

Internet-based audiological interventions: An update for clinicians

Abstract

Purpose: Advancements in digital and computing technologies have created opportunities for innovations in the provision of healthcare remotely. The aim of this paper is to provide audiological professionals with a summary of literature regarding existing audiological Internet-based interventions (IBI's). The specific objectives are to (1) provide an overview of the range of audiological IBI's for adults with hearing loss, balance disorders, and tinnitus; (2) identify the features included in these IBI's and possible benefits; and (3) identify difficulties and challenges regarding the implementation and use of audiological IBI's.

Method: Relevant articles were identified through literature review conducted in the PubMed database and grey literature. The relevant information from these sources, such as the type of intervention and main outcomes, were summarized.

Results: A range of IBI's were identified, with the majority addressing tinnitus distress. Those for hearing loss have been applied at different stages of the patient journey. Unguided IBI's for vestibular difficulties included self-help for Ménière's Disease and vestibular rehabilitation. Most tinnitus IBI's provided cognitive behavioural therapy. Overall IBI's showed benefits in terms of outcome and accessibility. Barriers include uncertainties surrounding the cost effectiveness, optimal level of support and improving intervention compliance.

Conclusions: Telehealth applications are expanding in audiology and IBI's have been developed to provide auditory rehabilitation, vestibular rehabilitation, and tinnitus interventions. IBI's have the potential to offer accessible and affordable services. Further work is required to further develop these interventions and optimize outcomes.

Key Words

Hearing loss, Vestibular disorder, Tinnitus, Internet-based intervention, Teleaudiology, Telehealth, Rehabilitation, Self-help

Introduction

Hearing loss, vestibular disorders, and tinnitus are some of the most prevalent disabilities worldwide. Around 15% of the world's population have some degree of hearing loss (Olusanya, Neumann, & Saunders, 2014) with hearing loss of greater than 20dB being the second most common impairment (Vos et al., 2015). The prevalence of dizziness has been reported to be about 20–30% among adults (Agrawal, Carey, Della Santina, Schubert, & Minor, 2009; Benecke, Agus, Goodall, Kuessner, & Strupp, 2013) and at least 10% of the adult population has tinnitus (Bhatt, Lin, & Bhattacharyya, 2016; Shargorodsky, Curhan, & Farwell, 2010). Often hearing-related conditions may not occur in isolation as hearing loss is one of the most common causes for developing tinnitus (Nondahl, et al. 2011), and tinnitus is often accompanied by hyperacusis (Baguley & Andersson, 2008). In certain pathologies, vertigo attacks, hearing loss, and tinnitus may co-occur as is the case in Ménière's disease (Nakashima et al., 2016). Hearing-related conditions thus add to the healthcare and societal economic burden. Untreated hearing

loss poses an annual global cost of \$750 billion dollars (Chadha, Cieza & Krug, 2018), and greater healthcare costs over a 10-year period compared with those without hearing loss (Reed et al. 2018). The annual cost of tinnitus interventions in the United Kingdom was calculated to be £750 (\$960) million in total and the annual societal costs relating to tinnitus was calculated at £2.7 (\$3.5) billion (Stockdale et al., 2017). In the United States, the annual economic burdens of unilateral and bilateral vestibular disorders was found to be \$3531–\$13019 per patient (Sun, Ward, Semenov, Carey, & Della Santina, 2014).

In most cases, hearing-related difficulties such as hearing loss, tinnitus and vestibular disability may require longer-term support. This largely involves provision of extensive rehabilitation consisting of several interrelated components including the use of amplification, behavioral modification and psychological support (Fuller et al., 2017). Although the provision of hearing aids and cochlear implants are instrumental in improving outcomes for those with hearing loss (Barker, Mackenzie, Elliott, Jones & De Lusignan, 2016), they are unable to restore natural hearing and listening effort may remain (Peelle & Wingfield, 2016). The adoption of amplification is influenced by many factors, such as provision of additional support and rehabilitation (Ng & Loke, 2015). Additional support and rehabilitation is crucial due to the negative impact hearing-related difficulties can have on daily function and quality of life (Miura et al., 2017; Nordvik et al., 2018), often leading to social isolation, reduced cognitive function, anxiety, and depression (Benecke et al., 2013; Ciorba, Bianchini, Pelucchi, & Pastore, 2012; Hall et al., 2018; Langguth, 2011). Although such support would be ideal, provision of this extensive rehabilitation is difficult, in the context of many healthcare systems facing increasing pressures

and limited resources. Despite proven benefits, audiological services are unavailable to provide this rehabilitation to much of the world's population (Swanepoel & Hall, 2010), and there remains a shortage of audiologists worldwide (Mulwafu, Ensink, Kuper, & Fagan, 2017; Windmill & Freeman, 2013). It is estimated that in more developed countries, there is one audiologist per 20, 000 people. This ratio decreases to one audiologist per 0.5 to 6.25 million people in less developed countries (Goulis & Patuzzi, 2008). Even in countries with extensive healthcare such as the UK, specialist audiological services are not readily available, particularly in remote geographical regions (Hoare et al., 2015). Lack of resources and suitably trained professionals with specialist skills to address complex audiological conditions are further barriers in the provision of evidence-based practice (Hall et al., 2011). The challenge is thus overcoming these restrictions in the provision of audiological rehabilitation. A further challenge is planning for growing service demands as the proportion of elderly people is rising (Vos et al. 2015; World Health Organization, 2013) and the prevalence of auditory-related conditions generally increases with age (Bainbridge & Wallhagen, 2014; Jönsson, Sixt, Landahl, & Rosenhall, 2004; McCormack, Edmondson-Jones, Somerset, & Hall, 2016). Future planning to ensure that resources are in place, is vital.

Advancements in digital and computing technologies have allowed for innovations in healthcare service delivery models. One innovation which has made great progress in the last decade is the use of telehealth, which refers to the provision of healthcare delivered remotely by means of digital and telecommunication technologies (Capobianco, 2015). Widespread applications of telehealth are developing due to its potential to offer support to remote populations, thereby

improving healthcare accessibility at reduced costs (Andersson & Titov, 2014). Telehealth can provide access to clinical care for those with difficulty accessing face-to-face care. Reasons for these difficulties could include the proximity of clinics, transportation difficulties, health-related problems, loss of income when taking time off of work, or stigma associated with seeing healthcare professionals (Cuijpers, van Straten & Andersson, 2008). Within the field of audiology, various teleaudiology solutions have been developed for screening, diagnostic, pediatric, remote programming, and rehabilitation purposes (Krupinski, 2015, McCarthy, Leigh & Arthur-Kelly, 2018; Paglialonga, Nielsen, Ingo, Barr and Laplante-Lévesque, 2018; Swanepoel and Hall, 2010; Tao et al. 2018). Ways in which to deliver these solutions range from offline platforms (such as PC-based applications, DVD's; Vreeburg, Diekstra & Hosman, 2018) to Internet-based interventions (IBI's; Carlbring, Andersson, Cuijper, Riper, & Hedman-Lagerlöf, 2018) and mobile health devices such as smartphone applications (Akter & Rav, 2010). As the Internet is such a powerful tool, many telehealth self-help interventions are Internet-based (Reavley & Jorm, 2011). An IBI has been defined as *“a primarily self-guided intervention program that is executed by means of a prescriptive online program operated through a website and used by consumers seeking health- and mental-health related assistance. The intervention program itself attempts to create positive change and or improve/enhance knowledge, awareness and understanding via the provision of sound health-related material and use of interactive web-based components”* (Barak, Klein, & Proudfoot, 2009, p.5). Internet interventions are either independent of professional support (unguided) or offer some form of support (guided). Guidance is a mechanism whereby individuals can obtain “external” information about themselves and their progress (Barak, Klein, & Proudfoot, 2009). Guidance can be synchronous

(e.g., real-time chats), asynchronous (e.g., not occurring at the same time such as when using e-mail) or a blended approach combining various means. A systematic review has indicated that outcomes for guided interventions are more favorable than for unguided interventions (Baumeister, Reichler, Munzinger, & Lin, 2014). Routine use of tele-audiological screening and diagnostic applications have been implemented more widely than IBI's. A systematic review found that 79% of the identified papers related to hearing-related teleaudiology involved the identification of hearing loss (Molini-Avejonas, Rondon-Melo, Amato & Samelli, 2015). Due to the importance of rehabilitation in the audiological field, providing access to rehabilitation is important. The Internet is a valuable resource in delivering such interventions and frequently used by those with hearing impairment. Studies undertaken in Sweden, the United Kingdom, and Canada have indicated greater Internet use in people with hearing impairment than in the general population (Gonsalves and Pichaora-Fuller, 2008; Henshaw et al., 2012; Thorén et al., 2013). Promoting wider implementation of IBI's is one way of improving access to audiological rehabilitation. More familiarity regarding these interventions and the implications for clinical practice may help adaptation of tele-audiological rehabilitation options. The aim of this paper is to provide audiological professionals with a summary of the literature regarding existing audiological IBI's. The specific objectives were to (1) provide an overview of the range of audiological IBI's for adults with hearing loss, balance disorders, and tinnitus; (2) identify the features included in these IBI's and possible benefits; and (3) identify difficulties and challenges regarding the implementation and use of audiological IBI's.

Method

In line with the objectives of this paper to summarize the existing literature regarding IBI's, a preliminary literature review was undertaken. However, it is noteworthy that this is not a formal scoping or systematic review and hence, may not include all the studies conducted in this area. The focus of this preliminary review was to identify experimental studies that have evaluated the use of self-help related IBI's focused on adults (aged ≥ 18 years) with hearing loss, vestibular disorders, and tinnitus. The PubMed database together with searching grey literature such as google scholar was used to identify the types of Internet interventions available. To focus the scope of this review to self-help interventions, those targeting remote programming or cochlear implantation follow-ups and hearing aid fittings were not included. To focus on experimental studies, those focusing solely on the development, experiences, qualitative analysis or processes involved in such interventions were also excluded. Data that would be relevant for audiological professionals was gathered from the studies describing Internet-interventions. This included auditory training programs, isolated online support groups without additional interventional support; interventions (1) the country in which the intervention took place (3) Internet intervention type (auditory training; rehabilitation) (4) additional intervention features (5) online guidance, (6) effect size for the main outcome measure, and (7) main findings.

Results

Range of audiological Internet-based Interventions

Internet-based interventions for hearing loss

Internet-based interventions for hearing loss have taken a varied approach (see Table 1). They have been applied at different stages of the patient journey (pre-fitting, new and experienced

hearing aid users, and for those with significant hearing disability regardless of use of amplification). Of interest, was that support was provided in all the studies, either asynchronous online or taking a blended approach by supplementing face-to-face clinical care by such an intervention. Internet-based interventions can thus be used either as a replacement and/or supplementary to routine healthcare. Some of these interventions have been developed by the involvement of service users (e.g., Ferguson et al., 2015).

One study investigated the efficacy of an Internet-based pre-hearing aid fitting counselling intervention (Manchaiah et al., 2014). For this particular intervention, treatment compliance was poor and high dropout rates were found. The Internet has been used in a blended manner together with face-to-face counselling support for first time hearing aid users in three studies (Brännström et al., 2016; Ferguson et al., 2015; 2016). Brännström et al. (2016) found that Internet-based auditory rehabilitation leads to a significant reduction in self-reported hearing disability post intervention. Ferguson et al. (2015; 2016) provided hearing aid familiarisation for about 60 minutes via either DVD, PC or the Internet, and found that although knowledge of practical and psychosocial issues improved, self-reported hearing disability had not decreased after viewing the information. The Internet has also been used for experienced hearing aid users. Thorén et al. (2011; 2014) found that self-reported hearing disability decreased after provision of guided online rehabilitative education for existing hearing aid users. For this study, receiving or not receiving guidance seemed to have no effect on the outcome. The only effectiveness study was by Malmberg et al. (2017), indicating that the implementation of Internet-based aural rehabilitation for Swedish hearing aids users improved communication skills. The Internet has

furthermore been used to reduce psychological distress in those with hearing problems (Molander et al., 2018). In this study, Acceptance and Commitment Therapy (ACT) was used. ACT focuses on decreasing experiential avoidance by accepting the existence of negative thoughts and emotions (Hayes, Luoma, Bond, Masuda, & Lillis, 2006). The potential of incorporating the Internet at different stages of the patient pathway to reduce the effects of hearing loss is evident. Prior to implementation, further work is required to improve outcomes of these interventions. More effectiveness studies are required to assess outcomes on clinical populations.

<Table 1 near here>

Internet-based interventions for vestibular disorders

There have been two unguided Internet-based interventions for vestibular difficulties (see Table 2). A study in Finland by Pyykkö et al. (2017) investigated an Internet-based self-help intervention for the management of Ménière's Disease in a single group open trial. Improvements in post-traumatic growth and general health-related quality of life were reported. A UK-based randomised controlled effectiveness study by Geraghty et al. (2017) found that Internet-based vestibular rehabilitation reduced dizziness and dizziness-related disabilities in 296 older patients. Although this existing body of research is encouraging, IBI's have been largely unexplored in this area. Due to the prevalence of vestibular disabilities, there is an immediate need for the development of further IBI'S for vestibular disorders as well as research regarding the efficacy and effectiveness of these interventions.

<Table 2 near here>

Internet-based interventions for tinnitus

There is more published literature regarding Internet-interventions for tinnitus than for any other hearing-related difficulties. The first Internet-based tinnitus interventions was initiated in the late 1990's in Sweden (Andersson et al., 2002). The rationale for this study was to increase the availability of evidence-based tinnitus care. Cognitive Behavioral Therapy (CBT) is a psychological intervention for tinnitus, directed towards altering maladaptive responses to tinnitus through behavior modifications. As it has the most evidence of effectiveness in reducing tinnitus distress (Hesser et al., 2011), an Internet-based CBT intervention was developed (ICBT). Since this development, the efficacy of ICBT in reducing tinnitus distress has been evaluated in Sweden, Germany, Australia, and the UK (see Table 3). Service users were partly involved in the development of the UK intervention (Beukes et al., 2016). Due to the shortage of clinical psychologists providing CBT for tinnitus, guidance for the intervention developed in the UK was provided by an audiologist (Beukes et al. 2018a,b). Despite not having a CBT qualification, outcomes were similar to those trials with clinical psychologists providing guidance. Effect sizes have generally been greater in later studies that have benefited from using updated Internet features and tighter methodological designs (Weise et al., 2016). Further studies using active control groups have also indicated that outcomes using ICBT for tinnitus are similar to those of group-based care (e.g. Kaldo et al., 2008; Japer et al. 2014) and Internet-based Acceptance and Commitment Therapy (IACT; Hesser et al., 2012). The effectiveness of ICBT has furthermore

been evident when compared with outcomes for individualized face-to-face tinnitus care (Beukes et al., 2018b) and group-based CBT that provides rehabilitation to different groups of patients one at a time (Kaldo-Sandström et al., 2004; Kaldo et al., 2013). Outcomes have been maintained up to 1-year post intervention (Beukes et al. 2018c; Hesser et al., 2012, Kaldo et al. 2008, Weise et al. 2016). The intervention effects have moreover been shown to reduce tinnitus-related difficulties such as insomnia, anxiety, depression, and decreased quality of life (Beukes et al., 2018a; Beukes et al., 2018b; Hesser et al., 2012; Weise et al., 2016). As Internet-based tinnitus interventions have indicated long-term reduction of tinnitus distress and tinnitus-related comorbidities, they have the potential to be more widely implemented in order to improve accessibility to evidence-based tinnitus care.

Although a large number of management strategies have evolved, many lack empirical support. Psychological interventions, such as CBT, currently have the most evidence of efficacy in reducing tinnitus distress (Hesser et al., 2011; Martinez-Devesa, Perera, Theodoulou, & Waddell, 2010).

<Table 3 near here>

Features, benefits, and challenges of Internet-based interventions

The features and benefits of the IBI's identified for both patients and services, together with the challenges related to provision of IBI's are summarized in Table 4. Overall these interventions show potential to reduce hearing and dizziness-related disability and tinnitus distress, as well as comorbidities such as anxiety, depression and maintain these effects (where assessed 1 year post-

intervention). They offer an accessible intervention with the ability to monitor engagement and progress. Uncertainties surrounding IBI include a lack of clarity regarding cost effectiveness as cost-utility analysis has not been done. Further uncertainties include the optimal level of support and improving intervention compliance, which can be low.

<Table 4 near here>

Discussion

Range of Internet-based interventions

A range of Internet-based interventions for hearing rehabilitation, vestibular rehabilitation, and to address tinnitus distress, have been tested in efficacy and effectiveness trials. The majority of trials have targeted tinnitus in the form of ICBT. A range of different interventions have been applied to those with hearing loss as different stages of their treatment pathway, indicating the extensive rehabilitation required for this population, both before treatment commences, following hearing aid fitting as well as for experienced hearing aid users. IBI's are a means of providing such extended rehabilitation with limited resources. More uniformity in the intervention created may further promote the use of IBI'S for hearing loss. The area with the least development of IBI'S was for vestibular disabilities. Those with vestibular disorders often benefit from extensive vestibular rehabilitation. These interventions can also be tailored to the type of vestibular difficulties presenting. Further work in this area of IBI'S for vestibular difficulties will be beneficial. Within the included studies, only one hearing loss IBI (Malmberg et al., 2017), one vestibular rehabilitation IBI (Geraghty et al., 2017), and three tinnitus IBI's

(Beukes et al., 2018b; Kaldo-Sandström et al., 2004; Kaldo et al. 2013) have been studied. More effectiveness trials are required as well as studies formulating models to include these studies into routine clinical care.

Features of Internet interventions

Many of the interventions had a strong theoretical framework, being based on CBT or ACT principles. These components addressed everyday difficulties such as sleep and concentration difficulties (Beukes et al., 2016). They also added an element of tailoring, as some modules were selected only if a problem in that area was evident. Incorporating features known to increase the success of IBI'S are patient education, ways of promoting self-efficacy, self-management, and the inclusion of a frequent communication partner to promote social support and self-tailoring (Preminger & Rothpletz, 2016). None of the present interventions explicitly involved communication partners, indicating the need to include this feature during further development work.

Although IBI's are largely self-help interventions, the option of professional support (guided intervention) can be incorporated, as was the case for the majority of interventions. The communication mode was asynchronous (i.e., offline communication between healthcare professionals and patients, such as email), or a mixture of these two methods (blended approach). Elements of synchronous guidance (i.e., real-time communication between healthcare professionals and patients) was incorporated by including initial and final telephone calls. The later interventions are responsive to adapt to different screen sizes and thus accessible from

computers or mobile devices (e.g., Beukes et al., 2018a). Some had the choice of being viewed online, on DVD, or via PC application (Ferguson et al., 2015).

From a service development viewpoint, there are features that can streamline processes. One is that assessment measures and/or patient-reported questionnaire measures (PROMs) can be incorporated within the intervention (Vlaescu et al., 2016), creating the opportunity to administer various domains, such as severity of symptoms, quality of life, anxiety, and depression. In this way, patients can be managed in a more holistic manner.

Challenges

Although there is a shift towards delivery of health care services enabling self-management (Hood & Friend, 2011), achieving active participation in IBI'S is challenging (Pryce, Hall, Laplante-Lévesque, & Clark, 2016; Rolfe & Gardner, 2016). Compliance was particularly low for a pre-hearing aid fitting IBI (Manchaiah et al., 2014) and a tinnitus IBI run in Australia (Abbott et al., 2009). Low compliance may have been partly attributed to the interventions not having been adapted for the population's selected patients (e.g., industrial worker). It is encouraging that many of the IBI's indicated an involvement of service-users in the development processes (see Beukes et al., 2016), and more are developing (see Ferguson, Leighton, Brandreth, & Wharrad, 2018; Nielsen, Rotger-Griful, Kanstrup & Laplante-Lévesque, 2018; Thorén, Pedersen, & Jørnæs, 2016). Such developments may facilitate creating patient-centered IBI solutions tailored for specific populations. Interventions being used in IBI's should carefully

consider including design features to improve outcomes and active participation such as those provided by Morrison, Yardley, Powell & Michie (2012) and Yardley et al. (2016).

Not all the interventions reviewed had favorable outcomes. Identifying the factors that may have contributed to obtaining these outcomes is important. One method is running a process evaluation in parallel to consider the influence of factors such as the treatment dose delivered (completeness), treatment dose received (exposure), treatment fidelity, treatment adherence and maintenance, satisfaction and perceived benefit (Beukes et al., 2017). The identified factors can then be addressed. Technical barriers may be one barrier preventing active engagement (Beukes et al. 2016). Ensuring IBI's offer of personalized rehabilitation strategies are not technically challenging, especially for an elderly population, is an important aspect but poses various challenges (Nielsen et al., 2018). Considering the level of Internet competency for the target population is important, as this may influence engagement and subsequent outcomes. Ensuring the accessibility of the information provided in terms of ease of readability related to levels of comprehensiveness should be also be considered (Aldridge, 2004). Accessibility in terms of reading level is also important. Guidelines from the USA Health and Human Services and The American Medical Association (AMA) recommends that health material should be written in plain language at or below the 6th grade reading level. Reporting readability has only more recently been reported (e.g., Beukes et al., 2016). Prioritizing access in terms of readability is important as online hearing-related healthcare information has been reported to be above the recommended grade levels (Laplante-Lévesque & Thorén, 2015; Manchaiah et al. 2018).

Implications for audiology professionals

Teleaudiological application provided by a qualified provider, primarily developed for patients with limited access to health care, validated for efficacy and cost-effectiveness, with equivalent outcomes to those achieved via face-to-face (FTF) measures are supported by the American Academy of Audiology (AAA) and the American Speech-Language-Hearing Association (ASHA). At present, a low clinical adoption of teleaudiology has been identified (Eikelboom & de Wet Swanepoel, 2016) despite a positive attitude regarding acceptance of teleaudiology by professionals (Eikelboom & de Wet Swanepoel, 2016; Ravi, Gunjawate, Yerraguntla, & Driscoll, 2018; Singh et al., 2014). The lack of education and training regarding IBI provided in current degree programs could partly contribute to the low clinical adoption of teleaudiology. Provision of guidance online to that in a clinical setting is different and no standardized training to provide teleaudiology exists. Further education regarding teleaudiology application to students and audiological professionals is crucial to enable further adoption of IBI's. There are additional factors that may hamper the use of IBI such as licensing issues related to how Internet-based interventions are provided. Some states in the United States require a face-to-face consultation before offering Internet-based rehabilitation. IBI's are also not always recognized as a reimbursable service by insurance companies. Clear benefits regarding the cost-effectiveness of IBI's will be required prior to acceptance from insurance companies. Moreover, service development models providing both IBI rehabilitation and face-to-face care need to be designed. Identifying which patients are best suited for IBI's is still challenging. For some, the complexity of their condition may preclude them from an IBI. To date, outcome predictors from controlled

trials with regards to demographic and clinical variables has not been identified (e.g., Anderson, 2016; Beukes et al. 2018c; Kaldo-Sandström et al. 2004). There may be variables not yet considered that identify which patients are most suited for IBI's. Individuals who find attending clinics difficult due to working full time, who have transport difficulties, or who find that clinical environments create anxiety have valued the opportunity of receiving healthcare online (Beukes et al. 2018d).

Audiological IBI's can be further developed. In certain areas, there exists a need to extend the application of IBI's to wider populations such as elderly populations or military veteran populations. Social support for those with hearing-related difficulties is important. The availability of online support groups together with supportive family and friends have indicated benefits (e.g., Cummings & Sproull, 2002). A thematic analysis of tinnitus online discussion forums has indicated the benefits of these forums in terms of sharing knowledge and experiences and having support and finding additional coping strategies (Ainscough, Smith, Greenwell and Hoare, 2018). Less favorable consequences related to these interventions were also identified, which include negative messages, lack of communication, information overload, and conflicting advice. Further research into the value of these groups in isolation and together with interventional support is required.

Limitations and future directions

In this manuscript we present an overview of internet-based interventions in the area of audiology. The main limitation of this study is the limited scope and depth in the literature search

as we only used one database for search. Hence, it is worth noting that this manuscript may not include all the studies in this area. Also, in this manuscript we present the research studies in this area. However, our understanding is limited on where and what kind teleaudiology services are being offered across different countries. It would be useful to conduct a survey study to understand how teleaudiology is being applied in practice.

Conclusions

Numerous audiological IBI's have been developed in recent years focusing on hearing loss, vestibular disorders, and tinnitus. Effective ways of incorporating them into routine hearing healthcare delivery is required. Such models can only be developed when clinicians, researchers, professional organizations (e.g., AAA, ASHA), patient organizations (e.g., Hearing Loss Association of America), and other stakeholders work together to promote accessibility of audiological rehabilitation.

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Tables

Table 1: Internet-based interventions for hearing loss

Intervention focus	Reference	Country	Guidance	Stage	Reduction in hearing disability in comparison to the control group
Audiological rehabilitation (n = 6)	Brännström et al. (2016), Malmberg et al. (2017), Thorén et al. (2011) & Thorén et al. (2014)	Sweden (n = 4)	Asynchronous by clinical psychologist (n = 1) or an audiologist (n = 2) Blended approach (n = 3)	Fist time hearing aid users (n = 3) Experienced hearing aid users (n = 3)	Small effect (n = 2) Moderate effect (n = 1) No effect (n = 2) Greater knowledge of practical issues (n = 1)
	Ferguson et al. (2015) & Ferguson et al. (2016)	UK (n = 2)			
Acceptance and commitment therapy	Molander et al. (2018)	Sweden	Asynchronous: by clinical psychologists	Those with significant hearing disability	Large effect (n = 1)
Pre-fitting hearing aid counselling	Manchaiah et al. (2014)	UK	Asynchronous by an audiologist	Pre-hearing aid fitting	No effect (n = 1)

Table 2: Internet-based interventions for vestibular disorders

Intervention focus	Reference	Country	Guidance	Main outcomes
Vestibular rehabilitation	Geraghty et al. (2017)	UK	None	Lower dizziness-related disability compared with the control group
Rehabilitation for Ménière's disease	Pyykkö et al. (2017)	Finland	None	Improvement in general health related QOL and past-traumatic growth inventory

Table 3: Internet-based interventions for tinnitus

Intervention focus	Reference	Country	Guidance	Reduction in tinnitus distress
CBT(n =13)	Abbott et al. (2009)	Australia (n =1)	Asynchronous	Not superior to the control information only program
	Jasper et al. (2014), Nyenhuis et al. (2013), Weise et al. (2016)	Germany (n = 3)	Asynchronous by clinical psychologists (n = 2) None (n =1)	<u>Compared with a control group:</u> Small effect (n = 2), Medium effect (n = 2), and Large effect (n = 1) <u>Comparing the effect of guidance:</u> No difference (n =1) <u>Within group effect (no control):</u> Medium effect: (n =2) Where assessed, effects maintained 1-year post-intervention (n = 3)
	Andersson et al. (2002), Kaldo-Sandström et al. (2004), Kaldo et al. (2008), Kaldo et al. (2013), Rheker et al. (2015)	Sweden (n = 5)	Asynchronous by clinical psychologists (n = 5)	
	Beukes et al. (2017), Beukes et al. (2018a), Beukes et al. (2018b), Beukes et al. (2018c), Beukes et al. (2018d)	UK (n = 4)	Asynchronous by an audiologist (n = 4) Some synchronous guidance involving pre and post intervention phone calls	Large within-group effect size, no control group (n =1) Moderate effect size compared with a weekly check-in group (n =1) and maintained 1-year (n = 1) Similar improvements achieved to that obtained by specialized individualized clinical care (n =1)
One arm CBT, one arm ACT	Hesser et al. (2012)	Sweden	Asynchronous by clinical psychologists (n = 1)	Moderate effect for CBT and ACT and effects maintained 1-year post intervention

Table 4: Features, benefits and challenges of Internet-based interventions

Patient benefit or intervention feature	Example references	Difficulties in terms of uncertainties/ Challenges	Example references
Reduction in hearing and dizziness-related disability and tinnitus distress	Hearing loss (e.g., Brännström et al., 2016; Molander et al., 2018; Thorén et al., 2011; Thorén et al., 2014; Malmberg et al., 2017) Vestibular (e.g., Geraghty et al., 2017) Tinnitus (e.g., Beukes et al., 2017, 2018a; Weise et al., 2016; Hesser et al., 2012)	Clinically significant changes not obtained by all, range (40%-73%)	Beukes et al. (2018), Hesser et al. (2012), Jasper et al. (2014), Weise et al. (2016)
Similar outcomes to face-to-face support	Compared with group-based CBT (Jasper et al., 2014; Nyenhuis et al., 2013) Compared with specialized individualized tinnitus care (Beukes et al., 2018b)	Cost effectiveness/ cost benefit analysis not done	
Improved quality of life	IBI's hearing loss (Molander et al., 2018); Ménière's disease (Pyykkö et al., 2017);and tinnitus (Hesser et al., 2012; Beukes et al., 2018a)	Cost-utility analysis not done	
Reduction in anxiety and depression	IBI's related to hearing loss (Molander et al., 2018) and tinnitus (Kaldo-Sandström et al., 2004; Beukes et al., 2018a; Jasper et al., 2014; Thoren et al., 2011; Weise et al., 2016)		

Maintenance of long-term effects (1-year post intervention)	For ICBT for tinnitus (Andersson et al., 2002; Beukes et al., 2018c; Hesser et al., 2012; Kaldo et al., 2008; Weise et al., 2016), not investigated in other IBI's	Maintenance of long-term effects only evaluated for tinnitus interventions and not for longer than 1-year post intervention and not in controlled studies	
Self-efficacy promoted, understanding and knowledge of practical and psychosocial issues	Evaluated only in hearing loss IBI's (Ferguson et al., 2015; Thorén et al., 2014)	Uncertainty regarding the intervention features that aid favorable outcomes	
Support provided	Either by means of messages from a health professional (most tinnitus & hearing loss IBI's)	Optimum support not identified. No difference in outcomes when guidance provided and not provided.	Rheker et al. (2015)
Accessibility	Responsive on different devices: PC, laptop (iTerapie platform; Vlaescu et al., 2016)	Low uptake, partly attributable to poor Internet in more rural areas	Beukes et al. (2018b)
Service benefits			
Time-effective	2.7 times more time effective than individualized face to face care (Beukes et al. (2018b), 1.7 times more time effective than group therapy (Kaldo et al., 2008; Jasper et al., 2014)		
Integrated Assessments	Feature of interventions on the iTerapie system for example (iTerapie platform; Vlaescu et al., 2016)		

Able to monitor engagement and weekly-login	Able to send weekly questionnaires to monitor progress (e.g., Beukes et al., 2018a)	Compliance can be poor and variable	Low (e.g., Abbott et al., 2009; Manchaiah et al., 2014)
Tailoring/individualization possible	Able to select certain modules, worksheets, activities (iTerapie platform; Vlaescu et al., 2016)		
Data protection and anonymity	The majority of these interventions were developed on the iTerapie platform utilizing security features such as the use of encryption for data protection (Vlaescu et al., 2016)		