Climbing up the hearing rehabilitation ladder

Elisabeth Ingo

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EMPIRICAL STUDIES

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TABLE OF CONTENT

ABBREVIATIONS	1
INTRODUCTION	3
BACKGROUND	5
<i>HEARING IMPAIRMENT.....</i>	<i>5</i>
Etiology	5
Diagnosis	6
Hearing screening	7
Prevalence.....	8
Prevalence in Sweden	8
Societal cost	9
Health related concerns associated with hearing impairment.....	9
Cognitive decline	9
Psychosocial health.....	10
Hearing Rehabilitation	10
Hearing rehabilitation in Sweden	10
Effect of hearing aid use.....	11
Challenges in hearing rehabilitation.....	11
Possibilities for improvements in hearing rehabilitation.....	13
THEORETICAL FRAMEWORK	15
<i>eHEALTH SOLUTIONS IN AUDIOLOGY</i>	<i>15</i>
Internet use and access.....	16
Online hearing screening.....	16
Effect of online hearing screening	17
<i>MOTIVATION AND HEARING BEHAVIOR CHANGE.....</i>	<i>18</i>
Health psychology theories	18
Social cognitive models for behavioral change	18
The Stages of change model.....	19
Application of health psychology models in audiology.....	22
Application of the Stages of change model in audiology.....	22
Motivational Interviewing	23
Application of Motivational Interviewing in audiology	24
THESIS AIMS.....	27
<i>SPECIFIC AIMS</i>	<i>27</i>
EMPIRICAL STUDIES.....	29
<i>GENERAL METHODS</i>	<i>29</i>
Participants & Recruitment	32
Recruitment	32
Inclusion Criteria.....	32
Sample characteristics	32
Procedure.....	32
Study platforms	33
Speech-in-noise screening tests	33
Materials	35
Entry and follow-up questionnaires.....	35
Demographic and background variables.....	35
Self-assessment battery	35

Ethical Considerations.....	40
Limitations with the speech-in-noise tests.....	40
Participant Information and Consent.....	40
Data security	40
Feedback and referral.....	41
<i>SUMMARY OF EMPIRICAL STUDIES</i>	42
STUDY I.....	42
STUDY II.....	44
STUDY III.....	46
STUDY IV.....	49
GENERAL DISCUSSION	51
<i>MAIN FINDINGS</i>	51
Sample characteristics.....	51
Demographics	51
Self-reported hearing impairment.....	53
Psychosocial health.....	53
Help-seeking, hearing aid uptake, and hearing aid use	54
Extended online hearing screening.....	55
Predictive factors for hearing help-seeking.....	56
Stages of change in people who fail online hearing screening.....	56
Predictive validity for Stages of change in people who fail online hearing screening	58
Inclusion based on results from online hearing screening test.....	60
<i>METHODOLOGICAL CONSIDERATIONS</i>	60
Convenience samples.....	60
Technical barriers for online hearing screening and support.....	61
Outcome	61
Statistical considerations.....	61
CONCLUSIONS	63
<i>CLINICAL IMPLICATIONS</i>	64
<i>FUTURE DIRECTIONS</i>	65
GRADUATE STUDENT PROGRESS	67
CONFERENCE CONTRIBUTIONS	68
ADDITIONAL PUBLICATIONS	69
ACKNOWLEDGEMENT	71
REFERENCES	73

ABBREVIATIONS

AIADH	Amsterdam Inventory for Auditory Disability and Handicap
BBQ	Brunnsviken Brief Quality of Life
CSS	Communication Strategies Subscale
GAD-7	Generalized Anxiety Disorder (7-item scale)
HADS	Hospital Anxiety and Depression Scale
HL	Hearing Level
PTA4	Pure-tone Average over four frequencies
QOLI	Quality of Life Inventory
SA	Staging Algorithm
SNR	Signal-to-Noise Ratio
SRT	Speech Reception Threshold
URICA	University of Rhode Island Change Assessment
WHO	World Health Organization

INTRODUCTION

Hearing impairment has been recognized as a major public health problem, affecting one-third of people over 65 years of age (WHO, 2019). A range of physical, cognitive, and psychosocial health problems are associated with hearing impairment (Besser, Stropahl, Urry, & Launer, 2018). Reducing the impact of hearing impairment and supporting healthy aging is considered important public health goals (Dillon, Gu, Hoffman, & Ko, 2010). Most individuals with perceived hearing impairment do not seek help (Davis, Smith, Ferguson, Stephens, & Gianopoulos, 2007), do not opt for rehabilitation (mainly hearing aids) (Hartley, Rochtchina, Newall, Golding, & Mitchell, 2010), and do not use prescribed hearing aids adequately (Aazh & Moore, 2017). Many factors influencing help-seeking and rehabilitation have been reported including client motivation (Laplane-Lévesque, Hickson, & Worrall, 2013), perceived self-efficacy (Meyer, Hickson, & Fletcher, 2014), and poor societal awareness about hearing impairment, consequences, and rehabilitation options (Lin, Hazzard, & Blazer, 2016; Wallhagen, 2009).

This thesis applies two main strategies suggested to increase the proportion of individuals with hearing impairment that seek help for their hearing problems and thereby access adequate hearing rehabilitation. The first strategy is to conceptualize hearing impairment within a broader bio-psycho-social context (Davis et al., 2016). Specifically, applying theories from health psychology could help audiologists and other hearing health care professionals understand the psychological barriers that prevent people with hearing problems to seek help and take up rehabilitation (Babeu, Kricos, & Lesner, 2004). For that purpose, this thesis makes use of the Stages of change model, part of the Transtheoretical model for behavioral change (James O. Prochaska & DiClemente, 1983). The second strategy is to apply eHealth solutions in the form of online hearing screening. Offering online hearing screening has been proposed to improve help-seeking, access to care, and to increase public knowledge about hearing and hearing impairment (Ratanjee-Vanmali, Wet Swanepoel, & Laplane-Lévesque, 2019; Swanepoel & Hall, 2010).

The overarching aim of this thesis was to investigate behaviors related to hearing rehabilitation (help-seeking, hearing aid uptake, and hearing aid use) in adults who fail an online hearing screening. A second aim was to explore the usefulness

of the Stages of change model in predicting hearing rehabilitation related behavior in a self-selected online hearing screening sample.

The results reported in this thesis apply to native Swedish speaking adults who have opted for and conducted an online hearing screening. The term rehabilitation uptake is, within this thesis, equivalent to opting for hearing aids. The thesis consists of four original studies that all focus on online hearing screening.

BACKGROUND

HEARING IMPAIRMENT

Hearing impairment is often defined as an inability to perceive and interpret sound. Although hearing impairment affects the perception of all surroundings sounds, the key problem is often considered to be a difficulty with speech communication (Gates & Mills, 2005). Hearing impairment and hearing loss are often used synonymously and refer to a clinically significant deterioration in hearing function. Hearing disability, however, refers to a perceived disability due to one's hearing impairment. Deterioration in hearing function can be present without the individual experiencing any disability, or only experiencing disability in specific listening situations. Equally, an individual may experience hearing disability without fulfilling the clinical criteria for a deterioration in hearing function. In this thesis, the term hearing impairment is applied when referring to a clinically relevant deterioration.

Etiology

One might say that we hear with our ears and listen with our brains (Pichora-Fuller et al., 2016). Sound has to travel from the eardrum to the brain and be transformed through a complex chain. When the acoustic signal reaches the eardrum, it is converted into vibrations and transmitted to the three ossicles. The vibrations are modified, transformed and transmitted via the oval window to vibrations in the fluid in the cochlea. Vibrations in the fluid stimulate sensory hair cells. The outer hair cells serve as amplifiers for the inner hair cells that react to frequency and amplitude, and that are connected to the nervous system via spiral ganglion neurons. Vibrations are transformed into electrical impulses and transported via the auditory nerve to central structures in the brain stem and brain (Gelfand, 2009).

Disruption in this complex chain results in hearing impairment. Manifestations of hearing impairment are dependent on location, cause, and degree of disruption. Location is divided into peripheral and central hearing impairment. Peripheral hearing impairment is divided into conductive or sensory. Conductive hearing impairment occurs when sound is prevented from passing

unhindered to the cochlea (i.e. wax, damaged eardrum, fluid in the middle ear, or disruption of the ossicles). Sensory hearing impairment occurs when hair cells in the cochlea are damaged or dead. Hair cells are frequency specific and move when stimulated by their corresponding frequency. When hair cells corresponding to a specific frequency are damaged, stimulation at that frequency is prevented from being transferred to the acoustic nerve, resulting in distorted sound. Central refers to complications with neural (spiral ganglion neurons and acoustic nerve) and central (brainstem and auditory cortex) structures (Gelfand, 2009). Neurological components are often difficult to separate from sensory hearing impairment (Gates & Mills, 2005). Hence, the term sensorineural hearing impairment is frequently used in clinical audiology.

Age-related hearing impairment, also called presbycusis, is a progressive bilateral symmetrical sensorineural hearing impairment primary affecting higher frequencies (Davis et al., 2016). Presbycusis has long been considered mainly due to damage or loss of hair cells. Common causes of damage to, or loss of, hair cells are exposure to loud sounds, toxic substances such as some medication, diseases, and trauma. Results from animal studies suggest that degeneration of the stria vascularis and loss of spiral ganglion neurons, rather than loss of sensory cells, are predominant reasons for presbycusis. In this case, presbycusis should be considered a metabolic and neural disorder rather than a sensory disorder. However, the effects of noise exposure and age factors are difficult to separate in human studies (Dubno, Eckert, Lee, Matthews, & Schmiedt, 2013).

Sensory or sensorineural hearing impairment (including presbycusis) result in distorted sound. Soft sounds and certain frequencies are lost, and loud sounds become uncomfortable. An impaired ability to separate two sounds presented at the same time (frequency resolution) and to separate two sounds presented close in time (temporal resolution). These underlying factors result in the characteristic difficulty with understanding speech in background noise (i.e. when several individuals speak at the same time). This is also indicative of central hearing impairment, though due to different underlying factors (Gates & Mills, 2005).

Diagnosis

Hearing impairment is most often diagnosed through pure-tone audiometry. The patient listens to pure tones (sound with a sinusoidal waveform) presented under headphones. The softest level (in dB HL) of sound that an individual can detect, the audiometric threshold, is established for a range of frequencies for each ear separately (Schlauch & Nelson, 2015). A mean of the audiometric thresholds at the frequencies 0.5, 1, 2, and 4 kHz, referred to as pure-tone average 4 (PTA4) is often used as an indication of hearing impairment (Wilson, Tucci, Merson, & O'Donoghue, 2017). Internationally, there is no consensus on the classification of degree of hearing impairment (Stevens et al., 2013). Table 1 shows a common classification by WHO (Mathers, Smith, & Concha, 2000). A PTA4 of 40dB HL or worse in the better ear is usually considered a disabling hearing impairment (Davis et al., 2016).

Table 1. Degree of hearing impairment according to WHO.

Grade of Impairment	PTA4 in the better ear
No impairment	25 dB HL or less
Mild	26–40 dB HL
Moderate	41–60 dB HL
Severe	61–80 dB HL
Profound (including deaf)	81 dB HL or greater

Speech audiometry in quiet and in background noise is often used to complement pure-tone audiometry in a clinical setting. Hearing tests based on speech usually establish a percentage of speech intelligibility for a fixed sound pressure level or an adapted (providing a ratio between speech signal and background noise) (McArdle & Hnath-Chisolm, 2015). Pure-tone audiometry and speech audiometry are often referred to as behavioral hearing tests as they require a response from the participant (i.e. pressing a button, raising a hand, or repeating speech materials heard). Other test methods are objective hearing tests and self-reported measures. Objective hearing tests refers to measures that do not require a response from the participant, e.g. tympanometry and otoacoustic emissions. Self-reported measures refer to a wide range of self-assessment questionnaires used to measure perceived hearing impairment or hearing disability.

Behavioral, and self-reported measures of hearing are not strongly correlated (Hannula, Bloigu, Majamaa, Sorri, & Mäki-Torkko, 2011). This is not surprising as two patients with the same PTA4 might experience different hearing problems in daily life. Behavioral hearing tests are generally conducted in a controlled environment, raising questions about ecological validity.

Hearing screening

Periodic screening for hearing impairment in older adults is one important way of reducing the burden of untreated hearing impairment (Wilson et al., 2017). Several of the methods mentioned above can be used to screen for potential hearing impairment. Most commonly used are pure-tone, speech-in-noise, and self-reported measures. Hearing screening can be conducted on-site (e.g. temporary clinic) or remote (e.g. via telephone or internet). Pure-tone audiometry is widely used but requires calibrated equipment and is less suited for remote hearing screening. Self-reported measures are well suited for remote assessment but may be less sensitive to mild hearing impairment. Speech-in-noise procedures are more stable than pure-tone procedures in a remote setting but are language-specific complicating comparisons between studies (Stenfelt, Janssen, Schirkonyer, & Grandori, 2011).

The individual and societal benefits of screening adults for hearing impairment have been questioned. On-site hearing screening procedures are associated with high expenses for setup and staff (Chou, Dana, Bougatsos, Fleming, & Beil, 2011).

Studies point to only a slight improvement in hearing aid uptake (Gussekloo et al., 2003; Linssen, Joore, Theunissen, & Anteunis, 2013; Yueh et al., 2010) raising questions on cost-effectiveness (Chou et al., 2011). Online hearing screening has been proposed as a solution.

Prevalence

Estimates of the global prevalence of hearing impairment suffer from a lack of consistency in: data collection, degree of hearing impairment, measurements, and reporting data. This makes comparisons between studies difficult (Olusany, Neumann, & Saunders, 2014). Data are sparse and comparative conclusions should be made with caution. An analyzing of 42 studies from 29 countries published between 1973 and 2010 estimated the global prevalence of hearing impairment to be 9.8% for adult women aged >15, and 12.2% for adult men aged >15 (Stevens et al., 2013).

A range of coexisting factors contributes to the global prevalence of hearing impairment. More people are getting older, increasing the prevalence of presbycusis. Increased access to health care and modern hearing technology enables early detection of hearing impairment, raising the prevalence of diagnosed hearing impairment. In areas with insufficient vaccine coverage, diseases (e.g. gestational rubella) still contribute to the prevalence of hearing impairment. Environmental and occupational noise exposure due to poor regulations in dense areas with rapid urbanization also contributes to the prevalence of hearing impairment (Olusany et al., 2014).

Prevalence in Sweden

In 2016–2017, 18.3% of the adult Swedish population (>16 years of age) reported having difficulties hearing in group conversations. More men (20.4%) reported hearing problems compared to women (16.3%). The prevalence increases with age. In adults, 65–74, 39.7% of the men, and 24.6% of the women reported hearing problems. In adults, 75–84, 53.3% of the men and 38.7% of the women reported hearing problems. For the age group >85, 62.1% of the men and 52.9% of the women report hearing problems (Statistics Sweden, 2018).

Hearing impairment prevalence in Swedish 70-year-olds from 1971 to 2014 has been tracked (Hoff, Tengstrand, Sadeghi, Skoog, & Rosenhall, 2018). The hearing status of three cohorts of 70-year-olds from the city of Gothenburg, born in 1901–1907 (n=673), 1922 (n=226), and 1944 (n=1135), were compared. Both median audiometric thresholds and hearing impairment prevalence improved over time. The largest improvements were seen in men born in 1944 at 4 and 6 kHz. The authors suggest a reduction of heavy industry and thus fewer men exposed to occupational noise (Hoff et al., 2018).

Societal cost

WHO (2017) highlights that few studies have attempted to investigate the cost of hearing impairment, especially in low- and middle-income countries and at a global level. A tentative estimate of the annual cost of unaddressed hearing impairment is between \$750 and \$790 billion globally. For adults >15 years of age, loss of productivity, due to unemployment and early retirement was conservatively calculated at \$105 billion per year (WHO, 2017). Hearing impairment is often considered less urgent than other health problems and is therefore under prioritized (Besser et al., 2018). However, under prioritizing hearing impairment is costly in the end, for both individuals and society (Wilson et al., 2017).

In Sweden, 55 % of people with hearing impairment are of working age (18–65 years of age), and early retirement in this group is almost twice as high (9.3%) as for the general population (5.3%) which has significant societal costs (Hjalte, Brännström, & Gerdtham, 2012).

Health related concerns associated with hearing impairment

A vast range of physical, cognitive, and psychosocial health problems, have been associated with hearing impairment, including; greater disability in physical functioning (Chen, Genther, Betz, & Lin, 2014), increased mortality (Genther et al., 2015), increased cognitive decline and dementia (Jupiter, 2012; Lin, 2011), poorer quality of life, social isolation, and increased rates of depression, and anxiety (Arlinger, 2003; Nachttegaal et al., 2009). A recent review by Besser and colleges (2018) on associations between hearing impairment and other health conditions report inconsistent findings and a lack of knowledge about underlying mechanisms. Most studies investigating comorbidities and consequences of hearing impairment have used a cross-sectional design. Findings indicate associations with a range of health-related problems, including medical conditions, psychosocial problems, and demographical variables. Due to the lack of longitudinal studies, the relationship between hearing impairment and other health conditions, including potential mediators, is often unknown (Besser et al., 2018). Negative effects on physical and psychosocial well-being also extend to communication partners (Chung, Hung, Lin, & Sheu, 2015; Wallhagen, Strawbridge, Shema, & Kaplan, 2004).

Cognitive decline

An association between hearing impairment and cognitive decline has been observed in several studies (for a review see, Besser et al., 2018). However, confounding variables, such as increased age, increase the risk of experiencing both conditions (Livingston et al., 2017). To date, no consensus has been achieved regarding causality and the underlying mechanisms for the association between hearing impairment and cognitive decline (Livingston et al., 2017). Three main hypotheses on causality exist; the common cause hypothesis, the cascade

hypothesis, and the cognitive load hypothesis. The common cause hypothesis assumes that age-related decline in hearing and cognition is caused by a common factor (i.e. an age-related neurological degeneration that affects both hearing and cognition). The cascade hypothesis assumes that the deprivation of stimuli has a negative effect on cognition. Lack of auditory stimuli over a long period can be either direct, caused by deprived auditory stimuli, or secondary as an effect of social isolation. The cognitive load hypothesis assumes that hearing impairment increases cognitive load and less cognitive capacity is spared for other cognitive tasks (Besser et al., 2018; Dawes, Emsley, et al., 2015).

Psychosocial health

Associations between hearing impairment and psychosocial wellbeing, such as poor quality of life, increased rates of isolation, loneliness, depression, and anxiety, have been reported in several studies. However, the relationship between hearing impairment and psychosocial decline in older adults is still unknown (for a review see, Besser et al., 2018). The association between hearing impairment and anxiety and depression has, however, not been observed in studies on individuals who fail online hearing screening (Molander et al., 2015; Stam et al., 2014).

Hearing Rehabilitation

To date, there is no cure for hearing impairment. The main goal for hearing rehabilitation is to support communication and to optimize social and occupational functioning (Davis et al., 2016). The most common rehabilitation option offered for hearing impairment is hearing aids (Barker, Mackenzie, Elliott, Jones, & de Lusignan, 2016). Other hearing technologies include cochlear implants and assistive devices (Davis et al., 2016). In addition to hearing technologies, a range of non-instrumental interventions (e.g. communication strategies and auditory training) are available (Pronk et al., 2011). As hearing aids cannot compensate for central auditory damage, counseling and compensatory strategies such as increased knowledge, communication strategies, and environmental modifications are important parts of hearing rehabilitation (Davis et al., 2016). Older adults can also rely on accumulated experience and knowledge of context (Pichora-Fuller, 2008).

Hearing rehabilitation in Sweden

Hearing aids are the most common rehabilitation offered in Sweden (Jönsson, 2016). In 2016–2017, 4.8% of the adult Swedish population (>16 years of age) reported using hearing aids. In line with the increased prevalence of hearing impairment with age, the use of hearing aids also increases with age: 65–74 10.1%, 75–84 20.8%, >85 33.0%). Regardless of age group, hearing aid use is more common among women (Statistics Sweden, 2018). Audiological rehabilitation, including hearing aids, is relatively easy to access in Sweden and is subsidized to a high degree (Brännström et al., 2013). The Nordic Society of Audiology

recently summarized the challenges the Swedish hearing health care system faces (Jönsson, 2016). As health care, including hearing health care, is commissioned by each of the 21 Swedish counties, each county has the mandate to regulate hearing health care. For example, counties differ in their decision regarding if/how to consign parts of the public hearing health care to private practice (Jönsson, 2016).

Effect of hearing aid use

Hearing aids improve communication in older adults, provided that hearing rehabilitation has been delivered using evidence-based practice (Humes et al., 2017). Individuals who experience more hearing difficulties in everyday life, social support and positive attitudes about using hearing aids experience more benefit from hearing aids (Hickson, Meyer, Lovelock, Lampert, & Khan, 2014; Singh, Pichora-Fuller, Malkowski, Boretzki, & Launer, 2014).

Though longitudinal studies exist, the isolation of potential effects of hearing aid use is difficult. It is unethical to actively restrain people from using hearing aids in controlled studies (Dawes, Emsley, et al., 2015). Still, observational studies can compare people with hearing impairment who use hearing aids with peers who do not. Studies point to a reduction in psychosocial problems when using hearing aids (Vestergaard Knudsen, Öberg, Nielsen, Naylor, & Kramer, 2010). For example, hearing aid use is known to improve health-related quality of life (Chisolm et al., 2007). However, few studies have investigated the effect of hearing aid use on psychosocial health, and their findings are mixed (Dawes, Cruickshanks, et al., 2015). Whether hearing aid use prevents cognitive decline and dementia is questionable as results are inconsistent. Different study designs, cognitive measures, and sample sizes complicate comparisons between studies (Dawes et al., 2015). A few publications have presented tentative support for the effect of hearing aids (Amieva et al., 2015; Deal et al., 2017). However, considerable methodological issues have been identified (Wallhagen & Strawbridge, 2016). Questions on whether early identification and hearing-aid uptake would slow the rate of cognitive decline and prevent further deterioration of hearing remain unanswered (Livingston et al., 2017). Though the effects of hearing aids on other health conditions remain uncertain the main goal is to improve communication (Contrera, Wallhagen, Mamo, Oh, & Lin, 2016).

Challenges in hearing rehabilitation

Hearing impairment is a chronic condition, often with a very gradual onset, and many factors influencing help-seeking and rehabilitation have been reported including demographical, audiological, psychosocial (Saunders, Chisolm, & Wallhagen, 2012), social, and cultural (Davis et al., 2016).

Hearing help-seeking rates are low, and people wait on average 10 years before seeking audiological services (Davis et al., 2007). Most individuals with perceived hearing impairment do not seek help for their problems (Hartley et al.,

2010), and among those who do, a majority do not opt for hearing rehabilitation (Vestergaard Knudsen et al., 2010). Also, several studies point to a low use of prescribed hearing aids (Aazh & Moore, 2017; McCormack & Fortnum, 2013). Several factors influence help-seeking for hearing impairment and, more generally, the adoption of behaviors that promote good health.

Demographical factors are often associated with health behavior. In general, younger individuals with higher socioeconomic status, lower stress, and more social support are more likely to practice good health behaviors (Conner & Norman, 2005). Though, hearing impairment increase with age, studies point to no relationship between help-seeking and increasing age. On the contrary, individuals of working age are more likely to seek help (Saunders et al., 2012).

Audiological factors including perceived hearing difficulty, perceived hearing disability, and degree of hearing impairment have been recognized as important factors for hearing help-seeking (Vestergaard Knudsen et al., 2010). Self-reported hearing disability alone has been found to be a good predictor for help-seeking, hearing aid uptake, and satisfaction with hearing aids in older adults (Vestergaard Knudsen et al., 2010).

Psychosocial factors have been suggested as influential throughout the hearing rehabilitation process (Ridgway, Hickson, & Lind, 2016). Psychosocial factors including client motivation (Laplante-Lévesque et al., 2013), perceived self-efficacy (Meyer, Hickson, & Fletcher, 2014), positive attitudes towards hearing aids, and support from communication partners, have emerged as important factors (Hickson et al., 2014).

Social and cultural factors also contribute to help-seeking. Hearing impairment is often perceived as a normal process of aging and might therefore easily be dismissed by the individual, significant others, and health care professionals. The perceived stigma of hearing impairment has also been acknowledged to influence the decision-making processes, and the initial acceptance of hearing impairment (Wallhagen, 2009). Poor societal awareness about hearing impairment, consequences, rehabilitation options (Lin et al., 2016; Wallhagen, 2009), and uncertain benefit of hearing aids on communication has been reported as barriers (Laplante-Lévesque, Hickson, & Worrall, 2012).

Health care professionals often have limited knowledge about hearing impairment and its associations with other health-related problems (Wallhagen, 2009). Little effort is spent on educating health care personnel on how to manage patients with hearing impairment (Lin et al., 2016). Hearing impairment in older adults is often neglected in primary care settings (Contrera et al., 2016). Studies conducted in primary care settings indicate that few older adults are inquired about their hearing or recommended to screen for hearing impairment (Wallhagen & Pettengill, 2008). Also, a low rate of remitted patients has been reported (Laplante-Lévesque et al., 2012). Also, many low- and middle-income countries, as well as and remote areas, suffer from a shortage of clinical staff,

limiting access to hearing health care. Financial costs of hearing aids have been identified as a barrier in some countries (Davis et al., 2016).

From the audiologist's perspective, a patient's behaviors related to hearing rehabilitation is often perceived as a journey including following key elements: the decision to seek help (help-seeking), the decision to acquire a hearing aid (uptake), and the decision to continue to use obtained hearing aids (hearing aid use) (Vestergaard Knudsen et al., 2010). Through interviews with 34 individuals with hearing impairment and different experiences with hearing aids, Laplante-Lévesque and colleagues (2012) discovered that most participants were unaware of the steps involved in hearing help-seeking (Laplante-Lévesque et al., 2012).

Possibilities for improvements in hearing rehabilitation

Reducing the impact of hearing impairment and supporting healthy aging is considered important public health goals (Dillon et al., 2010). Hearing impairment is not an isolated problem with one optimal solution that fits all. Strategies suggested to increase the proportion of individuals with hearing impairment that seeks help for their hearing problems and thereby access adequate hearing rehabilitation include applying a broader understanding of hearing impairment and increase accessibility to both hearing health care and information.

Many factors influencing help-seeking and rehabilitation have been reported including client motivation (Laplante-Lévesque et al., 2013), perceived self-efficacy (Meyer et al., 2014), and poor societal awareness about hearing impairment, consequences, and rehabilitation options (Lin et al., 2016; Wallhagen, 2009). Hearing impairment has traditionally been conceptualized within a biomedical model with a focus on compensating for biological changes and less time and concern spent on the psychosocial aspects of living with hearing impairment (Davis et al., 2016). The WHO International Classification of Functioning, Disability and Health (ICF; WHO, 2001), displayed in Figure 1, provides a framework to understand hearing impairment within a broader biopsychosocial context. The ICF incorporates function as well as related activities, participation, and contextual factors (Davis et al., 2016).

Figure 1 The ICF model adapted from WHO (WHO, 2001).

Conceptualizing hearing impairment within a broader bio-psycho-social context in by applying theories from health psychology could help audiologists and other hearing health care professionals understand the psychological barriers that prevent people with hearing problems to seek help and take up rehabilitation (Babeu et al., 2004). Several models from health psychology have therefore been investigated and discussed in audiology (e.g. Babeu et al., 2004; Ferguson, Maidment, Russell, Gregory, & Nicholson, 2016; Laplante-Lévesque et al., 2013; Ridgway et al., 2016; Saunders, Frederick, Silverman, Nielsen, & Laplante-Lévesque, 2016).

Screening for hearing impairment in older adults is one important way of reducing the burden of untreated hearing impairment (Wilson et al., 2017). Early detection and rehabilitation are crucial for the effect of hearing rehabilitation (hearing aids) on communication (Cacciatore et al., 1999) suggesting screening procedures followed by adequate intervention to be of essence (Pronk et al., 2011). Offering online hearing screening has been proposed to improve help-seeking, access to care, and to increase public knowledge about hearing and hearing impairment (Ratanjee-Vanmali et al., 2019; Swanepoel & Hall, 2010). eHealth solutions can limit the burden of untreated hearing impairment by increasing the number of individuals who seek help and receive hearing rehabilitation (Paglialonga, Cleveland Nielsen, Ingo, Barr, & Laplante-Lévesque, 2018). Complementing hearing health care as usual with eHealth solutions might help with some of the barriers for behaviors related to hearing rehabilitation (e.g. poor knowledge about hearing impairment, associations with other health-related problems, and benefit of hearing aids on communication among both society and other health care professions) (Singh et al., 2014).

Recent years have seen a growing interest in the application of health psychology models in audiological research, and the potential benefits of hearing screening to increase hearing help-seeking rates and public awareness.

THEORETICAL FRAMEWORK

eHEALTH SOLUTIONS IN AUDIOLOGY

This thesis follows the WHO definitions that: “eHealth is defined as the use of electronic means to deliver information, resources and services related to health. It covers many domains, including electronic health records, mobile health and health analytics, among others. eHealth can put information in the right place at the right time, providing more services to a wider population and in a personalized manner” (WHO, 2016). The provision of eHealth solutions can be achieved in either a synchronous or in an asynchronous manner (Davis et al., 2016). The use of eHealth promises to relieve demands on healthcare by easing and increasing access to healthcare across vast geographical areas, providing services and information in the absence of a health professional, and offering individuals the opportunity to be more involved in their healthcare (Lluch, 2013). Systematic reviews and meta-analyses concluded that support the cost-effectiveness of eHealth interventions in somatic diseases (Elbert et al., 2014).

Technological progress has expanded audiological services outside the clinic, and the demand for eHealth solutions is increasing (Paglialonga et al., 2018). Platforms for eHealth solutions in audiology span from offline versions to internet-based and mobile-based platforms (Paglialonga et al., 2018). To date, several reviews on eHealth solutions in audiology have been published including wide-ranging applications (Swanepoel & Hall, 2010), eHealth applications in hearing amplification and cochlear implantation (Bush, Thompson, Irungu, & Ayugi, 2016), use of eHealth in clinical activities supporting the HA adult patient journey (Paglialonga et al., 2018), services in adult hearing rehabilitation (Tao et al., 2018), and interventions for adults with hearing loss, tinnitus, and vestibular disorders (Beukes, Manchaiah, Allen, Baguley, & Andersson, 2019).

The rationale for the growing interest in eHealth solutions in audiology includes a demand for cost-effective alternatives, remote services in rural areas, and alternatives for patients who are not able to visit a clinic (Paglialonga et al., 2018). Hearing health care delivered over the internet can reach a large number of patients (Donahue, Dubno, & Beck, 2010). eHealth solutions are one strategy to compensate for the lack of sufficient hearing health care services in many

countries worldwide, including high-income countries with rural areas as well as facilitating access to audiological services (Ratanjee-Vanmali et al., 2019; Swanepoel & Hall, 2010). However, whether these interventions are cost-effective remain to be supported by research evidence (Beukes & Manchaiah, 2019). eHealth can also support the advancement of public health policies on hearing rehabilitation (Penteado, Ramos, Battistella, Marone, & Bento, 2013) and might serve as a solution for inadequate information and referrals by other health care personnel (Singh et al., 2014).

Support from practitioners and patients is needed for eHealth solutions to become successfully and widely implemented in clinical practice (Saunders & Chisolm, 2015). Through interviews with healthcare practitioners in Canada, Singh and colleagues (2014) investigated attitudes towards eHealth solutions in hearing healthcare. eHealth was believed to have a positive effect on access to hearing healthcare, but only minimal effect on the delivery of hearing healthcare. Practitioners were most open to eHealth solutions incorporating information exchange, counseling, and screening (Singh et al., 2014). Through an online survey with audiologists from 28 countries, Eikelboom and Swanepoel (2016) investigated attitudes towards and experience with the use of eHealth in clinical practice. Though attitudes were positive, less than 25% of the audiologists had used eHealth solutions in clinical practice (Eikelboom & Swanepoel, 2016).

Internet use and access

Studies from Canada, the United Kingdom, and Sweden report higher degrees of internet use among people with hearing impairment than in the general population (Gonsalves & Pichora-Fuller, 2019). Computer and internet use is high among the adult Swedish population suggesting a suitable base for implementation of eHealth solutions in hearing health care (Thorén, Öberg, Wänström, Andersson, & Lunner, 2013). When exploring internet use among adult Swedish citizens with hearing impairment in 2013, 78% of participants aged 65–74, and 35% of participants aged 75–96 reported having access to the internet (Thorén et al., 2013).

Online hearing screening

Hearing screening, including remote forms such as telephone and web-based, has been suggested to improve public awareness regarding hearing health care (Swanepoel & Hall, 2010), as well as to improve help-seeking (Arlinger, 2003). Especially automated telephone-, internet-, and mobile-based hearing screening procedures can reach large populations at a low cost (Donahue et al., 2010). Such procedures are effective, and relatively inexpensive ways to detect hearing loss in adults (Wilson et al., 2017).

Online hearing screening is most commonly conducted using a speech-in-noise procedure (Stenfelt et al., 2011). In speech-in-noise tests the participant is typically asked to identify an object or a range of numbers. It measures the ability

to understand speech-in-noise by determining the signal-to-noise ratio (SNR) that corresponds to 50% intelligibility, referred to as the speech reception threshold (SRT). These tests are applied to discriminate between normal hearing and sensorineural hearing impairment. Online hearing screening, based on a speech-in-noise task, is a reliable measure of hearing ability that can be administered remotely without the need for calibrated equipment (Smits, Merkus, & Houtgast, 2006).

Effect of online hearing screening

Mixed findings have been reported on the impact of hearing screening, regardless of delivery mode. Already in 2002, Milstein and Weinstein (2002) suggested that screening for hearing impairment is unlikely to increase help-seeking rates. Receiving a confirmation of hearing impairment may not prompt individuals to seek help and obtain hearing rehabilitation (Saunders et al., 2012). Hearing screening may promote help-seeking, but positive effects on hearing-aid uptake and hearing aid use remain uncertain (Chou et al., 2011; Linssen et al., 2013; Meyer et al., 2011; Smits et al., 2006).

In a first publication on the Dutch national hearing test, Smits and colleagues (2006) conducted a follow up on 881 participants who took part in a hearing screening either online or via telephone. A majority (55%) conducted the screening due to concern, and 13% due to advice from other people. However, 20% participated out of curiosity (Smits et al., 2006). Half had followed recommendations to seek hearing health care. Following the screening, poorer screening results and female sex was associated with a visit to a hearing specialist. Similarly, Meyer and colleagues (2011) conducted a 4–5-month follow-up on 193 participants who failed a telephone-based triple-digit test in Australia. Only 33% reported conducting the screening due to experiencing hearing concerns. An additional 33% conducted the screening due to curiosity about their hearing, and 10% due to advice. When asked about their screening results at follow-up, 28% of participants did not remember if they passed or failed. At follow-up, only 36% of them had sought help. Participants who had previously considered hearing aids and who recalled their screening results were more likely to have sought help (Meyer et al., 2011).

Barriers and facilitators to help-seeking and hearing aid uptake vary and the pathway from failing a hearing screening to successful rehabilitation must be clearly planned and communicated to the target population. Currently, most pathways include referral to a professional and/or the provision of hearing aids as the main or only rehabilitative option (Pronk et al., 2011). However, understanding a participant's motivation levels at the time of a hearing screening may help provide tailored support (Ekberg, Grenness, & Hickson, 2016).

MOTIVATION AND HEARING BEHAVIOR CHANGE

The definition of and use of the term motivation is diverse, e.g. drives and needs (Maslow, 1943), external reinforcement (Skinner, 1953), and cognition (Bandura, 1977). This thesis applies a cognitive definition of motivation. From a cognitive perspective motivation may be defined as being moved to act and is considered a key reason for individuals to take up new behaviors. Motivation can be either intrinsic (evoked from within the individual) or extrinsic (evoked by others or events) (Ryan & Deci, 2000).

Health psychology theories

Conner and Norman (2003) argue for a broad definition of health psychology that would include any activity undertaken to prevent or detect disease or for improving health and well-being. Health behaviors (e.g. smoking and diet) can explain a considerable proportion of the suffering from leading causes of death and such behaviors are modifiable. Research in this field aims to gain insight into why individuals perform certain behaviors and to design interventions for support behavioral change (Conner & Norman, 2005). From a public health perspective, human behaviors are assumed to contribute to many of the world's leading causes of mortality. Behavior can also protect the health, such as taking part in health screening and seeking health care (Michie, West, Sheals, & Godinho, 2018).

Several models of health behavior exist and most focus on explaining how individuals decide whether to adopt behavioral change (Rothman, 2000). Commonly, these models aim to identify underlying variables that predict health behavior. These models can often be applied to a range of health behaviors (Armitage & Conner, 2000). Intrinsic factors for health behavior (e.g. sociodemographic factors, personality, social support, cognition), rather than extrinsic factors (e.g. taxing tobacco and subsidizing health care) has been the focus in health psychology. Cognitive factors have been recognized as the most important and social cognition models are dominant in health psychology (Conner & Norman, 2005).

Social cognitive models for behavioral change

There are a number of different social cognitive models for behavioral change include the Health belief model (Janz & Becker, 1984), Social Cognitive Theory (Bandura, 1998), the Transtheoretical model (James O. Prochaska & DiClemente, 1983), the Theory of planned behavior (Fishbein, Jaccard, Davidson, Ajzen, & Loken, 1980), Health action process approach (Schwarzer, Lippke, & Ziegelmann, 2008), Protection Motivation Theory (Rogers, 1983), and precaution adoption process (Weinstein, 1988). The social cognitive models have similar conceptual frameworks. According to Rothman (2000), most models assume that health behavior change can be summarized as a complex cost/benefit analysis of taking action where the individual contemplates pros- and cons for taking action

(often referred to as decision making). Another fundamental aspect for action in social cognitive models is self-efficacy, which is the belief in one's own ability to perform actions and reach goals. Self-efficacy can be developed by four main sources of influence with the most effective one being mastery. Successes build a robust belief in one's personal efficacy whilst failures undermine it. Experiencing other people succeed and adopting proven skills and strategies from others and being told about one own's capability also boost self-efficacy. Experiencing positive mood and less stress also facilitate behavior change. For example, persons with higher self-efficacy present greater adherence to treatment recommendations (Bandura, 1977).

Social cognitive models provide a framework for understanding the determinants of behavior and behavior change (Rothman, 2000). Describing the key cognitive factors (i.e. knowledge about behavior health links, perceptions of health risk, potential efficacy of behaviors in reducing this risk, perceived social pressures to perform the behavior, and control over performance of the behavior) and their inter-relationships in the regulation of behavior have been developed and extensively applied to the understanding of health behaviors. Social cognitive determinants are assumed to be easier to change than other intrinsic factors and have therefore often been in focus when designing interventions for health behavioral change (Conner & Norman, 2005).

Social cognitive models are divided into stage-based and continuum-based models (Rothman, 2000). For continuum-based models (e.g. the Health belief model and Social Cognitive Theory), the main focus lies in identifying variables that influence action and combine those in a prediction equation. How variables are combined are assumed to be the same for all and the individual is placed on a continuum of likelihood for action (Weinstein, Rothman, & Sutton, 1998). The likelihood of behavior change is assumed to be a linear function of degree motivation/intention. The probability is assumed to increase along the continuum but action can be taken at any part of the scale (Conner & Norman, 2005). Stage-based models (e.g. the Transtheoretical model and Precaution adoption process) assume that behavioral change occurs through stages (Weinstein et al., 1998). Stage-based models assume that people at different stages will be qualitatively different, and that the kinds of interventions and information needed to advance to the next stage will be different from stage to stage (Armitage & Conner, 2000). Different factors (e.g. self-efficacy) are important for different stages but might also be important for more than one stage (Conner & Norman, 2003). This has clinical implications since type of intervention and or counseling needed differ between the stages (Weinstein et al., 1998).

The Stages of change model

The Transtheoretical model of (intentional) health behavior change was originally developed through participant experiences with the process of quitting smoking but has since been applied to a variety of health behaviors such as drug use and exercise (Prochaska & DiClemente, 2005). The model assumes that

intentional behavioral change is intrinsic and that the nature of the behavioral change process is the same whether a person has support (i.e. any type of intervention) or not (DiClemente & Prochaska, 1982). The model is not an evident social cognitive model but is often considered as part of the conceptual framework (Conner & Norman, 2005). However, the unclear links to social cognitive variables have been questioned (Armitage & Conner, 2000).

The transtheoretical model is often referred to as the Stages of change model though it consists of five key concepts: process of change, decision balance, Stages of change, self-efficacy, and temptation. The Stages of change model is a conceptual model of how and why changes occur and describe the process towards health behavior change in separate stages for people facing behavior changes (Prochaska & DiClemente, 1983). The number of stages has varied over the years with the five stages: precontemplation, contemplation, preparation, action, and maintenance being the most commonly used (Prochaska & DiClemente, 2005). On top of these a relapse and a termination stage have been acknowledged (Prochaska, 2008). The stages are problem-specific and an individual may be in different stages for different behaviors (Prochaska & DiClemente, 2005). The progress does not have to be linear. An individual can relapse or pendulate between stages. According to the Stages of change model, each stage represents both a period of time and a set of cognitive and behavioral processes to be accomplished to move to the next stage. In line with other stage-based models, some processes concern more than one stage (Conner & Norman, 2005). An overview of the five most commonly discussed stages of change and underlying processes of change is displayed in Figure 2.

Figure 2. Overview of the Stages of change model and the underlying processes of change adapted from Prochaska and DiClemente (2005).

The Stages of change represent when a shift in attitude has occurred whilst the processes of change describe by which mechanisms a shift in attitude occur. The cognitive processes (consciousness raising, dramatic relief, environmental

reevaluation, social liberation, and self-reevaluation) are important in precontemplation and preparation whilst the behavioral processes (self-liberation, reinforcement management, counter conditioning, stimulus control, and helping relationships) are important in preparation, action, and maintenance (Prochaska, DiClemente, & Norcross, 1992).

Precontemplation is a stage before the individual start contemplation pros- and cons with changing a specific behavior (Block & Keller, 1998). The individual can be unaware of the problem, unwilling to change, or does not believe that the negative aspects of change outweigh the positive aspects and expresses no intention to change behavior in the near future or (Norcross, Krebs, & Prochaska, 2011).

Contemplation is characterized by experiencing concerns with a present behavior and by an ambivalence to change (Prochaska & DiClemente, 2005). The individual is aware of the problem exists but has not yet made a commitment to take action (Norcross et al., 2011). Contemplating pros- and cons with behavioral change require a knowledge of consequences with taking action versus remain in status quo (Block & Keller, 1998). The individual often struggles with the amount of effort a behavior change will take (Norcross et al., 2011). During contemplation the individual often actively seek out information (Prochaska & DiClemente, 2005). Perceived severity has been suggested as an important factor for moving on to preparation (Block & Keller, 1998).

Preparation is characterized by indications towards readiness to change. The individual intends to take action in the near future and may have made small changes or tried to reduce the problem (Norcross et al., 2011). Indications and small changes can involve both attitudes and behaviors. If action is not planned within a near future the individual is considered still contemplating (Prochaska & DiClemente, 2005).

Action involves an evident act of doing something about the problem (Prochaska et al., 1992). Action involves modify behaviors, experiences, and/or the environment to overcome the problem (Norcross et al., 2011). To reach action requires both self-efficacy and considerable commitment of time and energy. Individuals in the action stage have begun to take the necessary steps involved in changing the behavior.

The Stages of change model is appealing because it is intuitive and easy to link to clinical practice (Armitage & Conner, 2000). However, its accuracy and usefulness have been questioned within health psychology research (Armitage, 2009). In general, stage-based models have not been sufficiently tested (Hertzhog, 2008). Methodological limitations of previous studies in terms of study design, with most previous studies using a cross-sectional design, make it difficult to verify the predictive validity of concepts within the model (Sutton, 2000). Longitudinal designs have been asked for to qualify the usefulness of the transtheoretical model (Armitage, 2009).

Application of health psychology models in audiology

Having accepted the presence of hearing impairment and gained readiness for seeking professional help have been identified as important factors for good audiological rehabilitation outcomes (Vestergaard Knudsen et al., 2010). Seeking help for perceived hearing problems, taking up rehabilitation, and maintain to use tools for rehabilitation are examples of changes in health behaviors (Laplante-Lévesque, Brännström, Ingo, Andersson, & Lunner, 2015). These can be explored using health behavior models to gain a better understanding of behavior change (Ferguson, Woolley, & Munro, 2016). Theories of motivation for health behavior change from health psychology have therefore been frequently discussed in audiology (Babeu et al., 2004; Ferguson, Maidment, et al., 2016; Laplante-Lévesque et al., 2013; Ridgway et al., 2016; Saunders et al., 2016, 2013). The Transtheoretical Model (e.g. the Stages of change model) and the Health Belief Model are the most commonly applied in audiology (Manchaiah, Hernandez, & Beck, 2018).

Application of the Stages of change model in audiology

Within audiology, the five-stage version of the model is the most commonly used. The relapse and termination stages seldom apply to an audiology context (Manchaiah et al., 2018). Fifteen years ago, Babeu and colleagues published an interpretation of the Stages of change model adopted to the hearing rehabilitation journey and proposed strategies to help patients through the cognitive and behavioral processes required to advance stages (Babeu et al., 2004).

Precontemplation is represented by a lack of awareness of a possible hearing problem and an unwillingness to act on a perceived hearing problem or a belief that it cannot be solved by behavioral or attitudinal change. Other main features of the precontemplation stage include reluctance to change, rebellion against outside pressures, resignation, and rationalization of the problem. The contemplation stage is characterized by an awareness of a perceived hearing problem and it may include considering the pros and cons of taking action (e.g. seeking help at an audiological clinic or deciding on rehabilitation uptake). Within this stage, people often actively seek information. The preparation stage is also characterized by information seeking, but with an aim to seek help (e.g. a first contact with the audiologist for questions) within the near future. The contemplation and preparation stages are characterized by ambivalence, contemplating the pros and cons of behavior change: people in these stages benefit from consultation targeting ambivalence and self-reflection. The action stage is characterized by actually doing something to change the present hearing situation (e.g. seeking help at an audiology clinic or acquire hearing aids) (Babeu et al., 2004).

Findings from Vestergaard Knudsen and colleagues (2010) suggest readiness for hearing help-seeking might be a separate process from readiness for hearing-aid uptake and hearing aid use (Vestergaard Knudsen et al., 2010). Also, Laplante-Lévesque and colleagues (2012) discovered that most participants were unaware

of the steps involved in hearing help-seeking (Laplante-Lévesque et al., 2012). These findings suggest caution with assuming that the Stages of change model reflects key elements along the hearing rehabilitation journey.

In a recent review, Manchaiah and colleagues (2018) reported on applications of the transtheoretical model in studying attitudes and behaviors in adults with hearing impairment. Most studies focused on help-seeking and rehabilitation uptake though the relationship between Stages of change and rehabilitation uptake and outcomes. Studies point to positive associations between Stages of change and help-seeking, rehabilitation uptake, and outcomes. No associations between Stages of change and intervention decision and intervention use were reported (Manchaiah et al., 2018).

Knowledge of a patient's Stages of change could be useful for the audiologist when fit a rehabilitation plan (Babeu et al., 2004; Ekberg et al., 2016). Assessing audiology patients' readiness for change through the history-taking during the first appointment, and whether their readiness effected hearing aid uptake has been investigated by Ekberg and colleagues (2016). In line with expectations, only 20% of participants in precontemplation accepted hearing aids when offered. Among participants in contemplation and preparation, respectively 71% and 80% opted for hearing aids (Ekberg et al., 2016).

People who are not ready to seek help and undergo hearing aid rehabilitation might benefit from online information on options and knowledge about hearing impairment (Rothpletz, Moore, & Preminger, 2016). The contemplation and preparation stages are characterized by ambivalence, contemplating the pros and cons of behavior change: people in these stages benefit from consultation targeting ambivalence and self-reflection (Babeu et al., 2004).

Motivational Interviewing

Motivational interviewing is a collaborative person-centered form of guidance to elicit and strengthen motivation for change whilst avoiding to eliciting or strengthening resistance for change. Motivational interviewing focuses on exploring and resolving ambivalence to change through evoking the person's own motivation to change by exploring the individual's personally held values and goals in life in a nondirective way. Motivational interviewing is a style or approach for communication, rather than a deterrent technique and can be used within existing treatment techniques (e.g. Cognitive behavioral therapy) (Stephen Rollnick & Miller, 1995). In contrast to client-centered counseling, motivational interviewing is goal-oriented and has an intentional direction toward change (Miller & Rollnick, 2009).

Motivational interviewing revolves around a set of key concepts including ambivalence, change talk, and resistance. An ambivalent patient often expresses both change talk and resistance, even within one statement. Through reflective listening, the clinician listens for, elicits, and responds selectively to certain forms of change talk (Miller & Rollnick, 2009). The patient is the expert and the clinician

should, instead of providing a solution, show trust in the patient's own ability to talk him/her self into change (Miller & Rollnick, 2004). The clinician needs to be skilled in listening, identifying, and encounter statements in the proper way, avoiding conflict and resistance (status quo) within the client. The skilled clinician can support change talk without pushing and risk that the patient turns to the opposite side of the inner debate (Miller & Rollnick, 2004).

Motivational interviewing is both a theoretical framework and a clinical method to enhance personal motivation for change. However, compared to the transtheoretical model for behavior change and other models for behavior change, motivational interviewing does not provide a comprehensive theory of change (Miller & Rollnick, 2009). It is a prevalent misconception that TTM and motivational interviewing have the same source. In reality, they developed in parallel. They depend on comparable main ideas but have completely distinct aims and are not dependent on each other. Although motivational interviewing has similarities with the transtheoretical model, it applies similarly to other health behavior theories (Miller & Rollnick, 2012).

Early on, motivational interviewing was applied as preparation for other psychological interventions. The potential of Motivational interviewing to trigger change without additional interventions was soon acknowledged (Miller & Rollnick, 2004). Studies suggest duration to be less important, with motivational interviewing showing good effect with brief interventions (e.g. alcohol addiction, see Moyer, Finney, Swearingen, & Vergun, 2002). The usefulness of short, one-session, motivational interviewing interventions have gained interest outside of clinical psychology. It has been acknowledged as suited for other healthcare professions, such as primary health care (Miller & Rollnick, 2004; Moyer et al., 2002)

Motivational interviewing is traditionally used in a face-to-face setting but has been used in a synchronous online format (West et al., 2016). An automated online program-based on motivational interviewing has been used for smoking cessation (Bommelé et al., 2017). Bommelé and colleagues found that an automated 30-minute program increased receptivity to information about smoking and reduced the number of cigarettes per day compared to a control condition. However, intention to quit and attempts to quit were not affected (Bommelé et al., 2017).

Application of Motivational Interviewing in audiology

Not all people who fail a hearing screening have the same motivation to seek help. People who are not ready to seek help and undergo hearing aid rehabilitation might benefit from online information on options and knowledge about hearing impairment (Rothpletz et al., 2016). Though theories of health behavior change have been frequently discussed in audiology, little empirical data are available regarding how to change behavior and increase hearing help-seeking rates and rehabilitation uptake. People who are not prepared for change may benefit from counseling aimed at motivating and enhancing insight, because

changes in cognitions and behaviors may be required for seeking professional help (Weineland et al., 2015). Acceptance of hearing impairment and need for hearing aids and adequate continues support from the clinician are important factors for a maintained adequate use of prescribed hearing aids (Solheim, Kværner, Sandvik, & Falkenberg, 2012).

Within audiology, motivational interviewing has been applied in hearing rehabilitation to increase hearing aid use among people who reported low usage of their devices (Aazh, 2016). Aazh (2016) found support for incorporation motivational interviewing strategies in hearing aid rehabilitation compared to standard care to increase hearing aid use. No known studies have investigated whether motivational interviewing can promote hearing help-seeking.

THESIS AIMS

The overarching aim of this thesis was to investigate behaviors related to hearing rehabilitation (help-seeking, hearing aid uptake, and hearing aid use) in adults who fail an online hearing screening. A second aim was to explore the usefulness of the Stages of change model in predicting hearing rehabilitation related behavior in a self-selected online hearing screening sample.

SPECIFIC AIMS

Study I is a cross-sectional study of Swedish adults who opt for and fail an online hearing screening. The aim was to describe correlations between three Stages of change measures of different lengths; URICA, Staging algorithm, and the Line.

Study II is a longitudinal, 18-month follow-up of participants from study I. The aim was to explore the prevalence of help-seeking, hearing aid uptake, and hearing aid use 18-month after failing an online hearing screening. The aim was further to explore the predictive validity of the Stages of change measures.

Study III is a randomized controlled trial investigating the effect of extending online hearing screening with a short, fully automated, intervention based on MI. The main aim was to determine the prevalence of help-seeking, hearing-aid uptake, and hearing aid use after intervention versus control. The secondary aims were to explore improvement on self-reported measures of hearing disability, quality of life, anxiety, depression, and hearing self-efficacy after intervention versus control, and to explore predictive factors for help-seeking.

Study IV is a cross-sectional study embedded in a larger randomized controlled trial that aims to implement and evaluate further extending online hearing screening to increase motivation and knowledge about communication strategies, and to explore the effect of a clinician providing this support versus receiving automated support. The specific aim of Study IV was to explore whether it is optimal to include/exclude individuals from a 6-week online intervention study on hearing and communication strategies, based on their results on an online hearing screening.

EMPIRICAL STUDIES

The thesis covers four empirical studies, based on three separate samples of Swedish adults. The regional ethics committee in Linköping, Sweden provided ethical clearance for all four studies. Participants received no compensation or reimbursement.

GENERAL METHODS

An overview of the three samples and the four studies is displayed in Figure 3. Study I and II used the same sample. An overview of study design and methods for the four studies is displayed in Table 2.

Figure 3. Overview of samples and studies.

The first sample was recruited for a longitudinal study with the aim to investigate behaviors related to hearing rehabilitation (help-seeking, hearing aid uptake and hearing aid use) in adults who fail online hearing screening. Study I report on baseline data for 224 participants. Study II report on follow-up data on 122 participants.

The second sample was recruited for a randomized controlled trial investigating the effect of an extended online hearing screening with a short, fully automated, intervention based on MI. Study III report on the full randomized controlled trial. A study protocol has also been published (Weineland et al., 2015).

The third sample was recruited for a randomized controlled trial with the aim to implement and evaluate extended components to an online hearing screening to increase motivation and knowledge about communication strategies, and to explore clinician effect. Study IV reports on baseline data for a first cohort of participants.

Table 2. Overview of study design and methods.

	Sample 1				Sample 2	Sample 3
	Study I	Study II	Study III	Study IV		
Participant recruitment	Self-selection	Self-selection	Self-selection	Self-selection		
Design	Cross-sectional	Longitudinal	RCT*	Cross-sectional		
Year/-s^	2013	2013–2014	2014–2015	2018		
Assessment points	Baseline	Baseline 18-month follow-up	Baseline Post 9-month follow-up	Baseline		
Sample size	224	122	117	68		

*Randomized controlled trial, ^Years of recruitment and data collection

Participants & Recruitment

Recruitment

Participants in Study I, II, and III were recruited through an advertisement for free online hearing screening. All individuals who failed the online hearing screening during the study period, met the inclusion criteria, and indicated interest in participating in research were invited to participate in the study. Participants in Study IV were recruited through an advertisement for a free online study on hearing and communication strategies. Participants had to sign up for the study before conduction the online hearing screening.

Inclusion Criteria

All studies applied the same basic inclusion criteria: ≥ 18 years old, Swedish as first language, having computer- and internet experience, and not previously fitted with hearing aids. Study IV reports on both included and excluded participants.

Sample characteristics

Sample characteristics from the four studies are displayed in Table 3. These findings are further discussed in the general discussion.

Table 3. Sample characteristics

	Sample 1		Sample 2	Sample 3
	Study I	Study II	Study III	Study IV
Age, mean	68	69	68	63
Females (%)	42	43	51	53
University degree (%)	44	44	63	72
Living with other-/s (%)	77	77	79	82

Procedure

In Studies I, II, and III, participant information was sent out after the hearing screening and sharing of screening results. Participants were not aware of the upcoming study, nor the inclusion criteria when conducting the screening. All participants who met the inclusion criteria were asked to provide a valid email address. Potential participants received a unique link to the participant information and an entry questionnaire. Consent was given in two steps, first by proving an email address, and second by submitting the entry questionnaire. At follow-up, participants received a unique link to a follow-up questionnaire via email. No reminders to complete the entry or follow-up questionnaires were sent out. In Study I the order of the different questionnaires of the self-assessment

battery was counterbalanced to investigate order effects on scores. Since the order did not result in significant differences in questionnaire scores, the order of the different questionnaires in Studies II, III, and IV was not counterbalanced.

In Study IV, participant information was sent out before conducting the hearing screening. Information about the study and inclusion criteria were displayed on the public webpage. Participants registered on the public webpage by providing a valid email address. The participant received a unique link to the participant information and consent. After signing up and consent to the study, participants were provided with a unique link to the entry questionnaire and the hearing screening test.

Study platforms

Studies I, II, and III were part of an online hearing screening research program at Linköping University, Sweden. The study platform and the free of charge online hearing screening test (Molander et al., 2013) were developed by the research institute The Hearing Bridge and governed by the Swedish Association of People with Hearing Loss. The hearing screening test is accessible to all on the Swedish Association of People with Hearing Loss website (<http://horseltestaren.se>). On the website, The Hearing Bridge provided a direct link to the Swedish Association of People with Hearing Loss website for further information or counseling. Help and instruction for how to contact hearing health care were accessible on the website. However, the utilization of the link was not investigated. The hearing screening was, during data collection for Studies I, II, and III, only accessible via computers, not mobile devices such as smartphones and tablets.

Study IV used a platform developed and governed by Linköping University (Vlaescu, Carlbring, Lunner, & Andersson, 2015). The Swedish version of the triple-digit-test (unpublished, see Zokoll et al., 2013) was used as online hearing screening test. Advertisement guided people to a public webpage on the platform. To access the study and online hearing screening participants had to register with a valid email, received a username, and create a password. This hearing screening test is only accessible for research purposes and is not currently available through a widely accessible website. The hearing screening was accessible via computers and mobile devices such as smartphones and tablets. The platform did not provide any direct link to further information or counseling. It was necessary to change platform for Study IV due to changes in availability of technical support.

Speech-in-noise screening tests

This thesis make use of two speech-in-noise-tests. Both speech-in-noise tests have been validated using adult native Swedish speaking participants, and established cut-offs are only applicable to that population. Both tests included written instructions and a set of practice rounds. Individuals could not stop the test nor

repeat instructions when the test had been started. A slight difference in test results when using speakers compared to headphones have been reported (Molander et al., 2013), and therefore all participants were encouraged to use headphones. Both ears were tested simultaneously, reflecting the status of the better ear.

Studies I-III applied a speech- in-noise test developed by the research institute The Hearing Bridge. The test consists of a close-set of 10 words (Hagerman, 1982) presented in background noise. Each word is displayed with a corresponding icon on the participant's computer screen. Before starting, participants are instructed to adjust the volume of the speech to a comfortable level. The test presents 20 words in a random order and participants are instructed to click on the icon representing the word presented. If a correct answer is given, the background noise increases (SNR decreases), and vice versa in 2 dB steps. For each participant, the resulting speech-in-noise recognition threshold (expressed as a signal-to-noise ratio, SNR) at which 50% intelligibility is achieved is calculated from the 10 last words presented. A -3.4 dB SRT cut-off corresponds to a true positive rate of 79% and a false-positive rate of 24%, given a pure-tone average threshold of 35 dB HL. Validation for the hearing screening used PTA for the better ear at the frequencies 250, 500, 1k, 2k, 3k, 4k, and 6k Hz (Molander et al., 2013).

Study IV applied the triple-digit-test (Smits, Kapteyn, & Houtgast, 2004; Smits et al., 2006) in its Swedish version (unpublished, see Zokoll et al., 2013). The triple-digit-test consists of 23 digit-triplets (e.g., 5-3-7) presented in background noise. A digit-pad is displayed on the screen and participants are instructed to repeat the digit triplets. A correct answer is given when all three digits are given in the correct order. The noise level was fixed during the test. If a correct answer is given, the speech-signal decreases (SNR decreases), and vice versa in 2 dB steps. For each participant, the resulting speech-in-noise recognition threshold (expressed as a signal-to-noise ratio, SNR) at which 50% intelligibility is achieved is calculated from the 20 last digit-triplets presented. Scores are categorized as good, insufficient, or poor with the latter two indicating hearing impairment. The present thesis adopted only two categories (pass/fail) where insufficient and poor were categorized as fail (Smits et al., 2004, 2006). The triple-digit-test is available in several languages including Dutch (Smits et al., 2004), German (Wagener et al., 2005, 2006), French (Jansen, 2008), and Swedish (unpublished, see Zokoll et al., 2013). The cut-off used in the original Dutch version has a true positive rate of 91% and a false-positive rate of 93% (Smits 2006). Validation for the hearing screening used PTA for the better ear at the frequencies 250, 500, 1k, 2k, 4k, and 8k Hz. A -6,9 dB SRT is applied for the Swedish version (Zokoll et al., 2013). True positive and false positive rates have not been published for the Swedish version. The rationale for changing the hearing screening test in Study IV was to improve comparability.

Materials

Entry and follow-up questionnaires

In Studies I–III participants received a unique link to the entry questionnaire along with the participant information after conducting the online hearing screening test. The entry questionnaire consisted of both demographics and a self-assessment battery (displayed in Table 4). In Study IV participants received a unique link to the entry questionnaire and the online hearing screening test once signed up on the platform. The entry questionnaire consisted of both demographics and a self-assessment battery (displayed in Table 4).

The two longitudinal studies (Studies II & III) made use of follow-up questionnaires sent via email. Both consisted of a self-assessment battery (displayed in Table 4) and questions regarding experience with behaviors related to hearing rehabilitation. The primary outcome in the both studies was experience with self-reported hearing help-seeking behavior. Participants were asked: Have you sought help and had your hearing tested (yes/no)? Specific examples of typical places / people involved in hearing help-seeking in Sweden were mentioned: hospital audiology clinic, ear, nose and throat clinic, and private hearing clinic. If participants reported having sought help they were asked if they had opted for hearing aids (yes/no/my hearing was normal, and I was not a candidate for hearing aids). If they had opted for hearing aids participants were asked to report how many hours per day they used their hearing aids.

Demographic and background variables

Demographic and background variables collected varied between the studies, though some variables were collected in all studies. Biological sex, age, educational level, living situation (alone/with other/-s), additional chronic conditions (yes/no) were collected in all studies.

Additional information collected in **Studies I and II** were years with perceived hearing impairment.

Additional information collected in **Study III** was whether participants had ever discussed their hearing with health care personnel.

Additional information collected in **Study IV** was previous experience with hearing help-seeking.

Self-assessment battery

Content of the self-assessment battery differed between the studies. An overview of the self-assessment battery is shown in Table 4.

Table 4. Outcome measures used in the studies.

Measure	Study I	Study II	Study III	Study IV
URICA	Baseline	Baseline	Post intervention	Baseline
Staging algorithm	Baseline	18-month follow-up	9-month follow-up	Baseline
	Baseline	Baseline		
The Line	Baseline	18-month follow-up		
		Baseline		
AIADH		18-month follow-up		Baseline
		Baseline	Baseline	
Hearing Self-efficacy			9-month follow-up	Baseline
			Baseline	
QOLI			9-month follow-up	
			Baseline	
BBQ			9-month follow-up	Baseline
			Baseline	
HADS			9-month follow-up	
GAD-7			Baseline	Baseline
			9-month follow-up	
CSS				Baseline
				Baseline

The **University of Rhode Island Change Assessment (URICA)** (McConaughy, Prochaska, & Velicer, 1983) measures Stages of change. URICA is the most commonly assessment for Stages of change in audiology (Manchaiah et al., 2018). Here the Swedish translation (Farbring, 2010) was used. Although the Swedish translation is used in clinical settings, its validation has not been published. The original URICA questionnaire consists of 32 items with eight items for each of four stages; precontemplation, contemplation, action, and maintenance. The items are neutral statements where the term “problem” can be adapted to a specific health condition. An example of a precontemplation item is “As far as I am concerned, I do not have any hearing problems that need changing”. Respondents describe the level of agreement for each item by choosing one of five response options; strongly disagree (1), disagree (2), undecided (3), agree (4), and strongly agree (5). In this thesis, a modified factor structure that recognizes the additional preparation stage, derived from URICA results on a sample of 153 adults with hearing impairment, was used (Laplante-Lévesque et al., 2013). Items relating to the maintenance stage were removed as they were not relevant for the population, resulting in 24 items; eight for precontemplation, four for contemplation, five for preparation, and seven for action. The construct validity of the Swedish URICA for people with hearing impairment has been published (Laplante-Lévesque et al., 2015). URICA scores can be summarized in different ways. In this thesis, the stage with the highest score was used. A mean value for each of the four stages is calculated and the stage with the highest mean is considered an individual’s stage. In case two or more stages have the same mean value, the highest (more advanced) stage is used. Each participant is thereby classified by the stage that received the highest score. The reason for using the stage with the highest score method was to be able to compare URICA with SA.

The **Staging algorithm** (Milstein & Weinstein, 2002) is a single item questionnaire assessing Stages of change. Many behavior-specific staging algorithms have been developed to assess Stages of change (Weinstein et al., 1998). The first attempt to apply the Stages of change model in audiology included developing a hearing specific Staging algorithm for audiological screening purposes (Milstein & Weinstein, 2002). The Staging algorithm consists of a single item with four response options each corresponding to a stage of change: 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 (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). No validated Swedish translation of the Staging algorithm exists.

The **Line** (Rollnick, Mason, & Butler, 1999) is a single item measuring levels of perceived importance for change, here targeting hearing: How important is it for you to improve your hearing right now? (Rollnick et al., 1999; Tønnesen, 2012). The participant is instructed to answer on a VAS scale from 0 (not important at

all) to 10 (highly important) (Rollnick et al., 1999). In this thesis, a discrete 11-point scale was used.

The **hearing help-seeking self-efficacy scale** (Weineland et al., 2015), based on Self-efficacy (Bandura, 1977), is a four-item questionnaire developed for Study III (Weineland et al., 2015), as no other measure was already available to quantify this construct. The questionnaire consists of four items rated on a scale from 0 (not confident at all) to 10 (very confident). Responses to each item are analyzed separately. In this thesis, the questions are referred to as Self-efficacy_1 (I am confident that I could identify a health care professional for my hearing problems), Self-efficacy_2 (I am confident that I could arrange an appointment with a health care professional for my hearing problems), Self-efficacy_3 (I am confident that I could physically get to a health care professional for my hearing problems), and Self-efficacy_4 (I am confident that I could succeed in making an appointment to a health care professional for my hearing problems).

The **Amsterdam Inventory for Auditory Disability and Handicap (AIADH)** (Kramer, Kapteyn, Festen, & Tobi, 1995) measure self-reported hearing problems. The AIADH consists of 30 items, divided over five subscales (distinction of sound, localization, intelligibility in noise, intelligibility in quiet, and detection of sounds). Mean scores on each subscale and the total mean score for AIADH range between 0 and 3, with a higher score indicating more self-reported hearing disability (Hallberg, Hallberg, & Kramer, 2008). The validated Swedish version was used (Hallberg et al., 2008). For the studies presented in this thesis, AIADH total mean score ≥ 1 was indicative of self-reported hearing disability.

The **Communication Strategies Scale (CSS)** (Demorest et al., 1987) is a 25-item questionnaire measuring frequency of communication strategies. Each item describes a specific behavior or a situation and is divided over three subscales: maladaptive behaviors (e.g. avoiding conversation or interrupt other talkers) with nine items, verbal strategies (e.g. remind others of the hearing impairment or ask others to repeat) with eight items, and non-verbal strategies (e.g. focusing on the talker's face or move to a better seat) with eight items. Answers ranges from rarely, almost never (1) to usually, almost always (5). Total score for each subscale averaged. Swedish normative data is based on 199 adults with confirmed hearing impairment (L. R. M. Hallberg, Eriksson-Mangold, & Carlsson, 1992). Mean and standard deviation for the three subscales are 1.88 (0.69), 3.12 (0.82) 3.86 (0.79) respectively (L. R. M. Hallberg et al., 1992).

The **Quality of Life Inventory (QOLI)** (Frisch, Cornell, Villanueva, & Retzlaff, 1992) measures quality of life in 16 key areas: Health, Self-regard, Philosophy of life, Standard of living, Work, Recreation, Learning, Creativity, Social service, Love relationship, Friendships, Relationship with children, Relationship with relatives, Home, Neighborhood, and Community. In QOLI, each area is rated in two steps. Firstly, the participant is instructed to rate the experienced importance of said area (0=not at all important, 1=important, 2=extremely important). Secondly, the participant is instructed to rate the satisfaction with the said area (from -3=very dissatisfied to 3=very satisfied). Each area score is calculated as a

product of importance $\times$ satisfaction. Areas rated as extremely important have therefore a larger impact than those rated as important. Items rated as not important are removed before calculating the total score. A total score is calculated by dividing the sum of included items with the number of included items, resulting in a value between -6 and 6, with higher scores indicating higher quality of life. The Swedish translation was used (Paunovi & Öst, 2004). QOLI has the ability to discriminate clinical from non-clinical populations (Lindner, Andersson, Öst, & Carlbring, 2013).

The **Brunnsviken Brief Quality of Life (BBQ)** is based on the same structure as QOLI (Lindner et al., 2016). The 12 items cover 6 life areas: Recreation, Philosophy of life, Creativity, Learning, Friends and friendship, and Self-regard. The individual rates: 1) the importance of and, 2) experienced satisfaction with each life area. Each item scores from 0 (not agree at all) to 4 (fully agree). The score for importance is multiplied with the score for experienced satisfaction for each item, resulting in a score for each life area between 0 and 16. Scores for each life area are summed to establish a total score ranging from 0 to 96, with higher scores indicating higher quality of life. Swedish norm values are based on 167 students with a mean age of 26.9 years. The norm value mean was 60.08 (SD 15.72). The BBQ has the ability to discriminate clinical from non-clinical populations, but is more sensitive to change than QOLI. The optimal cut-off score between clinical and non-clinical populations is 52.5 (Lindner et al., 2016).

The **Generalized Anxiety Disorder 7-item scale (GAD-7)** (Spitzer, Kroenke, Williams, & Löwe, 2006) is a 7 item, non-diagnostic, questionnaire to identify signs of generalized anxiety disorder. Participants are asked to report how often they have been bothered by different problems over the last 2 weeks, (e.g. becoming easily annoyed or irritable). Possible answers are not at all (0), several days (1), more than half the days (2), and nearly every day (3). The total score ranging from 0 to 21 with cut-off values for mild, moderate, and severe anxiety being 5, 10, and 15, respectively (Spitzer et al., 2006).

The **Hospital Anxiety and Depression Scale (HADS)** (Zigmond & Snaith, 1983) is a 14 items, non-diagnostic, questionnaire to measure or identify anxiety and depression. HADS is divided in two separate subscales (HADS-anxiety and HADS-depression), with 7 items each. Participants are asked to report how often they have felt (e.g. like something terrible is going to happen) over the last 2 weeks. Possible answers ranging from 0–3 with a total score of 21 for each subscale. A higher score indicates more problems with anxiety or depression. A score of 8 or higher on either subscale is indicative of clinically relevant symptoms. We used the Swedish version (Lisspers, Nygren, & Söderman, 1997). Swedish norm data for HADS-anxiety and HADS-depression are 4.55 (SD 3.73) and 3.98 (SD 3.46) respectively (Lisspers et al., 1997).

Ethical Considerations

Limitations with the speech-in-noise tests

False-positive and false-negative results were expected to occur due to test sensitivity. In other words, an individual with a PTA4 >35 dB HL might pass the screening test. Likewise, an individual who fails the screening test might have a PTA4 <35dB HL. No physical or psychological harm has been identified when conducting the hearing screening tests or filling out the questionnaires. False-positive and false-negative results could cause concern for the individual. Referring a participant without a clinically significant hearing impairment could be argued as being less problematic compared to not referring when hearing impairment is present. The compensatory ethical approach applied included information and a general recommendation to seek help in case of concern before conducting the hearing screening test. Participants were informed about the test being a screening tool and that the result was only an indication, not comparable with completing a hearing test at a clinic.

Participant Information and Consent

Each data collection included information on participation and sought consent. Participant information included a short description of the study's purpose and procedure. Participants were informed that they could revoke participation in the study at any time, without stating any reason, and that doing so would not affect participation in future studies, nor affect access to any future treatments. The study information stipulated that medical counseling (Studies I–IV) and counseling outside the study topic (Study IV) would not be provided. Participation was stated as non-suitable for participants suffering from severe psychiatric conditions (e.g. psychosis or drug addiction).

Data security

Sensitive information collected in Studies I, II, and III consisted of email addresses only. All email addresses were securely stored by the research institute The Hearing Bridge, who was responsible for sending emails and collecting data. Email addresses were not accessible to the researchers. Email addresses were logged to prevent participants from conducting the screening multiple times.

Sensitive information collected in Study IV consisted of email addresses and phone numbers. Both were securely stored by Linköping University and accessible only to the researchers. Email addresses were logged to prevent participants from conducting the screening multiple times. Each participant was assigned a random study ID (four numbers followed by four letters) and asked to create a secure password. Study ID and password were used to access the platform.

Feedback and referral

Results on the hearing screening test (pass/fail) were shared with participants immediately after conducting the test. Results on the self-assessment questionnaires were not routinely shared with the participants. Referral consisted of the recommendation to seek hearing healthcare. Participants were not recommended specific rehabilitation options. General help-seeking pathways were given as examples, including hospital audiology clinic, ear, nose and throat clinic, and private hearing clinic.

SUMMARY OF EMPIRICAL STUDIES

STUDY I

Rationale – The Stages of change model has been proposed as a useful tool for clinicians delivering hearing health care (Babeu et al., 2004). Support for using the URICA questionnaire with a clinical sample of adults seeking help for the first time exists (Laplante-Lévesque et al., 2013). However, the URICA is lengthy and unsuitable for a clinical appointment. A shorter alternative, that can be handed out online before clinical visits or within a clinical setting, could potentially be of clinical use (Laplante-Lévesque et al., 2015). The Staging algorithm and the Line are two one-item measures for Stages of change.

Aim – To examine correlations between three Stages of change measures of different lengths; URICA, Staging algorithm, and the Line.

Hypothesis – Most participants were expected to be in either of the two stages associated with ambivalence (contemplation and preparation). The three questionnaires, all based on the same theoretical concept, were expected to correlate. Due to better psychometric properties with the 24-item URICA compared to the one-item Staging algorithm and the Line, strong correlations were not expected.

Design – The study was cross-sectional. Participants were recruited between December 2012 and February 2013 using national advertisements published in newspapers, on the radio, and in online media. Participants consented by stating their email address for contact. All participants who failed the online hearing screening during this period and met the inclusion criteria were invited to participate in the study. The three self-assessment measures (URICA, the Staging algorithm, and the Line) were merged into one coherent online questionnaire together with additional questions regarding amount of years with perceived hearing problems, and whether people could imagine themselves using hearing aids if recommended to them. To investigate sequence impact of the three stages of change measures, the order was counterbalanced. Since the order did not result in significant differences in scores, all questionnaire data were combined.

Sample – During the study period, 365 individuals meet the inclusion criteria and were sent a unique link to the questionnaire. In total, 224 participants (61%) completed the questionnaire.

Analysis – Correlations with Spearman's Rho were conducted to investigate correlations between scores on the three Stages of change measures.

Results – The mean age of the sample was 68 years and reported years with perceived hearing problems had a mean slightly over 10 years. Almost half of the sample had a university degree.

The distribution of participants according to URICA, the Staging algorithm, and the Line is displayed in Figure 4. According to URICA, 85 participants (37.9%) were in the contemplation stage and half of the participants (50%) were in the preparation stage, and. The precontemplation stage was represented by 21 participants (9.4%), and the action stage by six participants (2.7%). According to the Staging algorithm, most participants were divided between contemplation, with 100 participants (44.6%), and preparation with 101 participants (45.1%). Six participants (2.7%) were in the precontemplation stage and 17 participants (7.6%) were in the action stage. The mean value on the Line was 6.14 (SD 2.8). Distribution of participants according to the three measurements are shown in Figure 4. Staging algorithm and The Line correlated with a high effect size, $r_{\text{info}}(224)=0.63$, $p<0.001$. Staging algorithm, $r_{\text{rho}}(224)=0.15$, $p=0.025$, and The Line $r_{\text{rho}}(224)=0.14$, $p=0.035$, also had both statistically significant correlations with URICA. However, both with small effect sizes.

Staging algorithm Line mean (SD)	URICA Stage with highest score Line mean (SD)				Total n (%)
	Precontemplation 2.48 (2.27)	Contemplation 6.84 (2.53)	Preparation 6.28 (2.62)	Action 6.67 (3.93)	
Precontemplation 1.83 (2.14)	4	0	2	0	6 (3)
Contemplation 4.48 (2.26)	16	31	52	1	100 (44)
Preparation 7.58 (2.17)	1	48	50	2	101 (45)
Action 8.88 (2.23)	0	6	8	3	17 (8)
Total n (%)	21 (9)	85 (38)	112 (50)	6 (3)	224 (100)

Classification	Total n (%)
0 stage away (perfect classification)	88 (39)
1 stage away	126 (56)
2 stages away	10 (5)
3 stages away (very wrong classification)	0
Total	224 (10)

Figure 4. Distribution of participants according to URICA, Staging algorithm, and the Line.

Conclusions – All three stages of change measures correlated significantly with each other, with the largest correlation between the Staging algorithm and the Line. The small effect sizes in the form of correlations between the URICA and Staging algorithm and the Line may suggest that they generally measure different concepts.

STUDY II

Rationale – Stages of changes, measured with the URICA, predict rehabilitation uptake in patients visiting the hearing clinic for the first time (Laplante-Lévesque et al., 2013). In Study I, support was found for the shorter Staging algorithm and the Line for measuring Stages of change (Ingo, Brännström, Andersson, Lunner, & Laplante-Lévesque, 2017). In addition, longitudinal studies investigating the predictive validity for Stages of change is needed (Sutton, 2000).

Aim – To explore the prevalence of help-seeking at a hearing clinic, hearing aid uptake, and hearing aid use 18-month post failing an online hearing screening. The aim was further to explore the predictive validity of the Stages of change measures.

Hypothesis – Based on findings from Laplante-Lévesque et al. (2013), URICA scores at the time of online hearing screening was expected to be associated with help-seeking 18 months later. Though weakly correlated with URICA, the Staging algorithm and the Line were expected to also have predictive validity for hearing help-seeking.

Design – Study II was an 18-month follow-up on participants from Study I. All 224 participants were invited to complete a second online questionnaire. The online questionnaire consisted of the three measures of stages of change the URICA, the Staging algorithm, and the Line. Further, participants' experiences with hearing help-seeking and hearing aid uptake were assessed.

Sample – A total of 122 participants (54%) completed the follow-up questionnaire, including the three measures and questions regarding experience with hearing help-seeking, hearing aid uptake, and hearing aid use.

Analysis – Student's independent sample t-tests or chi-square tests were conducted to investigate group differences in baseline data for participants from Study I who did not participate in the follow-up ($n = 102$) and participants who completed the follow-up ($n = 122$). Chi-square tests (corrected with Fisher's exact test due to few observations) conducted with baseline scores of the URICA, the Staging algorithm, and the Line were used to investigate the predictive validity of the three measures. Baseline scores of the URICA, the Staging algorithm, and the Line were dichotomized to investigate if scoring in the lower half versus scoring in the higher half of these three measures was associated with help-seeking at follow-up.

Results – When surveyed 18 months after failing an online hearing screening, 61% of participants had sought help. In total, ten participants (8% of those who sought help) reported their hearing assessment to reveal normal results, which is in line with the 79% true positive rate of the online hearing screening test (Molander et al, 2013). An overview of behaviors related to hearing rehabilitation at 18-month follow-up is displayed in Figure 5. After seeking help at a hearing

clinic, 31 (25% of the total sample surveyed) had obtained hearing aids: of those, 17 (14%) used the hearing aids ≥ 4 hours per day.

Figure 5. Overview of behaviors related to hearing rehabilitation at 18-month follow-up.

Participants who were in the preparation and action stages at baseline as measured by the Staging algorithm were statistically significantly more likely to have sought help 18 months later relative to those in precontemplation and contemplation. Baseline scores on URICA and the Line could not predict hearing help-seeking at 18-month follow-up.

Conclusion – The Staging algorithm had the best ability to predict help-seeking 18 months after having failed a hearing screening. The high rate of attrition (46%) is a considerable methodological limitation, and may have affected present findings.

STUDY III

Rationale – People who are not yet ready for hearing behavior change and hearing help-seeking may benefit from counseling aimed at motivating and enhancing insight. The rationale for assessing a short automated, online intervention to promote help-seeking is twofold. Firstly, the time spent should correspond to a one-time clinical session, which is the foundation for Motivational interviewing. Secondly, the intervention should have a possible clinical value for hearing health care. A short intervention for ambivalent clients/patients could be offered as pre-consultation, remote or at the clinic.

Aim – The main aim was to provide a brief online intervention to people who had failed an online hearing screening and to determine the prevalence of help-seeking, hearing-aid uptake, and hearing aid use after intervention versus people who received a control intervention. The secondary aims were to explore improvement on self-reported measures of hearing disability, quality of life, anxiety, depression, and hearing self-efficacy after intervention versus control, and, to explore predictive factors for help-seeking.

Hypothesis – Individuals who fail an online hearing screening and receive an intervention focusing on motivation for hearing behavioral change were expected to be more likely to seek help, take up hearing aids, and use them. Further, they were expected to move along the Stages of change and to have greater self-efficacy and quality of life, and to have reduced self-reported hearing difficulties, anxiety, and depression compared to people who received a control condition.

Design – This randomized controlled trial included participants who had failed an online hearing screening. Participants were randomly allocated to either the intervention group or the control. Participants were unaware of which group they had been assigned to. A flowchart of the methods according to CONSORT is displayed in Figure 6.

The automated intervention, consisting of text material with an empathic and hopeful tone, questions with feedback, pictures, videos, audio files and written open-ended exercises, combined principles from Motivational interviewing, self-efficacy, and Acceptance and Commitment Theory (Weineland et al., 2015). The control condition consisted of an online book on the history of hearing aids (Nielsen, 2012). Both allocations took around 40 minutes to complete.

Figure 6. Flowchart of the methods according to CONSORT (Schulz, Altman, Moher, & CONSORT Group, 2010).

Sample – A total of 117 participants met the inclusion criteria: 58 participants were assigned to the brief motivational online intervention; and 59 were assigned to control. Of these, 68 (58%) (30 intervention; 38 control) completed the 9-month follow-up.

Analysis – The primary outcomes were hearing help-seeking behavior (help-seeking yes/no, hearing aid uptake yes/no, and hearing aid usage at least 4 hours daily yes/no). Secondary outcomes were self-reported hearing difficulties, quality of life, anxiety, depression, and process of change. Adherence to the intervention was estimated through engagement in included non-mandatory exercises. Attrition bias was investigated by comparing baseline data for participants who completed follow-up with data for participants who did not complete follow-up with Student's independent sample t-tests and chi-square tests.

Chi-square tests were used to test the difference in experience with hearing help-seeking, and hearing aid uptake, between participants who completed brief motivational online intervention versus the control. They were corrected with Fisher's exact test due to few observations. A one-way ANCOVA was conducted to compare groups on hearing disability, quality of life, anxiety, depression, and hearing self-efficacy, whilst controlling for baseline scores. Chi-square tests were

used to test the difference in URICA scores between the groups post-intervention and at follow-up, and to test the difference in URICA scores at follow-up between participants who sought help and participants who did not. Logistic regression was applied to explore predictive factors, at baseline, for hearing help-seeking behavior. Correlations with Spearman’s Rho between all baseline variables and the outcome variable hearing help-seeking behavior were carried out to select possible predictors for the logistic regression. Predictive factors for hearing aid uptake and hearing aid use were not investigated due to few participants who took up hearing aids.

Results – The intervention did not significantly improve hearing help-seeking behavior compared to control, and it did not lead to a reduction in self-reported hearing difficulties, anxiety, and depression; nor to an improvement in quality of life (all $p > 0.05$). An overview of behaviors related to hearing rehabilitation at 9-month follow-up is displayed in Figure 7. People who had discussed their hearing with health care personnel at a previous occasion were significantly more likely to have sought help at 9-month follow-up.

Figure 7. Overview of behaviors related to hearing rehabilitation at 9-month follow-up.

Conclusion – Providing an automated brief online intervention based on Motivational interviewing to people who had failed an online hearing screening did not improve hearing help-seeking behavior compared to control. The high rate of attrition (42%) is a considerable methodological limitation, and may have affected present findings.

STUDY IV

Rationale – From this research group's experience, most participants who conduct an online hearing screening pass it, i.e. there is no indication that they have a PTA > 35 dB HL in the better ear (Molander et al., 2015). However, they may experience hearing difficulties and may benefit from hearing health care. Results on behavioral hearing tests do not correlate highly with self-reported hearing problems (Hannula et al., 2011). Online interventions could be a cost-effective option for people who pass behavioral hearing tests but report hearing difficulties.

Aim – Explore whether it is ideal to include/exclude individuals from a 6-week online intervention study on hearing and communication strategies, based on their results on an online hearing screening test.

Hypothesis – 1) Most individuals who sign up for a 6-week online intervention on hearing and communication strategies would fail the online hearing screening, and 2) Those who fail the online hearing screening would report more hearing disability, more advanced Stages of change, poorer quality of life, and less adequate use of communication strategies, than those who pass the online hearing screening.

Design – The study was a cross-sectional study embedded in a larger randomized controlled trial that aims to implement and evaluate further extending online hearing screening to increase motivation and knowledge about communication strategies, and to explore the effect of a clinician providing this support versus receiving automated support.

Sample – A total of 68 participants with a mean age of 62.54 (SD 12.70) conducted the online hearing screening.

Analysis – The primary outcome was the percentage of participants who completed the Swedish triple-digit-test and failed it. Comparisons were made between individuals who failed and those who did not fail on variables obtained in the entry questionnaire: demographics and self-assessment battery data.

Results – Most participants (64.7%) passed the online hearing screening. No statistically significant difference was found in perceived hearing impairment, Stages of change, quality of life, anxiety, or use of communication strategies between those who failed and those who did not fail the online hearing screening test.

Conclusion – The results provided tentative evidence against using the Swedish triple-digit-test as the sole criterion on which to decide who should have access to online interventions on hearing and communication strategies. Inclusion could be based on a more comprehensive assessment or participation in the course could be offered to all who sign up, regardless of result on the speech in noise test.

GENERAL DISCUSSION

The overarching aim of this thesis was to investigate behaviors related to hearing rehabilitation (help-seeking, hearing aid uptake, and hearing aid use) in adults who fail an online hearing screening. A second aim was to explore the usefulness of the Stages of change model in predicting hearing rehabilitation related behavior in a self-selected online hearing screening sample.

MAIN FINDINGS

The following sections will focus on findings related to the thesis aim and study hypothesizes.

Sample characteristics

Demographics

Central demographic data from the four studies are displayed in Table 5. The mean age for participants in Studies I–III is slightly below the mean age for first time hearing help-seeking (75 years of age) reported by Davis and colleagues (2007). The mean age of participants in Study IV was slightly lower and in line with findings presented by Molander and colleagues (2015) who reported on both participants who failed and participants who passed an online hearing screening.

Table 5. Demographical data from Studies I–IV.

	Study I	Study II	Study III	Study IV
Age, mean	68	69	68	63
University degree (%)	44	44	63	72
Living with other-/s (%)	77	77	79	82
Duration of perceived HI in years, mean	10	10		
Chronic condition (%)			13	7
Discussed hearing (%)			53	
Previous hearing test (%)				44

Participants in all four studies were more educated than the general population. For the age-group 65–74, approximately 30% have studied at the university (Statistics Swedish, 2018). Most participants were living together with someone. Living together with someone is, per se, not associated with hearing help-seeking (Vestergaard Knudsen et al., 2010). However, having social support (which may be related to living arrangement) is an important factor for engaging in behaviors that promote health (i.e. conducting hearing screening) (Conner & Norman, 2005). The duration of perceived hearing impairment, investigated in study I–II, yielded an average of 10 years. These findings are in line with the 10-year waiting time, from awareness to help-seeking, reported by Davis and colleagues (2007).

Participants in Studies III–IV reported low levels of other chronic conditions. In 2016–2017, over 50% of Swedish adults >65, reported having chronic illness or health-related problems (including hearing impairment) (Statistics Sweden, 2018). Finding suggests that the studies might have reached a very healthy population. This is partly supported by the low levels of anxiety and depression, and above-average levels for quality of life compared to the general population. It may also have to do with how respondents were asked. Participants in Study III and IV were asked about unspecified additional chronic conditions or disabilities and might therefore have failed to report. This explanation is partly supported by finding from Stam and colleagues (2014). When asking people who conducted online hearing screening about several specific chronic conditions. A total of 72%, in a considerable younger sample (mean age of 46), reported having one or more chronic conditions. The present finding may also be due to a combination of the two.

Study III investigated whether participants had discussed their hearing with, unspecified, health care personnel at a previous occasion. More than half (53%) had done so. This finding suggests that online hearing screening might serve as a second opinion. In other words, it might have attracted individuals who have already sought help. Also, the fact that most had already talked about their hearing might reflect the perception of hearing impairment as a normal process of aging and that hearing impairment in older adults often is neglected in primary care settings (Contrera et al., 2016; Wallhagen & Pettengill, 2008). However, whether the discussion was with hearing-related health care personnel or not was not further investigated. Nor were the time since the (most recent) discussion took place and the discussion outcome (e.g. referral to an audiologist) asked about.

Study IV investigated whether participants had undergone hearing diagnostics (at a clinic) at a previous occasion. Almost half (44%) had done so. This finding suggests the online course offered in Study IV could be of interest to people who are not candidates for hearing aids or who do not feel a current need for hearing aids. However, time since the (most recent) hearing test was not investigated.

Self-reported hearing impairment

Baseline data on self-reported hearing impairment (measured with AIADH) from the four studies are displayed in Table 6. On average, participants reported low levels of perceived hearing impairment, a result in line with previous findings from online hearing screening studies (Molander et al., 2015). Participants in Study IV, who had signed up for an online course on hearing and communication strategies, did not, as expected, report more perceived hearing impairment than people who opt for conducting an online hearing screening.

Table 6. Baseline data on self-reported hearing impairment from Studies I–IV.

Measure	Study I	Study II	Study III	Study IV
AIADH, mean (SD)	0.67 (.38) *		.82 (.42)	.65 (.39)
Distinction of sound			.84 (.40)	.41 (.38)
Localization			.71 (.58)	.65 (.66)
Intelligibility in noise			1.21 (.68)	1.22 (.56)
Intelligibility in quiet			.74 (.47)	.65 (.46)
Detection of sounds			.60 (.45)	.45 (.43)

*Reported in a separate publication (see Laplante-Lévesque et al. 2015)

Psychosocial health

Data on psychosocial health (quality of life, anxiety, and depression) from Studies III–IV are displayed in Table 7. Participants in Studies III–IV reported, on average, high quality of life, and low levels of anxiety and depression compared to the general Swedish population.

Table 7. Baseline data on psychosocial measures from Studies I–IV.

Measure, mean (SD)	Study I	Study II	Study III	Study IV
QOLI			2.96 (1.26)	
BBQ				72.81 (17.80)
HADS-A			4.82 (3.66)	
HADS-D			2.82 (2.51)	
GAD-7				2.85 (3.73)

Possible explanations for the low levels of psychosocial problems at baseline include study design and study sample. In line with Besser and colleagues (2018), mixed findings have been reported on the association between hearing impairment, anxiety, and depression. Stam and colleagues (2014), did not find an association in a self-selected sample who failed the Dutch version of the triple-digit test (Stam et al., 2014). One reason could be that online hearing screening attracts individuals with high functioning and less psychosocial problems. In a study on internet-delivered cognitive behavioral therapy for depression Lindner and colleagues (2015) found that participants recruited via newspaper were older and had relatively low levels of depression, anxiety, and reductions in quality of life compared to participants recruited via clinics or websites for mental health

problems (Lindner, Nyström, Hassmén, Andersson, & Carlbring, 2015). The present findings, in combination with the low levels of self-reported hearing impairment, suggest that online hearing screening advertised in newspapers, social media, and via radio attracts a population that is not too affected by their perceived hearing impairment.

However, a few participants did report significant problems with anxiety and depression. Unfortunately, scores above 8 on HADS (indicative of clinically relevant symptoms of anxiety or depression) or above 5 on GAD-7 (indicative of mild anxiety) were not addressed further within the studies. Future studies should contemplate integrating screening for multiple health-related factors associated with hearing impairment and to provide a clear and tailored pathway for each participant (e.g. referral to adequate health care or equivalent online intervention).

Help-seeking, hearing aid uptake, and hearing aid use

The first overarching aim of this thesis was to investigate behaviors related to hearing rehabilitation (help-seeking, hearing aid uptake, and hearing aid use) in adults who fail an online hearing screening. Mixed findings on the impact of online hearing screening have been reported (Meyer et al., 2011; Smits et al., 2006). Since the first speech-in-noise-test online (Smits et al., 2006), several studies, from different countries, have sought to understand the contribution of hearing screening to help-seeking. Studies II and III contribute with a thorough description of the motivational profile of people who fail an online screening in Sweden and a longitudinal design. However, both studies suffered from high rates of attrition (dropout) which is a considerable methodological limitation. The two studies reported help-seeking rates of 61% and 28%, respectively. The differences may be explained by the twice as long follow-up period applied in Study II (18-month) compared to Study III (9-month). The previous studies by Smits and colleagues (2006) and Meyer and colleagues (2011), using a considerably shorter follow-up period of 4–5 months, reported help-seeking rates of 50% and 36%, respectively. In Study II, 25% of the sample had obtained hearing aids and 14% reported using the hearing aids more than four hours per day. Corresponding rates in Study III were 9% and 4%, respectively. Meyer and colleagues (2011) reported that 15% had obtained hearing aids and 6% used their hearing aids more than one hour per day. Participants in Meyer's study had a mean age of 68 which corresponds to Studies II and III. Participants in Smits study were considerably younger (median age of 40 years for the internet version and 54 years for the telephone version). This difference might reflect that individuals of working age are more likely to seek help for perceived hearing impairment than older individuals (Saunders et al., 2012).

A relatively long follow-up period was considered necessary to capture seeking help, undergo rehabilitation, and maintain hearing aid use, especially given the long delays in typical help-seeking for hearing impairment reported by Davis and colleagues (2007). Present findings suggest that a sufficient follow-up period is needed to capture an effect of online hearing screening on help-seeking,

hearing aid uptake, and hearing aid use. It would be interesting to investigate even longer follow-up periods to see whether online screening may have a delayed impact.

Extended online hearing screening

Online hearing screening, compared to hearing screening via telephone, has the advantage to offer further information and interventions immediately following the screening. In Study III, the short fully-automated intervention aimed to promote motivation did not improve hearing help-seeking behavior 9-month after online hearing screening compared to control. The intervention targeted motivation and ambivalence for hearing help-seeking, not for rehabilitation or hearing-aids. Whether the intervention had an effect on hearing help-seeking or not remains unclear due to the high rate of attrition (42%) which may have affected the present findings. Though no differences between participants who completed the follow-up and those who did not could be detected on baseline variables, unknown factors may have contributed to the null result of the intervention. It is possible that those who actually had sought help were not interested in taking part of the follow-up. This, of course, might have biased the inferences of the effect of the intervention.

Also, intervention content, adherence to treatment, means of delivery, duration, sample, and measured outcomes may have contributed to the findings. Targeting relevant mechanisms of action is essential for behavioral change interventions to be effective (Michie et al., 2018). The brief motivational online intervention tried to mimic core principles derived from motivational interviewing, self-efficacy, and Acceptance and commitment therapy. Based on completed exercises, adherence to treatment was good in the intervention group suggesting the intervention was utilized as intended. However, time spent on reading text material, watching pictures and videos, and listening to audio-files was not recorded. Adherence was not investigated for the control group. The automated online format might not have captured the effective components. Miller and Rollnick (2004) argue that interaction with another person ought to be a crucial factor. However, Miller and Rollnick (2012) claim that motivational interviewing has a significant effect as a one-time pre-consultation intervention, and that contact time is less important. Participants in the preparation and action stages should not require ambivalence support. Encouraging self-reflection in people who no longer struggle with ambivalence could have been counterproductive. There might also be a mismatch between intervention and outcome measures. In line with Bommelé and colleagues (2016), the brief motivational online intervention did not have any effect on primary health behavioral change. However, the intervention might have influenced underlying processes such as acceptance, increased receptivity to information and other variables important for health behavior change. Unfortunately, these processes were not measured in the trial. Results from process analysis could have shed light on whether this type of intervention is capable of targeting relevant processes, which in turn might influence long-term behavioral outcomes (e.g., help-seeking).

Predictive factors for hearing help-seeking

Several factors influence help-seeking for hearing impairment and, more generally, the adoption of behaviors that promote good health. Both Study II and III investigated whether demographical variables and baseline scores on self-assessment questionnaires could predict behaviors related to hearing rehabilitation. Since few participants in Studies II and III had opted for hearing aids both studies focused on predictive factors for hearing help-seeking.

Results from Studies II and III could not replicate the following previously reported predictors for hearing help-seeking: degree of hearing impairment, degree of perceived hearing impairment, and duration of perceived hearing impairment. These factors have been found to be good predictors for hearing help-seeking in older adults (Vestergaard Knudsen et al., 2010). One explanation of why these associations were not observed in Studies II and III might be that the recruitment strategy reached a very healthy population.

Study II found a significant association between a dichotomized version of the Staging algorithm and whether the participants had sought help or not at 18-months follow-up. Participants who were in the preparation and action stages at baseline as measured by the Staging algorithm were statistically significantly more likely to have sought help relative to those in precontemplation and contemplation. This finding is consistent with the Stages of change model.

Study III found a significant association between a previous discussion about hearing with health care personnel and whether the participants had sought help or not at 9-months follow-up. Participants who reported having had a previous discussion were statistically significantly more likely to have sought help relative to those who had not. This supports the role of online hearing screening as a second opinion or an extra motivator towards help-seeking.

Hearing help-seeking, hearing aid uptake, and use may not be reasonable end goals of online hearing screening. All individuals who fail online hearing screening or are diagnosed with a clinically relevant hearing impairment do not need hearing aids. Future studies should contemplate underlying processes of behavioral change (e.g. acceptance, increased receptivity to information). That would also have clinical implications for the development of future online hearing screening programs and supportive and motivational interventions in the area.

Stages of change in people who fail online hearing screening

The second overarching aim of this thesis was to explore the usefulness of the Stages of change model in predicting hearing rehabilitation related behavior in a self-selected online hearing screening sample. This thesis applied the three Stages of change measures most commonly used in audiology: URICA, The Staging algorithm, and the Line. The URICA questionnaire was used in Studies I–IV, the Staging algorithm was used in Studies I, II, and IV, and the Line was used in

Studies I–II. The distribution of participants according to URICA and the Staging algorithm, and mean scores on the Line are displayed in Table 8.

Table 8. Baseline data on URICA, Staging algorithm, and the Line from Studies I–IV

Measure	Study I	Study II	Study III*	Study IV
URICA, %				
<i>Precontemplation</i>	9	6	10*	0
<i>Contemplation</i>	38	35	32*	37
<i>Preparation</i>	50	56	52*	63
<i>Action</i>	3	3	6*	0
Staging algorithm, %				
<i>Precontemplation</i>	3	3		2
<i>Contemplation</i>	44	45		25
<i>Preparation</i>	45	44		66
<i>Action</i>	8	8		7
The Line, mean (SD)	6.14 (2.8)	6.16 (2.8)		

*Stages of change assessed post intervention/control

Findings from Study I show that all three Stages of change measures correlated significantly with each other. Staging algorithm and The Line correlated with a high effect size. However, the small correlations between the URICA and Staging algorithm and the Line may suggest that they generally measure different concepts.

Based on the interpretation of the Stages of change model presented by Babeu and colleagues (2004), people who respond to a national advertisement for online hearing screening in newspapers, radio, and social media and opt to complete the screening ought to be in contemplation or preparation at baseline. Findings from studies I–III suggest that people who opt for and fail online hearing screening are mainly in contemplation and preparation. In Study III, Stages of change was assessed post intervention. However, no significant difference in score between the intervention and control group was found. The distribution found in Studies I–III is similar to the findings of Rothpletz and colleagues (2016) who found that in 27 people who failed an on-site hearing screening most were in contemplation and preparation. Though the recruitment strategy was similar to the one in Studies I–III participants scored higher on action. Rothpletz and colleagues (2016) suggest that taking part in an on-site hearing screening as part of a research study may, to a higher extent than conducting online hearing screening, have been perceived as actually doing something about the hearing problems.

Study IV, reporting on both participants who passed and failed the Swedish triple-digit-test found no statistical difference in URICA or the Staging algorithm between the groups at baseline. Findings suggest that most people who sign up for an online course on hearing and communication strategies are in preparation. Signing up for an online course on hearing and communication strategies fit well

with the idea that people in preparation may do small changes in attitudes or behaviors or try to reduce the problem (Norcross et al., 2011). Present findings are in line with previous studies on Stages of change along the hearing rehabilitation journey. In studies investigating Stages of change in people who seek help for the first time, a majority has been in action (Laplanche-Lévesque, Hickson, & Worrall, 2013; Saunders, Frederick, Silverman, Nielsen, & Laplanche-Lévesque, 2016). This can be compared to the findings from Milstein and Weinstein (2002) where older adults failing a face-to-face hearing screening were mostly in precontemplation and contemplation. Participants were invited to take the hearing screening and did not seek it themselves. This might be one explanation for many being in precontemplation. Results on the Line cannot be directly transferred into a stage according to the Stages of change model. However, the mean of 6.14 reported in Study I can be compared to the mean of 9 reported by Ferguson and colleagues (2016) in first-time hearing aid users. Present findings provide tentative support for Stages of change as a useful classification tool to indicate individual needs for further information and guidance. In line with the study by Ekberg and colleagues (2016), knowledge of a patient's Stages of change could be useful for the audiologist in terms of preparing a rehabilitation plan.

Predictive validity for Stages of change in people who fail online hearing screening

Previous studies have reported positive associations between Stages of change, rehabilitation uptake, and benefit of/satisfaction with hearing aids. However, most studies in audiology applying the Stages of change model have been cross-sectional and performed in high-income countries (Manchaiah et al., 2018). Longitudinal studies on the Stages of change model for hearing impairment has been asked for in previous research (Sutton, 2000). Both Studies II and III used a longitudinal design to assess the predictive validity of the Stages of change model towards help-seeking.

Studies II and III could not replicate the findings from Laplanche-Lévesque et al. (2013) on the predictive validity of the URICA towards hearing aid uptake and use. These results show that the URICA has not the same predictive validity in all populations of adults with hearing impairment. Possible explanations include differences in mode of administration, language, and population. Also, when used with patients in a clinical setting, the hearing problem has been diagnosed and rehabilitation options displayed. In Studies II and III participants completed the Stages of change measures in connection to being informed that they failed the online hearing screening.

The Stages of change model assume that the (problematic) behavior in need of change is known and specified (e.g. alcohol consumption) even if it is not recognized as a problem by the individual. Whether failing an online hearing screening clarifies and specifies the behavior in need of change (i.e. living with an untreated hearing impairment) is less certain. Also, the model assumes that the behavioral change required is known and specified (e.g. stop drinking). Individuals who fail online hearing screening have, compared to patients in a

clinical setting, not been informed about options to compensate for hearing impairment. In the case of tinnitus, Kaldo and colleagues (2006) suggest a conceptual mismatch with the Stages of change model and especially the precontemplation stage as all people with tinnitus recognize the problem. Believing that the problem cannot be solved by behavioral or attitude change is highly applicable but this part of precontemplation is seldom present in Stages of change measures (Kaldo, Richards, & Andersson, 2006). A Stages of change measure that captures different aspects of the precontemplation stage could be useful for a screening population.

One explanation for the lack of relationship between measures of Stages of change and help-seeking could be the imprecise term, hearing problem. Each of the three measures for Stages of change applies the term “hearing problem”. To do something about your hearing might be too vague for individuals who have failed an online hearing screening. Participants perception of taking action on one’s hearing problem might change along the patient journey. Conducting an online hearing screening could be considered taking action, the same goes for visiting a clinic or opting to acquire hearing aids. As suggested by Vestergaard Knudsen and colleagues (2010), the journey from recognition of hearing difficulties to successful rehabilitation might include several separate hearing behavior changes. This could also explain previously mixed findings on the effect of online hearing screening.

According to the interpretation by Babau and colleagues (2004), the different stages are associated with key milestones along the hearing rehabilitation journey. From a clinician’s perspective, this interpretation is logical. However, a mismatch between clinician and patient perceptions of the hearing rehabilitation journey has been reported elsewhere (Laplane-Lévesque, Hickson, et al., 2012). Factor analyses of URICA scores in people with health conditions where the necessary behavioral change is unclear (e.g. tinnitus) than for example in the case of addiction have resulted in subscales being merged or split up, suggesting a poor fit of the model (Kaldo et al., 2006).

Acknowledges week points with the Stages of change model include a lack of qualitative transformations across stages and arbitrary time frames (Bandura, 1998). Precontemplation and contemplation differ mainly in degree of readiness for behavioral change. Likewise, duration is the main factor separating action from maintenance (Bandura, 1998). A clear rationale for suggested timeframes is missing for the model (Hertzog, 2008). This thesis does not focus on timeframes due to the nature of the behavior change in focus.

Based on Stages of change, and motivational interviewing, patients who receive stage-appropriate consultation should be more likely to advance towards behavioral change, compared to those who receive stage-inappropriate consultation. Future studies should contemplate using a miss-matched design when investigating the effectiveness of online interventions with the aim of increasing hearing help-seeking behavior.

Inclusion based on results from online hearing screening test

From this research group's experience, most participants who conduct an online hearing screening pass it, i.e. there is no indication that they have a PTA > 35 dB HL in the better ear (Molander et al., 2015). Molander and colleagues (2015) have reported that among 1325 Swedish adults who conducted a free online hearing screening (same as used in Study I–III) based on a speech in noise test, only 19% failed. Participants were recruited via newspaper advertisements and had a mean age of 63 years (Molander et al., 2015). Also, studies suggest that a significant amount of people who conduct online hearing screening have other reasons than concern about their hearing status (Meyer et al., 2011; Smits et al., 2006).

Presumably, most participants who signed up for Study IV felt a need for or interest in increased knowledge regarding hearing and communication strategies. However, a minority of participants (35.3%) failed the triple-digit-test. This points to an online intervention on hearing and communication strategies being mostly appealing to healthy adults with no obvious hearing impairment. Also, no statistical difference was found between participants who passed and those who failed an online hearing screening, suggesting a mismatch between inclusion criteria and people interested in the intervention. Most participants (56%) had undergone hearing diagnostics previously suggesting the offered course to be of interest to people who are not candidates for hearing aids or do not feel a current need for hearing aids. Most participants (over 80%) lived with someone else and some might have registered because their significant other have hearing problems. It could also be that they appreciated the opportunity to engage in a preventive health strategy offered free of charge by a university.

The results provided tentative evidence against using the Swedish triple-digit-test as the sole criterion on which to decide who should have access to online interventions on hearing and communication strategies. Inclusion could be based on a more comprehensive assessment or participation in the course could be offered to all who sign up, regardless of result on the speech in noise test. Inclusion based on perceived needs seems more adequate and in line with The WHO International Classification of Functioning, Disability and Health (ICF, 2001).

METHODOLOGICAL CONSIDERATIONS

Convenience samples

In studies I–IV, recruitment through advertisements in newspapers, radio, and social media reached a large and diverse population. However, self-recruited samples may not be representative of the general population. For example, study participants had a higher level of education than the target population. Therefore, the findings of the present study cannot be generalized to other

populations. Furthermore, Swedish citizens with other ethnical and cultural backgrounds are not represented in the sample, as hearing screening norms had been developed on native Swedish speakers. However, it would be difficult to reach people with hearing impairment in a random population sample. Furthermore, the thesis focused on people who wish to complete an online hearing screening. To compensate, this thesis used a broad advertisement strategy through written, audio, and online media. The wide inclusion criteria, with for example all adult ages and comorbidities being included, is a strength.

Technical barriers for online hearing screening and support

That all study participants needed to complete an online hearing screening is both inclusive and exclusive. It is inclusive because participants could join in the study regardless of location, schedule, etc. It is exclusive because technical literacy, Swedish literacy, and Internet access were required for participation. Participants were informed about the requirement for basic computer and internet knowledge before signing up. Technological barriers were an obstacle in all studies, especially the log in process in Study IV. In Study III, a few participants stated that navigating through the intervention required more than basic computer knowledge.

When targeting an older population, potential vision impairment ought to be expected. In Study IV, font types and sizes, as well as the contrast between font color and background color, followed with the recommendations by The Swedish Association of the Visually Impaired. This should also have been done in Studies I, II, and III.

Outcome

The studies did not include a standardized face-to-face audiological assessment. Experiences with hearing help-seeking, hearing status, hearing aid uptake, and hearing aid use as reported by patients at follow-up were not cross-checked against clinical records. False reports may have occurred. However, it is unlikely to have been underreported – if anything, it could have been overreported (social desirability bias). Previous research points to participants providing more honest answers when filling out questionnaires online compared to pen and paper (Thorén, Andersson, & Lunner, 2012).

Statistical considerations

Missing data is a serious problem that can both bias estimates of parameters (e.g., means and correlations) and inferential statistics (e.g., t-tests). The high rate of attrition (dropout) is a considerable methodological limitation in both Study II and Study III with an attrition rate at follow-up of 46% and 42%, respectively. Although automatic reminders were used to positively influence attrition rates in Study IV, reasons for the large drop-out could be related to a long follow-up period and to the lack of reminders for follow-up completion. Furthermore,

online data collection is known to yield lower response rates than face-to-face data collection (Eysenbach, 2005). We tested for attrition bias by comparing baseline characteristics of participants who completed follow-up with the participants who did not complete follow-up. Given that no differences were found, participants with missing data were simply ignored. Other modern methods for handling missing data that rest on less restrictive assumptions could have been used. Still, it is difficult to interpret results arising from studies with such high attrition as the mechanisms underlying the nonresponse is unknown (Enders, 2011).

Furthermore, the large dropout rate also affects statistical power negatively to detect effects of practical importance. Power is most problematic in studies III and IV given the combination of small sample sizes and missing data. Thus, it is, of course, important to be cautious here: the lack of evidence for an effect in these studies does not imply a result of no differences or no associations! It just simply means that we cannot support our experimental hypotheses.

Missing data on individual items were less of a problem. All items in entry and follow-up questionnaires were mandatory in the platforms and both platforms had automatic notifications preventing participants from skipping items. This is a clear advantage of online questionnaire administration. However, forcing participants to answer might create bias in itself. If participants do not understand a question or cannot relate to any of its response options, they must guess or deliberately give an incorrect answer. To potentially prevent this, control questions could have been added within questionnaires.

Some inferential tests (e.g., t-tests) used in the studies rely on parametric assumptions that may have been violated. This can affect both estimates and inferential statistics. For example, certain variables were not perfectly normally distributed. Modern robust methods correcting for violations to parametric model assumptions (e.g., non-normality) could have been used instead (Field & Wilcox, 2017).

Finally, in order not to inflate type-I error rates Bonferroni corrections were made. Although this keeps the alpha at nominal level, Bonferroni is known to be conservative and increases the risk of making type-II errors and hence lowering statistical power.

CONCLUSIONS

The overarching aim of this thesis was to investigate behaviors related to hearing rehabilitation (help-seeking, hearing aid uptake, and hearing aid use) in adults who fail an online hearing screening. A second aim was to explore the usefulness of the Stages of change model in predicting hearing rehabilitation related behavior in a self-selected online hearing screening sample.

In conclusion, the four studies show tentative support for offering online hearing screening and for supplementary interventions for increasing help-seeking. However, online hearing screening is not enough: most participants who failed online hearing screening had not sought help at 9-month follow-up (Study III). At 18-month follow-up (Study II) slightly more than half had sought help. In line with previous studies, hearing-aid uptake, and hearing-aid use after failing an online hearing screening was low. Offering a fully-automated brief motivational online intervention to people who failed online hearing screening did not improve hearing help-seeking behavior compared to a control condition.

Whether hearing help-seeking, hearing-aid uptake, and hearing-aid use are reasonable end goals of online hearing screening may be questioned. All individuals who fail online hearing screening or are diagnosed with clinically relevant hearing impairment do not need hearing aids.

Study II found predictive validity for a dichotomized version of the Staging algorithm 18-month after screening. The result could not be replicated in Study III applying a 9-month follow-up. In study III, having discussed one's hearing with health care personnel on an earlier occasion could significantly predict help-seeking at follow up, suggesting that online hearing screening may benefit people who seek a second opinion after having discussed their hearing previously. The variable was not asked for in Study I, II, and IV.

The results provided tentative evidence against using the Swedish triple-digit-test as the sole criterion on which to decide who should have access to online interventions on hearing and communication strategies. Inclusion could be based on a more comprehensive assessment or participation in the course could be offered to all who sign up, regardless of result on the speech in noise test. If failure on an online hearing screening remains an indicator for further care (i.e. indicator for hearing aid candidacy), participants who pass the online hearing

screening could be offered alternative support such as automated online information on communication strategies.

CLINICAL IMPLICATIONS

Online hearing screening is low-cost for both implementation and maintenance. In this sense, a modest improvement in help-seeking could still be considered successful. All patients should be given time and support to accept the current hearing situation, to feel ready for change, and to explore their own goals before starting a hearing rehabilitation journey. Presented findings point to online hearing screening benefiting those seeking a second opinion or searching online after having discussed or assessed their hearing previously. Despite no clear-cut effect of the brief automated online-intervention, no negative effects were reported. Hence, such interventions might still hold promise in audiological rehabilitation although further studies are warranted. Automated interventions in connection to a failed online hearing screening (e.g. the brief motivational online intervention used in Study III), requiring no clinician time to administer or supervise, could be offered before a first clinic visit or as an intervention for participants who decline rehabilitation.

Findings from Studies I–IV provide tentative support for Stages of change as a useful classification tool to indicate individual needs for further information and guidance. In line with the study by Ekberg and colleagues (2016) and Babeu and colleagues (2004) knowledge of a patient's Stages of change could be useful for the audiologist in terms of preparing a rehabilitation plan. If used with a pre-clinical population, the behavior change investigated has to be clear and specific (e.g. to book a consulting with an audiologist or to have the hearing tested at a clinic). Measures for Stages of change (e.g. URICA, the Staging algorithm, and the Line) may need to be adapted/validated for a pre-clinical population.

The online course on hearing and communication strategies offered to participants in Study IV could be a cost-effective preventive strategy to promote healthy aging and could be offered regardless of the result from the online hearing screening test. Specifically, since it might attract individuals who do not perceive hearing impairment at the moment but who are interested in preventive strategies, either for their own benefit or for the benefit of their communication partners. In line with suggestions by Pronk and colleagues (2011), such non-instrumental interventions could be offered online regardless of clinically relevant hearing impairment or use of hearing aids.

FUTURE DIRECTIONS

Results presented in this thesis are preliminary and in need of replication. Several future directions might be of interest:

- ◇ Future studies should contemplate integrating screening for multiple health-related factors associated with hearing impairment and to provide a clear and tailored pathway for each participant (e.g. referral to adequate health care or equivalent online intervention).
- ◇ Longer follow-up periods could be used for online hearing screening to investigate whether the hearing screening may have a delayed impact.
- ◇ Perception of the hearing rehabilitation journey from a patient perspective needs to be further understood. Mixed findings on the effectiveness of online hearing screening on help-seeking, rehabilitation uptake, and satisfaction with rehabilitation may be misleading and risk undermining the benefits. Other potential outcomes of online hearing screening (e.g. acceptance and increased receptivity to hearing health care information) need to be further understood.
- ◇ Measures of Stages of change should apply more specific terminology. Also, a new version of the URICA, where the items could be reformulated to be grammatically simpler and closer to the reality of people with hearing impairment, could be of potential use. A cross-theoretical approach, blending different models for health behavior change as a fruitful next step for applying health psychology theory to audiology as suggested by Saunders and colleagues (2016).
- ◇ Based on results from Study IV, criteria for online hearing interventions need to be further refined and optimized in order not to miss individuals who may benefit from such interventions.
- ◇ One interesting future approach suggested by Lin and colleagues (2016) is broad-based public information campaigns based on a cross-disciplinary approach with audiology and public health. In this context, online hearing screening programs could be combined with easy to access information on hearing, hearing impairment, communication strategies, rehabilitation options and healthy aging in general.

GRADUATE STUDENT PROGRESS

Each study has been conducted in an interdisciplinary research team where knowledge and competence from audiology, psychology, and technology have interacted. For each of the studies, all co-authors have contributed uniquely with their knowledge and competence. With this statement in mind, the following section highlights the graduate student's specific contribution and progress.

Study I – The graduate student had the leading role in data analysis, writing, and preparing the manuscript for publication. The role of corresponding author was held by the graduate student. The study has been independently presented and discussed at two international conferences.

Study II – The graduate student had the leading role in writing the ethical application, study design, data collection, data analysis, writing, and preparing the manuscript for publication. The role of corresponding author was held by the graduate student.

Study III – The graduate student had an active role in data collection (follow-up), and the leading role in data analysis, writing and preparing the manuscript for submission. The role of corresponding author is held by the graduate student. The study has been independently presented and discussed at one international conference.

Study IV – The graduate student had the leading role in writing the ethical application, study design, data collection, data analysis, writing, and preparing the manuscript for submission. The role of corresponding author is held by the graduate student. The study has been independently presented and discussed at one international conference.

CONFERENCE CONTRIBUTIONS

The author has independently presented and discussed research at both international and national conferences.

Relevant conference contributions are listed in chronological order:

- 2019 Cognitive hearing science for communication (CHSCOM), Linköping, Sweden.
- 2018 Hearing across the lifespan (HEAL), Como, Italy.
- 2017 Swedish Audiologist Society (SvAf), annual conference, Uppsala, Sweden.
- 2015 Second International meeting on Internet & Audiology, Eriksholm Research Centre, Snekkersten, Denmark.
- 2015 Swedish Audiologist Society (SvAf), annual conference, Malmö, Sweden.
- 2014 First International meeting on Internet & Audiology, Linköping, Sweden.
- 2014 Nordic Audiology Society (NAS) conference, Åbo, Finland.

ADDITIONAL PUBLICATIONS

The author has co-authored five publications outside the thesis framework.

Co-authored publications are listed in alphabetic order:

Brännström, K. J., Öberg, M., Ingo, E., Månsson, K. N. T., Andersson, G., Lunner, T., & Laplante-Lévesque, A. (2015). The Process of Developing an Internet-Based Support System for Audiologists and First-Time Hearing Aid Clients. *American Journal of Audiology*, 24, 320–324.

Brännström, K. J., Öberg, M., Ingo, E., Månsson, K. N. T., Andersson, G., Lunner, T., & Laplante-Lévesque, A. (2016). The initial evaluation of an Internet-based support system for audiologists and first-time hearing aid clients. *Internet Interventions*, 4, 82–91.

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

Paglalonga, A., Cleveland Nielsen, A., Ingo, E., Barr, C. & Laplante-Lévesque, A. (2018). eHealth and the hearing aid adult patient journey: a state-of-the-art review, *BioMedical Engineering On Line*, 17:101.

Weineland, S. M., Andersson, G., Lunner, L., Carlbring, P., Hesser, H., Ingo, E., Molander, P., Nordqvist, P. & Laplante-Lévesque, A. (2015). Bridging the Gap Between Hearing Screening and Successful Rehabilitation: Research Protocol of a Randomized Controlled Trial of Motivational Interviewing via Internet, *American Journal of Audiology*, 24, 302–306.

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