0016

Ferguson, M., & Henshaw, H. (2015). Computer and Internet interventions to optimize listening and learning for people with hearing loss: Accessibility, use and adherence. *American Journal of Audiology, 24*(3), 338–343. https://doi.org/10.1044/2015_AJA-14-0090

Ferguson, M., Woolley, A., & Munro, K. J. (2016). The impact of self-efficacy, expectations, and readiness on hearing aid outcomes. *International Journal of Audiology, 55*(Suppl. 3), S34-S41. https://doi.org/10.1044/2015_AJA-14-0090

Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). SAGE.

Gonsalves, C., & Pichora-Fuller, M. K. (2008). The effect of hearing loss and hearing aids on the use of information and communication technologies by community-living older adults. *Canadian Journal on Aging/La Revue Canadienne Du Vieillissement, 27*(2), 145–157. https://doi.org/10.3138/cja.27.2.145

Greenwell, K., Featherstone, D., & Hoare, D. (2015). The application of intervention coding methodology to describe the tinnitus e-programme, an Internet-delivered self-help intervention for tinnitus. *American Journal of Audiology, 24*(3), 311–315. https://doi.org/10.1044/2015_AJA-14-0089

Ham, H. S., Bunn, P., Meyer, C., Khan, A., & Hickson, L. (2014). Exploring the relationship between technology use, hearing help-seeking, and hearing aid outcomes in older adults. *International Journal of Audiology, 53*(Suppl. 1), S38–S42. https://doi.org/10.3109/14992027.2013.847287

hearX Group (Pty) Ltd. (2020). [Homepage]. http://www.hearxgroup.com

Henshaw, H., Clark, D. P. A., Kang, S., & Ferguson, M. A. (2012). Computer skills and Internet use in adults aged 50–74 years: Influence of hearing difficulties. *Journal of Medical Internet Research, 14*(4). https://doi.org/10.2196/jmir.2036

Interacoustics A/S. (2019). Middelfart, Denmark. https://www.interacoustics.com

Klyn, N. A. M., Shaikh, Z. M., & Dhar, S. (2020). Health literacy and self-reported hearing aid use in the health and retirement study. *Ear and Hearing, 41*(2), 386–394. https://doi.org/10.1097/AUD.0000000000000770

Knudsen, L. V., Öberg, M., Nielsen, C., Naylor, G., & Kramer, S. E. (2010). Factors influencing help seeking, hearing aid uptake, hearing aid use and satisfaction with hearing aids: A review of the literature. *Trends in Amplification, 14*(3), 127–154. https://doi.org/10.1177/1084713810385712

Laplante-Lévesque, A., Brännström, K. J., Ingo, E., Andersson, G., & Lunner, T. (2015). Stages of change in adults who have failed an online hearing screening. *Ear and Hearing, 36*(1), 92–101. https://doi.org/10.1097/AUD.0000000000000085

Laplante-Lévesque, A., Hickson, L., & Worrall, L. (2013). Stages of change in adults with acquired hearing impairment seeking help for the first time: Application of the transtheoretical model in audiologic rehabilitation. *Ear and Hearing, 34*(4), 447–457. https://doi.org/10.1097/AUD.0b013e3182772c49

Maidment, D., Brassington, W., Wharrad, H., & Ferguson, M. (2016). Internet competency predicts practical hearing aid knowledge and skills in first-time hearing aid users. *American Journal of Audiology, 25*(3S), 303–307. https://doi.org/10.1044/2016_AJA-16-0022

Meyer, C., & Hickson, L. (2012). What factors influence help-seeking for hearing impairment and hearing aid adoption in older adults. *International Journal of Audiology, 51*(2), 66–74. https://doi.org/10.3109/14992027.2011.611178

Meyer, C., Hickson, L., & Fletcher, A. (2014). Identifying the barriers and facilitators to optimal hearing aid self-efficacy. *International Journal of Audiology, 53*(Suppl. 1), S28–S37. https://doi.org/10.3109/14992027.2013.832420

Milstein, D., & Weinstein, B. E. (2002). Effects of information sharing on follow-up after screening for older adults. *Journal of the Academy of Rehabilitative Audiology, 35,* 43–58.

Moore, A. N., Rothpletz, A. M., & Preminger, J. E. (2015). The effect of chronological age on the acceptance of Internet-based hearing health care. *American Journal of Audiology, 24*(3), 280–283. https://doi.org/10.1044/2015_AJA-14-0082

Moret-Tatay, C., Beneyto-Arrojo, M. J., Gutierrez, E., Boot, W. R., & Charness, N. (2019). A Spanish adaptation of the computer and mobile device proficiency questionnaires (CPQ and MDPQ) for older adults. *Frontiers in Psychology, 10,* 1165. https://doi.org/10.3389/fpsyg.2019.01165

Ng, J., & Loke, A. (2015). Determinants of hearing-aid adoption and use among the elderly: A systematic review. *International Journal of Audiology, 54*(5), 291–300. https://doi.org/10.3109/14992027.2014.966922

Or, K. L. (2008). *Development of a model of consumer heath information technology acceptance of patients with chronic illness* (Doctoral dissertation). Retrieved from the ProQuest Dissertations and Theses database. (UMI No. 3348754)

Paglialonga, A., Nielsen, A. C., Ingo, E., Barr, C., & Laplante-Lévesque. (2018). eHealth and the hearing aid adult patient journey: A state-of-the-art review. *BioMedical Engineering Online, 17*(101), 1–26. https://doi.org/10.1186/s12938-018-0531-3

Potgieter, J.-M., Swanepoel, D. W., Myburgh, H. C., Hopper, T. C., & Smits, C. (2016). Development and validation of a smartphone-based digits-in-noise hearing test in South African English. *International Journal of Audiology, 55*(7), 405–411. https://doi.org/10.3109/14992027.2016.1172269

Potgieter, J. M., Swanepoel, D. W., Myburgh, H. C., & Smits, C. (2018). The South African English smartphone digits-in-noise hearing test: Effect of age, hearing loss and speaking competence. *Ear and Hearing, 39*(4), 656–663. https://doi.org/10.1097/AUD.0000000000000522

Prochaska, J. O., DiClemente, C. C., & Norcross, J. C. (1992). In search of how people change: Applications to addictive behaviors. *American Psychologist, 47*(9), 1102–1114. https://doi.org/10.1037/0003-066X.47.9.1102

Pronk, M., Deeg, D. J., Versfeld, N. J., Heymans, M. W., Naylor, G., & Kramer, S. E. (2017). Predictors of entering a hearing aid evaluation period: A prospective study in older hearing-help seekers. *Trends in Hearing, 21,* 2331216517744915. https://doi.org/10.1177/2331216517744915

Ratanjee-Vanmali, H., Swanepoel, D. W., & Laplante-Lévesque, A. (2019). Characteristics, behaviors and readiness of persons seeking hearing healthcare online. *International Journal of Audiology, 58*(2), 107–115. https://doi.org/10.1080/14992027.2018.1516895

Ratanjee-Vanmali, H., Swanepoel, D. W., & Laplante-Lévesque, A. (2020). Patient uptake, experience and satisfaction using online and face-to-face hearing health services. *Journal of Medical Internet Research, 22*(3), e15875. https://doi.org/10.2196/15875

Rollnick, S., Mason, P., & Butler, C. (1999). *Health behavior change: A guide to practitioners*. Churchill Livingstone.

Roque, N. A., & Boot, W. R. (2018). A new tool for assessing mobile device proficiency in older adults: The Mobile Device Proficiency Questionnaire. *Journal of Applied Gerontology, 37*(2), 131–156. https://doi.org/10.1177/0733464816642582

SAS Version 9.4. (2020). [Computer software]. SAS Institute, Inc.

Saunders, G. H., Frederick, M. T., Silverman, S. C., Nielsen, C., & Laplante-Lévesque, A. (2016) Health behavior theories as predictors of hearing-aid uptake and outcomes. *International Journal of Audiology, 55*(Suppl. 3), S59–S68. https://doi.org/10.3109/14992027.2016.1144240

Simpson, A. N., Matthews, L. J., Cassarly, C., & Dubno, J. R. (2019). Time from hearing aid candidacy to hearing aid adoption: A longitudinal cohort study. *Ear and Hearing, 40*(3), 468–476. https://doi.org/10.1097/AUD.0000000000000641

SPSS Version 25. (2015). [Computer software]. SPSS, Inc.

Tennant, B., Stellefson, M., Dodd, V., Chaney, B., Chaney, D., Paige, S., & Alber, J. (2015). eHealth literacy and web 2.0 health information seeking behaviors among baby boomers and older adults. *Journal of Medical Internet Research, 17*(3), e70. https://doi.org/10.2196/jmir.3992

Thorén, E. S., Öberg, M., Wänström, G., Andersson, G., & Lunner, T. (2015). Internet interventions for hearing loss. *American Journal of Audiology, 24*(3), 316–319. https://doi.org/10.1044/2015_AJA-15-0009

Thorén, E. S., Öberg, M., Wänström, G., Andersson, G., & Lunner, T. (2013). Internet access and use in adults with hearing loss. *Journal of Medical Internet Research, 15*(5), e91. https://doi.org/10.2196/jmir.2221

Tønnesen, H. (2012). *Engage in the process of change: Facts and methods*. Bispebjerg University Hospital.

Qualtrics.XM. (2020). [Homepage]. https://www.qualtrics.com/uk/?rid=ip&prevsite=en&newsite=uk&geo=ZA&geomatch=uk

Vroman, K. G., Arthanat, S., & Lysack, C. (2015). "Who over 65 is online?" Older adults' dispositions toward information communication technology. *Computers in Human Behavior, 43,* 156–166. https://doi.org/10.1016/j.chb.2014.10.018

Mobile Device Proficiency Questionnaire (MDPQ-16)

About the MDPQ

This questionnaire asks about your ability to perform a number of tasks with a **mobile device**.

What is a Mobile Device?

A mobile device is a device that allows you to perform many of the same tasks as a standard computer but without the use of a physical keyboard and mouse. Instead, these devices use a touchscreen as their interface between the user and computer programs (called Apps – short for applications).

Mobile devices come in many sizes. Depicted above are two different sized tablets, as well as a smartphone. These are the types of devices we are interested in.

ROQUE, N. & BOOT, W.R. (2018). A NEW TOOL FOR ASSESSING MOBILE DEVICE PROFICIENCY IN OLDER ADULTS: THE MOBILE DEVICE PROFICIENCY QUESTIONNAIRE (MDPQ). JOURNAL OF APPLIED GERONTOLOGY, 37(2), 131-156. https://doi.org/10.1177/0733464816642582.

Please answer each question by placing an X in the box that is most appropriate.

If you have not tried to perform a task with a mobile device or do not know what a task is, please mark "NEVER TRIED", regardless of whether or not you think you may be able to perform the task. **Remember, you are rating your ability to perform each of these tasks specifically using a mobile device (tablet or smartphone).**

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1. Mobile Device Basics

Using a mobile device I can:	**Never tried (1)**	**Not at all (2)**	**Not very easily (3)**	**Somewhat easily (4)**	**Very easily (5)**
a. Navigate onscreen menus using the touchscreen					
b. Use the onscreen keyboard to type					

2. Communication

Using a mobile device I can:	**Never tried (1)**	**Not at all (2)**	**Not very easily (3)**	**Somewhat easily (4)**	**Very easily (5)**
a. Send emails					
b. Send pictures by email					

ROQUE, N. & BOOT, W.R. (2018). A NEW TOOL FOR ASSESSING MOBILE DEVICE PROFICIENCY IN OLDER ADULTS: THE MOBILE DEVICE PROFICIENCY QUESTIONNAIRE (MDPQ). JOURNAL OF APPLIED GERONTOLOGY, 37(2), 131-156. https://doi.org/10.1177/0733464816642582.

3. Data and File Storage

Using a mobile device I can:	Never tried (1)	Not at all (2)	Not very easily (3)	Somewhat easily (4)	Very easily (5)
a. Transfer information (files such as music, pictures, documents) on my mobile device *to* my computer					
b. Transfer information (files such as music, pictures, documents) on my computer *to* my mobile device					

4. Internet

Using a mobile device I can:	Never tried (1)	Not at all (2)	Not very easily (3)	Somewhat easily (4)	Very easily (5)
a. Find information about my hobbies and interests on the Internet					
b. Find health information on the Internet					

ROQUE, N. & BOOT, W.R. (2018). A NEW TOOL FOR ASSESSING MOBILE DEVICE PROFICIENCY IN OLDER ADULTS: THE MOBILE DEVICE PROFICIENCY QUESTIONNAIRE (MDPQ). JOURNAL OF APPLIED GERONTOLOGY, 37(2), 131-156. https://doi.org/10.1177/0733464816642582.

5. Calendar

Using a mobile device I can:	Never tried (1)	Not at all (2)	Not very easily (3)	Somewhat easily (4)	Very easily (5)
a. Enter events and appointments into a calendar					
b. Check the date and time of upcoming and prior appointments					

6. Entertainment

Using a mobile device I can:	Never tried (1)	Not at all (2)	Not very easily (3)	Somewhat easily (4)	Very easily (5)
a. Use the device's online "store" to find games and other forms of entertainment (e.g. using Apple App Store or Google Play Store)					
b. Listen to music					

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7. Privacy

Using a mobile device I can:	Never tried (1)	Not at all (2)	Not very easily (3)	Somewhat easily (4)	Very easily (5)
a. Setup a password to lock/unlock the device					
b. Erase all Internet browsing history and temporary files					

8. Troubleshooting & Software Management

Using a mobile device I can:	Never tried (1)	Not at all (2)	Not very easily (3)	Somewhat easily (4)	Very easily (5)
a. Update games and other applications					
b. Delete games and other applications					

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COMPUTER PROFICIENCY QUESTIONNAIRE

Note: Questions that are retained in the short form of the CPQ (CPQ-12) are indicated with an asterisk

This questionnaire asks about your ability to perform a number of tasks with a computer. Please answer each question by placing an X in the box that is most appropriate. If you have not tried to perform a task or do not know what it is, please mark **"NEVER TRIED"**, regardless of whether or not you think you may be able to perform the task.

1. Computer Basics

I can:	Never tried$_1$	Not at all$_2$	Not very easily$_3$	Somewhat easily$_4$	Very easily$_5$
a. Turn a computer on and off					
b. Use a computer keyboard to type *					
c. Use a trackball					
d. Use a mouse *					
e. Adjust the volume of the computer speakers					
f. Adjust size of the text on screen					

2. Printer

I can:	Never tried$_1$	Not at all$_2$	Not very easily$_3$	Somewhat easily$_4$	Very easily$_5$
a. Print documents					
b. Print photographs					
c. Load paper into the printer					
d. Load ink into the printer *					
e. Fix the printer when paper jams *					

3. Communication

I can:	Never tried$_1$	Not at all$_2$	Not very easily$_3$	Somewhat easily$_4$	Very easily$_5$
a. Open emails *					
b. Send emails *					
c. Send the same email to multiple people at the same time					
d. Store email addresses in an email address book or contact list					
e. View pictures sent by email					
f. Send pictures by email					
g. Chat using Internet chat rooms					
h. Chat using instant messaging					
i. Post messages to the Internet (e.g., to blogs, Facebook, Twitter, online forums)					

4. Internet

I can:	Never tried$_1$	Not at all$_2$	Not very easily$_3$	Somewhat easily$_4$	Very easily$_5$
a. Use search engines (e.g., Google)					
b. Find information about local community resources on the Internet *					
c. Find information about my hobbies and interests on the Internet *					
d. Read the news on the Internet					

I can:	Never tried$_1$	Not at all$_2$	Not very easily$_3$	Somewhat easily$_4$	Very easily$_5$
e. Make purchases on the Internet					
f. Bookmark websites to find them again later (e.g., make favorites)					
g. Save text and images I find on the Internet					

5. Calendar

I can:	Never tried$_1$	Not at all$_2$	Not very easily$_3$	Somewhat easily$_4$	Very easily$_5$
a. Use a computer to enter events and appointments into a calendar *					
b. Check the date and time of upcoming and prior appointments *					
c. Set up alerts to remind me of events and appointments					

6. Entertainment

I can:	Never tried$_1$	Not at all$_2$	Not very easily$_3$	Somewhat easily$_4$	Very easily$_5$
a. Use a computer to play games					
b. Use a computer to watch movies and videos *					
c. Use a computer to listen to music *					