CHARACTERISTICS AND HELP-SEEKING BEHAVIOUR OF PERSONS FAILING A NATIONAL HEARING SCREENING TEST

by

Danielle Schönborn
(14074550)

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Supervisor: Professor De Wet Swanepoel
Co-supervisors: Dr Faheema Mahomed Asmail, Mrs Karina De Sousa

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LIST OF ABBREVIATIONS

ANCOVA: Analysis of covariances

ANOVA: Analysis of variance

dB: Decibel

DIN: Digits-in-noise

iOS: Internet operating system

NIHL: Noise-induced hearing loss

SNR: Speech-to-noise ratio

SPSS: Statistical package of the social sciences

SRT: Speech reception threshold

FORMATTING

APA referencing style was used in this dissertation.

ABSTRACT

A digits-in-noise test was launched as the smartphone hearing screening of South Africa (*hearZA*™) in 2016. This study investigated characteristics, help-seeking behaviour, and follow-up actions of individuals who failed the hearing screening, considering their stage of behavioural change. The study had two phases; phase one was a retrospective, cross-sectional intervention readiness (stage of change) analysis of 3092 listeners who failed the test. Phase two was a prospective survey of 59 participants to investigate follow-up actions after a failed test. In the retrospective study, the majority of listeners were in the precontemplation stage (75.5%), while the remaining were in contemplation (9.7%), preparation (8.2%), and action (6.6%) stages. Age and stage of change were significant predictors of the digits-in-noise speech recognition threshold (DIN SRT) ($p < .05$). SRTs deteriorated significantly ($p < .05$) with increasing age, and listeners in the precontemplation stage were significantly younger than in other stages ($p < .05$). In the prospective study, 1007 potential participants were contacted through electronic mail or short message services to complete the survey; however, only 59 did so. Of those, most (82.4%) did not think they have a hearing loss. Only, 13.6% followed up with an audiologist. Older individuals presented with poorer DIN SRTs and were in a more advanced stage of change. The majority that did not follow up after failing the screening test did not believe they had a hearing problem. A combination of factors, including poor DIN SRT, older age, and more advanced stage of change predisposed participants to follow up with audiological care.

Keywords: Digits-in-noise, stage of change, Staging algorithm, speech reception threshold, speech-to-noise ratio, hearing loss, help-seeking, online hearing screening, smartphone application, transtheoretical model

1. INTRODUCTION

The World Health Organisation (2018) estimates that 466 million individuals in the world have a disabling hearing loss, accounting for 5.3% of the world's population. Worldwide, approximately one-third of adults over 65 years have a disabling hearing loss, the prevalence in sub-Saharan Africa being one of the highest in the world (WHO, 2013, 2018). In many instances, individuals are not aware of their hearing loss, and it takes them, on average, approximately ten years to recognise that they have a hearing loss (Davis, Smith, Ferguson, Stephens, & Gianopoulos, 2007). The presence of an untreated hearing loss may impact the lives of the affected individuals, family members, and communication partners, through exclusion from communication and social interaction. This exclusion may also have an effect on a larger scale by affecting society and economic development (Ratanjee-Vanmali, Swanepoel & Laplante-Lévesque, 2018; WHO, 2013). The reduction in auditory and intellectual stimulation due to the hearing loss has been linked to changes in the central nervous system and may give rise to dementia (Arlinger, 2003; Livingston et al., 2017; Wilson, Tucci, Merson, & O'Donoghue, 2017).

These negative consequences of hearing loss could be combatted by employing hearing screening (Arlinger, 2003). Secondary prevention strategies, such as hearing screening programs, are essential to detect hearing loss early and to ensure that intervention is provided promptly (Wilson et al., 2017). In order to make hearing loss detection methods widely available, screening in the form of digits-in-noise (DIN) tests delivered through telephone and internet platforms, have proliferated in recent years (Jansen, Luts, Wagener, Frachet, & Wouters, 2010; Smits, Kapteyn, & Houtgast, 2004; Watson, Kidd, Miller, Smits, & Humes, 2012). DIN tests are highly correlated with pure tone audiometry, with test sensitivity and specificity up to 90% (Potgieter, Swanepoel, Myburgh, Hopper, & Smits, 2016).

The improvement of smartphone dispersion provides a promising development to improve the cost-effectiveness of health care services, improving access to care and decrease the overall impact of disease and disability (Clark & Swanepoel. 2014). Worldwide, the current mobile device use is estimated at 5 billion individuals, with more than half accounting for smartphones (Pew Research Center, 2019). It has been predicted that smartphone adoption will grow by 20 per cent between 2017 and 2025, indicating that three out of four phones will be a smartphone (GSMA, 2018). The increase in smartphones provided a viable option to deliver hearing healthcare in areas where services and resources are minimal (Rutherford & Petersen, 2019). Service delivery supported by electronic health solutions could provide a link to facilitate better access to hearing healthcare professionals and services (Ratanjee-Vanmali et al., 2018). Therefore, a smartphone platform for screening opens a wide range of extensive and impactful opportunities to increase hearing loss awareness, detection, and uptake of hearing aids (Swanepoel, 2017). These screening advances can reduce the prevalence of hearing loss by up to 50% (Wilson et al., 2017). Therefore, due to poor landline penetration (Statistics South Africa, 2016), a national hearing test was launched as a smartphone app (*hearZA*™) in South Africa in 2016 (De Sousa, Swanepoel, Moore, & Smits, 2018; Potgieter et al., 2016; Potgieter, Swanepoel, Myburgh & Smits, 2018).

The *hearZA*™ test is clinically validated and uses digits presented in speech-weighted noise to adaptively determine the signal to noise ratio where 50% of the digits are recognised correctly (Potgieter et al., 2016, 2018). Although sentences are typically preferred for speech-in-noise assessment, the use of digits is arguably more ecologically valid since digits are easily understood in multilingual environments or for persons with limited linguistic skills (Smits, Goverts, & Festen, 2013). Especially within a multilingual context where numerous languages use English numerals within their language (Branford & Claughton, 2002). The test indicates functional hearing ability and is sensitive to detect sensorineural hearing loss with high sensitivity and specificity for native (high English proficiency) and non-native (lower English proficiency) English-speakers (Potgieter et al., 2018).

Besides hearing screening, the DIN test app also serves as a public awareness tool for hearing loss; can monitor a person's hearing status using personalised profiles and can connect persons to a hearing healthcare provider using location-based referral systems (De Sousa et al., 2018; Swanepoel, 2017). Furthermore, it includes a decision support tool, developed in collaboration with the Ida Institute (Denmark), encouraging users to take the next step to manage their hearing loss (De Sousa et al., 2018; Swanepoel, 2017). In this way, smartphone-based screening methods are offering new possibilities not only for detection but to support patients in linking them with professionals and aid decision making (Swanepoel, De Sousa, Smits, & Moore, 2019).

The principle of hearing screening is that a failed screening result would encourage help-seeking and rehabilitation for hearing difficulties (Yueh, Shapiro, MacLean, & Shekelle, 2003). However, while the DIN test provides access to accurate screening, it does not guarantee follow-through with actions to address hearing difficulties (Chou, Dana, Bougatsos, Flemming, & Bell, 2011; Gussekloo et al., 2003; Laplante-Lévesque, Brännström, Ingo, Andersson, & Lunner, 2015; Linssen, Joore, Theunissen, & Anteunis, 2013; Meyer et al., 2011; Smits, Merkus, & Houtgast. 2006; Swanepoel et al., 2019; Yueh et al., 2003). Various factors, such as the perception of symptom severity or stigma associated with hearing loss, have been reported to influence readiness to take up action (Gussekloo et al., 2003; Wallhagen, 2009). Furthermore, access to hearing specialists and cost of audiological services and aids could negatively affect help-seeking efforts (Bainbridge & Ramachandran, 2014). Analysing help-seeking for hearing loss within a framework of a multifactorial model, such as the transtheoretical stage of change (SoC) model, could help provide health care practitioners understand individual behaviours toward health care practices and ways to alter these behaviours (Saunders, Chisolm, & Wallhagen, 2012).

The transtheoretical model originated from health psychology, explaining how individuals advance through the different health behaviour SoC (Ingo, Brännström, Andersson, Lunner, & Laplante-Lévesque, 2017). The transtheoretical SoC model is designed to describe an individual's current attitudes, behaviours, and intentions to assess their readiness for change (Ekberg, Grenness, & Hickson, 2016; Prochaska & DiClemente, 1983). It was developed through in-depth interviews with individuals attempting to quit smoking (Prochaska & DiClemente, 2005); but additional research has indicated that it can be used for a variety of health conditions including hearing impairment (Laplante-Levesque et al., 2015; Laplante-Lévesque, Hickson, & Worrall, 2013; Prochaska & DiClemente, 1983). The original model consisted of four sequent SoC: precontemplation, contemplation, action, and maintenance (Prochaska & DiClemente, 1983). The model was later revised to include the preparation stage (Prochaska, DiClemente, & Norcross, 1992), which acknowledges the need for adequate guidance for adults who are yet to seek help for their hearing (Laplante-Lévesque et al., 2013, 2015). These individuals have a more definite plan of action (Laplante-Levesque et al., 2013).

Along with the transtheoretical model, other models such as the Andersen behavioural model of healthcare utilisation, and the health beliefs model (HBM) exist to examine readiness to change (Andersen, 1968; Hochbaum, 1958; Rosenstock, 1974). The Andersen behavioural model of healthcare utilisation is a framework for analysing the factors that are associated with patient utilisation of healthcare services (Phillips, Morrison, Andersen, & Aday, 1998). The model incorporates individual and contextual determinants of health services use, including the patient predisposing factors (demographics, social factors, mental factors), enabling factors (financial and organisational factors), and need factors (perceived need versus evaluated need) (Babitsch, Gohl, & von Lengerke, 2012). The HBM is based on six constructs that influence the likelihood that people will take action to prevent, screen, or control health conditions (Rosenstock, 1974). It proposes that value and expectancy beliefs guide behaviours. The principles are perceived susceptibility (vulnerable or at risk), perceived severity (health and social consequences of condition), perceived benefits (intervention leading to positive benefits), perceived barriers (barriers to overcome to receive intervention), perceived self-efficacy (belief to gain benefit intervention), and cues to action (prompts to take action) (Janz & Becker, 1984).

The Staging algorithm in the form of a screening questionnaire was developed by Milstein and Weinstein (2002), based on the transtheoretical model of change, to categorise persons with hearing loss within a specific SoC. The algorithm consists of a single question: 'Which of the following statements best describes your view of your current hearing status?' Four possible answers are offered, each referring to one of four SoC (Milstein & Weinstein, 2002): (1) I do not think I have a hearing problem, and therefore nothing should be done about it (precontemplation); (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 & Weinstein, 2002; Prochaska et al., 1992). A recent study indicated that the Staging algorithm was the measure that best predicted hearing help-seeking behaviour 18 months after the initial contact (Ingo, Brännström, Andersson, Lunner & Laplante-Lévesque, 2016).

The SoC model has been shown to predict that most individuals with a hearing impairment who see a clinician for help will reside in the action stage and those who are undergoing hearing screening may be in the preparation stage (Laplante-Levesque et al., 2013, 2015). Individuals that are aware and making efforts to seek assistance have been shown to primarily be in the contemplation and preparation stages (Manchaiah, Rönnberg, Andersson, & Lunner, 2015a). Resultantly, participants who are unaware or are in denial reside in the precontemplation stage. Identifying an individual's SoC may ultimately help tailor a screening and intervention programme to promote help-seeking and rehabilitation (Ekberg et al., 2016; Ingo et al., 2017; Laplante-Lévesque et al., 2013, 2015).

Help-seeking and rehabilitation is a desired behavioural standard for individuals with hearing difficulties (Ingo et al., 2016). However, to date, there is limited evidence on the effectiveness of adult hearing screening for hearing aid uptake and rehabilitation (Gussekloo et al., 2003; Yueh et al., 2003; Smits et al., 2006; Chou et al., 2011; Meyer et al., 2011; Linssen et al., 2013; Laplante-Lévesque et al., 2015). Characteristics of individuals who are aware of their hearing difficulty, but are not seeking help, or, decline rehabilitation are elusive (Manchaiah et al., 2015a). Hearing screening may increase the rate of help-seeking but may not necessarily increase hearing aid uptake (Smits et al., 2006). Meyer et al. (2011) followed up on 193 participants that failed a telephone-based hearing screening, four to five months after the test and found that only 36 sought help. Nineteen were recommended hearing aids, and 8 followed the recommendations with only six reporting successful hearing aid outcomes (Meyer et al., 2011). Therefore, about 3% of individuals who failed the screening achieved the desired outcome of rehabilitation. Laplante-Lévesque and colleagues (2015) classified a sample of 224 adults who failed an online screening test using the Staging algorithm and found that for 50% of participants were in the preparation stage, 38% in the contemplation, 9% in precontemplation, and only 3% in action stages. The small percentage in the action stage, which signals readiness for taking up care, suggests that screening alone may not be sufficient motivation to seek professional assistance (Laplante-Levesque et al., 2015). The low rates of hearing aid uptake may also be attributed to the severity of the hearing loss (Lin, Thorpe, Dordon-Salant, & Ferrucci, 2011). Lin and colleagues (2011) showed that those with mild hearing loss, 3.4% used hearing aids, compared to 40.0 % and 76.6% for those with moderate or severe hearing loss, respectively. Furthermore, the perception of the severity of the loss could have an influence on the motivation to seek out assistance for hearing difficulties (Gopinath et al., 2011). Laplante-Lévesque and colleagues (2013) found that individuals with less severe hearing impairment, who report less hearing disability, and who have lived with their hearing impairment for a shorter duration of time are prone to be in the earlier SoC. This suggests that those with mild hearing impairment do not perceive their difficulties as having a negative impact on their lives. As a result, they do not seek assistance.

Delayed help-seeking for hearing difficulties can span between seven to ten years (Davis et al., 2007; Fischer et al., 2011; Hickson, Meyer, Lovelock, Lampert, & Khan, 2014; Meyer, Hickson, Lovelock, Lampert, & Khan, 2014). Help-seeking behaviours for chronic conditions such as hearing loss are complex (Saunders et al., 2012), and many factors may influence these behaviours. Meyer and colleagues (2011) identified two factors that could influence the decision to take action. These include the individual's consideration of hearing aids before a hearing screening test and their ability to recall their test results (Meyer et al., 2011). Almost half (45%) of individuals who correctly recalled their test results sought out help for their hearing difficulties, compared to 15% who did not recall their test results and did not follow up (Meyer et al., 2011). However, of their total sample of participants, only 6.5% pursued amplification. Moreover, research suggests that individuals with a moderate to severe hearing impairment and self-reported hearing-related activity limitations or participation restrictions are more likely to seek out help and/ or adopt hearing aids than those who report a mild hearing impairment and less activity/participation restrictions (Meyer & Hickson, 2012). Additionally, they indicated help-seeking and hearing aid adoption were influenced by age, hearing loss perception, consideration of the benefits, and their perception of hearing rehabilitation support from their significant other (Meyer & Hickson, 2012).

Miller and Rollnick (2002) suggest that the SoC can inform intervention and counselling needs when motivational interviewing takes place. Moreover, a randomised controlled trial found that motivational interviewing achieve better treatment outcomes than traditional methods of advice for both psychological and physiological health conditions (Rubak, Sandbaek, Lauritzen, & Christensen, 2005). SoC measures implemented together with online hearing screening provide good predictive validity for help-seeking (Ingo et al., 2016), and can therefore direct appropriate motivational counselling towards timely uptake of interventions.

Consequently, population-based DIN screening may provide individuals with a means to confirm a hearing problem but may be insufficient to motivate transition towards more action SoC (Laplante-Lévesque et al., 2015). A more extensive understanding of an individual's motivation at the time of the screening may better predict, and perhaps influence, actions taken (Ingo et al., 2016). Additional evidence on the SoC model is required to understand the patient journey towards rehabilitation (Manchaiah et al., 2015a). Identifying a person's profile and specific needs would be valuable to provide appropriate person-centred intervention (Manchaiah et al., 2015a). Therefore, these behavioural changes towards the improvement of hearing are encouraged (Ingo et al., 2016). The national hearing screening test for South Africa was launched in 2016 as a smart device DIN app (hearZA^{TM}) to increase access by capitalising on the widespread penetration of smart devices (De Sousa et al., 2018). The purpose of the study was, therefore, to investigate user characteristics, SoC and help-seeking behaviour of persons who failed the South African DIN national hearing screening, considering their stage of behavioural change.

2. METHODOLOGY

2.1. Research objectives

This study had two research objectives:

Study objective 1

To describe the characteristics and stage of change of users who referred on the national hearing screening test.

Study objective 2

To prospectively determine help-seeking behaviour following a failed test result on the national hearing screening test.

2.2. Research design

The research study implemented two study objectives which made up the two phases of this study. Study objective 1 (Phase one) determined listener characteristics and SoC of individuals that referred on the national hearing screening test. Phase one of this study employed a retrospective, descriptive cross-sectional research design. A retrospective design uses existing data collected for reasons other than research (Hess, 2004). The specific research design was employed as the data used for analysis was collected only once, at the time of the screening test, which took place from March 2017 to March 2018. The study was a descriptive design as the researchers did not actively participate in collecting the data but used retrospective data to describe persons who failed the national hearing screening test with regards to their SoC. To accomplish the first study objective, retrospective data from the national hearing screening test database were obtained for analysis. Data from the screening test was analysed by the SoC to determine their motivational level to seek out help for their hearing difficulties.

Study objective 2 (Phase two) determined follow-up behaviour the participants engaged in after a refer result on the test by asking a series of questions. Phase two employed a prospective, descriptive survey design. This design enables researchers to obtain individualised answers to specific questions about participants' behaviour, attitudes, beliefs, or emotions administered over mail, telephone, internet, face to face, or in a group setting (Salkind, 2010). Salkind (2010) indicated it as an advantageous design as it provides an efficient manner to collect information from large numbers of participants; which is evident in this phase of our study. The specific research design was employed as the researchers acquired information from a subgroup of participants from phase one who failed the national hearing screening test and requested to follow-up contact by hearing healthcare professionals. An electronic mail or Short Message Service (SMS) contact method was implemented to obtain their current opinions and the previous actions taken after they obtained a refer result on the hearing screening test.

2.3. Ethical considerations

Ethical approval aims to ensure that the research being carried out is not harmful or malicious and that no harm comes to those participating in the research (Wisker, 2009). The Faculty of Humanities Research Ethics Committee, the University of Pretoria granted ethical approval before the data collection commenced (GW20181112S) (Appendix A). *Permission*

Consent from the CEO of the *hearX™ group* to use the relevant data was attained (Appendix B). Each prospective phase participant granted permission via an electronic mail (Appendix C).

Informed consent

Informed consent is essential for all participants participating in a research project. It is imperative to provide the objectives of the research as comprehensively as possible, as well as the anticipated outcomes and risks it poses to them (Brynard, Hanekom & Brynard, 2014). Within the first phase of the study, online informed consent to use data in an anonymized format was provided by accepting the terms and conditions and privacy policy of the hearZA™ app (Appendix B, Appendix D). Within the second phase of the study, data were collected prospectively. Informed consent to contact participants for phase two was provided within the app in phase one. Additionally, informed consent to participate in phase two was provided by clicking on the link to complete the survey. (Appendix C).

Confidentiality

Research conducted on human participants requires that the participants need a right to privacy and the information obtained from a participant may not, unless specified, be made readily available to the public (Leedy & Omrod, 2010). The *hearX™ group* provided data to the researcher with the details of each listener. The researcher ensured confidentiality and anonymity of each participants' information from phase one and two by assigning numerical coding when analysing the results. Results of participants were kept confidential.

Protection from harm

Protection from harm entails that the researches should not expose the participants in a study to unnecessary physical or psychological harm. Generally, participants should not endure any more risk than they would typically in the average day-to-day life. It is especially true for vulnerable populations (Leedy & Ormrod, 2015). The participants were not at risk for any physical or psychological harm as they already provided their information with consent when they completed the hearing screening test. The DIN test presented no health risks, such as hearing damage. Prospectively, no harm came to the participants.

Benefits

Participants for phase two of the study were aware that a prize draw would take place for three *Takealot*™ vouchers upon completion of the data collection. Participants were also aware that the results of the research could provide insight into how the hearing screening procedure could benefit individuals with hearing difficulties.

Release of findings

Participants were informed that the information obtained in the study might be published in professional journals and used in future research.

Plagiarism

Plagiarism is the act of using another's ideas or writings and passing it off as your work without proper acknowledgement (Brynard et al., 2014). The sources used in this study was appropriately cited within the text as well as in the reference list.

2.4. Phase one: Description of the characteristics and stage of change of users who referred on the national hearing screening test.

2.4.1. Participants

The retrospective data collected used a non-probability purposive sampling method. Data of the listeners who completed the national hearing screening test during March 2017 and 2018 was provided by the *hearX*™ group. Within the time frame, a total of 14573 individuals completed the national hearing screening test. Data of 5331 failed tests from March 2017 to March 2018 were exported anonymously for analyses. Data of persons younger than 18 years or older 100 years (*n* = 1025) or those who completed the test without earphones (*n* = 1008) were excluded to prevent possible confounding variables. Earlier versions of the app did not prevent test completion when earbuds or headphones were not plugged in, which was subsequently changed. Although the national hearing screening test was available on both iOS and Android platforms, the Staging algorithm was not adequately captured for iOS and was therefore excluded (*n* = 755), resulting in 3178 tests for analyses. The iOS devices did not accurately collect data because the iOS platform was not fully implemented at the time testing.

Data were grouped based on listeners' self-report of English-speaking competence, rated on a non-standardized scale from 1 to 10, where a higher score indicated better competence. As described previously, Potgieter and colleagues (2016, 2018) people who reported ≥ 6 out of 10 were described as having high English proficiency. Listeners with low English proficiency (≤ 5/10) were excluded due to the small sample size (n = 86), as this group was too small to include in the regression analyses as a separate variable. Pass and fail criteria were based on norms established by Potgieter et al. (2018): N& NN (high English proficiency) ≥ 6 with a digits-in-noise speech recognition score (DIN SRT) cut-off of -9.6 dB speech to noise ratio (SNR). Other forms of speech-in-noise (SIN) test, such as the words-in-noise (WIN) normative criteria differ compared to the DIN. Better DIN cut-off could be attributed to DIN tests that are closed-set stimuli, the overlearned nature of the digits, and simpler linguistic structure (Miller et al., 1951; Smits, Kapteyn, & Houtgast, 2009). Only listeners with who failed were included, resulting in 3092 listeners for analyses.

2.4.2. Procedures

Listeners completed the DIN test by downloading the national hearing screening test application on their smartphone. Prior to initiating the test, the application requires a listener to enter their date of birth, home language, presence of known hearing difficulty and to rate English speaking competence. In addition, listeners were linked to a SoC using adapted phrasing of the Staging algorithm (Figure 2.1), presented in the form of one or two questions (Ingo et al., 2016, 2017; Ratanjee-Vanmali et al., 2018). The adapted phrasing was based on the original model (Appendix E) by Milstein and Weinstein (2002). The application instructed the listener to select a comfortable listening intensity, where after the test commenced using a fixed overall level with an adapted SNR (Potgieter et al., 2016, 2018). The application presented the digits diotically (stimuli presented binaurally and identically to ear) in the presence of speech-weighted masking noise. The listener was required to enter the digits heard onto the keypad provided on the screen. If they responded correctly, the application presented the speech signal at 2 dB SNR lower, and if the answer was incorrect, it increased the next presentation at 2 dB SNR higher, while the masking noise was fixed at 70 dB SPL. The test presented 23 digit triplets, of which the DIN SRT was calculated by averaging the last 19 SNRs (Potgieter et al., 2016, 2018). After completing the test, listeners who failed, indicative of four frequency pure-tone average (PTA) (0.5 – 4 kHz) > 25 dB HL in the better ear, could opt to provide their contact details to be contacted by their closest hearing healthcare professional based on their geolocation when completing the DIN test. Data was stored on a secure cloud-based server.

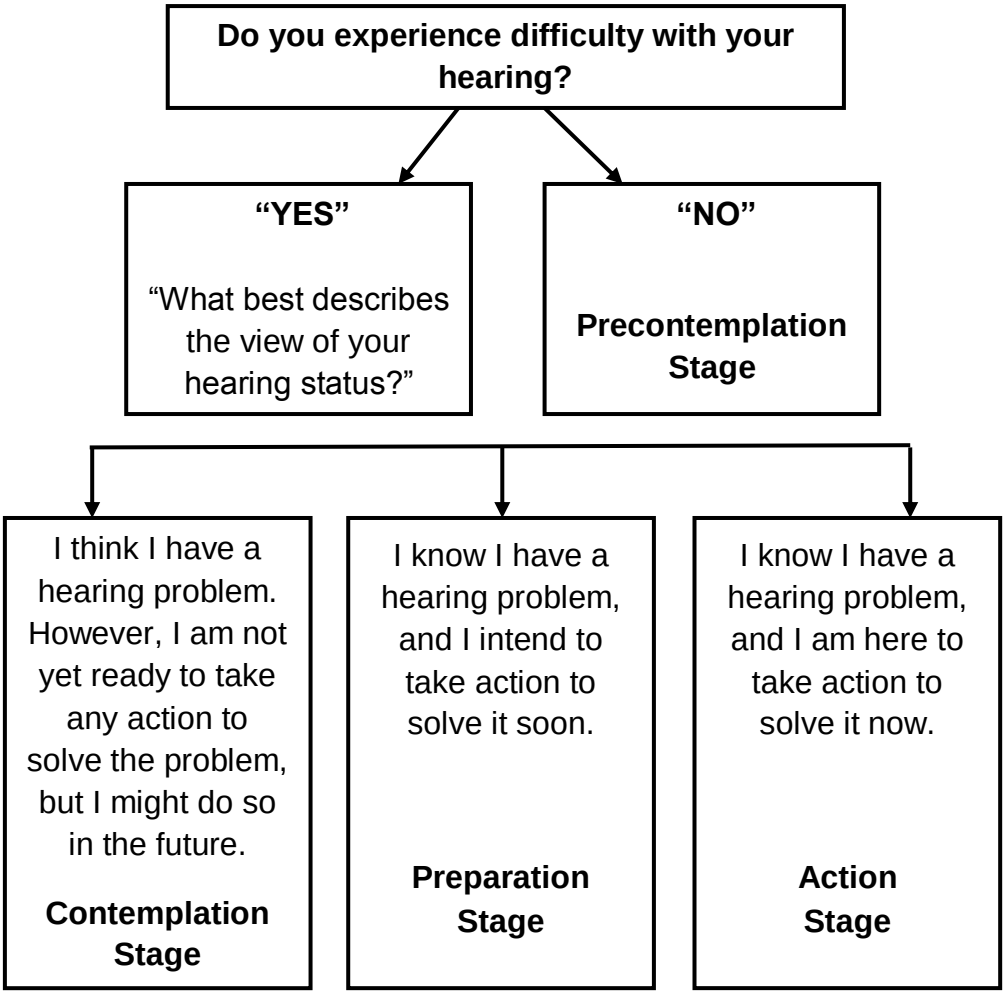

Figure 2.1. Staging algorithm embedded in hearZA™ application

2.4.3. Data processing procedure

Data were extracted from the *hearZA*™ cloud-based server and prepared in Microsoft Excel™ (Microsoft Inc., Redmond, USA). The data was imported into the Statistical Package for the Social sciences Version 25 (IBM SPSS v25.0, Chicago, Illinois) for analysis.

2.4.4. Data analysis procedure

Data were analysed using the Statistical Package of the Social Sciences (SPSS v.25.0). A *p*-value of 0.05 was used to indicate significance for all statistical test. An ordinal regression analysis was conducted to assess whether DIN SRT and age affected a listener's SoC. A one-way analysis of variance (ANOVA) and analysis of covariance (ANCOVA) was used to determine age and DIN SRT differences between SoC, respectively. Post hoc tests were done using a Bonferroni adjustment. Furthermore, data were also analysed descriptively.

2.5. Phase two: To prospectively determine help-seeking behaviour following a failed test result on the national hearing screening test

2.5.1. Participants

Phase two of the study used purposive sampling. The researcher purposively selected the group of 1007 participants that failed the hearing screening test between March 2017 and 2018 and requested contact by a hearing care professional, to determine follow up actions they took. An average delay of 20.7 months (SD 3.1 months) was present between the fail screening result and completion of the online survey. Fifty-nine participants between the age of 18 and 81 years (average 48.3 years; SD 17.2 years) responded.

2.5.2. Procedures

A cohort of the total sample of listeners who completed the test by downloading the national hearing screening test application on their smartphone failed the test and requested contact with a hearing healthcare professional. A link to an online survey (Appendix F) was sent using either a Short Message Service (SMS) or electronic mail. Individuals were only contacted once, as South Africa's Protection of Personal Information Act, which applies to the application, prohibits multiple contact attempts if individuals do not respond to the initial request. Participants were informed that they could win one of three *Takealot*™ by participating in the research study. After the data collection was completed, a number generator selected three random numbers from the participant pool as winners of the vouchers. The online survey was designed (Google forms) to obtain information on attendance with an audiological follow-up appointment after the screening, and for some who did not follow up, potential reasons. Furthermore, information on the recommendations made, follow-up actions, and satisfaction of outcomes via a 4-point Likert scale were collected. The participants could provide personalised reasons why they did not follow through with the recommendations.

2.5.3. Data processing procedure

Data were extracted from the questionnaire created on Google Forms via a Microsoft Excel (Microsoft Inc, Redmond, USA) spreadsheet. The SPSS Version 25 (IBM SPSS v25.0, Chicago, Illinois) imported the data for analysis.

2.5.4. Data analysis procedure

Data were analysed using (SPSS v.25.0). For phase two, due to the small sample size being underpowered, no inferential statistics was conducted. However, survey answers were analysed descriptively. Independent-samples t-test and Chi-square test for association was used for comparison of characteristics of phase one- and two.

2.6. Validity and Reliability

Validity

The validity of a measurement instrument is referred to as the extent to which the instrument measures what it is intended to measure (Leedy & Omrod, 2010). The Staging algorithm has been validated by Milstein and Weinstein (2002) to ensure it is a valid measurement of the SoC. Potgieter et al. (2016) validated the national hearing screening test for adults. The test can indicate functional hearing ability with a sensitivity and specificity of more than 70% to detect a sensorineural hearing loss in the better ear of more than 25 dB HL. Furthermore, specific normative data was determined to identify the hearing loss based on the participant's self-rated English competency level (Potgieter et al., 2016).

Reliability

Reliability refers to the consistency with which a measuring instrument yields a specific result when the unit measured has not changed (Leedy & Omrod, 2010). Each listener received the in-application questions and test in the same manner, to ensure reliability within the study. Additionally, the electronic mail and SMS contact methods ensured reliability by sending a uniform scripted template to each participant (Appendix C). Furthermore, survey questions were presented in the same manner for all participants (Appendix F).

3. CHARACTERISTICS AND HELP-SEEKING BEHAVIOUR OF PEOPLE FAILING A SMART DEVICE SELF-TEST FOR HEARING

Authors: Danielle Schönborn, Faheema Mahomed Asmail, Karina C. De Sousa, Ariane Laplante-Lévesque, David R Moore, Cas Smits, and De Wet Swanepoel

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3.1. Abstract

Purpose: The present study investigated user characteristics, help-seeking behavior, and follow-up actions of people who failed an app-based digits-in-noise (DIN) hearing screening, considering their stage of behavioral change.

Method: Test and user characteristics of 3092 listeners who failed the test were retrospectively analyzed. A post-test survey determining follow-up actions was sent to listeners who failed the test (n = 1007), of which 59 responded.

Results: The majority of listeners were in the precontemplation stage (75.5%). Age and stage of change were significant ($p < .05$) predictors of the digits-in-noise speech recognition threshold (DIN SRT). Listeners in the precontemplation stage were significantly younger than in other stages ($p < .05$). Post-test survey response rate was low (5.9%). Of those, most (82.4%) did not think they have a hearing loss. Only, 13.6% followed up with an audiologist.

Conclusion: Older people presented with poorer DIN SRTs and were typically in a more advanced stage of change. The majority of those who did not follow up after failing the screening test did not believe they had a hearing problem. A combination of factors, including poor DIN SRT, older age, and a more advanced stage of change inclined participants to follow up with audiological care.

Keywords: Digits-in-noise; stage of change; adult hearing screening

3.2. Introduction

Secondary prevention strategies, such as hearing screening programs, are essential to detect hearing loss early and to ensure that intervention is provided promptly (Wilson, Tucci, Merson, O'Donoghue, 2017). To make hearing loss screening methods widely available, digits-in-noise (DIN) tests delivered through telephone and internet platforms have proliferated in recent years (Jansen, Luts, Wagener, Frachet, & Wouters, 2010; Smits, Kapteyn, & Houtgast, 2004; Watson, Kidd, Miller, Smits, & Humes, 2012). To cope with poor landline penetration in South Africa (Statistics South Africa, 2016), a hearing test was launched as a smart device app (*hearZA*™) in 2016 (De Sousa, Swanepoel, Moore, & Smits, 2018; Potgieter, Swanepoel, Myburgh, Hopper, & Smits, 2016; Potgieter, Swanepoel, Myburgh, & Smits, 2018). *hearScreen USA*™ and *hearWHO*™ were also recently launched as similar apps for online hearing screening tests in other countries. The test is clinically validated and uses digits presented in speech-weighted noise to adaptively determine the signal-to-noise ratio where 50% of the digit-triplets are recognized correctly (Potgieter et al., 2016, 2018). Although sentences were historically preferred for speech-in-noise assessment, the use of digits makes speech in noise testing widely applicable because digits are easily understood in multilingual environments and by people with limited linguistic skills (Smits, Goverts & Festen, 2013). The test indicates functional hearing ability with high sensitivity and specificity (> 70%) to detect a sensorineural hearing loss in the better ear of more than 25 dB HL using a four frequency pure-tone average, for native (high English proficiency) and non-native (lower English proficiency) English-speakers (Potgieter et al., 2018).

Besides hearing screening, the DIN test app also serves as a public awareness tool for hearing loss. It can monitor oneself or someone else's hearing status using personalized profiles and can connect people to a hearing healthcare provider using location-based referral systems (De Sousa et al., 2018; Swanepoel, 2017). The app includes a decision support tool, developed in collaboration with the Ida Institute (Denmark), encouraging listeners to take the next step to manage their hearing loss (De Sousa et al., 2018; Swanepoel, 2017). In this way, smart device based screening methods are offering new possibilities, not only for detection, but supporting listeners by aiding their decision making and linking them with professionals (Swanepoel, De Sousa, Smits & Moore, 2019).

Although the DIN test provides access to accurate screening, it does not guarantee follow-through with actions to address hearing difficulties (Chou, Dana, Bougatsos, Flemming, & Bell, 2011; Gussekloo et al., 2003; Laplante-Lévesque, Brännström, Ingo, Andersson, & Lunner, 2015; Linssen, Joore, Theunissen, & Anteunis, 2013; Meyer et al., 2011; Smits, Merkus, & Houtgast. 2006; Swanepoel et al., 2019; Yueh, Shapiro, MacLean, & Shekelle, 2003). Various factors, such as the perception of symptom severity or stigma associated with hearing loss, have been reported to influence readiness to take up action (Gussekloo et al., 2003; Wallhagen, 2009). Furthermore, access to hearing specialists and cost of audiological services and aids could negatively affect help-seeking efforts (Bainbridge & Ramachandran, 2014). Help-seeking and rehabilitation is a desired behavioral standard for individuals with hearing difficulties (Ingo, Brännström, Andersson, Lunner, & Laplante-Lévesque, 2016). However, although hearing screening may increase the rate of help-seeking, it may not necessarily increase rehabilitation uptake (Arlinger, 2003; Smits et al., 2006). Characteristics of individuals who are aware of their hearing difficulty, but who are not seeking help or decline rehabilitation, are elusive (Manchaiah, Rönnberg, Andersson, & Lunner, 2015). Meyer et al. (2011) followed up 4 to 5 months after the test on 193 participants who failed a telephone-based hearing screening and found that only 36 sought help by contacting a professional. Nineteen were recommended hearing aids, but only 8 received hearing aids, of whom 6 reported successful outcomes (Meyer et al., 2011). Therefore, about 3% of individuals who failed the screening achieved the desired outcome of rehabilitation. Analyzing help-seeking for hearing loss within a framework of a multifactorial model of behavior change, such as the transtheoretical stages of change model (SoC), could help provide health care practitioners understand individual behaviors toward health care practices and ways to alter these behaviors (Saunders, Chisolm, & Wallhagen, 2012).

The transtheoretical SoC model is designed to describe an individual's current attitudes, behaviors, and intentions to assess their readiness to change by adopting and sustaining healthy behaviors (Ekberg, Grenness, & Hickson, 2016; Prochaska & DiClemente, 1983). The original model consisted of four sequential SoC: precontemplation, contemplation, action, and maintenance (Prochaska & DiClemente, 1983). The model was later revised to include the preparation stage between contemplation and action stage (Prochaska, DiClemente, & Norcross, 1992), which acknowledges the need for adequate guidance for adults who are yet to seek help for their hearing (Laplante-Lévesque et al., 2015; Laplante-Lévesque, Hickson, & Worrall, 2013). These individuals have a more definite plan of action than those in the earlier stages (Laplante-Lévesque et al., 2013). Identifying an individual's SoC may ultimately help tailor a screening and intervention program to promote help-seeking and rehabilitation (Ekberg et al., 2016; Ingo, Brännström, Andersson, Lunner & Laplante-Lévesque, 2017; Laplante-Lévesque et al., 2013, 2015).

A staging questionnaire (Staging algorithm), based on the SoC, was developed by Milstein and Weinstein (2002), based on the SoC, to categorize people with hearing loss into a specific stage of readiness to contemplate or accept intervention (e.g., hearing aids). The algorithm consists of a single question: Which of the following statements best describes your view of your current hearing status? Four possible answers are offered, each referring to one of four SoC (Milstein & Weinstein, 2002): (1) I do not think I have a hearing problem, and therefore nothing should be done about it (precontemplation); (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 & Weinstein, 2002; Prochaska et al., 1992).

Laplante-Lévesque and colleagues (2015) classified adults who failed an online screening test using the staging questionnaire and found that 50.0% of participants were in preparation, 38.0% in contemplation, 9.0% in precontemplation, and only 3.0% in the action stage. The small percentage of participants in the action stage suggests that screening alone may not be sufficient motivation to seek professional assistance (Laplante-Lévesque et al., 2015). Lin, Thorpe, Dordon-Salant, & Ferrucci (2011) found substantial differences in the rates of hearing aid use according to the severity of the hearing loss. Of those with mild hearing loss, 3.4% used hearing aids, compared to 40.0 % and 76.6% for those with moderate or severe hearing loss, respectively. Furthermore, the perception of the severity of the loss could have an influence on the motivation to seek out assistance for hearing difficulties (Gopinath et al., 2011). Laplante-Lévesque and colleagues (2013) found that individuals with less severe hearing impairment, who report less hearing disability, and who have lived with their hearing impairment for a shorter duration of time are prone to be in the earlier SoC. This suggests that those with mild hearing impairment do not perceive their difficulties as having a negative impact on their lives. As a result, they do not seek assistance.

Help-seeking behaviors for chronic conditions such as hearing loss are complex (Saunders et al., 2012), and many factors may influence these behaviors. Meyer and colleagues (2011) identified two factors that could influence the decision to take action, the individual's consideration of hearing aids before a hearing screening test and their ability to recall their test results (Meyer et al., 2011). Almost half (45.0%) of individuals who correctly recalled their test results sought out help for their hearing difficulties: in individuals who did not recall their test results, 15.0% sought help (Meyer et al., 2011). Low reported recall rates may be attributed to individuals not being ready to accept that they have a hearing impairment severe enough to warrant taking action, and therefore do not disclose their test results (Meyer et al., 2011). However, they may also indicate a problem with the transfer of test results from tester to client/patient (Meyer et al., 2011)

Miller and Rollnick (2002) suggest that the SoC can inform intervention and counselling needs when motivational interviewing takes place. Moreover, a randomized controlled trial found that motivational interviewing achieve better treatment outcomes than traditional methods of advice for both psychological and physiological health conditions (Rubak, Sandbaek, Lauritzen, & Christensen, 2005). SoC measures implemented together with online hearing screening provide good predictive validity for help-seeking (Ingo et al., 2016), and can therefore direct appropriate motivational counselling towards timely uptake of interventions.

Population-based DIN screening may thus provide individuals with a means to confirm a hearing problem but may be insufficient to motivate transition towards action (Laplante-Lévesque et al., 2015). A more extensive understanding of an individual's motivation at the time of the screening may better predict, and perhaps influence, actions taken (Ingo et al., 2016). More evidence on the SoC model as applied to hearing loss is required to understand the patient journey towards rehabilitation (Manchaiah et al., 2015). Identifying a person's profile and specific needs would be valuable to provide appropriate person-centered intervention (Manchaiah et al., 2015). The national hearing screening test for South Africa was launched in 2016 as a smart device DIN app (hearZA^{TM}) to increase access by capitalizing on the widespread penetration of smart devices (De Sousa et al., 2018). The purpose of the present study was, therefore, to investigate characteristics, help-seeking behavior, and follow-up actions of people who failed the South African DIN national hearing screening, considering their stage of behavioral change.

3.3. Method

The study received Institutional Review Board approval from the Faculty of Humanities Research Ethics Committee, University of Pretoria (GW20181112S).

Participants

Phase one – retrospective cross-sectional analysis of listener characteristics

In the period from March 2017 to March 2018, anonymized data from 5331 failed *hearZA*™ tests were collected. Online informed consent to use data in an anonymized format was provided by accepting the terms and conditions and privacy policy of the *hearZA*™ app. Data of people younger than 18 years or older than 100 years (n = 1025) or those who completed the test without earphones (n = 1008) were excluded. Earlier versions of the app did not prevent test completion when earbuds or headphones were not plugged in, which was subsequently changed. Although the *hearZA*™ test is available on both iOS and Android platforms, the Staging algorithm implementation was adequate for Android platforms only, so tests completed on iOS devices were excluded (n = 755), resulting in 3178 tests for analyses. The iOS devices did not accurately collect data because the iOS platform was not fully implemented at the time testing.

South Africa has 11 official languages and although English is widespread, is it estimated that less than 10% of the population speaks English as their first language (Statistics South Africa, 2018). Participants reported their level of English proficiency on a scale from 1 to 10. As described previously, Potgieter and colleagues (2016, 2018) people who reported ≥ 6 out of 10 were described as having high English proficiency. Listeners with low English proficiency (≤ 5/10) were excluded due to the small sample size (n = 86), as this group was too small to include in the regression analyses as a separate variable. Pass and fail criteria were based on norms established by Potgieter et al. (2018): High English proficiency ≥ 6 with a digits-in-noise speech recognition threshold (DIN SRT) cut-off of -9.6 dB signal-to-noise ratio (SNR). When the DIN and another form of speech-in-noise tests, such as words-in-noise (WIN) were compared, normative criteria for cut-off differed. Better DIN cut-off could be attributed to DIN tests that are closed-set stimuli, the overlearned nature of the digits, and simpler linguistic structure (Miller et al., 1951; Smits, Kapteyn, &

Houtgast, 2009). Only listeners with a fail were included, resulting in 3092 listeners left for analyses.

Phase two – prospective help-seeking survey

Informed consent to contact participants for phase two was provided within the app in phase one, as they selected the terms set out in the application. Only participants that indicated their English competence was high (≥ 6/10) received further communication for phase two. Additionally, informed consent to participate in phase two was provided by clicking on the link to complete the survey. A prospective survey was sent to the participants from phase one who requested to be contacted by a hearing care professional (*n* = 1007). An average delay of 20.7 months (SD = 3.1 months) was present between the fail screening result and completion of the online survey. Fifty-nine participants between the age of 18 and 81 years (average 48.3 years; SD = 17.2 years) responded.

Procedures

Phase one – retrospective cross-sectional analysis of listener characteristics

Listeners completed the DIN test by downloading the *hearZA*™ app (available on AppStore and Google Play) on their smart device (smartphone/ tablet). The app was available in other countries where app stores were available. Prior to initiating the test, the application required the listener to enter their date of birth, home language, presence of known hearing difficulty, and self-rated English competence. In addition, listeners were linked to a SoC using adapted phrasing of the Staging algorithm (Figure 3.1), presented in the form of either one or two questions (Ingo et al., 2016, 2017; Ratanjee-Vanmali, Swanepoel, & Laplante-Lévesque, 2018). Then speech-in-noise testing started. First, the application instructed the listener to select a comfortable listening intensity before the test commenced using a fixed overall level with an adapted SNR (Potgieter et al., 2016, 2018). The application presented the digits diotically within speech-weighted masking noise. The listener was required to enter the digits heard onto the keypad shown on the screen. The test used a fixed overall level (i.e., the level of the mixed speech and noise signal) and a 1-up, 1-down adaptive procedure with a 2-dB step size (Potgieter et al., 2016; 2018). When triplets with

negative SNRs were presented, the noise remained at a fixed level (70 dB SPL) while the speech level varied in 2-dB steps. When triplets with positive SNRs were presented, the speech level became fixed, and the noise level varied. The application presented the digits diotically together with broadband speech-weighted masking noise. If they responded correctly, the application presented the next presentation signal at a 2 dB lower SNR, and if the answer was incorrect, it increased the SNR of the next presentation with 2 dB, while the masking noise was fixed at 70dB SPL. The test presented 23 digit triplets, of which the DIN SRT was calculated by averaging the last 19 SNRs (Potgieter et al., 2016, 2018). After completing the test, listeners who failed, indicative of 4FPTA >25 dB HL in the better ear, could opt to provide their contact details to be contacted by their closest hearing healthcare professional based on their geolocation when completing the DIN test. Data were stored on a secure cloud-based server.

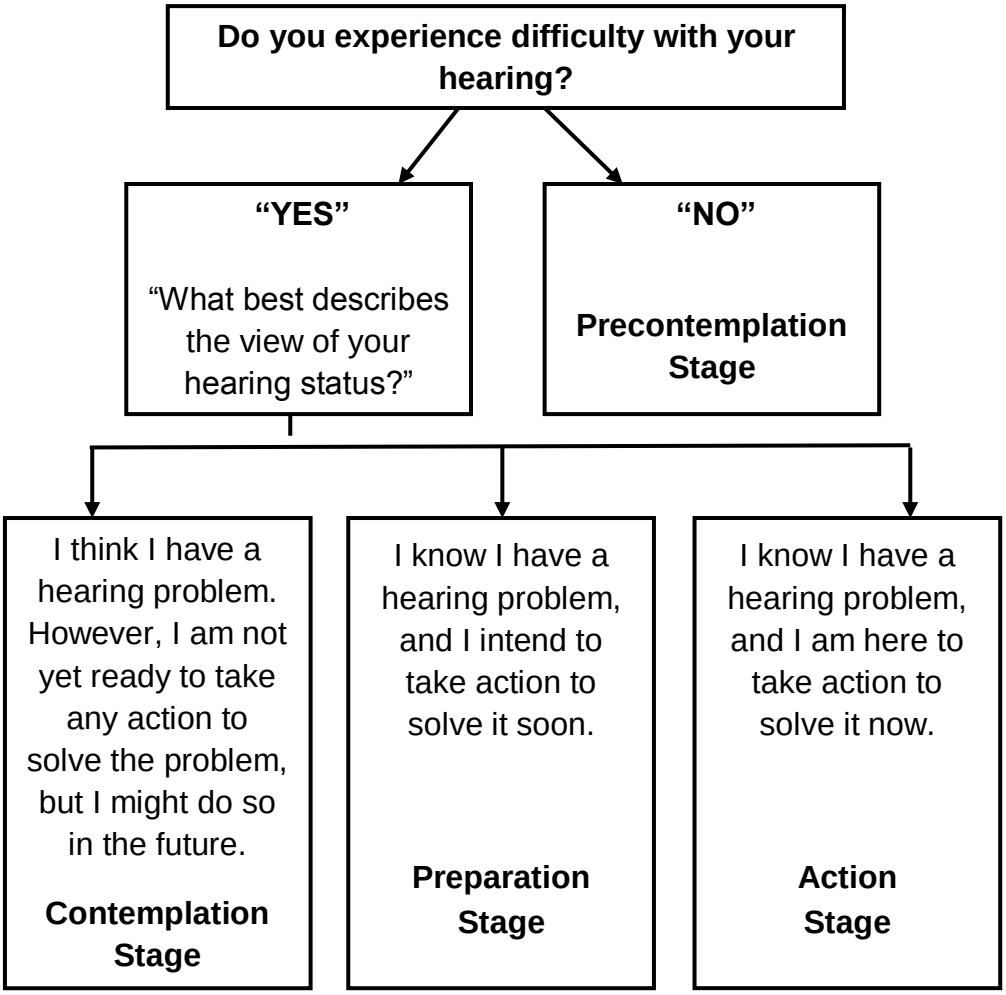

Figure 3.1. Staging algorithm embedded in *hearZA*™ application

Phase two – prospective help-seeking survey

People who failed the *hearZA*™ screening test and requested contact with a hearing healthcare professional in their area were included in this phase. People requesting to be contacted by an audiologist, based on geolocation, left their contact details. These were subsequently shared securely to the three closest audiology practices registered on the *hearZA*™ referral platform. For this phase, these individuals were sent a link to an online survey (Appendix F) using either a Short Message Service (SMS) or electronic mail. Individuals were only contacted once, as South Africa's Protection of Personal Information Act, which applies to the application, prohibits multiple contact attempts if individuals do not respond to the initial request. The online survey was designed (Google forms) to obtain information on attendance to an audiological follow-up appointment after the screening, and for those who did not follow up, to give personalized reasons why they did not proceed to seek help. Furthermore, information on the recommendations made and follow-up actions were collected. Satisfaction of the outcomes was collected with a 4-point Likert scale (Appendix F). Additionally, participants could provide personalized reasons for not following through with the recommendations.

Data analysis

Data were analyzed using the Statistical Package of the Social Sciences (SPSS v.25.0). For the retrospective phase, an ordinal regression analysis was conducted to assess whether DIN SRT and age affected a listener's SoC. A one-way analysis of variance (ANOVA) and analysis of covariance (ANCOVA) was used to determine age and DIN SRT differences between SoC, respectively. Post hoc tests were done using a Bonferroni adjustment. Independent-samples t-test and Chi-square test for association was used for comparison of characteristics of phase one- and two.

3.4. Results

Phase one – retrospective cross-sectional analysis of listener characteristics

The average age of listeners who failed the test (n = 3092) was 46.0 years (SD 18.5 years). The minimum age of the listeners was 18 years and the maximum 99 years. Of the listeners who indicated gender (446/3092), 190 were female (43.0%). The distributions of SoC indicated 75.5% of listeners were in the precontemplation stage, 9.7% in the contemplation stage, 8.2% in the preparation stage, and 6.6% in the action stage. For each of the four SoC, Figure 3.2. depicts their corresponding age and DIN SRT.

Ordinal logistic regression showed that poorer DIN SRT (OR 1.03 [CI = 1.015, 1.046], Wald x^2 (1) = 15.072, p < .001) and increasing age (OR 1.031 [CI = 1.026 1.035], Wald x^2 (1) = 166.938, p < .001) increased the odds of being in a more advanced SoC. Listeners in the precontemplation stage were significantly younger than the participants in other stages, F(3, 3088) = 11.155, p < .0005. Listeners in the action stage had a significantly worse DIN SRT than participants in other stages, F(3, 3087) = 9.487; p< .0005.

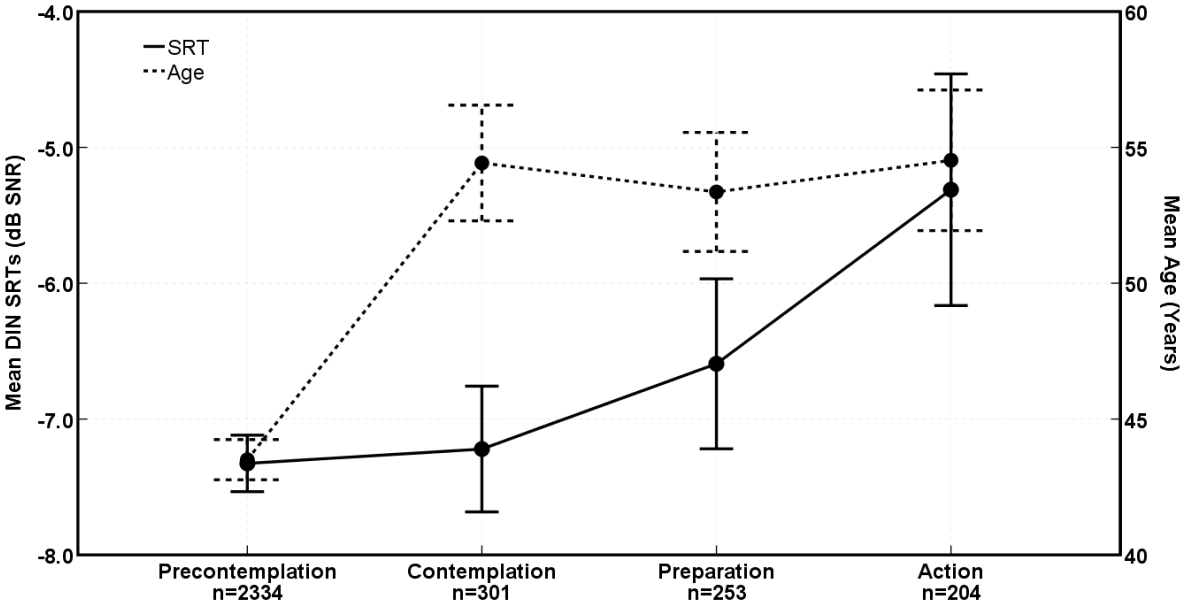

Figure 3.2. Mean age and DIN SRT for corresponding stage of change. Error bars indicate ± 2 standard errors from the mean. *DIN SRT; digits-in-noise speech reception threshold, dB; decibel, SNR; signal to noise ratio.*

Phase two – prospective help-seeking survey

Approximately one third (1007/3092) of participants from phase one who failed the screening requested to be contacted by a hearing healthcare professional. These participants were invited to take part in the prospective survey: the response rate for the survey was 5.9% (59/1007). Of these, 20.3% (12/59) of participants were in the contemplation, preparation, or action stage at the initial hearing screening test. Approximately 80% (47/59) of surveyed respondents were in the precontemplation stage (Table 3.1). Only 10.6% of participants (5/47) in the precontemplation stage attended an appointment with an audiologist after a failed screening test. In contrast, 25.0% of participants (3/12) in contemplation to action stages attended an appointment with an audiologist (Table 3.1). Participants in the precontemplation stage had a mean DIN SRT of -7.5 dB SNR and mean age of 46.7 years compared to a mean DIN SRT of -4.9 dB and mean age of 54.3 years across contemplation to action stages, suggesting that those with poorer speech understanding in noise and those who were older tended to be in a more advanced state of change. (Table 3.1).

Table 3.1. Initial stage of change, age, DIN SRT, and follow-up action for surveyed respondents (*n* = 59)

	Percentage *(n)*	**Mean age (SD)**	**Mean DIN SRT (SD) (min; max)**	**Participants who followed up with an audiologist (*n*)**	
				Yes	**No**
Precontemplation	79.7% (47/59)	46.7 (17.2)	-7.5 (5.5) (-9.8; 16.5)	5	42
Contemplation	11.9% (7/59)	58.6 (16.9)	-7.8 (1.7) (-9.8; -6.2)	1	6
Preparation	5.1% (3/59)	46.0 (20.4)	2.6 (13.1) (-9.6; 16.5)	1	2
Action	3.4% (2/59)	52.0 (12.7)	-6.1 (0.7) (-9.6; -5.6)	1	1

13.6% (8/59) of participants followed up with an audiologist, of whom half were recommended hearing aids, two were referred to an otorhinolaryngologist (ENT), and two had normal audiometric results, confirmed by normal audiometric results. Four participants proceeded with these recommendations, three with hearing aids, and one with an ENT evaluation. Two participants who did not proceed with the recommendations indicated that they would do something about their hearing in the next year. Furthermore, two participants with normal audiometric results received no further recommendations.

Only 5.1% (3/59) of participants indicated that an audiologist contacted them following their failed screening test. Fifty-one of the total sample of participants (86.4%) did not independently seek further help by contacting an audiologist. These participants chose from options 1-3 (Table 3.2) in the survey that provided a reason for their lack of help-seeking. However, the majority (82.4%; 42/51) of those did not think they had a hearing loss and therefore were in the precontemplation stage. Participants could also opt to select an 'other' option to provide individualized answers. Table 3.2 displays the most frequently reported personalized reasons for not pursuing any actions after a failed test.

Table 3.2. Main reason identified by participants for not following up after a failed test result (*n* = 51)

Reason for no follow-up action:	%
1. Did not think they have a hearing loss	51.0 %
2. Aware of hearing loss but not ready to seek help	13.7 %
3. Aware of hearing problem and will seek help within the next year	13.7%
4. Financial constraints	11.8%
5. Not contacted by an audiologist	5.9%
6. Stigma	2.0%
7. Living abroad	2.0%

As can be seen in Table 3.3, although the response rate of phase two was only 59/1007 (5.9%), the characteristics of the respondents did not differ significantly from the 3092 participants who failed the DIN test in phase one consider age, DIN SRT and SoC.

Table 3.3. Characteristic comparison of samples of phase one and phase two. No significant differences in age, DIN SRT, or distribution of stage of change between the two samples.

	Phase one *n* = 3097	Phase two *n* = 59	Group differences
			Independent sample t-test
Age (mean; SD)	46.0 (18.5)	48.3 (17.2)	*p*>.05
DIN SRT (mean; SD)	-7.1 (5.0)	-6.9 (5.9)	*p*>.05
Stage of change (SoC)			*Chi-square*
Precontemplation	75.5% (*n*=2334)	79.7% (*n*=47)	*(Precontemplation versus remaining combined stages)* *p>.05*
Contemplation	9.7% (*n*=301)	11.9% (*n*=7)	
Preparation	8.2% (*n*=253)	5.1% (*n*=3)	
Action	6.6% (*n*=204)	3.4% (*n*=2)	

3.5. Discussion

Phase one – retrospective cross-sectional analysis of listener characteristics

Overall, hearing screening has been proposed as a method to promote help-seeking for people with hearing loss (Arlinger, 2003). Various studies have investigated the help-seeking rates following adult hearing screening and the outcomes have varied greatly, from as low as 2.7% to as high as 61.0% (Ingo et al., 2016, 2017; Laplante-Lévesque et al., 2015; Meyer et al., 2011; Ratanjee-Vanmali et al., 2018; Smits et al., 2006; Yueh et al., 2010). In the present study, a minority (6.6%) of listeners who completed the *hearZA*™ smart device screening were in the action stage of readiness, with the majority (75.5%) in the precontemplation stage and typically not willing to pursue further diagnostics or intervention at the time. Similar findings regarding online screening programs have been reported with less than 8.0% of people who failed the screening test in the action stage (Ingo et al., 2017; Laplante-Lévesque et al., 2015). Screening on its own may not be enough to promote help-seeking for hearing difficulties (Laplante-Lévesque et al., 2015). Assisting people to decide to follow up with a hearing healthcare professional using tailored tools inspired by health behavior change theories could promote follow-up action (Pronk et al., 2011). However, a recent randomized controlled trial indicated that an automated online motivational intervention for people who failed an online hearing screening did not significantly improve help-seeking rates amongst its 68 participants 9 months later (Ingo et al., submitted). However, having discussed hearing difficulties with a professional on a previous occasion, significantly predicted help-seeking. Furthermore, Ratanjee-Vanmali and colleagues (2018) indicated that online digital tools, in combination with face-to-face consultations may hold promise for improved service delivery outcomes. They suggested that service providers can use such modes to support individuals during initial stages of seeking hearing health care online before attending a physical appointment (Ratanjee-Vanmali et al., 2018).

Previous studies indicated that people with more severe hearing loss are more inclined to seek diagnostic help and intervention (Laplante-Lévesque et al., 2013; Meyer & Hickson, 2012). The DIN SRT was significantly worse in the action stage compared to the preceding stages. The more severe the DIN SRT, the more likely an individual was to be in a later SoC, and therefore to seek out assistance for their hearing loss. This indicated DIN SRT was a predictor of SoC. In contrast, a study that used online adaptive hearing screening with a closed set of words to determine SRT did not report a relationship between SRT and SoC (Laplante-Lévesque et al., 2015). In that study by Laplante-Lévesque and colleagues (2015), SoC was determined after the screening, whereas our study collected it before the screening. Providing the results of the screening could thus influence participants' the SoC measured. However, earlier research has indicated that the stage of readiness for intervention did not differ when the SoC was presented before and after hearing screening (Milstein & Weinstein, 2002). The average age of listeners in our study was 46 years compared to 68 years in a previous study (Ingo et al., 2016, 2017; Laplante-Lévesque et al., 2013, 2015). The younger age of participants in our study may be attributable to the smart device screening test being advertised through digital marketing campaigns. The test was marketed as a tool for younger people to know their hearing status, rather than to confirm a suspected hearing loss (De Sousa et al., 2018). Moreover, the study by Laplante-Lévesque and colleagues (2015) implemented the University of Rhode Island Change Assessment (URICA) SoC measurement, whereas the present study used the Staging algorithm. The former study showed no relationship between the URICA SoC measurement and SRT, but our study indicated a relationship between the Staging algorithm measures and DIN SRTs. The Staging algorithm may be a better-suited measure than URICA to identify a relationship between SoC and DIN SRT.

Age significantly predicted SoC, with listeners in the precontemplation stage significantly younger than those in successive stages. As found in other studies using online DIN hearing screening (De Sousa et al., 2018; Ratanjee-Vanmali et al., 2018). With younger age also associated with better DIN SRT, fewer hearing difficulties may be perceived, leading to more participants in the precontemplation stage. Older age is associated with hearing loss, as approximately one-third of individuals, 65 and older, are affected by a disabling hearing loss (WHO, 2018). Since noticing hearing difficulties, it takes individuals, on average, ten years to seek help (Davis, Smits, Ferguson, Stephens, & Gianopoulos, 2007; Hickson, Meyer, Lovelock, Lampert, & Khan, 2014; Meyer, Hickson, Lovelock, Lampert, & Khan, 2014). Consequently, older individuals have had a longer time lapse since the onset of hearing difficulties to accept them. Our listeners may thus be represented mainly in the precontemplation stage due to their younger age. They were recruited through marketing campaigns directed at discovering hearing status, rather than confirming a hearing loss, so they may not actively be seeking out assistance for their hearing difficulties. In comparison, the participants in Laplante-Lévesque et al. (2015) were older and subsequently more represented in the contemplation and preparation stages.

Phase two – prospective help-seeking survey

One in every three participants who failed the initial hearing screening test opted to be contacted by a hearing professional. Approximately 13% of the participants in this study followed up with a hearing care professional, of whom the majority (63.0%) proceeded with treatment recommendations, including acquiring hearing aids and complying with ENT referrals. One in ten participants in the precontemplation stage followed up with a hearing care professional as opposed to one in four across the contemplation, preparation, and action stages. Meyer et al. (2011) reported that 36.0% of failed screenings sought help, and only 5.0% acquired hearing aids, which is similar to the 5.0% hearing aid uptake (3/59) in the current study. Ingo et al. (2016) observed higher follow-up rates (60.8%), with 25.4% of those who failed the screening obtained hearing aids, despite only 12.2% being in the action stage. Only 1.4% of participants in the Ingo et al. (2016) study who sought help were in the precontemplation stage before their initial screening compared to 10.6% in the current study. In another previous study, participants who were in the precontemplation stage had less

successful intervention outcomes compared to those who scored higher on the action stage, being more likely to take up hearing intervention six months later (Laplante-Lévesque et al., 2013). Similarly, Saunders and colleagues (2016) indicated that less than 15% of participants in the precontemplation stage at baseline acquired hearing aids six months later, compared to the nearly 80% of participants who were in the action stage at baseline and acquired hearing aids. Using the transtheoretical SoC can, therefore, be a robust predictor of intervention uptake and successful outcomes. Targeting those in the precontemplation stage could inform candidacy for audiological rehabilitation and help identify clients before they are likely to require more clinical attention (Laplante-Lévesque et al., 2013; Laplante-Lévesque, Hickson, & Worrall, 2012).

In the current study, very few (5.1%) of the surveyed respondents reported being contacted by a hearing professional. This points to a problem in the pathway from *hearZA*™ referral to successful professional support, and therefore further investigation is required to identify its causes. The majority (86.4%) of participants who failed the screening test and requested to be contacted by an audiologist did not self-initiate further action. Primary reasons for not following up included not noticing hearing difficulties (51.0%), followed by not being ready to take action yet (13.7%) or planning to take action in the next year (13.7%). Financial constraints were also highlighted (11.8%) as a prohibitive reason. Cost of hearing healthcare, and of hearing aids in particular, have been identified as a reason for the delay in not seeking out help for hearing difficulty (Fischer et al., 2011; Kochkin, 2007).

Most surveyed participants were in the precontemplation stage at the screening. The precontemplation stage is characterized by people not realizing they have a hearing loss or thinking nothing should be done about it (Milstein & Weinstein, 2002). Interestingly, these participants still opted to be contacted. However, participants provided their SoC before taking the screening test and only submitted contact details once informed of the fail result. It could be that they initially thought no hearing difficulties were present but, once they failed, may have wanted further information on their test result. Furthermore, the SoC may better be represented as a continuum rather than a movement from one distinct step to another (Laplante-Lévesque et al., 2013). Therefore, these individuals may be represented across more than one stage or as transitioning between stages.

Screening test outcomes were followed up and related to the SoC measure to determine the effectiveness of hearing screening without additional motivators. This study provides outcomes of the application of the Staging algorithm as a single measure of SoC presented together with online hearing screening. Clinically, this is of importance as we can provide directed support based on their SoC to ensure timely help-seeking. Furthermore, participants could provide reasons for their lack of follow-up, highlighting barriers to help-seeking following a fail result, with particular focus on the precontemplation stage. Screening, in combination with additional motivators might improve help-seeking.

Although the response rate in phase two was low, there was no evidence of response bias (i.e., systematic difference between participants who responded and those who did not). Participants in phase one (retrospective) and phase two (prospective) did not differ significantly (table 3.3) in terms of age, DIN SRT, and distribution of SoC supporting the assumption that it is a representative subsample of phase one participants.

Future research could assess whether timely follow-up from a professional or online aural rehabilitation after a failed screening increases awareness of hearing difficulties experienced.

Study limitations

Online marketing led to samples that were younger than typical first-time audiology patients, in a public health perspective of prevention and early detection and intervention Younger age may impede help-seeking behavior due to milder degrees of hearing loss compared to older populations (Meyer & Hickson, 2012). Therefore conclusions are only relevant for pre-clinical populations and are unlikely to be generalizable to people seeking traditional diagnostic services. The average delay of almost two years between hearing screening and the follow-up survey could have led to inconsistencies in reporting. Furthermore, although the response bias has been addressed and participants for phase two is a representation of the larger population, the sample still provided inadequate power for any inferential statistics.

Audiological services require technology for assessment and intervention for hearing loss. In South Africa, service provision and resources are constrained, particularly within the public sector (Swanepoel, Störbeck, & Friedland, 2009). This rather than lack of readiness may have been a barrier to help-seeking by participants in the present study, due to poor access, and perceived affordability of hearing care. The SoC model may, therefore not capture all the factors determining help-seeking behavior.

Conclusion

Older people who completed a hearing screening presented with poorer DIN SRTs and were typically in more advanced SoC than younger participants. Therefore, a combination of factors predisposes people to follow-up screening with audiological care.

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Declaration of Conflicts of Interest

The 5th and last author has a relationship with the *hearX™ Group (Pty) Ltd*, which includes equity, consulting, and potential royalties. The authors report no other conflicts of interest.

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4. DISCUSSION AND CONCLUSION

4.1. Discussion of results

This study determined the characteristics and SoC of listeners that failed the national hearing screening test and determined the influence of these identified factors on follow-up help-seeking behaviour. Results indicated that older individuals presented with poorer DIN SRTs and were typically in a more advanced SoC, and therefore and predisposed them to follow up audiological care.

Phase one

Help-seeking rates in studies investigating follow-up outcomes after adults hearing screening vary greatly from 2.7% to 61% (Ingo et al., 2016, 2017; Laplante-Lévesque et al., 2015; Meyer et al., 2011; Ratanjee-Vanmali et al., 2018; Smits et al., 2006; Yueh et al., 2010). In the present study, a minority (6.6%) of listeners who completed the national hearing screening test were in the action stage of readiness, with the majority (75.5%) in the precontemplation stage. Those in the precontemplation stage may be at an earlier point in the process of hearing deterioration (e.g. presbycusis) and therefore may not be willing to pursue further diagnostics or intervention at the time. Similar findings regarding online screening programs have been reported with less than 8.0% of individuals who failed the screening test in the action stage (Ingo et al., 2017; Laplante-Lévesque et al., 2015). Screening, on its own, may not be enough to promote help-seeking for hearing difficulties (Laplante-Lévesque et al., 2015). Laplante-Lévesque et al. (2015) suggested that intervention be rooted in motivational interviewing and tailored according to the individuals' SoC profile could be used to improve these help-seeking and rehabilitation rates.

DIN SRT was a predictor of progressing SoC with significantly poorer DIN SRTs in the action stage compared to the preceding stages. Individuals with more severe hearing impairment may, therefore, be more inclined to seek diagnostic help and intervention (Laplante-Lévesque et al., 2013; Meyer & Hickson, 2012). The more severe the DIN SRT, the more likely an individual was to be in a later SoC, and therefore to seek out assistance for their hearing loss. This indicated DIN SRT was a predictor of SoC. In contrast, a study that used online hearing screening with an adaptive SIN with a closed

set of words to determine SRT did not report a relationship between SRT and SoC (Laplante-Lévesque et al., 2015). In the study by Laplante-Lévesque and colleagues (2015), SoC was determined after the screening, while our study collected it before the screening. Providing the results of the screening prior to the SoC measurement could perhaps influence the SoC. However, earlier research had indicated that the stage of readiness for intervention did not differ when the SoC was presented before and after hearing screening (Milstein & Weinstein, 2002). The younger average age of listeners in this study was lower than the average age of 68 years in similar studies (Ingo et al., 2016, 2017; Laplante-Lévesque et al., 2013, 2015). The younger age representation in this study can be attributed to the fact that a smartphone screening test attracts a broader age group through online modes of recruitment and digital marketing campaigns biased towards younger populations (De Sousa et al., 2018). Marketing for the national hearing screening test was also targeted as a tool for younger individuals to know their hearing status rather than confirming a suspected hearing loss (De Sousa et al., 2018). Moreover, the study by Laplante-Lévesque and colleagues (2015) implemented the University of Rhode Island Change Assessment (URICA) SoC measurement, whereas the present study used the Staging algorithm. The former study showed no relationship between the URICA SoC measurement and SRT, but our study indicated a relationship between the Staging algorithm measures and DIN SRTs. The Staging algorithm may be a better-suited measure than URICA to identify a relationship between SoC and DIN SRT.

Age significantly predicted SoC with listeners in the precontemplation stage significantly younger than those in successive stages. As with other studies concerning online DIN hearing screening (De Sousa et al., 2018; Ratanjee-Vanmali et al., 2018), age was a significant predictor of DIN SRT in this study. With younger age associated with better DIN SRT, less hearing difficulties may be perceived and are therefore represented in the precontemplation stage. Older age is associated with hearing impairment as approximately one-third of individuals 65, and older are affected by a disabling hearing loss (WHO, 2018). Since noticing hearing difficulties, it takes individuals approximately ten years to seek help (Davis et al., 2007; Hickson et al., 2014; Meyer et al., 2014). Consequently, older individuals have had a more substantial time lapse since the onset of hearing difficulties to accept it. Younger individuals may only start noticing hearing difficulties. Our listeners may be represented mainly in the

precontemplation stage due to their younger age representation and as a result, not actively seeking out assistance for their hearing difficulties. In comparison, Laplante-Lévesque et al. (2015) participants' were older and subsequently more represented in the contemplation and preparation stages.

Alternatives to the transtheoretical model may have been better substitutes to measure readiness to change as contributing factors are taken into account when analysing why/ why not action was taken. However, no studies to date have utilised the Andersen behavioural model of healthcare utilisation within an online hearing screening context, and therefore additional research is needed to validate it for the specific use. The health belief model has been utilised within the hearing screening context as it has described main attitudinal beliefs and external cues to action that influenced decisions to seek help for hearing loss and adopt hearing aids (Meyer et al., 2014). The Staging algorithm, however, provides the capability to be incorporated into telehealthcare solutions, in particular, application-based screenings as it is a rapid manner to identify readiness for help-seeking.

Phase two

One in every three participants who failed the initial hearing screening test opted to be contacted by a hearing professional. Studies by Meyer et al. (2011) and Ratanjee-Vanmali et al. (2018) similarly showed that only 18.8% and 36.0% respectively sought further assistance after failing an online screening test. It was suggested that some test users might be curious about their hearing status, but not ready to take action (Ratanjee-Vanmali et al., 2018).

Approximately 13% of the participants in the present study followed up with a hearing care professional, of whom the majority (63.0%) proceeded with treatment recommendations, including acquiring hearing aids and complying with ENT referrals. One in ten participants in the precontemplation stage followed up with a hearing care professional as opposed to one in four across the contemplation, preparation, and action stages. Meyer et al. (2011) reported that 36.0% of failed screenings sought help and only 5.0% acquired hearing aids, which is similar to the 5.0% hearing aid uptake (3/59) in the current study. Ingo et al. (2016) observed higher followed-up rates (60.8%), with 25.4% of those who failed the screening complying with treatment

recommendations, despite only 12.2% being in the action stage. Only 1.4% of participants in the Ingo et al. (2016) study who sought help were in the precontemplation stage before their initial screening compared to 10.6% in the current study. In a previous study, participants who were in the precontemplation stage had less successful intervention outcomes compared to those who scored higher on the action stage, being more likely to take up hearing intervention six months later (Laplante-Lévesque et al., 2013). Similarly, Saunders and colleagues (2016) indicated that less than 15% of participants in the precontemplation stage at baseline acquired hearing aids six months later, compared to the nearly 80% of participants who were in the action stage at baseline and acquired hearing aids. Using the transtheoretical SoC model can, therefore, be a robust predictor of intervention uptake and successful outcomes. Targeting those in the precontemplation stage could inform candidacy for audiological rehabilitation and help identify clients before they are likely to require more clinical attention (Laplante-Lévesque et al., 2013; Laplante-Lévesque, Hickson, & Worrall, 2012).

In the current study, very few (5.1%) of the surveyed respondents reported receiving a call or email from an audiologist. This points to a problem on the part of professionals to act on leads generated through the test referral platform and requires investigation to identify the exact points of breakdown. The majority (86.4%) of participants who failed the screening test and requested to be contacted by an audiologist did not self-initiate further action. Primary reasons for failure to follow up included that they did not believe they had a hearing loss (51.0%), followed by not being ready to take action (13.7%) or that they were planning to take action in the next year (13.7%). Financial constraints were also highlighted (11.8%) as a prohibitive reason. Cost of hearing healthcare, and of hearing aids in particular, have been identified as a reason for the delay in not seeking out help for hearing difficulty (Fischer et al., 2011; Kochkin, 2007).

Furthermore, 2% of our participants attributed stigma for their lack of taking action. A systematic review on the effects of stigma on acquiring hearing aids for hearing difficulties revealed that concealing their hearing difficulties was the most common stigmatic behaviour, with the size and visibility of a hearing aid playing a significant role in the use of the device (David & Werner, 2015). A multi-country study on the social representation of hearing aids showed that individuals generally have negative

or neutral connotations (Manchaiah et al., 2015b). Manchaiah et al. (2015b) and Solheim (2011) suggested that having negative expectations and attitudes toward hearing aids without any subjective experience are generally formulated by various societal factors and could, therefore, have important clinical implications.

Although the response rate in phase two was low, there was no evidence of response bias (i.e., systematic difference between participants who responded and those who did not). Participants in phase one (retrospective) and phase two (prospective) did not differ significantly (table 3.3) in terms of age, DIN SRT, and distribution of SoC supporting the assumption that it is a representative subsample of phase one participants.

The majority of surveyed participants were in the precontemplation stage at the screening. The precontemplation stage is characterised by individuals not realising they have a hearing loss or thinking nothing should be done about it (Milstein & Weinstein, 2002). Interestingly, these participants still opted to be contacted. However, participants provided their SoC before taking the screening test and only submitted contact details once informed of the fail result. It could be that they initially thought no hearing difficulties were present but, once they failed, may have wanted further information on their test result. Furthermore, the SoC may better be represented as a continuum rather than a movement from one distinct step to another (Laplante-Lévesque et al., 2013). Therefore, these individuals may be represented across more than one stage or as transitioning between stages.

4.2. Clinical implications

Overall, phase one of the study demonstrated that the majority of listeners were in the precontemplation stage (75.5%) despite having received a failed test result following their hearing screening. Clinically, this may indicate that individuals are taking the first step by identifying a hearing difficulty, but require more than just screening to motivate help-seeking behaviour. The lower average age of listeners in this study indicated that the national hearing screening test is reaching a younger age population than before. As younger ages are being reached, this tool can be used to identify hearing difficulties earlier.

In phase two of the study, screening test outcomes were followed-up and related to the SoC measure to determine the effectiveness of hearing screening without additional motivators. Clinically, combining additional motivators with a specific SoC may provide guidance on the possibility of directed counselling based on their SoC to ensure timely help-seeking. The low follow-up by audiologists indicates a gap in intervention on the side of the professionals. Shedding light on the low follow-up rates may increase follow-up procedures and aid in increased hearing care intervention.

The addition of SoC to the screening procedure allows the audiologist to measure the decisional stage of an individual, enabling the provision of patient-directed counselling based on the stage identified. Clinically, by providing directed counselling, audiologists can adapt the intervention plan to suite patient-specific needs. Utilising this method provides patient centred directed intervention and ultimately supports timely uptake of hearing aids.

4.3. Critical Evaluation

A critical evaluation is necessary to evaluate the study regarding its strengths and limitations.

Strengths of study

Phase one of the study had a large sample of participants (*n* = 3092), allowing the researchers to accurately make deductions about user characteristics and help-seeking behaviour following the hearing screening. Therefore, phase one provided adequate power for statistical deductions This study provides outcomes of the application of the Staging algorithm as a single measure of SoC presented together with online hearing screening. Screening test outcomes were followed-up and related to the SoC measure to determine the effectiveness of hearing screening without additional motivators. This was accomplished by the use of a combined retrospective and prospective study design on the same participants over an extended period to make these predictions. Furthermore, participants could provide personalised feedback for their lack of follow-up, providing an understanding of the pattern following a fail result, with particular focus on the precontemplation stage. Screening in combination with additional motivators, help-seeking may improve.

Limitations of study

The use of online marketing to advertise the national hearing screening test may have led to the sample to be younger than the typical first-time audiology patients. Therefore, outcomes may only apply to the pre-clinical population and cannot be applied to individuals seeking traditional diagnostic services. For phase two of the study, low survey response rates (59/1007) may have resulted in sampling bias. Sampling bias arises when the study sample is not representative of the entire population due to inadequate random sampling of participants (Salkind, 2010). Only participants that completed the national hearing screening test were eligible to be included; therefore, already eliminating a population that does not have access to smartphone services.

Furthermore, the study sample selection for our study involved excluding participants based on the platform used to complete the test, the manner of testing (earbuds vs free field) and English language competence which may have limited some responses that could have contributed to the broader representation of the entire population. Therefore, this sample may not be representative of the broader population of individuals who failed the hearing screening. Moreover, the average delay of 20.7 months between hearing screening and the follow-up survey could hinder the accurate recall of results. Although the response bias has been addressed and participants for phase two is representative of the larger population, the sample still provided inadequate power for any inferential statistics. Therefore, due to the underpowered nature of phase two, limited deductions can be made about the follow-up behaviour of individuals after failing the screening test. Thus, the present study struggles to address the second research question presented entirely.

4.4. Future research

Future research efforts investigating the success of adding an aural rehabilitation tool to online hearing screening protocols could provide valuable insight by analysing the rates of help-seeking following the adapted protocol. Rutherford and Petersen (2019) indicated assisting users in deciding to follow up with a hearing healthcare professional using tools such as the Ida Telecare Toolkit resource (e.g., “Why improve my hearing?”) could potentially be used to promote follow-up action. Therefore, these findings could be the basis for future research to determine the effectiveness of the implementation of these tools. Furthermore, an investigation into timely follow-up procedures (i.e. telephonic calls, email, video call) following a failed result could provide insight on whether it affects the decision-making process to seek help for their hearing difficulties. Future research could potentially change the order of the test procedure by completing the hearing screening test before selecting an option that is best suited to the view of their hearing difficulties (stage of change). The order change could potentially influence help-seeking behaviour by having knowledge of their hearing status before deciding their view of their hearing difficulties.

4.5. Conclusion

A combination of factors, including a poorer DIN SRT result, older age, and more advanced SoC are likely to predispose to follow-up audiological care. The lack of follow-up after a failed hearing screening could also be attributed to hearing screening needing to be accompanied by additional motivators to promote the transition from earlier to later stages of readiness.

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6. APPENDICES

Appendix A: Faculty of Humanities Ethical Clearance

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Research Ethics Committee

31 January 2019

Dear Ms Schonborn

Project:	**Help-seeking behaviour after failing the South African National Hearing Test – Influence of stage of change**
Researcher:	**D Schonborn**
Supervisors:	**Prof DCD Swanepoel, Dr F Mahomed, Ms KC Swanepoel**
Department:	**Speech-Language Pathology and Audiology**
Reference Number:	**14074550 (GW20181112S)**

Thank you for your response to the Committee's correspondence.

I have pleasure in informing you that the Research Ethics Committee formally **approved** the above study at an *ad hoc* meeting held on 31 January 2019. Data collection may therefore commence.

Please note that this approval is based on the assumption that the research will be carried out along the lines laid out in the proposal. Should your actual research depart significantly from the proposed research, it will be necessary to apply for a new research approval and ethical clearance.

We wish you success with the project.

Sincerely

Prof Maxi Schoeman
Deputy Dean: Postgraduate and Research Ethics
Faculty of Humanities
UNIVERSITY OF PRETORIA
e-mail: PGHumanities@up.ac.za

cc: Prof DCD Swanepoel, Dr F Mahomed, Ms KC Swanepoel (Supervisor)
Dr J van der Linde (HoD)

Fakulteit Geesteswetenskappe
Lefapha la Bomotho

Research Ethics Committee Members: Prof MME Schoeman (Deputy Dean); Prof KL Harris; Mr A Bizos; Dr L Blokland; Dr K Booyens; Dr A-M de Beer; Ms A dos Santos; Dr R Fasselt; Ms KT Govinder Andrew; Dr E Johnson; Dr W Kelleher; Mr A Mohamed; Dr C Puttergill; Dr D Reyburn; Dr M Soer; Prof E Taljard; Prof V Thebe; Ms B Tsebe; Ms D Mokalapa

Appendix B: Consent for anonymised data from the *hearX™ group*

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Department of Speech-Language Pathology and Audiology

TO: Mr. Nic Klopper, CEO (HearX™ Group)

RE: Permission to use anonymous hearZA™ data for a research project

Dear Mr. Nic Klopper

I, Danielle Schönborn am conducting a project on the use of mHealth technology in hearing healthcare. My primary focus is on the smartphone-based national hearing test (hearZA™). I am hereby requesting permission to use the test data for users of the hearZA™ App for our research project entitled 'Help-seeking behaviour after failing the South African National Hearing Screening Test – Influence of stage of change.' The test data should be dated from March 2017 to March 2018.

The data required for this particular study is information on a pass or refer result on the hearZA™ test. Additional information on the individuals that referred is needed, with regards to if they requested to be contacted by a hearing healthcare professional following the hearing screening. Information on each participant's stage of change from the in-application questionnaire (Staging algorithm) is also required. The data needs to be stratified for age and gender. Therefore the information needs to be able to separate into male and female, as well as separate age categories starting from 20 years and above. Each age increment is as follows: 20-29, 30-39, 4049, 50-59, 60-69, 70-79, 80-89. The name and contact number of the participant who failed and requested to be contacted by the hearing healthcare professionals are required as those individuals need to be contacted telephonically for an interview to determine their help-seeking behaviour after contact with a hearing healthcare professional.

The purpose of the project is to describe the participants' stage of change in conjunction with a failed test result on the hearZA™ application. The participants will be divided into two groups which form part of the retrospective and prospective part of the study. The stage of change will be linked to help-seeking behaviour for each group respectively. Therefore it will aim to understand why some individuals seek out health care assistance for their hearing difficulties and why others do not, as it is such a vital point for seeking intervention. The study will focus on adult participants from 20 years and upwards.

If you will allow me to use the data indicated in the abovementioned study, please sign the attached consent letter. Should you require any additional information, do not hesitate to contact me at 0845106131.

Fakulteit Geesteswetenskappe
Departement Spraak-Taalpatologie en Oudiologie
Lefapha la Bomotho
Kgoro ya Phatholotši ya Polelo-Maleme le Go kwa

Sincerely,

Danielle Schönborn

Masters student

PERMISSION TO ACCESS DATA OF THE HEARZA™ NATIONAL HEARING TEST FOR A RESEARCH PROJECT

Herewith, I NJ Klopper, permit on behalf of the HearX™ Group to Danielle Schönborn from the University of Pretoria to use the anonymous hearZA™ test data for his project entitled: '*Help-seeking behaviour after failing the South African National Hearing Screening Test – Influence of stage of change.*' We will provide you with a datasheet with test results recorded dating back from March 2017 to March 2018.

Date:

Nic Klopper

Chief Executive Officer: HearX™ Group

Appendix C: Phase two: Participant informed consent letter

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Department of Speech-Language Pathology and Audiology

HearX in conjunction with UP research

Dear hearZA user,

hearX would like to invite you to participate in a research project that the University of Pretoria is conducting on our hearZA hearing screening app. Our 2-minute survey gives you the chance to be one of three lucky participants to win R1000 Takealot vouchers that will be randomly selected. To access the survey click the link below. Alternatively, you can provide us with your contact details so that one of our team members can contact you to complete the survey telephonically.

This anonymised survey aims to understand how users who know their hearing screening result make decisions in regards to hearing services.

Hope to hear from you soon.

Danielle Schönborn (Masters Student in Audiology) and the hearX Team

Legal Notice: Kindly note that we will only be sending you this one email in conjunction with this research and will not illicit any further communication from you regarding this unless it is initiated by you. The results of this research will be fully anonymised and your data will be kept strictly confidential. This research has been granted ethical approval by the University of Pretoria (REF: GW20181112S).

Fakulteit Geesteswetenskappe
Departement Spraak-Taalpatologie en Oudiologie
Lefapha la Bomotho
Kgoro ya Phatholotši ya Polelo-Maleme le Go kwa

Appendix D: Participant informed consent via *hearX™ group*

hearX group

Date: 17 January 2019

Danielle Schonborn
dannyschonborn11@gmail.com

HEARZA RESEARCH SURVEY - PERMISSIONS COLLECTED FROM APPLICATION

Dear Danielle,

With reference to your research at the University of Pretoria, we would herewith like to confirm the following details regarding the permissions sought and information collected within the hearZA application. Kindly note that while we do not have physical 'permission forms', that the continued use of the application is dependant on your acceptance of the Terms and Conditions and Privacy policy, of which we have highlighted pertinent sections herein. The acceptance thereof by the user is thus implied by them completing the test.

With reference to the hearZA Privacy Policy; general permission for "Contacting the User" is listed as one of the uses of the collected data. This is listed in paragraph 3.4.

With regards to the user asking to be contacted, a checkbox is provided for the user to select. The wording on the page are as follows:
Heading:
"Supply your details below to connect with Audiologists of your choice"

Checkbox wording:
"I consent to share my contact information"

If checkbox isn't selected, the user will not share his/her information, and will not be able to continue. If this user completed a test, but did not provide this information, the user's test details will be stored as anonymous and no contact information stored.

ZA | +27 12 030 0268 US | +1 415 212 5500 UK | +44 1246 385500

Ground Floor, Building 2, Ashlea Gardens Office Park, 180 Garsfontein Road, Ashlea Gardens, 0081, Pretoria, South Africa

www.hearXgroup.com

info@hearxgroup.com

hearX Group (Pty) Ltd | Reg. No: 2016/198519/07
Directors: NJ Klopper, J Lim Fung Yen, DCD Swanepoel | Independent Director: IM Rademeyer

hearX group

To ensure that the users of the app receive the further choice to be contacted, as you are not an employee of hearX, nor an audiologist registered on the hearZA referral system, we suggest that hearX initiates first contact with users through email or phone call (only one) and that should the user indicate that they are not interested or simply do not reply, that no further attempts to contact the user will be made. As this communication (emails and phone calls) will be made by yourself, on behalf of hearX, all communication with app users needs to be signed off in writing first, by an authorised hearX representative.

We would like to reiterate that hearX takes the protection of the personal information of its app users very seriously and that no violations of the users' rights under the POPI Act (or any other relevant legislation) will be tolerated.

We look forward to working with you to make this research project successful.

Yours faithfully,

Seline van der Wat
General Manager (GM)

ZA | +27 12 030 0268 US | +1 415 212 5500 UK | +44 1246 385500

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Appendix E: Stage of change Staging algorithm questionnaire

Stage of change Staging algorithm Questionnaire

Which of the following statements best describes your view of your current hearing status?

(1) I do not think I have a hearing problem, and therefore nothing should be done about it.

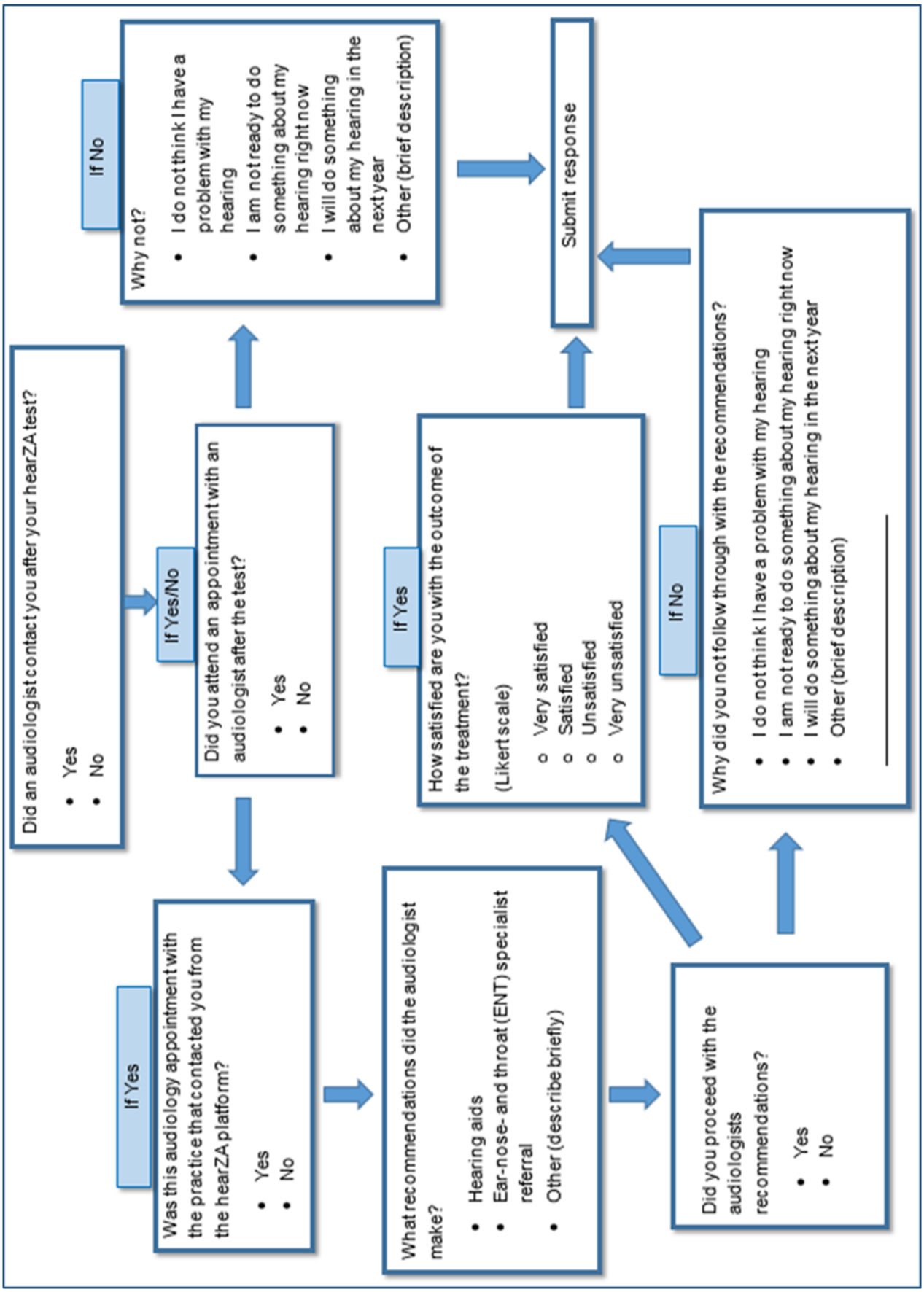
(2) I think I have a hearing problem. However, I am not yet ready to take any action to solve the problem, but I might do so in the future.

(3) I know I have a hearing problem, and I intend to take action to solve it soon.

(4) I know I have a hearing problem, and I am here to take action to solve it now.

(Milstein & Weinstein, 2002)

Appendix F: Phase two – Survey questions



Appendix G: Proof of article submission to an accredited journal

Date: Nov 07, 2019
To: "Danielle Schönborn" dannyschonborn11@gmail.com;u14074550@tuks.co.za
From: "AJA" aja@asha.org
Subject: Submission Confirmation for Characteristics and Help-Seeking Bahavior of People Failing a Smart Device Hearing Test

Dear Miss Schönborn,

This message serves as confirmation that your submission entitled "Characteristics and Help-Seeking Bahavior of People Failing a Smart Device Hearing Test" has been received by the American Journal of Audiology.

You will be able to check on the progress of your paper by logging on to Editorial Manager as an author. The URL is https://www.editorialmanager.com/aja/.

The manuscript number is AJA-19-00098.

If you or any co-authors intend to coordinate payment for voluntary open access, please reply to this message immediately with details so that a note can be created in the system.

Thank you for submitting your work to this journal.

Kind regards,

American Journal of Audiology

NIH-funded authors

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- Only the accepted manuscript may be deposited, not the edited and typeset final published article.
- When depositing an article, the author must stipulate that PubMed Central may release the manuscript for public access no sooner than 12 months after final online publication in the journal.
- Authors must include on the deposited manuscript a citation indicating where it will be published in its final form, including a link to the Web address of the journal in which it will be published.

If you are unclear on how to submit the manuscript, NIHMS offers many helpful resources, including slideshow tutorials: http://www.nihms.nih.gov/help/.

For more information on ASHA's policy regarding NIH-funded research and links to additional resources, visit: http://journals.pubs.asha.org/SS/Instructions_for_Authors.aspx.

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In compliance with data protection regulations, you may request that we remove your personal registration details at any time. (Use the following URL: https://www.editorialmanager.com/aja/login.asp?a=r). Please contact the publication office if you have any questions.