Evaluating hearing aid management: Development of the Hearing Aid Skills and Knowledge Inventory (HASKI)

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Abbreviations: HASKI-self: Hearing Aid Skills and Knowledge Inventory – self-administered; HASKI-clin: Hearing Aid Skills and Knowledge Inventory – clinician-administered; IOI-HA: International Outcome Inventory for Hearing Aids; ITE: in-the-ear; BTE: behind-the-ear; OHS: Office of Hearing Services; ICC: Intraclass Correlation; M: mean; SD: standard deviation.

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ABSTRACT

Purpose: Although hearing healthcare clinicians provide training on hearing aid handling and management as part of the rehabilitation program, clinical studies suggest that the level of management skill demonstrated by hearing aid owners is low. In the absence of a comprehensive clinical survey to identify these shortfalls in clinical training, the objective of this study was to develop and report the psychometric properties of the Hearing Aid Skills and Knowledge Inventory (HASKI: a self-administered version and a clinician-administered version). The HASKI evaluates the knowledge and skills required for hearing aid management. A secondary aim was to report the prevalence of hearing aid management difficulties in an Australian population.

Methods: Development of the HASKI and investigation of its psychometric properties in a prospective convenience cohort of 518 adult hearing aid owners, ranging in age from 18 to 97 years (M = 71 years, SD = 14), 60% male, 38% female and 2% undisclosed, recruited from seven hearing clinics across Australia.

Results: The Hearing Aid Skills and Knowledge Inventory (both the self-administered and clinician-administered) demonstrated high internal consistency, interdimensional relationships, construct validity, test-retest reliability, inter-observer reliability and criterion validity. A range of aptitudes were observed from low to full competency, with 99% of participants indicating difficulty with at least one item on the survey.

Conclusions: The Hearing Aid Skills and Knowledge Inventories are valid and reliable measures of hearing aid handling and management skills with good potential for use in clinical settings. Hearing aid management is an area of difficulty for the majority of hearing aid owners indicating the need for clinicians to improve the efficacy of hearing aid management training delivered.

INTRODUCTION

The World Health Organization estimates that there are over 360 million people in the world living with disabling hearing loss (WHO, 2014). Hearing loss can affect an individual's ability to communicate with others, resulting in significant social and emotional impacts on everyday life, such as causing feelings of loneliness, isolation and frustration (Pronk et al., 2011; Solheim, Kvaerner, & Falkenberg, 2011). Treating hearing loss with hearing aids can result in significant improvements in social activity and quality of life (Chisolm et al., 2007). However, a large proportion of individuals who self-identify as having hearing loss do not seek treatment, discontinue treatment programmes, or fail to use the hearing aids they have acquired (Hickson, Clutterbuck, & Khan, 2010; Hickson, Meyer, Lovelock, Lampert, & Khan, 2014; Kochkin, 2010; Staehelin et al., 2011).

Typically, hearing aids are provided as part of an aural rehabilitation program, where the hearing healthcare clinician sets up the hearing aid (physically and acoustically) to suit the individual needs of the hearing aid owner. During this appointment the clinician has the opportunity to provide education and training on the practical use of hearing aids, as well as affective counselling on the personal experiences of acquiring hearing aids. Affective counselling may include discussions on how the hearing aid will address their personal communication difficulties, what the hearing aid owner can expect from their hearing aid, the process of acclimatising to the new sounds they will hear, and how personal motivation and involvement influence the outcome of the rehabilitation program (Vestergaard Knudsen, Öberg, Nielsen, Naylor, & Kramer, 2010). The hearing aid is then reviewed and adjusted over subsequent appointments as the hearing aid owner adjusts to the new sounds and provides the clinician with feedback on their personal experiences when wearing the

hearing aid in their normal environment (such as at home, work or socialising) (Dillon et al., 2006). This process is takes 2-10 sessions (Kochkin et al., 2012; Bennett, Meyer, & Eikelboom, 2016).

While the clinician is primarily responsible for the physical set up and acoustic settings of the hearing aid, the hearing aid owner is responsible for the ongoing use, daily handling (such as inserting the hearing aid and changing the battery) and ongoing management (such as replacing tubing or domes). Thus, education and training in the handling and management of hearing aids is an essential component of any rehabilitation program (Boothroyd, 2007). The importance of good hearing aid management skills is evidenced by their association with hearing aid use (Kumar, Hickey, & Shaw, 2000), increased benefits from hearing aids (Campos, Bozza, & Ferrari, 2014) and higher self-reported hearing aid satisfaction (Bennett, Meyer, Taljaard, & Eikelboom, 2017a; Campos et al., 2014; Kumar et al., 2000). Although it is recommended that hearing healthcare professionals provide training on hearing aid handling and management as part of the rehabilitation program (American Speech-Language-Hearing Association, 1998; Audiology Australia, 2013), research suggests that the level of handling skills demonstrated by hearing aid owners remains low (Bennett et al., 2017a; Bertoli et al., 2009; Desjardins & Doherty, 2009; Upfold, May, & Battaglia, 1990).

The administration of a client survey is one means by which clinicians could assess and address gaps in hearing aid skill and knowledge. A recent review (Bennett, Taljaard, Brennan-Jones, Tegg-Quinn, & Eikelboom, 2015a) identified three clinician-administered surveys specifically designed to evaluate hearing aid handling skill (Desjardins & Doherty, 2009; Oberg, Wanstrom, Hjertman, Lunner, & Andersson, 2009; Pothier & Bredenkamp,

2006); however, the surveys were not comprehensive in that aspects of hearing aid management were not included, such as the use of a dehumidifier and replacement of domes, tubes or microphone covers. While statistical procedures, such as factor analysis and internal consistency, provide opportunity for survey developers to systematically reduce the number of items informed by the population for which the survey is designed, the process of item development and decisions surrounding item inclusion is often left to the developers (as was the case for the hearing aid surveys reviewed by Bennett et al., 2015a) and thus, without clear conceptual grounding, the content domain may not accurately represent the phenomenon under investigation (Rosas & Camphausen, 2007; Sheatsley, 1983).

Concept mapping provides a systematic mechanism for generating and identifying the conceptual framework of a phenomenon of interest and thus is an ideal platform for survey item development (Rosas & Camphausen, 2007). Concept mapping integrates qualitative and quantitative approaches in a multistep process that elicits the perspectives of key stakeholders (in this case hearing aid owners and clinicians) on a desired topic, followed by activities that involve grouping and rating the perspectives put forward by participants; thus these stakeholders play a valuable role in not only generating, but also interpreting the data (Trochim, 1989). Through involvement of key stakeholders, concept mapping identifies the survey items pertinent to the population for which it is intended to be used, thereby addressing face and content validity of the subsequent scale (Rosas & Camphausen, 2007).

Bennett et al. (2018a) used a group concept mapping approach to engage hearing aid owners (n = 24) and hearing healthcare clinicians (n = 22) to generate a comprehensive

list of the knowledge, tasks and skills required to use and manage a hearing aid. Participants identified 111 unique items describing hearing aid management within six concepts: 1) Daily Hearing Aid Use; 2) Hearing Aid Maintenance and Repairs; 3) Advanced Hearing Aid Knowledge; 4) Learning to Come to Terms with Hearing Aids; 5) Working With Your Clinician and 6) Communication Strategies. Items from the first three clusters above describe the physical aspects of hearing aid management and have subsequently formed the basis of the Hearing Aid Skills and Knowledge Inventory (HASKI), a 73-item questionnaire that can be self-administered (HASKI-self) or clinician-administered (HASKI-clin). The aims of this study were twofold: 1) to examine the psychometric properties of the Hearing Aid Skills and Knowledge Inventories, both the HASKI-self and HASKI-clin; and 2) to identify deficiencies in hearing aid skills and knowledge in an Australian population.

METHODS

Research Design

Survey developers demonstrate the clinical usefulness of a survey through reports of psychometric evaluation, specifically whether the survey actually measures what it purports to measure (validity) and whether the different scores represent differences between (or changes within) participants (reliability) (Fitzpatrick et al, 1998). A multicentre cohort study was conducted to evaluate the psychometric properties of the HASKI-self and HASKI-clin. Potential participants identified from seven hearing clinics in Australia were sent a survey set including the HASKI-self via post or email. A random sample of participants were selected and provided a second copy of the HASKI-self, enabling evaluation of test-retest reliability. Another random sample of participants were invited to attend a face-to-face

session and administered the HASKI-clin, enabling evaluation of criterion reliability. Additional psychometric properties investigated included internal consistency, interdimensional relationships, construct validity, inter-observer reliability and effect sizes.

Ethical Considerations

Ethical approval for this study was granted by the Human Research Ethics Office of The University of Western Australia and The University of Queensland's Human Research Ethics Committee. All participants provided written consent to participate.

Materials

Participants completed a survey set comprising a short clinical history form, the International Outcome Inventory for Hearing Aids (IOI-HA) (Cox & Alexander, 2002), and the HASKI-self (amended following the pilot study as described below). The survey set was available in paper and electronic format.

The short clinical history form included demographic and hearing aid device data, including participant age, gender, age of current hearing aid, duration of hearing aid use (total number of years of experience), style of hearing aid (Behind-the-ear or In-the-ear), hearing aid funding source (whether they paid in full for their hearing services: private; or received government subsidies through the Australian Office of Hearing Services: OHS), and satisfaction with hearing aids (with the response options "very dissatisfied", "dissatisfied", "neutral", "satisfied" and "very satisfied").

The IOI-HA is a seven-item survey developed to assess the effectiveness of hearing aids in improving hearing and general life enjoyment in real-life situations (Cox & Alexander, 2002). It was designed to be administered in conjunction with other related surveys in order

to provide a common platform to facilitate comparison of results between different audiological studies. The IOI-HA was included in this survey set to enable investigation into whether hearing aid management skills and knowledge were associated with daily hours of hearing aid use (IOI-HA item 1) and hearing aid benefit (IOI-HA item 2).

Survey Development

Two versions of the HASKI survey were developed. First, a self-administered version (HASKI-self) was developed to enable hearing aid owners to self-report hearing aid management skills and knowledge. A group concept mapping study by Bennett et al. (2018a) identified 64 statements describing hearing aid management across three domains: Daily Hearing Aid Use, Hearing Aid Maintenance And Repairs, and Advanced Hearing Aid Knowledge. Participants (hearing aid owners and clinicians) in the group concept mapping study were asked to indicate the importance of each of these statements for successful hearing aid use. The cohort's mean ratings for each statement fell within the top half of the rating scale indicating that they were very important for the successful use of hearing aids. As every item was deemed important to successful hearing aid use by participants, all items within these three domains were included in the HASKI-self survey. Then a clinician-administered version (HASKI-clin) was based on the first to enable clinicians to evaluate hearing aid management skills. Creation of a clinician-administered version enabled investigation into whether hearing aid owners are able to accurately self-evaluate hearing aid skills as compared to clinician evaluation of hearing aid skills, that is, comparisons between HASKI-self and HASKI-clin scores. Both versions of the HASKI were pilot tested by hearing aid owners and clinicians to inform appropriateness and feasibility of the surveys.

HASKI-Self

The HASKI-self consists of 14 questions across the three domains, with many of the questions having multiple parts, resulting in a total of 73 items describing skills or knowledge required for hearing aid use. For skill-based items participants were required to rate their ability on a four point Likert scale: “Never”, “Sometimes”, “Most of the time”, “Always”. For knowledge-based items, participants were required to identify whether they were aware of the item or not using a 3-point Likert scale: “Yes, I am aware”, “I now recall receiving this information, but had forgotten” and “I do not recall receiving this information”. A “not applicable” option is also available for many of the items.

Scoring of the HASKI-self was calculated by summing the total number of items identified as competent (not problematic) and converting it to a percentage of competency. Each individual item was classified as a pass where “Always” or “Yes, I am aware” was selected (allocated one point); all other responses were considered a fail (allocated zero points). To calculate the percentage competency, the points were summed and then divided by the total number of items for which a response was given. Items for which “Not applicable” was selected were not included in the calculation of the score. A higher overall score indicated greater competency (i.e. a score of 100% represents full competency).

Items are equally weighted. Although it can be argued that some items may describe more important skills (for example, ability to insert the hearing aid may be considered more important than ability to use the volume control), the difference in importance for each item are difficult to quantify as these may vary across individuals. In this way, the score represents percentage of competency, with a lower score indicating a greater number of areas of difficulty – but may not indicate degree of difficulty. The survey score can be used

to compare the extent of management difficulties for a single hearing aid owner before and after additional training, or across individuals.

HASKI-Clin

The HASKI-clin was primarily developed to enable investigation into whether self-reported hearing aid management skills and knowledge (using the HASKI-self) accurately reflected management skills as evaluated by a trained professional. Thus, the HASKI-clin was designed to be used by a professional trained to administer and score the survey, and therefore requires the administrator to be able to see the hearing aid owner being evaluated, such as face-to-face delivery. As with existing clinician-administered measures of hearing aid skill (Desjardins & Doherty, 2009; Kemker, 1999), it is ideally administered as part of a clinical consultation allowing the administrator to offer retraining at the same time.

Minor modifications were made to the language and scoring of the HASKI-self to generate the HASKI-clin. Given that the purpose of the HASKI-clin was for the clinician to evaluate the hearing aid owner's demonstrative skills regarding hearing aid management, some questions from the second domain (Hearing Aid Maintenance and Repairs; Qs 11 and 13) and all questions from the third domain (Advanced Hearing Aid Knowledge) were omitted from the clinician-administered version as they referred to knowledge rather than skill. The resulting survey included 40 items across the two domains: Daily Hearing Aid Use and Hearing Aid Maintenance and Repairs. The wording of each question was altered from "Can you..." to "Please show me how you...". Where the self-administered survey used a four-point Likert scale, the clinician-administered version used a dichotomous option of "Competent" or "Requires attention", and includes a "Not Applicable" option. A dichotomous scale was chosen because a pilot study (Bennett et al., 2017a) suggested that a

client requires additional support regardless of whether they show complete or partial incompetence. Additionally, a recent tutorial on inter-observer concordance suggested that the low inter-rater reliability observed with currently available hearing aid skills survey is likely due to: 1) having a greater number of possible responses to an item; 2) use of survey items that are unclear and require the administrator to provide explanation throughout testing and 3) where response items are not defined and require the administrator to make their own interpretation of whether the participants response is sufficient (Bennett, Taljaard, Olaithe, Brennan-Jones & Eikelboom, 2017b). For example, when asking a participant to demonstrate how they clean their hearing aid, administrators may have differing concepts of what specific tasks are required to fulfil this request. As such, the HASKI-clin provides limited response options and includes detailed descriptions of what is required to fulfil each item accurately as guidance for the administrator to specify exactly what tasks are required to be demonstrated to award a "pass" for that item. These definitions of what is required to achieve competency also appear on the HASKI-self.

Scoring of the HASKI-clin is the same as for the HASKI-self in that the overall score is calculated by summing the total number of items identified as competent and converting it to a percentage of competency.

Pilot Testing

All 24 hearing aid owners who had participated in the group concept mapping study (Bennett et al., 2018a), used to inform the development of the HASKI surveys, were invited to pilot-test the HASKI-self. They were asked to complete a paper version of the survey and to provide feedback using open ended questions on 1) how long the survey took to complete, 2) the appropriateness of the content, and 3) whether they felt the survey was

beneficial or worthwhile. Eleven participants returned a completed survey (response rate of 46%; six males (55%) and five females (45%), ranging in age from 67 to 89 years (M = 78, SD = 8 years)). Participants reported taking between 7 to 40 minutes to complete the survey (M = 20, SD = 11 mins). Participants reported positive experiences with completing the survey, and did not suggest any changes. One participant wrote "I found some of the tips quite educational". Another wrote "Very useful, section three contained a lot of information that was new to me, but now I know it all thanks to the survey". A third wrote "It's a great survey, quite informative, I learned a lot just by completing it, thank you".

The HASKI-clin was pilot tested by eight clinical audiologists: two male and six female, ranging in age from 26 to 51 years (M = 36, SD = 8), with a range of clinical experience (three to 28 years). They were asked to administer the survey with hearing aid users where appropriate in their daily clinical practice over the course of two weeks and provide feedback on the content and usability of the survey. Minor changes to the survey were made based on the clinicians' feedback, such as inclusion of alternative names for the wax guard and rewording of some items for clarity. Clinicians reported taking approximately 10-15 minutes to administer the survey, including providing retraining on items failed.

Participants

Hearing aid owners were recruited from seven hearing clinics across Australia. Clinics were based in Queensland (n = 2), New South Wales (n = 3), and Western Australia (n = 2). Six of the participating clinics provided access to government funded services (OHS) and privately paid services, and one provided only the latter. Within each clinic, services were provided by a mix of both audiologists (university trained with a postgraduate-level qualification) and audiometrists (non-university trained hearing aid technicians). There are

no universal or standardised clinical processes in Australia, and therefore the number of appointments provided for a hearing aid fitting, the time allowance for these appointments, and what occurred during these appointments differed across participants. The participating clinics varied in their preferences for hearing aid brands, their pricing structures and their business models (e.g. single clinician, small chain, not-for-profit). Therefore, the participants' experiences during the process of obtaining hearing aids, and the actual hearing aid they obtained, varied across participants in this study.

All clients aged 18 years or older recorded in the clinics' databases who had received hearing aids prior to the date of data collection were identified as potential participants. No inclusion or exclusion criteria were placed on duration of hearing aid use. Each clinic generated a list of potential participants. The research team used a random number generator to select the 400 potential participants from each of the larger four clinics. The entire list of the smaller three were included. Participants were contacted via email (to complete the survey online) or post (to complete the survey on paper), depending on their preferred method of contact and whether they provided a valid email and/or postal address. The total number of potential participants contacted was 2,400 (1000 via post and 1,400 via email). The response rates were 22% for the postal group and 21% for the email group.

Hearing health care clinicians participated as survey administrators for one part of this experiment, to calculate inter-observer reliability for the clinician-administered version of the survey (HASKI-clin). A random selection of three clinicians, from a pool of eight, participated at each data collection session. Clinicians ranged in age from 23 to 35 years (M = 25, SD = 4), one was male and seven were female. Only one of the clinicians was a

researcher involved in the design of the HASKI, whilst the other seven were all unfamiliar with the survey and each other's clinical methods of hearing aid management evaluation.

Procedure

All potential participants received a copy of the survey set in their preferred format (e.g., online or paper version) and were given two months to complete the survey. Reminders were not sent. Participants returned completed surveys in the stamped, self-addressed envelopes provided. The psychometric properties commonly reported in scale development were evaluated as described in Table 1.

Table 1. Psychometric properties assessed for the both the Hearing Aid Skills and Knowledge Inventory (HASKI)-self and HASKI-clin.

Psychometric property	Description	Method of assessment
Face and content validity	Examines the extent to which the concepts of interest are represented by the items on the survey	Item development was based on the results of the concept mapping study (Bennett, Taljaard, et al., 2017). Pilot testing was conducted with members of the target population.
Internal consistency	Examines the extent to which survey items correlate and, thus, measure the same concept (Terwee et al., 2007)	Cronbach's alpha reliability coefficient
Interdimensional relationships	Examines the relationships among survey domains	Pearson correlation coefficients
Construct validity	Evaluates the extent to which scores on a survey relate to characteristics of participants and subgroups of participants in a way that is consistent with theoretically derived hypotheses (Terwee et al., 2007)	Assessed using Pearson correlations (for continuous and ordinal data) and independent sample *t* test (for categorical data) for the following hypotheses: (a) Survey scores will be positively correlated with overall satisfaction with the hearing aid (Campos et al., 2014), (b) survey scores will be positively correlated with perceived benefit received from the hearing aid (based on IOI-HA Item 2; Campos et al., 2014), (c) survey scores will be positively correlated with overall hearing aid use, (d) survey scores will be negatively correlated with age (Desjardins & Doherty, 2009), and (e)

Table 1. Psychometric properties assessed for the both the Hearing Aid Skills and Knowledge Inventory (HASKI)-self and HASKI-clin.

Psychometric property	Description	Method of assessment
		survey scores will not be associated with gender (Desjardins & Doherty, 2009).
Test–retest reliability	Determines whether participants' scores are stable over time (Terwee et al., 2007)	Intraclass correlation (ICC) between participants' first and second HASKI-self survey scores, with a minimum of 1 week and a maximum of 2 weeks between test and retest. The guidelines of Landis and Koch (1977) were used to classify the results: less than 0 indicating *no concordance* (agreement/reliability), 0 to 0.20 *slight concordance*, 0.21 to 0.40 *fair concordance*, 0.41 to 0.60 *moderate concordance*, 0.61 to 0.80 *substantial concordance*, and 0.81 to 1.0 *almost perfect concordance*. ICC values exceeding 0.80 were deemed high and suggest that the survey is stable over time (Bennett, Taljaard, et al., 2015; Hyde, 2000).
Interobserver reliability	The degree of similarity between survey scores obtained by two or more administrators (Bennett, Taljaard, et al., 2015)	ICC between the three clinician observers
Criterion validity	Indicates whether the survey measures what it purports to measure (Terwee et al., 2007)	ICC to compare self-administered evaluation of management skills (HASKI-self) to clinician-administered evaluation of management skills (HASKI-clin) for survey scores (each domain and overall score)
Effect size	A quantitative measure of the strength of a phenomenon and can be used to demonstrate correlation between two variables, the mean difference, or even the risk with which something happens (Kelley & Preacher, 2012). An effect size estimate provides a value on the direction and magnitude of an effect of a treatment.	One-way ANOVA comparing survey scores across the seven clinics involved in the study

Note. IOHA-HA = International Outcome Inventory for Hearing Aids; ANOVA = analysis of variance.

To evaluate test-retest reliability of the HASKI-self, 100 participants (randomly selected from three of the participating clinics whose proprietors or managers gave

permission for the research team to contact the participants a second time) were sent the self-administered survey set a second time, in the same format as the first, 1-2 weeks after their initial survey responses were received (response rate of 38%). This time the survey also included a question pertaining to whether or not they had received any support or advice from a professional regarding their hearing aids in the previous week to ensure skills had not changed due to clinical intervention. Any participants reporting having received services in the meantime would have been excluded from this part of the experiment as their skills may have changed between test and retest; however, none of the participants reported receiving support.

To evaluate inter-observer reliability of the HASKI-clin, 80 randomly-selected participants were invited to a 30-minute, individual, face-to-face data collection session (response rate of 40%). The participants first completed the self-administered version of the HASKI, followed by the clinician-administered version. Three clinicians (from a pool of eight) were allocated to each session. During these sessions, one clinician-administered the HASKI-clin, reading the exact wording of each item, while all three clinicians assessed the participant's responses independently of each other. This data was also used to determine criterion reliability, by comparing participants' perceived level of hearing aid management skill (HASKI-self scores) to the clinicians' evaluation of level of skill (HASKI-clin scores).

Data analysis

Data was entered into Microsoft Excel and analysed using SPSS Statistics (version 21.0, Armonk, NY: IBM Corp). All data were inspected for outliers (i.e. visual inspection of boxplots and |z| score calculations using a cut-off point of 2.58), after which tests of normality and skewness (i.e. Shapiro-Wilk test of normality and Q-Q plots) were conducted.

As per Osborne & Overbay (2004), all outliers were removed to avoid errors in statistical analyses. To address Aim 1, a variety of methods were used to evaluate the psychometric properties of the HASKI-self and HASKI-clin, as described in Table 1. To address Aim 2, deficiencies in hearing aid skills and knowledge were reported by tabulating the frequency of how often each problem occurred in the population sampled.

RESULTS

Participants (n = 518) ranged in age from 18 to 97 years (M = 71 years, SD = 14) and included 310 (60%) males and 193 (38%) females (2% of participants did not specify their gender). Over half of the participants completed the survey electronically (58%), with 42% completing the paper version. Almost all of the participants reported being fit binaurally (93%), with the remainder (7%) reporting monaural amplification. Most of the participants wore behind-the-ear (BTE) style hearing aids (84%), one of whom had a cochlear implant on the contra-lateral ear, and 16% wore in-the-ear (ITE) style hearing aids. More than half (57%) of participants had owned a hearing aid prior to their current one. Two thirds of the participants had owned their current hearing aid for more than 12 months (66%), with 34% having owned their hearing aid for less than 12 months (as little as two weeks in one case). Two thirds of the participants paid for their hearing aids and hearing services privately (65%), with 35% receiving government subsidies for their hearing aid and associated services.

Participants reported high levels of hearing aid use with 84% reporting more than four hours of use per day. However, not all participants regularly used their hearing aids with 2% reporting using their hearing aid for less than one hour per day, and an additional

2% reporting never using their hearing aid. Satisfaction was high, with 78% of participants indicating they were “Satisfied” or “Very Satisfied” with their current hearing aids. IOI-HA scores ranged from 1.2 to 5.0 (mean 3.97; SD 0.65). Self-reported hearing aid benefit was high, with 70% indicating that their hearing was “Quite a lot” or “Very much” better when using their hearing aid on the IOI-HA (item 2). IOI-HA item One (hearing aid use), item Two (hearing aid benefit) and IOI-HA scores were consistent with reported scores from other Australian and internationally reported populations (Cox & Alexander, 2002; Heuermann, Kinkel & Tchorz, 2005; Hickson, Clutterbuck, & Khan, 2010).

Psychometric properties

Reliability estimates of the HASKI-self exceeded the recommended internal consistency alpha levels of 0.60 (Gliem & Gliem, 2003), indicating acceptable internal consistency for the survey total scores ($\alpha = 0.785$) and for each of the three domains: Daily Hearing Aid Management ($\alpha = 0.842$), Hearing Aid Repairs and Maintenance ($\alpha = 0.671$) and Advanced Hearing Aid Knowledge ($\alpha = 0.814$). Similarly, reliability estimates of the HASKI-clin demonstrated acceptable internal consistency for the survey total scores ($\alpha = 0.775$) and for each of the two domains: Daily Hearing Aid Management ($\alpha = 0.749$) and Hearing Aid Repairs and Maintenance ($\alpha = 0.674$). These results suggest that there is a strong relationship among the subscale items and that the set of items for the total survey are well integrated (Gliem & Gliem, 2003).

Interdimensional relationships reported in Table 2 show significant, moderate correlations between domains, demonstrating that the different domains are somewhat related. Relationships were stronger within the HASKI-self than the HASKI-clin.

Table 2. Interdimensional relationships explored using Pearson correlation coefficient provide insight into the relationships between survey domains.

Survey subsections	***df***	***r***	***p***	***df***	***r***	***p***	***df***	***r***	***p***
HASKI-self	**Part 1: daily hearing aid use**			**Part 2: hearing aid maintenance and repairs**			**Part 3: advanced hearing aid knowledge**		
Part 2: hearing aid maintenance and repairs	498	.496	< .001	—					
Part 3: advanced hearing aid knowledge	496	.430	< .001	496	.454	< .001	—		
Total HASKI score	500	.782	< .001	498	.862	< .001	496	.749	< .001
HASKI-clin	**Part 1: daily hearing aid use**			**Part 2: hearing aid maintenance and repairs**			**Part 3: advanced hearing aid knowledge**		
Part 2: hearing aid maintenance and repairs	32	.998	.001	—					
Total HASKI score	32	.536	.002	32	.829	< .001	—		

Note. HASKI = Hearing Aid Skills and Knowledge Inventory.

Four of the five hypotheses tested for construct validity of the HASKI-self were met (Table 3). The hypothesis related to gender was not met, with HASKI-self scores of males (M = 68%, SD = 17) being significantly greater than the scores of females (M = 64%, SD = 18) [t(492) = 2.602, p = 0.010]. Three of the five hypotheses tested for construct validity of the HASKI-clin were met (Table 3). No correlation was identified for the hypotheses related to age [t=-0.236(32), p=0.194] and daily hours of hearing aid use [t=0.195(16), p=0.469].

Inter-observer reliability of the HASKI-clin was established, with an ICC across three observers (selected from a pool of eight clinicians) being “almost perfect” (ICC = 0.933, p < 0.001; CI 95%: 0.879 to 0.965).

Table 3. Associations between Hearing Aid Skills and Knowledge Inventory (HASKI) scores and participant demographic and self-report outcome factors to establish construct validity of the HASKI.

	HASKI-self						HASKI-clin					
Participant variables	**Pearson correlation analysis**			**Independent-samples *t* test**			**Pearson correlation analysis**			**Independent-samples *t* test**		
	df	***r***	***p***	***df***	***t***	***p***	***df***	***r***	***p***	***df***	***t***	***p***
Overall satisfaction with the hearing aid	416	.225	< .001				16	.566	.022			
Perceived benefit received from the hearing aid	482	.209	< .001				16	.750	.001			
Overall hearing aid use	485	.109	.017				16	.195	.469			
Age	477	−.132	.004				32	−.236	.194			
Gender				492	2.602	.010				30	1.847	.075

The test-retest reliability of the HASKI-self survey was performed on a sample of 38 participants, 23 males and 15 females, with a mean age of 81 years (SD = 9). It is important to note that the test-retest cohort was significantly older than the full cohort [t(442) 5.022, $p < 0.001$]. Intra-observer reliability between test (M = 66%, SD = 18) and retest (M = 67%, SD = 22) HASKI-self total survey scores was “almost perfect” (ICC = 0.869, $p < 0.001$; CI 95%: 0.748 to 0.932).

Criterion validity (whether the survey measures what it purports to measure) was assessed by comparing self-administered evaluation of hearing aid skills and knowledge (HASKI-self scores) to clinician-administered evaluation of handling skills (HASKI-clin scores). Inter-observer reliability between HASKI-clin and HASKI-self scores was “fair” and not significant for the first domain (Daily Hearing Aid Use: ICC=0.233 p=0.248, 95%CI: -0.658 to 0.645), “substantial” and significant for the second domain (Hearing Aid Maintenance And Repairs: ICC=0.713 p=0.001, 95%CI: 0.380 to 0.867), and “moderate” and significant for total scores (ICC=0.578 p=0.014, 95%CI: 0.088 to 0.805).

Effect sizes (measuring the strength of correlation between HASKI-self scores and the clinic from which participants were recruited) was evaluated using one-way ANOVAs. Sample size requirements for the one-way ANOVA calculations were 13.31 for each clinic, based on a 90% power, effect size of 0.5 and significance of 0.05. As such, only the five clinics with more than 13 participants were included in the ANOVA. Data was normally distributed following "reflect and inverse" transformation, and there was homogeneity of variances, as assessed by Levene's test of homogeneity of variances (p = 0.120). HASKI-self scores were significantly different between the clinics, with clinic 5 (M = 72%, SD = 15) demonstrating significantly higher HASKI-self scores than clinics 1 (M = 64%, SD = 18) and 3 (M = 62%, SD = 19), $F(4, 396) = 4.129$, p = 0.003. This was confirmed with Bonferroni corrections demonstrating a mean difference of 8.164 (p = 0.025) between clinics 5 and 1, and a mean difference of 9.557 (p = 0.003) between clinics 5 and 3. Effect sizes were low but significant (η^2 = 0.04), suggesting that 4% of the variance in HASKI-self scores were accounted for by the clinic visited. Given the association between age and hearing aid handling skills reported in the literature (Desjardins & Doherty, 2009), associations between client age and clinic attended was investigated using one way ANOVA to identify whether participant age contributed to the higher HASKI-self scores observed from clinic 5. Results indicated that participants from clinic 5 were significantly younger than each of the other four clinics, $F(4, 383) = 18.372$, $p < 0.001$.

Prevalence of hearing aid management skill and knowledge deficiency

HASKI-self scores ranged from 14 to 100%, with a mean score of 66% (SD = 17), which approximates to difficulty with an average of 25 of the 74 items of the HASKI. The mean score for the top performing 50 participants was 80%, or 15 individual items of

difficulty. Scores differed across the three domains: Daily Hearing Aid Use (M = 73%, SD = 20), Hearing Aid Maintenance and Repairs (M = 54%, SD = 24); and Advanced Hearing Aid Knowledge (M = 72%, SD = 21). Section Two of the HASKI-self, describing hearing aid maintenance and repairs, was generally the most problematic for participants, with participants reporting difficulty with an average of 12 of the 26 items in this section. No participants scored zero and only three achieved 100%.

HASKI-clin total scores ranged from 4 to 88%, with a mean score of 73% (SD = 10), which equates to observed difficulty performing 11 of the 40 tasks of the HASKI-clin. There was a significant difference between mean scores for the two domains of the HASKI-clin, with participants performing better on tasks associated with Daily Hearing Aid Use (M = 86%, SD = 9) than Hearing Aid Maintenance and Repairs (M = 50%, SD = 22). All participants demonstrated difficulty with at least one item on the HASKI-clin.

The HASKI-self requires the hearing aid owner to first identify whether their hearing aid has manually adjustable features, followed by self-evaluation of how well they manage each feature. Two thirds of participants reported having access to a volume control, one third used manual programs and one quarter owned hearing aid accessories (such as remote control, FM or Bluetooth streamer) (Table 4). Regarding telephone use, 76% (n = 266) of participants reported using the telephone; however, 69% (n = 184) of telephone users reported being unsure how to use their hearing aids appropriately with the telephone.

Table 4. Percentage of participants with access to manually adjustable volume control, programs, or remote controls.

Hearing aid feature	Yes	No	Unsure
Adjustable volume control	67.15% (*n* = 274)	25.74% (*n* = 105)	7.11% (*n* = 29)
Manually adjustable program control	36.98% (*n* = 152)	44.04% (*n* = 181)	18.98% (*n* = 78)
Additional hearing aid accessories	23.34% (*n* = 95)	72.92% (*n* = 297)	3.69% (*n* = 15)

The prevalence of hearing aid management skill and knowledge deficiencies are reported as mean responses for each individual item of the two HASKIs (Table 5). The items relating to batteries and hearing aid insertion were the least problematic for participants. The hearing aid management skills identified to be most problematic on the HASKI-self and the HASKI-clin included: Q5c "Do you know what volume level to set your hearing aid(s) at in different situations?", Q6c "Do you know which program to select in different situations?", Q7a "Do you know how to hold the phone in the optimal position when using the telephone program on your hearing aid(s)?", and most of the items describing hearing aid cleaning tasks.

Table 5. Percent (and number) of participants reporting or demonstrating difficulty on each individual item of the Hearing Aid Skills and Knowledge Inventory (HASKI).

HASKI items	**HASKI-self % (*n*)**	**HASKI-clin % (*n*)**
Part 1: daily hearing aid use		
1. Can you identify whether your hearing aid(s) is working?	31.95 (131)	6.25 (32)
2. Can you turn your hearing aid(s) off and on?	17.32 (71)	0 (32)
3a. Regarding hearing aid batteries, can you change the battery?	4.93 (20)	0 (32)
3b. Regarding hearing aid batteries, do you know when to change your battery?	13.22 (53)	3.13 (31)
3c. Regarding hearing aid batteries, do you know where to purchase/collect additional batteries?	2.23 (9)	0 (32)
3d. Regarding hearing aid batteries, do you know how to store and dispose of batteries safely?	6.42 (26)	9.38 (32)
4a. Regarding hearing aid insertion and removal, can you identify the left from the right hearing aid?	5.80 (22)	0 (29)
4b. Regarding hearing aid insertion and removal, can you insert your hearing aid with ease?	11.52 (47)	0 (32)
4c. Regarding hearing aid insertion and removal, is your hearing aid comfortable when sitting in the ear?	42.44 (174)	6.25 (32)
4d. Regarding hearing aid insertion and removal, does your hearing aid stay in/on your ear (i.e., not fall out/off)?	31.94 (130)	3.13 (32)
4e. Regarding hearing aid insertion and removal, can you remove your hearing aid comfortably and without damaging it?	6.57 (27)	3.13 (32)
5a. Regarding the volume control on your hearing aid(s), can you make adjustments to the volume of your hearing aid(s)?	28.72 (83)	36.84 (19)

Table 5. Percent (and number) of participants reporting or demonstrating difficulty on each individual item of the Hearing Aid Skills and Knowledge Inventory (HASKI).

HASKI items	HASKI-self % (*n*)	HASKI-clin % (*n*)
5b. Regarding the volume control on your hearing aid(s), can you hear and recognize the different beeps that alert you to the changes you are making to the volume setting?	31.83 (92)	47.37 (19)
5c. Regarding the volume control on your hearing aid(s), do you know what volume level to set your hearing aid(s) at in different situations?	62.46 (178)	61.11 (18)
6a. Regarding the program control on your hearing aid(s), can you make adjustments to the program setting of your hearing aid(s)?	52.11 (99)	81.82 (11)
6b. Regarding the program control on your hearing aid(s), are you able to hear and recognize the different beeps that alert you to the program changes you are making?	45.60 (88)	81.82 (11)
6c. Regarding the program control on your hearing aid(s), do you know which program to select in different situations?	57.98 (109)	63.64 (11)
7a. Do you know how to hold the phone in the optimal position when using the telephone program on your hearing aid(s)?	62.50 (185)	48.28 (29)
7b. Can you turn on the telephone program on your hearing aid?	78.48 (124)	75 (4)
8a. Regarding the program control on your hearing aid(s), do you know how to use your hearing aid accessory?	32.43 (36)	0 (5)
8b. Regarding the program control on your hearing aid(s), do you know when to use your hearing aid accessory and in what situations?	35.19 (38)	0 (5)
9c. Regarding your dry aid kit, do you know how to use the dry aid kit?	20.24 (83)	0 (7)
9d. Regarding your dry aid kit, do you know when to use the dry aid kit? Tip: such as when it is humid, after sweating/exercising, wet ears from showering/swimming	25.82 (47)	28.57 (7)
10. When cleaning your hearing aid, do you do the following:		
10a. Wipe the externals with a dry (or moist, but never wet) cloth/tissue	46.42 (188)	51.61 (31)
10b. Wipe inside the battery compartment with a dry cloth/tissue	77.56 (311)	77.42 (31)
10c. Wipe/brush the microphone port/cover	67.58 (271)	70.97 (31)
10d. Wipe/brush the speaker	70.30 (277)	35.48 (31)
10e. Clean the vent with a brush or puffer	69.97 (268)	21.74 (23)
10f. Clean the tubing and molds/domes	66.95 (235)	41.67 (24)
Part 2: hearing aid maintenance and repairs		
11a. Do you know where to purchase cleaning products from, such as puffers and brushes?	26.96 (103)	
11b. Do you know where to purchase hearing aid parts from, such as battery doors, wax protection systems, microphone covers, tubes, domes, or molds?	16.54 (64)	
11c. Do you know how to change the wax protection system? (also called the *wax buster*, *wax guard*, or *cerustop*)?	40.56 (144)	
11d. Do you know how often to clean your hearing aid?	39.55 (159)	

Table 5. Percent (and number) of participants reporting or demonstrating difficulty on each individual item of the Hearing Aid Skills and Knowledge Inventory (HASKI).

HASKI items	HASKI-self % (*n*)	HASKI-clin % (*n*)
11e. Do you know how often to change the wax protection system?	52.84 (186)	
11f. Do you know how often to change the tubes and domes/molds?	60.35 (207)	
11g. Do you know how often to change the microphone covers?	75.91 (249)	
12a. Do you know how to overcome feedback/whistling?	56.23 (230)	70 (30)
12b. Do you know what to do if the hearing aid sounds dull or stops working?	25.74 (105)	15.63 (32)
12c. Do you know what to do if the hearing aid gets wet?	52.57 (215)	22.58 (31)
13a. Are you aware you need to complete personal grooming prior to putting the hearing aid in (shower, dry ears/hair, apply hair spray)?	9.44 (39)	
13b. Are you informed of the servicing, batteries, and maintenance programs available from your clinic?	12.59 (52)	
13c. Are you aware of the importance and benefits of regular hearing assessments and hearing aid adjustments?	9.69 (40)	
13d. Are you aware of the importance of wiping hearing aids with alcohol wipes before inserting them in your ear if you are experiencing outer ear infections?	56.20 (231)	
Part 3: advanced hearing aid knowledge		
14a. It can be useful to collect extra batteries before going away, rather than running out or having to find a place to buy batteries while away.	3.14 (13)	
14b. Having your hearing aids serviced before going away can prevent problems occurring while away.	34.94 (145)	
14c. There are a range of rechargeable battery options available.	73.22 (298)	
14d. Hearing aid batteries will go flat after the battery sticker is removed, regardless of whether it has been used or not.	47.95 (199)	
14e. Hearing aid batteries can leak if left in a hearing aid for extended periods of time (months/years). This can permanently damage the hearing aid.	32.13 (133)	
14f. The life of a hearing aid battery can fluctuate. Batteries go flat faster if the hearing aid is used in noisy environments, used for Bluetooth streaming, used for longer hours each day, or if the batteries are of a lesser quality.	35.18 (146)	
14g. Hearing aid battery life can be slightly extended if you wait 1 min after removing the battery sticker before inserting it into the hearing aid.	61.93 (257)	
14h. It is possible to get a faulty battery and/or packet. It will need to be discarded and a new battery placed in the hearing aid.	35.51 (147)	
14i. Hearing aid batteries pose a danger to animals and children if swallowed and should be disposed of safely.	2.88 (12)	
14j. Having ear wax regularly removed prevents buildup in the ear canals and reduces the amount of wax and debris that may clog up the hearing aid.	13.59 (56)	
14k. Softening the ear wax before seeing your doctor/hearing professional for wax removal can make it a quicker, safer, and more comfortable experience. Appropriate options for softening ear wax include chemist-purchased sprays and drops and olive oil.	31.46 (129)	

Table 5. Percent (and number) of participants reporting or demonstrating difficulty on each individual item of the Hearing Aid Skills and Knowledge Inventory (HASKI).

HASKI items	HASKI-self % (*n*)	HASKI-clin % (*n*)
14l. Hearing aids should be comfortable when sitting in your ear. If the hearing aid is uncomfortable, there are things your clinician can do to improve the comfort for you.	10.95 (45)	
14m. The sound delivered by the hearing aid should always be comfortable. There are things your clinician can do to improve the comfort for you.	7.04 (29)	
14n. Hearing aids should not fall off/out of the ear regularly. If the hearing aid continuously falls off/out, there are things your clinician can do to improve this for you.	8.98 (37)	
14o. Some home insurance policies will cover hearing aids.	30.58 (126)	
14p. Even people with hearing loss are susceptible to further noise-induced hearing loss and tinnitus. It is important to always wear hearing protection (ear muffs or plugs) when exposed to loud sounds.	16.63 (68)	
14q. Hearing aids are not the only solution for people with hearing loss. Sometimes people just need hearing assistance only in a specific situation, such as when watching TV or on the phone. Assistive listening devices encompass a broad range of technologies designed to assist people with a hearing impairment, which may be used either independently or in conjunction with hearing aids.	35.19 (145)	
14r. Hearing aids increase the volume of sounds but may not always improve the ability to understand speech due to severe damage in the inner ear. A cochlear implant bypasses the damaged parts of the inner ear by stimulating auditory nerve fibers directly and can provide better hearing for some people with this type of hearing loss.		

The three knowledge items that participants were most often aware of included: Q14a “It can be useful to collect extra batteries before going away, rather than running out or having to find a place to buy batteries while away”; Q14i “Hearing aid batteries pose a danger to animals and children if swallowed and should be disposed of safely”; and Q14m “The sound delivered by the hearing aid should always be comfortable. There are things your clinician can do to improve the comfort for you”. The four knowledge based items that participants most often reported not being aware of included: Q14c “There are a range of rechargeable battery options available”; Q14d “Hearing aid batteries will go flat after the battery sticker is removed, regardless of whether it has been used or not”; Q14g “Hearing aid battery life can be slightly extended if you wait one minute after removing the battery sticker before inserting it into the hearing aid”; and Q14r “Hearing aids increase the volume

of sounds but may not always improve the ability to understand speech due to severe damage in the inner ear. A cochlear implant bypasses the damaged parts of the inner ear by stimulating auditory nerve fibres directly and can provide better hearing for some people with this type of hearing loss."

DISCUSSION

The aims of this study were twofold: 1) to report the development and psychometric properties of the Hearing Aid Skills and Knowledge Inventory, both the HASKI-self and the HASKI-clin; and 2) to report common deficiencies in hearing aid skills and knowledge in an Australian population.

The HASKI-self is the only comprehensive self-administered survey designed to measure hearing aid management skills and knowledge. Where clinician-administered surveys require face-to-face administration, the development of a self-administered survey evaluating hearing aid management skills may reduce the clinical load, save consultation time, and facilitate more frequent use than face-to-face consultations allow. The HASKI-clin was developed for the purpose of investigating the validity of the HASKI-self in identifying hearing aid management skill deficiency. Development of a clinician-administered survey using identical wording as the HASKI-self enabled demonstration that hearing aid owners were able to accurately self-evaluate and report hearing aid management skills via use of the HASKI-self. Although the sample of 32 adult hearing aid owners who completed the HASKI-clin was sufficient for this measure of criterion validity, a sample size of 32 is insufficient to draw conclusions on the performance of the HASKI-clin in clinical populations. None-the-less, the HASKI-clin shows promise as a comprehensive clinical tool. Although

similar clinician-administered tools exist, the Practical Hearing Aid Skills Test (PHAST: Desjardins & Doherty, 2009) evaluates 8 items pertaining to hearing aid management skill, the Hearing Instrument Operation Checklist (HIOC: Kemker, 1999) evaluates 6 items and the recently published Hearing Aid Skills and Knowledge (Saunders, Morse-Fortier, McDermott, Vachhani, Grush, Griest, & Lewis, 2018) evaluates 32 items, making the HASKI-clin (evaluating 40 items) the most comprehensive clinician-administered survey designed to evaluate hearing aid management skills. Furthermore, where item development for the other surveys was based on hearing aid user manuals and existing surveys, the HASKI-clin was developed using participatory methods, wherein hearing aid owners and clinicians developed a framework describing what is required for hearing aid management, including generation of a list of the skills and knowledge required for hearing aid management. Thus the HASKI surveys have high content and face validity as item development and the language used within the surveys was developed by the population for which they were indented to be used (i.e. hearing aid owners).

Psychometric properties

Reliability estimates of the HASKIs were high. Internal consistency and interdimensional relationship estimates suggested there was a strong relationship among the subscale items and between domains. Test-retest reliability coefficients suggested low measurement error and that the HASKI-self was a stable measure of hearing aid management skills and knowledge. The high inter-observer reliability observed for the HASKI-clin suggests that it has low observer bias and is effective at distinguishing individuals with good handling skills from those with poor handling skills. The HASKI-clin exhibited higher inter-observer reliability (ICC = 0.93) than existing clinician-administered measures of

hearing aid handling skills (ICC = 0.77: Ferrari, Jokura, Silvestre, Campos & Paiva, 2015), likely due to the design of the surveys, the language used and the number of response options provided (Bennett et al., 2017b). The HASKI-clin specifies exactly what the administrator is to say when administering the survey and includes a description of what must be performed in order to pass each item to reduce observer bias. The high reliability observed in this study supports the clinical use of the HASKIs for evaluation of hearing aid management skills and knowledge.

Construct validity testing indicated that for the most part, the HASKIs performed as expected based on existing literature describing associations between hearing aid management skills and participant factors. The positive association between hearing aid skill and self-report benefit of and satisfaction with hearing aids supports previous reports (Campos et al., 2014) and highlights the importance of addressing gaps in hearing aid skills and knowledge to obtain optimal rehabilitation outcomes. Where previous studies reported no association between hearing aid skills and participant gender (Campos et al., 2014; Desjardins & Doherty, 2009), the current study found HASKI-self scores of males to be significantly greater than the scores of females. Contributing factors may include males' superior spatial abilities (Voyer, Voyer, & Bryden, 1995) or female's predisposition to rate their health as poorer than men with the same health status (Waldron, 1983). The possible gender effect identified here warrant further investigation as it may inform how hearing aid skills should be taught to men and women.

Criterion validity was found to be moderate with hearing aid owners self-reporting more difficulties than clinicians observed. This disparity was greater for Hearing Aid Maintenance and Repairs than for Daily Hearing Aid Use. The observed difference in skills

may be due to the complexity of maintenance tasks (Bennett, Jayakody, Eikelboom, Taljaard, & Atlas, 2015b) or a by-product of the focus placed by clinicians on daily tasks, offering less training and advice on maintenance and repair tasks. Participants' tendency to over report hearing aid management difficulties was also observed in a pilot study comparing self-report hearing aid handling skills to clinician evaluation of skills (Bennett et al., 2017a). This pilot study suggested the discrepancy was possibly influenced by the involvement of self-efficacy in skill acquisition. That is, to self-perceive the ability to perform a task a person needs to not only have the skill, but also the confidence in their ability to complete the task; described as self-efficacy. Hickson et al. (2014) reported hearing aid self-efficacy to influence older adults' success with aural rehabilitation, specifically daily hours of hearing aid use and self-reported benefit from hearing aids. Therefore, the HASKI-self could play an important role in identifying not only competency, but also self-efficacy for hearing aid tasks. Arguably, the nature of the HASKI-self, being self-administered, does not allow for delineation of competency from self-efficacy. Thus, individuals with low self-efficacy may indicate low skill on the HASKI-self despite having adequate skill for certain tasks. When these individuals present to the clinic, the clinician can spend time on training (for skill deficiencies) or counselling and support (for areas for which the client has low self-efficacy). To evaluate only competency, one could use the HASKI-clin. To evaluate only self-efficacy, one could use the Measure of Audiologic Rehabilitation Self-efficacy for Hearing Aids MARS-HA (West & Smith, 2007).

Prevalence of hearing aid management skill and knowledge

The individual items of skill reported to have the greatest deficit by participants in this study included those relating to use and understanding of the hearing aid's volume

control, program control, telephone compatibility, and the questions relating to hearing aid cleaning, in line with previous clinical reports of hearing aid skills (Campos et al., 2014; Desjardins & Doherty, 2009). It is likely that these items were more problematic than the others as they tend to be more challenging to perform due to the small size of the features or the additional cognitive element of knowing when and how to use these features. For example, some of the tasks required for hearing aid cleaning can be difficult due to the small size and fragility of the pieces requiring replacing, such as microphone covers or wax guards (Bennett et al., 2015b). Less frequently performed tasks, such as use of customised programs or replacing the dome or microphone covers, appeared to be more problematic than the other items in the survey. Although comprehensive training may assist in reducing the high prevalence of hearing aid handling difficulties, for some users the size and design of the device is the obstacle (Bennett et al., 2015b). Hearing aid manufacturers may want to consider improving the design of their devices to improve the useability, especially for older populations with poorer dexterity and vision (Singh, Pichora-Fuller, Hayes, Schroeder, & Carnahan, 2013).

Participants reported difficulty not only with physical manipulation of the volume control and use of manual programs, but also with when and how to use it in different situations. Furthermore, almost 20% of the participants reported being unsure whether they had a volume control or access to programs with their current device. When setting up manually adjustable features for hearing aid owners (such as manually accessible programs), clinicians need to be sure that the feature is not only required, but that hearing aid owners understand how to use them appropriately. The HASKI surveys can assist by evaluating the hearing aid owners' knowledge and skills regarding their hearing aid.

Participants in this study reported on whether they were aware of individual items of knowledge relating to hearing aid management. Each item listed in this section of the survey was problematic for at least one participant. Participants most often identified as "I do not recall receiving this information" for items relating to the hearing aid battery and cochlear implants. While it is possible that hearing aid owners forgot some of the information provided by the clinic (Ferguson, Brandreth, Brassington, & Wharrad, 2015; Reese & Hnath-Chisolm, 2005), it is also possible that clinicians are not providing the necessary information to every patient they see (Bennett et al., 2018a). It is possible that information regarding the three items relating to the hearing aid battery (availability of rechargeable batteries; that the battery will drain following removal of the sticker irrespective of whether the battery is in use; and extension of battery life by waiting one minute following removal of the sticker before using the battery) are not often imparted to clients as clinicians assume that it is common knowledge, that they are unaware of the information themselves, or that they assume the client will read the battery packet to learn about its use. However, reliance on these assumptions is not ideal as consumers do not routinely read instructions, especially for products frequently used (Wright, Creighton, & Threlfall, 1982). Also, hearing aid owners often report wanting to be more informed about the devices they own and how to use them most effectively (Bennett et al., 2018a; Laplante-Lévesque, Hickson, & Worrall, 2010; Laplante-Lévesque, Jensen, Dawes, & Nielsen, 2013). Simultaneously though, they also report receiving too much information and that the information received is too technical (Bennett et al., 2018a; English, 2008). Information delivery in this setting is most commonly verbal, with little use of written or electronic supplemental materials (Kochkin et al., 2010). Hearing aid owners describe receiving little benefit from the written materials currently provided (Bennett, Meyer & Eikelboom, 2018b), most likely due to the the low quality and

poor readability of hearing aid user manuals (Caposecco, Hickson, & Meyer, 2014) and the high level of health literacy required to understand the content of written information concerning hearing aids (Brooke et al., 2012; Nair & Cienkowski, 2010). Furthermore, given the time constraints put on clinicians to deliver the large amount of information and training associated with hearing aid use, it is possible that clinicians make a judgement call and omit certain aspects of information for certain people (Bennett et al., 2018a). Thus, clinicians face a balancing act of managing the individual hearing aid owners preferred amount and technicality of information exchanged, their ability to understand and retain information, and the conflicting aspects of time management and clinical requirements for an appointment. The HASKI-self offers clinicians a novel alternative to hearing aid education. Clinicians can administer the HASKI-self towards the end of the rehabilitation program, allowing hearing aid owners to self-evaluate their level of skill and knowledge, and simultaneously learn these items of skill and knowledge through the detailed descriptions provided in the survey.

The fourth item of knowledge that participants were most often unaware of related to the benefits of cochlear implantation. While it is possible that clinicians only discuss implantable options with patients who they deem to be candidates, it has been suggested that in general, clinicians lack awareness of cochlear implant candidacy and often don't discuss cochlear implants as an option (Athalye, Mulla, & Archbold, 2014). Nonetheless, patients have expressed a desire for more information relating to their condition and thus clinicians may want to consider providing patients with information regarding all options relating to their hearing aids and beyond (Ong, De Haes, Hoos, & Lammes, 1995).

Clinical Implications

Surveys evaluating hearing aid management skills (including the HASKIs) are basic in design and some may question whether they are necessary in the clinical setting. Although clinicians currently provide hearing aid training as part of the rehabilitation program, clinical reports suggest that the level of handling skills demonstrated by hearing aid owners remains low (Bennett et al., 2017a; Campos et al., 2014; Desjardins & Doherty, 2009). This has led research groups to investigate alternative or supplemental training techniques, such as digital materials demonstrating how to perform hearing aid management tasks (Ferguson et al., 2015), and internet based training programs (Thorén, Öberg, Wänström et al. 2014). An improtant aspect of a training program is the evaluation of skill, specifically whether the hearing aid owner has learned the skills necessary for hearing aid use and management. Although clinician-administered surveys evaluating hearing aid management skill exist, they have been developed based on hearing aid user manuals or existing surveys and thus evaluate fewer items of skill than the HASKIs, which were developed using participatory methods. Furthermore, this is the first study to report levels of knowledge relating to hearing aid use, specifically whether hearing aid owners recall receiving the information from their hearing aid providers. Participants in this study reported and demonstrated a diverse range of skills and knowledge, highlighting the diverse competencies of hearing aid owners and the need for greater attention to be placed on hearing aid management training. In this way, the HASKI-self and HASKI-clin offer clinicians comprehensive evaluation of hearing aid management skills and knowledge.

The HASKI-self is the first self-administered survey evaluating hearing aid management skills and knowledge. It takes approximately 20 minutes to complete in a pen

and paper format and can be self-administered without requiring clinician input, thus reducing the clinician load. The variation in completion time reported by participants is likely due to manual dexterity, with those reporting longer completion times commenting on the difficulty their arthritis or Parkinson's causes them to complete paper surveys. It is possible that the length of the HASKI-self deterred some potential participants from completing the survey. However, those that did complete the survey often noted their gratitude for being provided the survey as it facilitated their learning. In the clinical setting, the HASKI-self could be completed by hearing aid owners prior to their appointments (either at home or in the waiting room) informing the clinician of possible areas of concern. The process of systematically evaluating whether a hearing aid owner possesses the skills and knowledge necessary for hearing aid management would normally be a time consuming exercise during a clinical appointment, and subsequently aspects of skill and knowledge important to the individual patient may be overlooked by the clinician (Bennett et al., 2018a). Thus the HASKI-self could be considered a time saving measure, as clinicians will no longer need to reiterate all aspects of hearing aid handling and management, but use the HASKI-self results as a guide, identifying those areas that require attention. Although the hearing aid owners would be required to spend additional time completing the survey themselves, it is ultimately time saving for them too, as deficiencies in skill and knowledge will be identified and addressed in a timelier manner.

Although the HASKI-clin was primarily developed to assist with validation of the HASKI-self, the high inter-observer reliability recorded support its use as a clinical tool evaluating hearing aid skills. The HASKI-clin is the most comprehensive clinician-administered survey evaluating hearing aid skills and thus may be preferred over existing surveys where clinicians want to ensure hearing aid owners have a thorough grasp on the

wide range of skills required for hearing aid use. Conversely, researchers may prefer a brief survey evaluating only the basic skills required for hearing aid use, such as the PHAST (Desjardins & Doherty, 2009). Although no randomised control trials exist demonstrating the clinical benefits of the PHAST, HIOC or HASKIs, a randomised intervention study involving cochlear implant users demonstrated that targeted training following identification of cochlear implant handling difficulties using client survey resulted in an improvement in skills, immediately and two weeks following (Bennett et al., 2015b). Thus, it is likely that provision of hearing aid training facilitated by client survey (such as the HASKI) may result in increased handling skills. The benefits of which have been suggested to include increased hearing aid use, benefit and satisfaction (Desjardins & Doherty, 2009; Campos et al., 2014; Kumar, Hickey, & Shaw, 2000).

Both versions of the HASKI offer additional clinical applications. For example, completing the HASKIs in the years following hearing aid acquisition may identify changes in hearing aid handling skills that may have arisen due to age-related changes in health status, such as those arising from reduced cognitive function (Pichora-Fuller & Singh, 2006), vision (Erber, 2003), or finger dexterity (Kumar et al., 2000; Singh et al., 2013). Another potential application may be to monitor hearing aid skills for patients receiving services from individual clinics or individual clinicians as a quality control measure. Managers could compare HASKI scores for hearing aid owners under the care of individual clinicians, or clinics against the data presented here to assist with setting performance goals in order to motivate staff to provide extensive and effective hearing aid training. Additionally, third party payers (such as Government bodies or insurance groups) may be interested in reports of hearing aid management skills to know that their financial contributions are achieving the best possible outcomes.

Limitations and future research

While the psychometric properties of the HASKIs were evaluated on a large and diverse multicentre sample of hearing aid owners, all participants were adult hearing aid owners from Australia and thus psychometric performance of the HASKI in other settings is unknown. Additionally, 96% of participants self-reported using their hearing aids for more than one hour per day. It would be interesting to survey hearing aid non-users to investigate whether low hearing aid handling skills influenced their decision to reject their hearing aids. Responsiveness of the HASKI to intervention (such as retraining) was not established in this study, thus it is difficult to determine what change in score would be considered sufficient to indicate clinical improvement in knowledge and skill, or whether the HASKI is sensitive enough to detect such changes. Future research investigating the responsiveness of the HASKIs may identify the minimal clinically important difference, described as the smallest change in survey score that an individual patient would identify as important and which would require a change in the patient's management (Fitzpatrick et al., 1998; Juniper, Guyatt, Willan, & Griffith, 1994). Participants' cognitive function was not evaluated in this study, so we are unable to determine whether all participants were able to complete the survey accurately. Investigations into whether baseline cognitive function affects hearing aid management skills and knowledge, or ability to complete the HASKIs would be useful for the clinical application of the HASKIs. Evaluation of the psychometric properties of the HASKI-clin with a larger sample would allow investigation into factors associated with HASKI-clin scores. Despite these limitations, the findings of this study suggest that the HASKIs show promise as valid and reliable measures to quantify hearing aid management skills and knowledge.

CONCLUSIONS

The finding that 99% of participants in this study reported difficulty with some aspect of hearing aid management skill or knowledge and that on average participants reported difficulty with one third of the items suggests that the informational and training needs of hearing aid owners are not being met by current clinical practices. The HASKIs are the most extensive clinical surveys currently available to evaluate the skills and knowledge required for hearing aid management. The psychometric evaluations presented in this study demonstrate that the HASKIs are valid and reliable tools for hearing aid management evaluation. Clinical use of the HASKIs have the potential to improve hearing aid fitting outcomes, specifically hearing aid use, benefit and satisfaction.

The HASKI-self and HASKI-clin are freely available and can be downloaded from www.earscience.org.au/research/clinical-research

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