INTERNATIONAL JOURNAL OF AUDIOLOGY
2019, VOL. 58, NO. 2, 107–115
https://doi.org/10.1080/14992027.2018.1516895

The British Society of Audiology
The International Society of Audiology
NAS NORDIC AUDIOLOGICAL SOCIETY
Taylor & Francis
Taylor & Francis Group

ORIGINAL ARTICLE

Characteristics, behaviours and readiness of persons seeking hearing healthcare online

Husmita Ratanjee-Vanmali[a,b], De Wet Swanepoel[a,c,d] and Ariane Laplante-Lévesque[e,f]

[a]Department of Speech-Language Pathology and Audiology, University of Pretoria, Pretoria, South Africa; [b]Hearing Research Clinic Non-Profit Company, Durban, South Africa; [c]Ear Sciences Centre, The University of Western Australia, Nedlands, Australia; [d]Ear Science Institute Australia, Subiaco, Australia; [e]Oticon Medical, Oticon A/S, Copenhagen, Denmark; [f]Department of Behavioral Sciences and Learning, Linköping University, Linköping, Sweden

ABSTRACT

Objective: This study describes characteristics, behaviours and readiness of people who are interested in seeking hearing healthcare (HHC) online.

Design: A non-profit clinic was established from which services through a virtual clinic are offered. Most of the patient–audiologist interactions are conducted online. We used online means to invite individuals to take a free online digit-in-noise (DIN) test. Upon failing the test, individuals reported their readiness to seek HHC by using two tools: the line and the staging algorithm.

Study sample: Individuals ≥18 years of age, within the greater Durban area, South Africa, were eligible to participate in the study.

Results: A total of 462 individuals completed the online DIN test during the first 3 months. Of those, 58.66% (271/462) failed the test and 11.04% (51/462) submitted their details for further contact from the clinic audiologist. Five individuals proceeded to a comprehensive hearing evaluation and hearing aid trial: all those individuals showed readiness to seek further HHC on the measurement tools. These individuals have reported knowing of their hearing challenges prior to taking the test and have waited for a period of between 5 and 16 years before seeking HHC. A significant association between age and DIN test result was found.

Conclusion: This explorative study is the first clinic to utilise digital tools across the entire patient journey in combination with face-to-face interactions in providing HHC. Internet-connected devices provide an opportunity for individuals to seek HHC and for providers to offer initial services to detect, counsel and support persons through the initial engagement process of seeking HHC. This may open up new audiology patient pathways through online hearing screening, assessment of readiness to seek further HHC and enhancement of service delivery using hybrid services by combining online and face-to-face modes of synchronous and asynchronous communication.

ARTICLE HISTORY

Received 26 January 2018
Accepted 22 August 2018

KEYWORDS

Online hearing healthcare; patient information; digit-in-noise test; hearing screening; hearing status; patient pathways; mHealth; eHealth; teleaudiology; South Africa

Introduction

According to the World Health Organization (WHO), 466 million people, or over 5% of the world's population, live with disabling hearing loss (WHO 2017). Prevalence of hearing loss varies significantly across the world and is higher in sub-Saharan Africa, South Asia and Asia Pacific than in other parts of the world (WHO 2017). With an ageing world population and with hearing loss being more prevalent in older age, hearing healthcare (HHC) needs will grow (Mulwafu et al. 2017).

Hearing loss has become a global health concern (Wilson et al. 2017). In 2010, hearing loss accounted for the 11th leading cause of years lived with disability (YLD), which then rose to the 4th leading cause in 2013 and 2015 (Wilson et al. 2017). The WHO estimates an annual global cost of 750 billion international dollars for unaddressed hearing loss including costs associated with the health sector, educational support, loss of productivity and societal costs (WHO 2017).

Without appropriate diagnosis and intervention, hearing loss has severe consequences on quality of life, loss of autonomy, impaired driving ability, mental health, societal integration and participation (Arlinger 2003; Davis et al. 2016). Untreated hearing loss is often associated with various negative health conditions like depression, isolation and dementia in adults aged ≥65 years (Livingston et al. 2017). The HHC could contribute to the prevention or delay of dementia, with one-third of dementia cases being preventable (Livingston et al. 2017).

Help-seeking for hearing loss is often delayed, taking an individual on average between 7 and 10 years from the time that hearing difficulties are first noticed to further investigation (Davis et al. 2007; Hickson et al 2014; Meyer et al 2014). On average, initial hearing aids are fitted at 74 years of age (Henshaw et al. 2012). The delay in seeking HHC is often due to the negative association of hearing loss with ageing, cognitive impairment, stigmatisation, embarrassment, loneliness, restricted employment options (Mulwafu, Kuper, and Ensink 2016; Wilson et al. 2017)

CONTACT Husmita Ratanjee-Vanmali husmita.r@gmail.com; husmita@hearingresearchclinic.org Department of Speech-Language Pathology and Audiology, University of Pretoria, Pretoria 002, South Africa

This article has been republished with minor changes. These changes do not impact the academic content of the article.

and partly attributed to limited accessibility and affordability of care (Swanepoel, Olusanya, and Mars 2010). Access to HHC for many individuals is scarce and awareness of hearing loss is low (WHO 2013: Lin, Hazzard, and Blazer 2016). Other barriers to access and affordability of services are due to limited accessibility to HHC solutions, high out-of-pocket costs with current treatment models and limitations of currently available hearing device technologies (Clark and Swanepoel 2014; Lin et al. 2016).

Human resources for ear and hearing care are unequally distributed in the world, with a higher concentration of HHC professionals in high- and upper-middle-income countries (WHO 2013). In low- to middle-income countries, the shortage of HHC professionals to the large population requiring services is well documented (Fagan and Jacobs 2009; Mulwafu et al. 2017). However, higher income countries like those in Europe also face a shortage of healthcare professionals which is mostly due to retirement rates surpassing recruitment rates (Lapão and Dussault 2017). A significant increase in the number of trained professionals is, however, unlikely, as training programmes are costly and on average take 2 to 4 years to complete (Clark and Swanepoel 2014).

Technological innovations could also improve access to HHC and the automation of specific tasks (Clark and Swanepoel 2014). Innovative HHC service delivery through eHealth and community health workers are needed to improve access and to complement current service delivery models (Lin et al. 2016). Service delivery supported by eHealth could be part of the solution as connectivity can facilitate better access to HHC professionals and services. Mobile phones are becoming more affordable. By the end of 2016, two-thirds of the world had a mobile subscription (Global System for Mobile Communications Association (GSMA) 2017). In 2020, it is projected that three-quarters of the population will subscribe to mobile services, with penetration rates of up to 50% in sub-Saharan Africa and 87% in Europe (GSMA 2017). With the promise of more people around the world being connected, this presents the opportunity to use this connectedness for global sustainability initiatives.

Telephone-based hearing screening tests have been tested in approximately 10 countries, including the Netherlands, United Kingdom and Australia (Smits, Kapteyn, and Houtgast 2004; Smits, Merkus, and Houtgast 2006; Stenfelt et al. 2011; Dillon et al. 2016). This adaptive test presents three digits in noise (DIN) and the listener has to recognise 50% of the digits correctly (Potgieter et al. 2018). In areas like sub-Saharan Africa where telephone landline penetration is poor, a self-administered hearing screening test available on a mobile device increases accessibility to HHC services (Potgieter et al. 2018). A South African household survey reported 87% of households had access to at least one mobile device, while 9.4% of households had access to both landlines and a cellular device, with only 0.1% of households solely having a landline connection (Statistics South Africa 2016a).

Earlier research successfully used electronic mail (email) communication between audiologists and patients as a tool to help first-time hearing aid users through the personal adjustment process (Laplante-Lévesque, Pichora-Fuller, and Gagné 2006). More recent research points to the successful use of Internet-based support systems for hearing aid users as an aural rehabilitation tool (Thorén et al. 2014; Brännström et al. 2016) as well as offering Internet-based cognitive behavioural therapy interventions for patients with tinnitus (Beukes et al. 2016). Computers and Internet delivery of hearing screening, information and intervention have been reported as a feasible method of dissemination to adults with hearing loss between the ages of 50 and 74 years (Henshaw et al. 2012). The increase in mobile penetration globally holds promise that more individuals will have access to the Internet, which may increase accessibility to HHC services. Therefore, this study aimed to target the $\geq$40 year age group in the light of the increased accessibility and feasibility to dissemination knowledge to individuals with hearing loss.

The challenges described above include the rise of hearing loss globally, the consequences of untreated hearing loss in terms of costs, the association to detrimental health conditions as well as the poor audiologist to patient ratio. It is therefore imperative that identification and treatment of hearing loss be addressed more proactively. This study aims to describe the characteristics, behaviours and readiness of individuals who seek HHC online through a virtual clinic offering using a sample from the greater Durban metropolitan area, South Africa. A secondary objective was to describe considerations in the virtual audiology clinic set-up and processes.

Methods

This is an exploratory project, describing online hearing health seeking characteristics, behaviours and readiness of persons who seek HHC through a virtual eHealth research clinic in South Africa. The University of Pretoria Faculty Of Humanities Research Ethics Committee approved the research (GW20170409HS).

A description of the virtual audiology clinic

A non-profit entity, *Hearing Research Clinic Non-Profit Company* (NPC) (http://hearingresearchclinic.org), was established in June 2017 in Durban, KwaZulu-Natal, South Africa. The greater Durban area (eThekwini) has a population of approximately 3.7 million people (Statistics South Africa 2016b). This is a virtual clinic: most of the patient–audiologist interactions are conducted online, with two face-to-face interactions in the patient's home or office, or a satellite site for the clinic. This face-to-face visit ensures any diagnostic red flags would be identified until a time that technology could possibly support this step with eHealth means. Patients pay for their services out-of-pocket and receive partial coverage from their private medical insurance if relevant. In South Africa, 17% of the population is covered by private medical insurance (Statistics South Africa 2016a). The clinic is a test bed to determine the viability of offering services through a hybrid model of face-to-face and online communication and services. The reason for the clinic being established as an NPC was to ensure that patients pay for the services they receive to avoid any confounding influence of receiving services free of charge.

The clinic aims to provide services throughout the patient journey, from the time of the first investigation of hearing challenges, through to hearing evaluation and treatment. We propose five steps using a hybrid eHealth model to support the patient along their journey to better hearing (Figure 1). This model uses both synchronous (real-time) and asynchronous (store-and-forward) modes of service delivery between the audiologist and patient. Asynchronous refers to data being collected and then sent via a network for later interpretation and usage (Krumm 2016).

As described above, the *Hearing Research Clinic Non-Profit Company* advertises its services through online presence and word of mouth. The clinic website was launched on 23rd June 2017 and has a responsive design to accommodate different devices. The quality of information presented on websites as well as attention to design, layout and readability is paramount for successful engagement and to ensure that the written

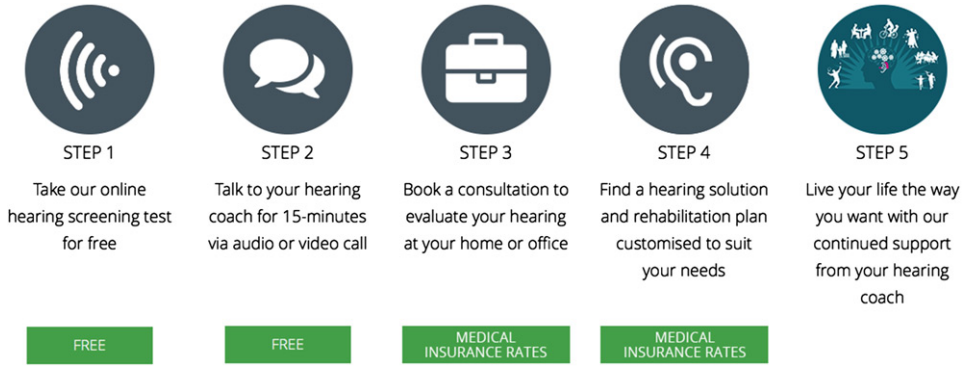

Figure 1. Five steps in the patient journey, using synchronous (real-time) and asynchronous (store-and-forward) modes of service delivery website.

information provided does not exceed the literacy levels of online hearing health seekers (Laplante-Lévesque et al. 2012; Laplante-Lévesque and Thorén 2015).

Therefore, the following five considerations were taken into account for the design and content of the website: (1) short sentences with limited text were used to ease readability; on average a, Flesch–Kincaid Grade Level of 8.8 was achieved on the web pages, where below 9 is considered good; (2) large fonts; (3) upbeat tone of voice; (4) segmentation of the website information into five sections; and (5) pictures that represent the cultural diversity of South Africa.

Participants

Inclusion criteria for the study were to be of adult age (≥ 18 years), living within the greater Durban area, and have access to a mobile, tablet or computer with Internet or mobile data access. The study period covered the first three months of the launch of the clinic (23rd June–22nd September 2017).

Recruitment

Before Step 1 (Figure 1), persons in the greater Durban area were invited to visit the clinic website to take the online DIN test on the website. A Facebook page was created for the clinic. A link to the DIN test which is hosted on the clinic's website was promoted on the clinic's Facebook page. During the study period, online advertising through the social media platform Facebook was the primary method of recruitment. Online advertising was targeted to Facebook users in the age group of ≥40 years and within the geolocation of the greater Durban area. Information regarding the importance of seeking HHC was disseminated from the clinic's Facebook page utilising image adverts, articles, blogs and videos. These were used to capture the attention of the audience and promote the importance of knowing one's hearing status. Eight Facebook posts were targeted to the ≥40 years age group. The clinic also shared one press release when it was launched. An online eHealth news channel published the press release and shared the press release on their Facebook page which was later shared on the clinic's Facebook page. Other means of recruitment included one interview on a community radio station, promotion of the clinic website by the WhatsApp messaging platform to personal friends and family contacts and finally word of mouth.

Procedures

Figure 1 depicts the five steps of the patient flow. Each step is described regarding the type of data collected, data collection method (synchronous and asynchronous), as well as the process of both the clinic audiologist and the participant.

Step 1 – online screening

The completion of the online DIN test hosted on the clinic's website is Step 1 (Figure 1) of the patient flow. This step is conducted asynchronously. At the completion of the DIN test, a score is immediately displayed indicating whether hearing loss may or may not be present (pass/fail result). At this point, all individuals had the opportunity (by consent) to share their contact details (name, telephone number and email address) with the clinic audiologist to make contact. More information on the DIN screening test is provided below.

Step 2 – audio/video phone call

During Step 2 (Figure 1), the clinic audiologist emailed (asynchronous communication) the individual to suggest a time and date for a 15-min audio or video call (synchronous) to discuss their hearing concerns. Even if no response was obtained by email, all participants who supplied their details were followed up with an audio call. During the call, the clinic audiologist addressed the individual's hearing concerns and used readiness assessment tools (the line and the staging algorithm) to determine whether the individual was ready for Step 3. When a participant scored above 5 on the line rating scale from 0 to 10 (Rollnick, Mason, and Butler 1999; Tønnesen 2012) and the staging algorithm a score of 3 or 4 (Milstein and Weinstein 2002), a face-to-face visit for the comprehensive hearing evaluation was scheduled. Reasons from participants not willing to proceed to Step 3 are listed in Table 4.

Step 3 – hearing evaluation and hearing aid trial

Step 3 (Figure 1) consisted of a face-to-face (synchronous) appointment either at the participants' home or at the satellite clinic. At this point, the individual provided written informed consent to participate in this project. This face-to-face visit included an in-depth case history (including history of hearing challenges, period of time since first difficulty, symptoms and signs, medical history, exposure to noise and so on), a comprehensive hearing evaluation which included counselling, a discussion of treatment plan options and a two-week hearing aid trial period if the

participant wished to proceed. During the trial period, the participant and clinic audiologist were in contact via audio or video call (synchronous) and/or instant messages WhatsApp/text messages/email (asynchronous) to discuss the progress and note any challenges the participant faced with the hearing aids.

Step 4 – hearing solution and rehabilitation plan

Step 4 (Figure 1) consisted of the participant successfully benefitting from the hearing aids and opting to purchase their hearing aids to continue their treatment plan. The fitting and verification of the hearing aids are conducted in a face-to-face appointment. These participants were then offered access to an online aural rehabilitation programme.

Step 5 – continued support and coaching

Continuous face-to-face and online support is offered from the clinic audiologist to the participant for additional fine-tuning of hearing aids as well as support during the personal adjustment to hearing aids. An online aural rehabilitation programme (Eriksholm Guide to Better Hearing) is also offered to these participants to become satisfied hearing aid users. The International Outcome Inventory – Hearing Aids (IOI-HA), as well as satisfaction ratings, measure the outcomes after completion of the Eriksholm Guide to Better Hearing (Cox et al. 2000).

Material and apparatus

Online hearing screening

The online DIN test is a triple-digit hearing screening test developed and validated for South African English which uses an adaptive digit-to-noise ratio procedure (Potgieter et al. 2016, 2018). The software widget (hearX Group (Pty) Ltd, Pretoria, South Africa) is embedded on the clinic website using validated materials (Potgieter et al. 2016, 2018). Digits are considered universal and less reliant on language competence. On beginning the DIN test in Step 1, each individual is required to insert their date of birth as well as their first language and self-reported English-speaking competency level on a scale of 1–10. For each individual completing the DIN test, the signal-to-noise ratio (SNR) was recorded. The geolocation was also provided which allowed verifying that participants were within the test geolocation, that is the greater Durban area. A pass on the DIN test was based on validation data correlating the speech reception threshold (SRT) to a four-frequency pure tone average (4FPTA: 0.5, 1, 2 and 4 kHz) $\leq$ 25 dB HL and refer or failed result to 4FPTA $>$25 dB HL. The DIN test uses English digits which is more familiar as language competency poses a challenge in the multilingual population of South Africa, with 11 official languages and only 9.6% of the population are native English speakers (Statistics South Africa 2011). Therefore, self-reported English competency level was categorised into two groups (0–5 and 6–10) leading to the following cut-off scores; English competency levels of 0–5 required ≤ -7.50 dB SRT and English competency levels of 6–10 required ≤ -9.55 dB SRT to pass the screening DIN test (Potgieter et al. 2018). The DIN test results are stored in a cloud-based system called mHealth studio which records information on all DIN tests taken even if no contact details were submitted with an accurate geolocation (hearX Group (Pty) Ltd, Pretoria, South Africa). Only the clinic audiologist has access to the back-end cloud-based mHealth studio (hearX Group (Pty) Ltd, Pretoria, South Africa) which is password-protected securing participant data.

Website visits

Data regarding usage, length of time spent on the website, new users who are unique to the website and recurring users to the website, type of mobile devices, operating systems used to access the website and IP address to track location were collected using Google Analytics (Google.com 2017a). Data were not collected on all users to the website as firewall and cookie settings on some devices block websites from collecting this type of data. Also, some mobile browsers send compressed files to Google Analytics making it difficult to correctly identify the browser and device used to take the DIN test (Google.com 2017a). Google Analytics does not report data on users $\leq$18 years according to the laws protecting minors. Google Analytics reports its data to be accurate with a low error rate of less than 2% (Google.com 2017b).

Readiness measures

Two readiness measures, the line and the staging algorithm, were used during Step 2 of the patient journey. The line is a one-item measure of readiness for hearing help-seeking which consists of the question: 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 (Rollnick et al. 1999; Tønnesen 2012). The Ida Institute have adapted the line for use within the audiology profession (Ida Institute, 2009). The staging algorithm is a one-item questionnaire assessing stages of change (Milstein and Weinstein 2002). The question has four possible answers, each corresponding with a stage of change: (1) I do not think I have a hearing problem, and therefore nothing should be done about it (pre-contemplation); (2) 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 (contemplation); (3) I know I have a hearing problem, and I intend to take action to solve it soon (preparation) and (4) I know I have a hearing problem, and I am here to take action to solve it now (action) (Milstein and Weinstein 2002).

Data analysis

Data were analysed using the software IBM SPSS Statistics for Windows, version 24 (SPSS Inc., Chicago, IL). Statistical significance was set at $p < 0.05$. Descriptive statistics were used to analyse the characteristics, online behaviours and readiness of the people who seek HHC online.

Results

Characteristics of people who visited the clinic website

Website traffic information

Within the three-month study period (23rd June–22nd September 2017), 2693 people visited the clinic website, of which 2667 (99.03%) were new (unique) visitors. This data are presented in Table 1. The majority (83.66%) of visitors were from South Africa. Only data pertaining to visitors located in the greater Durban area are presented as only participants from this

Table 1. Description of website traffic in the three-month study period (23rd June–22nd September 2017) obtained from Google Analytics for the greater Durban area.

	Number (Percentage)
Total website traffic	2693 (100%)
South Africa	2253 (83.66%)
Greater Durban area	1852 (82.20%)
Users (greater Durban area)	2035
New	1834 (90.10%)
Returning	201 (9.90%)
Age (greater Durban area)	
18–24	24 (2.40%)
25–34	71 (7.11%)
35–44	112 (11.22%)
45–54	180 (18.04%)
55–64	257 (25.75%)
65+	354 (35.47%)
Total number of age recorded	998 (37.06%)
Gender (greater Durban area)	
Female	758 (76.88%)
Male	228 (23.12%)
Total number of gender recorded	986 (36.61%)
Devices (greater Durban area)	
Mobile	1541 (83.21%)
Tablet	238 (12.85%)
Computers	73 (3.94%)
Total number of devices recorded	1852 (68.77%)
Operating system (greater Durban area)	
Android	1364 (73.65%)
iOS	409 (22.08%)
Windows	61 (3.29%)
Other	18 (0.98%)
Total number of operating systems recorded	1852 (68.77%)

Table 2. First language and self-reported English-speaking competency for participants in Step 1 ($n = 462$).

	English Competency						
First Language	5	6	7	8	9	10	Total
English	0	0	0	0	0	442	442
Afrikaans	5	1	0	4	6	2	18
Xhosa	0	0	1	0	0	0	1
Other	0	0	1	0	0	0	1
Total	5	1	2	4	6	444	462

target geolocation were eligible for further HHC (Steps 3–4) through the clinic. A total of 1852 visitors from the greater Durban area and aged ≥18 years, of which 1834 (90.10%) were new visitors, are described below.

Page visits, age and gender and device usage

On average, website visits indicated 1.17 sessions, 1.95 page views per session and 1 min and 38 s spent on the website per session. A total of 354 (35.47%) of 998 users were ≥65 years of age within the targeted geolocation. During the study period, the majority (76.88%) of website visitors were female. Most participants viewed the website from a mobile phone (83.21%), followed by a tablet (12.85%) and computer (3.94%) (Table 1). Most (73.65%) of the 1852 users who visited the website did so through an Android mobile phone.

Behaviours and readiness of people who took Step 1 (completing DIN test)

During the study period, 24.95% (462 of 1852) of the website visitors completed the DIN test (Table 2). Of the 462 individuals, 191 passed and 271 failed the online DIN test. The majority (442 people, 95.67% of the sample) of the participants in Step 1 reported English as their first language followed by Afrikaans 3.90% (18), Xhosa 0.22% (1) and Other (Marathi) 0.22% (1). Fifty-one individuals (18.82%) submitted their contact details to engage in Step 2 after completing the DIN test. After contacting the fifty-one individuals by phone and or email, five participants (9.80%) proceeded to Step 3 (hearing evaluation and hearing aid trial) and then two participants (40.00%) proceeded to Step 4 (see Table 3). The five participants in Step 3 waited for a period of 5–16 years to seek HHC from the time of suspecting hearing difficulty. Both participants in Step 4 indicated a score of 10 on the line and chose option 4 on the staging algorithm, indicating their readiness to seek help and to take action regarding their hearing challenges. The two participants in Step 4 have been registered to use the online aural rehabilitation programme (Eriksholm Guide to Better Hearing), therefore placing them in Step 5 for continuous coaching to becoming satisfied and competent hearing aid users.

Age of participants

The reported age range of individuals who completed the DIN test ($n = 462$) was 22–94 years, with a mean age of 56.61 years (SD 12.65). A Pearson correlation test indicated a statistically significant correlation ($p < 0.05$; $r = 0.21$) between age and the SNR ($n = 462$). Older participants presented with poorer SNR scores (Figure 2).

Relationship between age and DIN test score

As expected, this relationship was also reflected in the characteristics of those who passed/failed the DIN test. The minimum age of the 271 participants who failed the DIN test in Step 1 was 24 years and a maximum of 94 years, with a mean of 60.22 years (SD 11.77). When compared to the 191 individuals who passed the DIN test, this group had a minimum age of 22 years and a maximum of 79 years with a mean of 51.49 years (SD 12.11). People who passed the DIN test were significantly younger than those who failed the DIN test, $t(460) = 7.76$, $p < 0.001$.

Participants ($n = 51$) who proceeded to Step 2 included 29 (56.86%) females and 22 (43.14%) males with ages ranging from 28 to 85 years (mean age 60.08 years; SD 11.65). A mean SNR of −6.18 dB (SD 5.22) for the group of 51 participants who submitted their details and mean age of 59.94 years (SD 11.64) was recorded. For the group of 220 participants who did not submit their details, a mean SNR of −6.19 dB (SD 4.43) and mean age of 60.29 years (SD 11.83) were recorded. No statistical significance was found between SNR and age of the 51 participants who submitted their details compared to 220 participants who did not submit their details, $t(269) = 0.021$, $p = 0.98$ and $t(269) = -0.19$, $p = 0.85$ respectively.

The participants' reasons (Step 2) for taking action or not to Step 3 were collected during the audio call in Step 2 (see Table 4). Only 51 participants (18.82%) showed interest in seeking further HHC (Step 3). Four of the five participants in Step 3 were first-time amplification users, while one participant was experienced with amplification and has used hearing aids.

Time of day and day of the week that DIN test was completed

A graphical representation below indicates (Figure 3) a high portion of the 462 users who took the DIN test completed the test in the morning and evening. The highest number of DIN tests

Table 3. Number of participants for each step of the patient journey at the end of the three-month study period (22nd September 2017).

Pre-Step 1 Website behaviour	Step 1 DIN test	Step 2 Submitted details after fail result	Step 3 Evaluation and hearing aid trial after submitting details	Step 4 Treatment selected after evaluation and trial
Visitors to the website 1852	Total tests: 24.95% (462/1852)			
	Fail: 58.66% (271/462)	18.82%	9.80%	40.00%
	Pass: 41.35% (191/462)	(51/271)	(5/51)	(2/5)

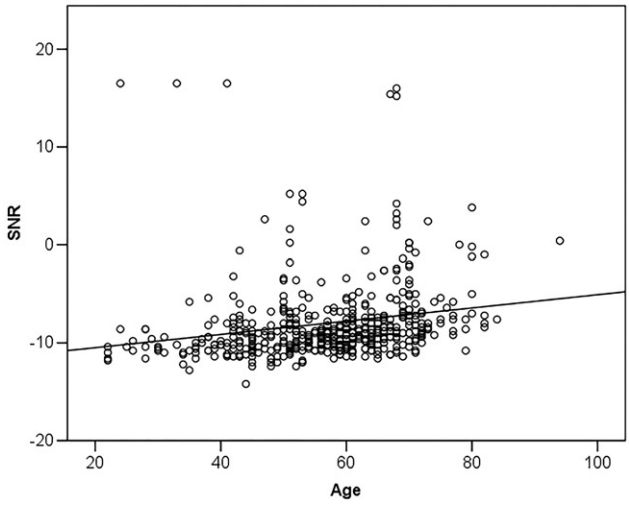

Figure 2. Relationship of DIN test result (SNR) and age of participants who completed the DIN test ($n = 462$).

Table 4. Summary of themes that participants in Step 2 reported in regards to taking action towards Step 3 ($n = 51$).

Not interested	38 (74.51%)
No answer	17 (44.74%)
Investigation:	11 (28.95%)
• Curious to try the online test	
• Has hearing aids and curious to recheck if hearing loss is still present	
Incorrect contact details	3 (7.89%)
Doctor said nothing can be done	3 (7.89%)
Finance	3 (7.89%)
Other: Beyond geographic location	1 (2.63%)
Interested	13 (25.49%)
Possibly in the future	8 (61.54%)
Trialled hearing aids but not purchased	3 (23.08%)
Trialled hearing aids and purchased	2 (15.38%)

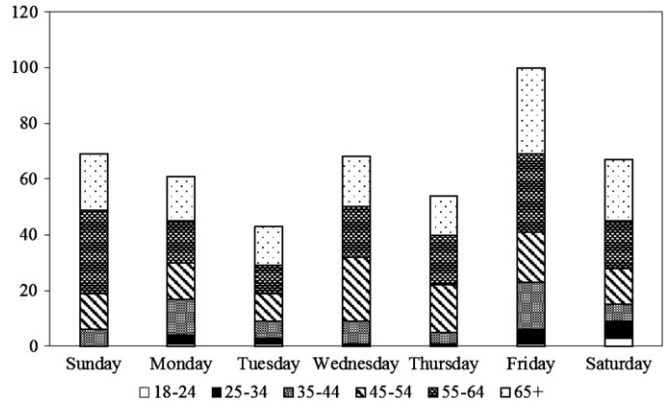

Figure 4. Distribution of DIN tests completed per age group and per day of the week ($n = 462$).

completed during the day was 28 at 7 am, 34 at 1 pm and ≥30 participants between 7 pm and 10 pm. This indicates that HHC services can be made available for self-administration (asynchronously) outside of the traditional 9 am to 5 pm work day.

When looking further at DIN tests taken, Friday had the highest number (31) of tests taken especially in the age group ≥65 years (see Figure 4). More than 65 participants completed the DIN test on Sunday, Wednesday, Friday and Saturday. This suggests that HHC services can be administered asynchronously at a time and place convenient for HHC seekers, often beyond the traditional five-day workweek according to different age groups.

Discussion

There is a pressing need for HHC services to meet the demand of an ageing population. The consequences of untreated hearing loss are detrimental on a micro-level of one's family and communication partners as well as at a macro-level affecting society at large. With the unequal distribution of resources and services

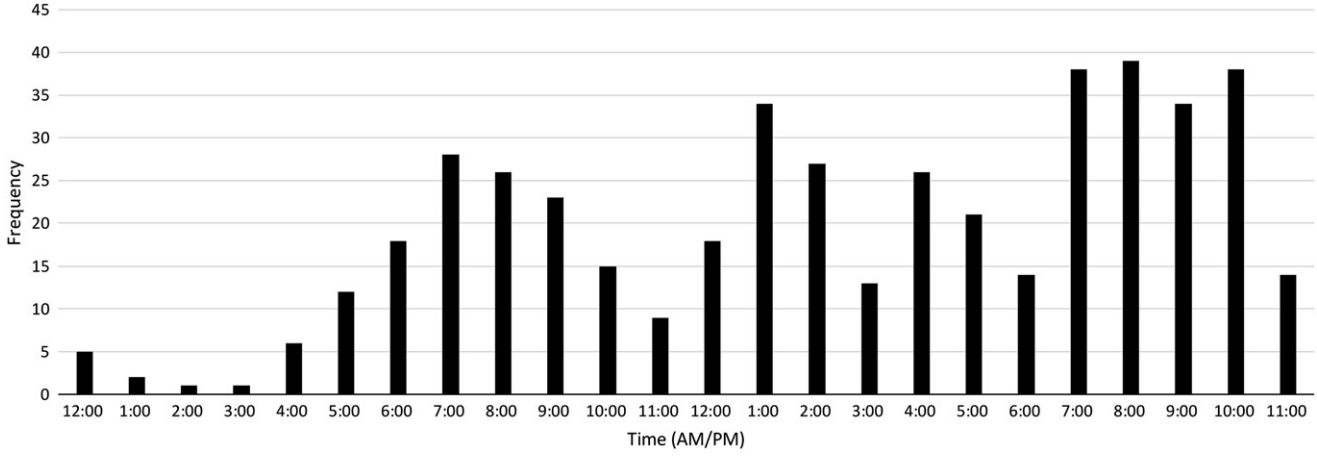

Figure 3. Distribution of DIN tests completed per time of day ($n = 462$).

challenging HHC, offering services using a combination of virtual and face to face in a hybrid offering is a possible alternative service delivery model.

Making individuals aware of the importance of testing their hearing and knowing their hearing status is a possible first step to raising HHC awareness. While the typical age for an initial hearing aid fitting is 74 years (Henshaw et al. 2012), this study used the advancements of technology to attract a broader age group ($\geq$ 40 years) of individuals to take a DIN test using online modes of recruitment. Making the DIN test available online allows for seekers of HHC to have access to a tool to screen their hearing asynchronously. This study provides insights on offering HHC services through a virtual platform.

Internet-based recruitment methods were used to create awareness of HHC services by offering free online hearing screening (DIN test) to individuals within the Durban area, South Africa. Within a limited period of three months, 1852 people visited the website within the targeted location. Of those, approximately 1 in 4 completed the online DIN test. Only 18.82% ($n = 51$) of individuals who failed the DIN test indicated possible further help-seeking with 9.80% ($n = 5$) of those taking the next step of completing a comprehensive hearing evaluation and 40% ($n = 2$) of those choosing to purchase hearing aids. Characteristics of people regarding age, gender and devices used to seek HHC online, and the behaviours related to motivation and readiness to seek HHC online are discussed below.

Age, gender and devices of people who seek HHC online

The clinic achieved its goal to target older adults with 35.47% (354/998) of users older than 64 years of age within the target geographic location through online recruitment. Online recruitment can, therefore, be one way in which to target an older age group from a specific geographical area. The majority (76.88%) of visitors to the webpage were female. The gender difference found in seeking HHC is comparable to literature which reported males to be more reserved in their actions (Smits et al. 2006). According to the Pew Research Center, 68% of the American adult population use the social media platform Facebook. When looking closer at the gender split, 62% of males use Facebook and females are slightly higher at 74% (PEW 2018). This indicates that more women are active on social platforms than men and tend to seek HHC help earlier than men. An implication of this would mean that providers of HHC should create gender-specific content to reach these specific target groups.

Mobile phones were most frequently (83.21%) used to access the DIN test over tablets and computers. In South Africa where lined Internet is limited, more individuals have access to a mobile device with Internet capabilities which increases one's accessibility to online services. Sub-Saharan Africa remains the fastest growing mobile market in the world with 420 million unique mobile subscribers and a penetration rate of 43% reported at the end of 2016 (GSMA 2017). By 2020, more than half a billion unique mobile subscribers will be from this region, by which time half of the population will subscribe to a mobile service (GSMA 2017). Android operating systems were predominantly (73.65%) used to access the website in this study geolocation highlighting the importance of responsive website design. This finding infers that mobile services developed for the test region of Durban, South Africa, are to be compatible on an Android platform.

Using the insights from the time of day and week that participants completed the online DIN test, this supports asynchronous hearing screening which can be self-administered at a time and place convenient for a person which brings HHC to them. Essentially offering services on the clinic's website which can be accessed 24/7 by a potential HHC seeker. This supports the notion put forward that this new era of healthcare is moving beyond the traditional clinic but rather into the daily lives of patients by striving to link the patient with the right care with the right provider at the right time (Gladden, Beck, and Chandler 2015).

Motivation to seek HHC services

More individuals completed the online DIN test and did not submit their contact details, and this would indicate that people are curious to know their hearing status, however, not ready to take action. Many individuals could have opted to seek HHC services from other providers after being made aware of their hearing result through the DIN test. This study, however, did not track these individuals. A study which followed up on individuals 4–5 months after failing a telephone-based DIN hearing screening test indicated that only 36% sought further HHC services (Meyer et al. 2011), while previous studies indicated that 46% and 57% of individuals who failed a DIN test sought further HHC services when recommended (Smits et al. 2006). In this study, the number of people who took Step 1 (DIN test) is high, and fewer individuals went on to take Step 2 by providing their details to make contact with the clinic audiologist. After Step 1, 81.18% of individuals did not leave contact details for the audiologist in Step 2. Persons may have dropped out since it may be more familiar to receive HHC information in a face-to-face consultation. This could also reflect that online seekers may not know how to validate the quality of online healthcare services or may not be ready to receive this type of information online without the referral of their healthcare provider. Therefore, this highlights the need to normalise online HHC offerings. The clinic was newly established for this project and did not have referral sources other than the online recruitment strategies described.

The individuals who decided to seek help (Steps 3–4) indicated higher scores on the line and staging algorithm indicating that motivational interviewing tools provide useful insights for planning rehabilitation (Ingo et al. 2017). In a study of 224 participants (Ingo et al. 2017), mean score of 6.14 (SD 2.80) was obtained on the line as compared to a mean score of 7.80 (SD 2.59) in our study. The difference in the mean scores and SD could be attributed to the small sample size which produced higher results in our study. Our study had two participants in the contemplation stage and three participants in the action stage of the staging algorithm. In the Ingo et al. (2017) study, 44.60% of persons were in the contemplation stage, and 7.60% were in the action stage with the remainder of the 47.80% of participants in the pre-contemplation (2.70%) and preparation (45.10%) stages of the staging algorithm. Younger participants had significantly lower (i.e. better) SNR scores and therefore were more likely to pass the DIN test in our study.

While many isolated eHealth studies have been conducted within HHC, there is a scarcity of studies of the entire patient journey using an eHealth paradigm. This study systematically combined the available tools to form this hybrid model of synchronous and asynchronous services while still remaining agile to include newer tools once technology allows for

services to be offered online. Even though not all touch points along the patient journey are ready to be included using online services; this is the first of its kind to place together the pieces which are ready to be tested using the advantages of both face-to-face and online modes of communication. This real-life study aims to be a sustainable model which other audiologists can look upon for inspiration when adapting to the changing landscape of HHC. The next steps of this study are to investigate the experiences and outcomes of the patients who have received HHC services through this hybrid model as well as a cost consequence analysis.

Implications and future directions

The implications of the virtual clinic offering make online hearing screening (DIN test) possible through asynchronous methods allowing access to individuals to take the screening test without the involvement of the audiologist are the first step towards the positive use of the audiologist's time be spent on other more complex tasks. Pre-qualifying individuals for hearing loss could potentially lead to time-saved for audiologists, as individuals who then opt to further their hearing help-seeking through diagnostic measures are made aware that hearing loss may be present. Another possibility is that individuals who may not have been aware of their hearing status may now become aware of their hearing challenges through an online offering which could potentially reach a younger audience using online recruitment strategies. Research points to the advances of innovative technology and greater access to global connectivity are opportunities which may change current HHC service delivery methods to maximise access, efficiency and impact (Clark and Swanepoel 2014). Moving the pre-qualifier as the online hearing screening test (DIN test) allows audiologists to free up some time to spend more time on complex tasks such as counselling and hearing aid fittings as well as to provide services to more patients, increasing service delivery efficiency (Margolis and Morgan 2008; Swanepoel et al. 2010).

Despite the online availability of HHC services, barriers to help-seeking continue to exist. This is indicated by a low number of individuals who provided their contact details after failing the DIN test. This explorative research study has provided initial results for the inclusion of a hybrid patient model within the HHC profession.

To the authors' knowledge, this study is the first clinic of its kind, utilising digital tools across the entire patient journey combined with face-to-face interactions to provide HHC. Currently, research along the entire patient journey using eHealth as a service delivery medium is still insufficient.

Study limitations

A limitation of the current study is its recruitment methods, which relied mainly on Facebook and not on other online sources such as doctor websites, patient organisations, or forums where people who might be more readily looking for HHC services or be trusting of online HHC information. Another limitation is that the website is only available in English and requires some literacy skills (reading level of at least Grade 9), whereas in South Africa there are 11 official languages and low literacy is common (Van der Berg 2015). However, 442 of the 462 participants who completed the DIN test reported level 10 English competency which indicates a high literacy level. Our study also did not focus on the reasons why some individuals visited the website but did not begin or complete the DIN test, suggesting that they had other needs than those the website addressed.

Conclusions

This study shows promise of using online recruitment to a virtual hearing clinic. The proposed hybrid model (combination of online and face-to-face modes of communication) holds promise by which services can be offered. Providers of services can take advantage of such a model to support an individual during the initial stages of seeking HHC online prior to a physical appointment. This can be done by using the hours in a day and days of the week strategically to provide access to services outside of office hours by using asynchronous methods which takes advantage of a virtual offering of services with the potential of being open 24/7.

The use of online platforms to create awareness of prevention and promotion of hearing loss and HHC services is possible and effective. As technological advancements increase over the coming years and accessibility increases, integration of this proposed hybrid model into existing audiology practices can lead to new audiology patient pathways through online hearing screening, assessing readiness to seek further HHC services using synchronous and asynchronous methods and the enhancement of service delivery models.

Acknowledgements

The authors would like to thank Thomas Behrens (Oticon A/S) and Lezanie Tietze (Oticon South Africa) for their input and valuable discussions.

Disclosure statement

Opinions expressed and conclusions arrived at, are those of the authors and are not necessarily to be attributed to the NRF (funding organisation).

The second author has a relationship with the hearX Group (Pty) Ltd, who owns the right to the IP that includes equity, consulting and potential royalties.

Funding

This work was supported by the National Research Foundation (NRF) of South Africa under the grant number 107728. A grant from the Oticon Foundation supports the larger project. The first author (PhD student) is supported by the NRF and University of Pretoria PhD support programme. The financial assistance of the National Research Foundation (NRF) towards this research is hereby acknowledged.

ORCID

Husmita Ratanjee-Vanmali http://orcid.org/0000-0002-8659-2398
De Wet Swanepoel http://orcid.org/0000-0001-8313-1636
Ariane Laplante-Lévesque http://orcid.org/0000-0002-4170-2426

References

Arlinger, S. 2003. "Negative Consequences of Uncorrected Hearing Loss–A Review." *International Journal of Audiology* 42 (sup2):17–20. doi:10.3109/14992020309074639

Beukes, E. W., G. Vlaescu, V. Manchaiah, D. M. Baguley, P. M. Allen, V. K. Kaldo, and G. Andersson. 2016. "Development and Technical Functionality of an Internet-Based Intervention for Tinnitus in the UK." *Internet Interventions* 6 (11):6–15. doi:10.1016/j.invent.2016.08.002

Brännström, K. J., M. Öberg, E. Ingo, K. N. T. Månsson, G. Andersson, T. Lunner, and A. Laplante-Lévesque. 2016. "The Initial Evaluation of an Internet-Based Support System for Audiologists and First-Time Hearing Aid Clients." *Internet Interventions* 4 (1):82–91. doi:10.1016/j.invent.2016.01.002

Cox, R., M. Hyde, S. Gatehouse, W. Noble, H. Dillon, R. Bentler, D. Stephens, et al. 2000. "Optimal Outcome Measures, Research Priorities, and International Cooperation." *Ear Hear* 21 (Supplement):106S–115S. doi:10.1097/00003446-200008001-00014

Clark, J. L., and D. W. Swanepoel. 2014. "Technology for Hearing loss-As We Know It, and As We Dream It." *Disability and Rehabilitation: Assistive Technology* 9 (5):408–413. doi:10.3109/17483107.2014.905642

Davis, A., C. M. McMahon, K. M. Pichora-Fuller, S. Russ, F. Lin, B. O. Olusanya, S. Chadha, and K. Tremblay. 2016. "Aging and Hearing Health: The Life-Course Approach." *The Gerontologist* 56 (Suppl 2):S256–S267. doi:10.1093/geront/gnw033

Davis, A., P. Smith, M. Ferguson, D. Stephens, and I. Gianopoulos. 2007. "Acceptability, Benefit and Costs of Early Screening for Hearing Disability: A Study of Potential Screening Tests and Models." *Health Technology Assessment (Winchester, England)* 11 (42):1–294. doi:10.3310/hta11420

Dillon, H., E. F. Beach, J. Seymour, L. Carter, and M. Golding. 2016. "Development of Telscreen: A Telephone-Based Speech-in-Noise Hearing Screening Test with a Novel Masking Noise and Scoring Procedure." *International Journal of Audiology* 55 (8):463–471. doi:10.3109/14992027.2016.1172268

Fagan, J. J., and M. Jacobs. 2009. "Survey of ENT Services in Africa: Need for a Comprehensive Intervention." *Glob Health Action* 2:1932–1939. doi:10.3402/gha.v2i0.1932

Gladden, C., L. Beck, and D. Chandler. 2015. "Tele-Audiology: Expanding Access to Hearing Care and Enhancing Patient Connectivity." *Journal of the American Academy of Audiology* 26 (9):792–799. doi:10.3766/jaaa.14107

Google.com. 2017a. Cookies and User Identification. Accessed November 17, 2017. https://developers.google.com/analytics/devguides/collection/analyticsjs/cookies-user-id

Google.com. 2017b. How Users Are Identified for Users Metrics. Accessed November 17, 2017. https://support.google.com/analytics/answer/2992042?hl=en

Global System for Mobile Communications Association (GSMA). 2017. The Mobile Economy. GSM Association: United Kingdom.

HearX Group (Pty) Ltd, www.hearxgroup.com (Pretoria, South Africa).

Henshaw, H., D. P. A. Clark, S. Kang, and M. A. Ferguson. 2012. "Computer Skills and Internet Use in Adults Aged 50-74 Years: Influence of Hearing Difficulties." *Journal of Medical Internet Research* 14 (4):e113. doi:10.2196/jmir.2036

Hickson, L., C. Meyer, K. Lovelock, M. Lampert, and A. Khan. 2014. "Factors Associated with Success with Hearing Aids in Older Adults." *International Journal of Audiology* 53 (sup1):S18–S27. doi:10.3109/14992027.2013.860488

Ida Institute. 2009. The Line. Accessed June 1, 2017. https://idainstitute.com/tools/motivation_tools/get_started/line/ (Naerum, Denmark).

Ingo, E., K. J. Brännström, G. Andersson, T. Lunner, and A. Laplante-Lévesque. 2017. "Stages of Change in Audiology: Comparison of Three Self-Assessment Measures." *International Journal of Audiology* 55:52–58. doi:10.1080/14992027.2017.1309466

Krumm, M. 2016. "A Review of Contemporary Tele-Audiology Literature." *Journal of Hearing Science* 6 (3):9–21. doi:10.17430/899978

Lapão, L. V., and G. Dussault. 2017. "The Contribution of eHealth and mHealth to Improving the Performance of the Health Workforce: A Review ." *Public Health Panorama* 3 (3):463–471. http://www.euro.who.int/__data/assets/pdf_file/0005/348341/Policy_Practice_2_ENG.pdf?ua=1

Laplante-Lévesque, A., K. J. Brännström, G. Andersson, and T. Lunner. 2012. "Quality and Readability of English-Language Internet Information for Adults with Hearing Impairment and Their Significant Others." *International Journal of Audiology* 51 (8):618–626. doi:10.3109/14992027.2012.684406

Laplante-Lévesque, A., K. M. Pichora-Fuller, and J. P. Gagné. 2006. "Providing an Internet-Based Audiological Counselling Programme to New Hearing Aid Users: A Qualitative Study." *International Journal of Audiology* 45 (12):697–706. doi:10.1080/14992020600944408

Laplante-Lévesque, A., and E. S. Thorén. 2015. "Readability of Internet Information on Hearing: Systematic Literature Review." *American Journal of Audiology* 24 (3):284–288. doi:10.1044/2015_AJA-14-0091

Lin, R. L., R. W. Hazzard, and G. D. Blazer. 2016. "Priorities for Improving Hearing Health Care for Adults – A Report from the National Academies of Sciences, Engineering, and Medicine." *JAMA* 316 (8):819–820. doi:10.1001/jama.2016.7916

Livingston, G., A. Sommerlad, V. Orgeta, S. G. Costafreda, J. Huntley, D. Ames, C. Ballard, et al. 2017. "Dementia Prevention, Intervention, and Care." *Lancet* 390 (10113):2673–2734. doi:10.1016/S0140-6736(17)31363-6

Margolis, R. H., and D. E. Morgan. 2008. "Automated Pure-Tone Audiometry: An Analysis of Capacity, Need, and Benefit." *American Journal of Audiology* 17 (2):109–113. doi:10.1044/1059-0889(2008/07-0047)

Meyer, C., L. Hickson, A. Khan, D. Hartley, H. Dillon, and J. Seymour. 2011. "Investigation of the Actions Taken by Adults Who Failed a Telephone-Based Hearing Screen." *Ear and Hearing* 32 (6):720–731. doi:10.1097/AUD.0b013e318220d973

Meyer, C., L. Hickson, K. Lovelock, M. Lampert, and A. Khan. 2014. "An Investigation of Factors That Influence Help-Seeking for Hearing Impairment in Older Adults." *International Journal of Audiology* 53 (sup1):S3–S17. doi:10.3109/14992027.2013.839888

Milstein, D., and B. E. Weinstein. 2002. "Effects of Information Sharing on Follow-up after Screening for Older Adults." *Journal of the Academy of Rehabilitative Audiology* 35:43–58.

Mulwafu, W., R. Ensink, H. Kuper, and J. Fagan. 2017. "Global Health Action Survey of ENT Services in Sub-Saharan Africa: Little Progress Between 2009 and 2015." *Global Health Action* 10 (1):1289736. doi:10.1080/16549716.2017.1289736

Mulwafu, W., H. Kuper, and R. J. H. Ensink. 2016. "Prevalence and Causes of Hearing Impairment in Africa." *Tropical Medicine & International Health* 21 (2):158–165. doi:10.1111/tmi.12640

Pew Research Center (PEW). 2018. *Internet & Technology Social Media Fact Sheet. I.* Washington, DC: Pew Research Center. http://www.pewinternet.org/fact-sheet/social-media/

Potgieter, J. M., D. W. Swanepoel, H. C. Myburgh, T. C. Hopper, and C. Smits. 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. doi:10.3109/14992027.2016.1172269

Potgieter, J. M., D. Swanepoel, H. C. Myburgh, and C. Smits. 2018. "The South African English Smartphone Digits-in-noise Hearing Test: Effect of Age, Hearing Loss and Speaking Competence." *Ear and Hearing.* 2018 Jul/Aug; 39 (4):656–663. doi:10.1097/AUD.0000000000000522.

Rollnick, S., P. Mason, and C. Butler. 1999. *Health Behavior Change: A Guide to Practitioners*. London: Churchill Livingstone.

Smits, C., T. S. Kapteyn, and T. Houtgast. 2004. "Development and Validation of an Automatic Speech-in-Noise Screening Test by Telephone." *International Journal of Audiology* 43 (1):15–28. doi:10.1080/14992020400050004

Smits, C., P. Merkus, and T. Houtgast. 2006. "How We Do It: The Dutch Functional Wearing-Screening Tests by Telephone and Internet." *Clinical Otolaryngology* 31 (5):436–440. doi:10.1111/j.1749-4486.2006.01195.x

Statistics South Africa. 2016a. General Household Survey 2016. Accessed May 2018. http://www.statssa.gov.za/publications/P0318/P03182016.pdf

Statistics South Africa. 2016b. Community Survey 2016. Metadata. Accessed May 2018. http://www.statssa.gov.za/publications/Report%2003-01-10/Report%2003-01-102016.pdf

Statistics South Africa. 2011. Census 2011: Census in Brief. Accessed May 2018. http://www.statssa.gov.za/census/census_2011/census_products/Census_2011_Census_in_brief.pdf

Stenfelt, S., T. Janssen, V. Schirkonyer, and F. Grandori. 2011. "e-Health Technologies for Adult Hearing Screening." *Audiology Research* 1 (1S):55–57.

Swanepoel, D. W., B. Olusanya, and M. Mars. 2010. "Hearing Health-Care Delivery in Sub-Saharan Africa-A Role for Tele-Audiology." *Journal of Telemedicine and Telecare* 16 (2):53–56. doi:10.1258/jtt.2009.009003

Thorén, E. S., M. Öberg, G. Wänström, G. Andersson, and T. Lunner. 2014. "A Randomized Controlled Trial Evaluating the Effects of Online Rehabilitative Intervention for Adult Hearing-Aid Users." *International Journal of Audiology* 53 (7):452–461. doi:10.3109/14992027.2014.892643

Tønnesen, H. 2012. *Engage in the Process of Change: Facts and Methods*. Denmark: Bispebjerg University Hospital.

Van der Berg, S. 2015. "What the Annual National Assessments Can Tell us About the Learning Deficits Over the Education System and the School Career." *South African Journal of Childhood Education* 5 (2):28–43.

Wilson, B. S., D. L. Tucci, M. H. Merson, and G. M. O 'Donoghue. 2017. "Global Hearing Health Care: New Findings and Perspectives." *Lancet*. doi:10.1016/S0140-6736(17)31073-5.

World Health Organization (WHO). 2017. *Deafness and Hearing Loss: Fact Sheet*. Geneva: World Health Organization Media Centre. http://www.who.int/mediacentre/factsheets/fs300/en/

World Health Organization (WHO). 2013. *Multi-Country assessment of national capacity to provide hearing care*. Geneva: WHO Document Production Services.