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Factors associated with hearing aid fitting outcomes on the IOI-HA

Abstract

A hallmark of quality clinical practice in audiology should be the ongoing measurement of outcomes in order to improve practice. The aims of this study were to describe outcomes for a large sample of clients fitted with hearing aids and to investigate factors associated with mean IOI-HA scores, with a view to providing guidance about factors that warrant particular attention in the clinic in order to improve outcomes. Measures used were the international outcome inventory – hearing aids (IOI-HA; Cox & Alexander, 2002) and a series of questions about satisfaction with hearing aid performance in different listening situations, hearing aid attributes, and clinical service. The participant sample consisted of 1653 adults, most often fitted bilaterally (78%); 81% had digital aids with at least two listening programs. Results of the regression analysis indicated that there were a number of significant factors that, in total, explained 57% of the variance in IOI-HA scores. Higher mean IOI-HA scores were most strongly associated with greater satisfaction with hearing aid attributes of aid fit/comfort, clarity of tone and sound, and comfort with loud sounds and with satisfaction in the listening situations of conversation with one person, in small groups, in large groups, and outdoors. These findings highlight the importance of focusing rehabilitation on improving satisfaction with aided listening across a range of environments and with key attributes of hearing aid performance.

Sumario

El sello de calidad de la práctica clínica audiológica debería ser la medición continuada de los resultados para poder mejorar la práctica. Los objetivos de este estudio fueron describir los resultados de una amplia muestra de clientes adaptados con un auxiliar auditivo e investigar los factores asociados con puntuaciones IOI-HA promedio, con la intención de proporcionar una guía sobre los factores que justifican la atención particular en la clínica para mejorar los resultados. Las mediciones utilizadas fueron el inventario internacional de resultados – auxiliares auditivos (IOI-HA; Cox & Alexander, 2002) y una serie de preguntas sobre satisfacción con el desempeño del auxiliar auditivo en diferentes situaciones auditivas, los atributos del auxiliar y el servicio clínico. La muestra de participantes consistió en 1653 adultos, en su mayoría con auxiliares auditivos bilaterales (78%); 81% tenían auxiliares digitales con al menos dos programas. Los resultados del análisis de regresión indicaron que hubo un número de factores significativos que en total explicaban el 57% de la varianza en los resultados de IOI-HA. Los resultados del IOI-HA altos en promedio estuvieron estrechamente asociados con una mayor satisfacción con los atributos del auxiliar auditivo como adaptación/confort y claridad del tono y sonido y confort con sonidos elevados y con la satisfacción en las situaciones de escucha de conversaciones con una persona, en grupos pequeños, en grupos grades y en el exterior. Estos hallazgos remarcan la importancia de enfocar la rehabilitación hacia el mejoramiento de la satisfacción con la audición asistida a través de un rango de ambientes y con los atributos clave del desempeño de los auxiliares auditivos.

Key Words

Hearing aid; outcome measures; IOI-HA; adults; hearing impairment; satisfaction; self-report

Abbreviations

APHAB: Abbreviated profile of hearing aid benefit
COSI: Client-oriented scale of improvement
HHQ: Hearing handicap questionnaire
IOI-HA: International outcome inventory – hearing aids
OLS: Ordinary least-square
SADL: Satisfaction with amplification in daily life
SSQ: Speech, spatial and qualities of hearing scale

Outcome measurement is a central tenet of quality assurance in the health care sector. It has been asserted that 'Health professionals need to be able to demonstrate, to both the community and resource providers, that the services they provide have a positive impact on their clients' functional status and quality of life' (Uriarte et al, 2005). Thus, outcome measures have the potential benefit of allowing clinicians to show that the intervention works. However, the application of outcomes measurement is not limited to this and Bec k (2000) points out the important role of such measures in improving clinical processes. A clinic that regularly measures outcomes can identify areas that require improvement, establish performance benchmarks, monitor performance over time, and assess the impact of system change.

In audiology, a number of self-report outcomes tools have been developed to facilitate this process. Different measures assess different outcomes. For example, client satisfaction can be assessed using the satisfaction with amplification in daily life (SADL; Cox & Alexander, 2001); benefit from hearing aids can be assessed using the abbreviated profile of hearing aid benefit (APHAB; Cox & Alexander, 1995); changes in relation to individual client goals can be assessed with the client-oriented scale of improvement (COSI; Dillon et al, 1997); and changes in the functional effects of hearing impairment can be assessed using the hearing handicap questionnaire (HHQ; Noble & Gatehouse, 2004). There are also measures that assess more than one type of outcome, named multi-dimensional measures, and the most well-known of these is the international outcome inventory – hearing aids (IOI-HA; Cox et al, 2000).

The IOI-HA is a questionnaire consisting of seven items which address the main dimensions of fitting outcome: (1) hearing aid usage, (2) benefit, (3) residual activity limitations, (4) satisfaction, (5) residual participation restrictions, (6) impact on others, and (7) quality of life. Each of the items has a five-point response scale and it is possible to calculate a total mean score for the measure, with higher scores reflective of more positive outcomes. An advantage of the IOI-HA is that there are a number of publications that have described results for large samples of clients ($n>150$) (Cox & Alexander, 2002; Cox et al, 2003; Heuermann et al, 2005; Kramer

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et al, 2002; Oberg et al, 2007) and it is therefore possible to compare outcomes with published reports. The present paper makes a contribution to this body of literature by presenting IOI-HA results for a large sample of adult clients fitted with hearing aids in private clinics in Australia.

A limitation of the IOI-HA is that it does not provide specific information about performance in different listening situations nor about satisfaction with particular aspects of the hearing aid or the hearing service provided. The outcomes measurement used in the present study is called EARtrak and it includes these dimensions, in addition to the IOI-HA. It was developed by a team of private practitioners based on the MarkeTrak survey (Kochkin, 2000a, 2005) and was aimed at obtaining the most practically useful clinical information.

If the measurement of outcome is part of the quality improvement process, then the aim of taking such measures must surely be to develop ways to improve outcomes for clients. We felt that a better understanding of factors that influence outcomes would help achieve this aim. Therefore, in the present study, we examined the possible influence of the following variables on IOI-HA scores: client age, gender, new versus return clients, funding source for amplification, hearing loss configuration, fitting (unilateral/bilateral), style of hearing aid, level of microphone technology fitted, degree of satisfaction with listening in different environments, and satisfaction with different hearing aid attributes. Previous research has considered a range of variables. In a sample of 505 adults, Kramer et al (2002) reported that higher IOI-HA scores were associated with participants having a longer duration of hearing loss and with being fitted bilaterally (compared to unilaterally). Age, gender, and living situation had no effect. Stephens (2002) examined the effect of demographic variables on each item of the IOI-HA in 161 adults and found that aid usage (item 1) was higher in younger people, in those who had previously had a hearing aid, and in those with bilateral aids rather than unilateral. He also reported that younger people reported greater benefit from hearing aids (item 2). Other non-significant variables were gender, social class, better or worse ear hearing levels, and the number of post-fitting visits the client attended. More recently, Heuermann et al (2005) investigated factors associated with IOI-HA outcomes in 466 adults and found no significant effects of age, gender, average hearing loss, bilateral versus unilateral fitting, or new versus return clients. Thus, the research to date has yielded somewhat conflicting results about factors that influence outcome. The present study provided an opportunity to further explore a broader range of possible factors with a larger sample than previously examined. In summary, the aims of this research were (1) to describe the outcomes of hearing aid fitting for a large sample of clients fitted in private practice settings in Australia, and (2) to investigate factors that significantly influence IOI-HA outcomes.

Method

Participants

Between April 2005 and December 2007, the EARtrak survey was sent to 2968 people, and 1653 responses were returned (response rate = 55.7%). There were no significant differences between responders and non-responders with respect to gender, and although there were some differences in the proportions of responders and non-responders in specific age categories, there was no consistent trend in terms of age. The 1653 participants were from 15 different private clinics around Australia, and the number of participants from each clinic varied from 24 to 297. The majority of participants (59%) were male, and all were aged over 20 years. The age of each participant was recorded in 10-year age groupings and the distribution for males and females is shown in Figure 1. Sixty-nine per cent of participants were aged between 50 and 79 years, with only 7% less than 50, and 22% aged 80 years or older. There were more males in the 50 to 79 year age group and more females in age groups over 80 years.

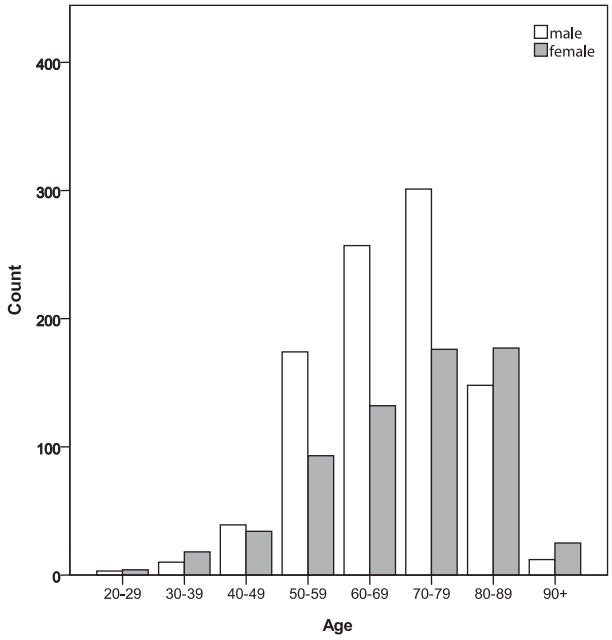

Figure 1. Number of participants by age and gender.

The audiogram in each ear was classified as one of eight different types (see Figure 2), based on a schema originally suggested by Doyle (1998). Nature of the hearing loss was not recorded. Audiogram types 1 and 2, indicating a sloping mild to moderate/severe hearing impairment, were the most common. These two patterns occurred in 57% of right and left ear audiograms. The next most common pattern was type 3, consistent with a severe loss, occurring in 13% of cases. A limitation of the data is that not all clinicians who completed the client information form entered the audiogram type for both ears. Thus, 12% of right audiograms and 11% of left audiograms were not classified. Examination of the data indicated that these omissions almost always occurred in cases of unilateral fitting, where the audiogram type was recorded only for the ear fitted.

In the 1262 cases where audiogram types were recorded for both ears, the same pattern was evident in both ears in 1160 cases, indicating that 92% had essentially symmetrical hearing loss. The most common pattern was bilateral type 1 audiograms (sloping mild to severe) in 32% of participants, and bilateral type 2 audiograms (sloping mild to moderate) in 30% of cases.

About half of the participants were new clients (48%), and 51% were return clients (i.e. they had previously been fitted with hearing aid/s). Approximately half of the clients (52%) were private and paid for hearing services and hearing aids with their own funds or with a combination of their own funds and private health insurance funds. Twenty-seven per cent received fully subsidized hearing services and devices from the Australian Government's Office of

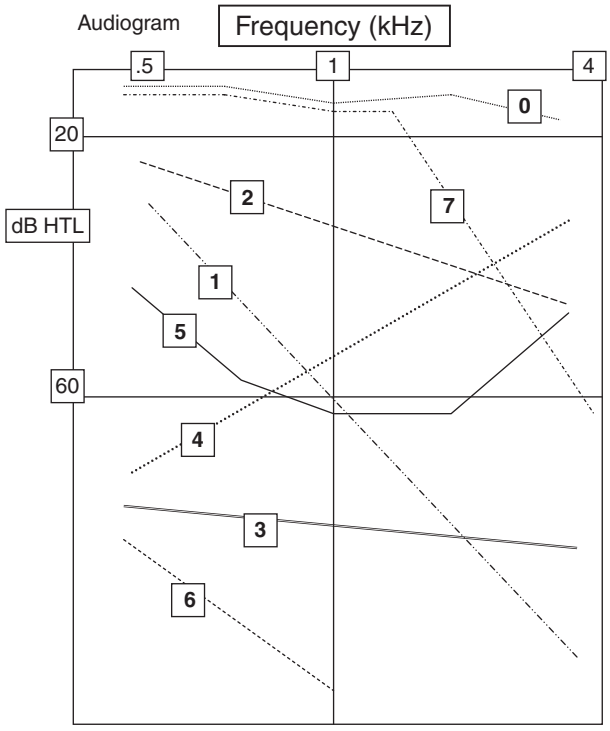

Figure 2. Audiogram types classified by audiologist for each participant sent the EARtrak survey.

Hearing Services, and a further 11% were partially subsidized by this government agency. This latter group of clients paid a 'top-up' amount to the practice for hearing devices with a higher level of technology (e.g. completely-in-the-canal aid, additional listening programs, remote control). The remaining 8% received fully subsidized services through workers' compensation.

The majority of fittings were bilateral (78%), with 22% unilateral and a small number of BICROS fittings (n = 14). A total of 2949 hearing aids were fitted to the 1653 participants. The majority of aids (81%) were digital devices with at least two listening programs. Of the remaining aids, 18% were single program digital devices, and less than 1% were analog aids. The majority of aids (72%) had dual microphones. Behind-the-ear aids (including open fittings which were not identified separately) were the most common, accounting for 67% of all devices, followed by in-the-canal aids (13%), in-the-ear aids (12%) and completely-in-the-canal aids (7%). Thus, the most common fitting was bilateral behind-the-ear digital hearing aids with dual microphones and two or more listening programs.

Materials

The EARtrak survey of client opinion consists of the following:

- the seven items of the IOI-HA
- an item asking participants to rate their overall satisfaction with hearing aids on a five-point response scale from very dissatisfied to very satisfied
- two items asking if the client would recommend hearing aids to a friend or family member or the hearing service provider to family and friends . These items have three response options: no, not sure, or yes.
- a rating of 11 different listening situations (e.g. in small groups, in a car) and their satisfaction with the hearing aids in each of these situations. There is a five point response scale from very dissatisfied to very satisfied, however the client also has the option of responding that a situation is not relevant.
- a rating of 12 different hearing aid attributes (e.g. comfort, battery life), with the same response options as the items about listening situations.
- a rating of seven different aspects of service delivery (e.g. professionalism of clinician, explanations given). The five point response scale from very dissatisfied to very satisfied was used.

In addition to the closed response items described above, the EARtrak survey includes a space for open-ended comments and the client can indicate if they would like to be contacted by the clinic that provided their hearing services. Results for the closed response items only are described in this paper. The full EARtrak survey is available online at www.eartrak.com

Procedure

At six months post hearing aid fitting, the clinician mailed the EARtrak survey to the client. The client was assured of the confidentiality of the data and was asked to return the surveys to the independent analyst (EARtrak) in a reply paid envelope. At the same time, the clinician forwarded data describing the client (age, gender, funding source, hearing loss), the fitting (bilateral/unilateral, new/replacement), and the hearing aid (style, technology, manufacturer, and model) to EARtrak. The client data from the survey and the demographic/hearing aid information provided by the clinician were linked by a number unique to each client and the clinic.

Data analysis

All data were entered into a spreadsheet and analysed using STATA release 10 (StataCorp, 2007). Descriptive statistics were used to show frequency and percentage responses to the questionnaire items. Multiple regression analysis was used to investigate factors associated with mean IOI-HA score. Of the 1653 participants, we excluded 25 participants with different styles of aids in each ear (e.g. behind-the-ear aid in one ear and in-the canal aid in the other), and 53 participants because they had not completed all items of the IOI-HA. Thus, the regression analysis was based on data from 1575 participants. The variables and their groups were:

- Age (five groups): < 50, 50–59, 60–69, 70–79, 80+ years
- Gender (two groups): male, female
- Fitting status (two groups): new client, return client
- Funding source (three groups): fully subsidized hearing aids (i.e. through the Office of Hearing Services or workers' compensation), partially subsidized hearing aids (i.e. Office of Hearing Services payment plus top-up payment by the client), privately funded hearing aids (although client may receive some rebate from their private health insurance fund).
- Audiogram (four groups): mild to moderate loss (i.e. types 0, 2, and/or 7 in both ears); mild to severe loss (i.e. type 1 in both ears, or type 1 in one ear and type 2 or 7 in the other ear); rising loss (i.e. type 4 or

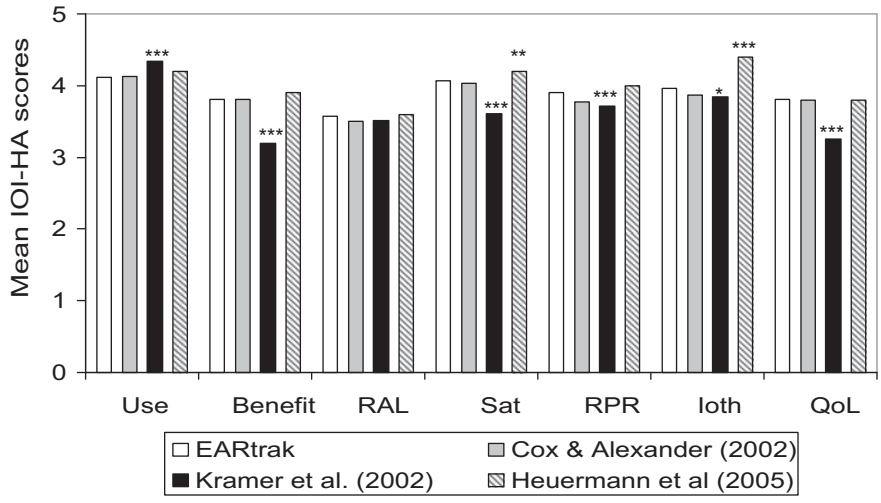

Figure 3. Comparison of mean item scores for the IOI-HA in the present study with other IOI-HA results.

5 in both ears, or type 4 or 5 in one ear and types 0, 1, 2, or 7 in the other ear); severe to profound (i.e. types 3 or 6 in either ear).
- Fitting (two groups): unilateral, bilateral
- Style of hearing aid (two groups): behind-the-ear aids, and custom moulded hearing aids (in-the-ear, in-the-canal, or completely-in-the canal aids). As stated above, 25 participants were excluded as they had different styles of aids in each ear.
- Microphone technology (two groups): single microphones in one or both ears, two or three microphones in at least one ear.
- Listening situation satisfaction: results on seven of the 11 items of the questionnaire were included as variables. These situations were chosen as we considered them to be reflective of a broad range of listening situations and the most relevant to the study sample. The seven selected items were: conversation with one person, conversation in small groups, conversation in large groups, outdoors, concert/movie, watching TV, and telephone. Responses were classified into three groups for the regression analysis: very dissatisfied/dissatisfied/neutral, satisfied, and very satisfied.
- Hearing aid attribute satisfaction: a selection of six variables, reflective of key issues in hearing aid fitting, were chosen from the total of 12. These were overall fit/comfort, visibility of aid, clarity of tone and sound, sound of own voice, comfort with loud sounds, and whistling/feedback/buzzing. Responses were classified into three groups: very dissatisfied/dissatisfied/neutral, satisfied, and very satisfied.

Consideration was given to including satisfaction with the hearing service provider in the regression analysis, however responses were uniformly high and there was insufficient range in the response options for their inclusion.

Results

Outcomes

The mean score for the seven item IOI-HA was 3.91 (SD=.65; Range=1.29 to 5). Mean scores for each item of the IOI-HA are presented in Figure 3 along with mean scores from Cox and Alexander (2002) in the USA, Kramer et al (2002) in the Netherlands, Heuermann et al (2005) in Germany. Cox and Alexander reported a response rate of 73% and their group consisted of 172 adults (Mean age=72 years; 42% female) fitted with hearing aids over a two-year period. Kramer et al reported on a larger sample of 505 adults (Mean age=64 years; 45% female) and had a response rate of 51%. Heuermann et al had a much lower response rate of 24% and studied 488 people (Mean age=72 years; 49% female). Gender and age distributions are similar across studies with the exception of Kramer et al's group who were younger on average. Results were not compared with those of Oberg et al (2007) in Sweden as that research was limited to 162 adults, all of whom were first time aid users, which is substantially different to the samples in the other studies which included new and return clients. Unequal variance t-tests revealed no significant differences between mean item values in the present study and those obtained by Cox and Alexander with the English version of the IOI-HA. There were significant differences between this study and that of Kramer et al on six of the seven items. Reported hours of use (item 1) was significantly better in the sample from the Netherlands, however, items 2, 4, 5, 6, and 7 mean scores were significantly lower than those found in the present study. The German sample from Heuermann et al had significantly higher average scores for satisfaction (item 4) and impact on others (item 6).

Figure 4 shows the distribution of scores for each IOI-HA item. For items 1 (aid use) and 4 (satisfaction), the highest score of 5 was the most frequently selected. For the remaining items, 4 was the most common score. The lowest score of 1 was used by less than 4% of participants for all items.

In response to the question, 'Overall, how satisfied are you with your hearing aid(s)?' The majority were either satisfied (48%) or very satisfied (30%), 15% were neutral, 6% were dissatisfied, and 1% very dissatisfied. Eighty-eight per cent of participants said they would recommend hearing aids to a friend or family member with a hearing problem; 10% were unsure, and 2% said no. Participants were very positive about the hearing service provider, with 92% responding that they would recommend them to a friend or relative with a hearing problem. Only 2% said they would not recommend the provider and 6% were unsure.

Table 1 summarizes satisfaction scores for the 11 different listening situations in the EARtrak survey. The most common score

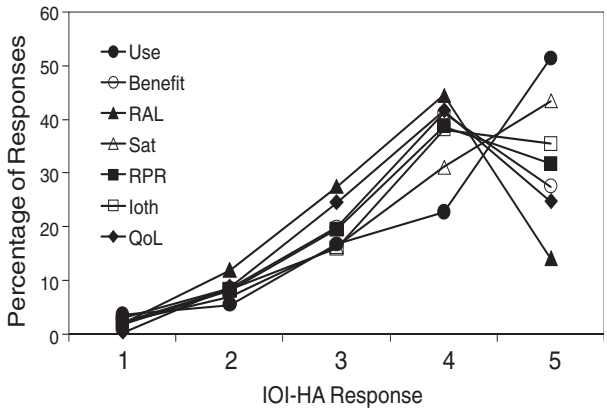

Figure 4. Distribution of responses for IOI-HA items. RAL: Residual activity limitations; Sat: Satisfaction; RPR: Residual participation restriction; Ioth: Impact on others; QoL: Quality of life.

to the item on listening in large groups was neutral; however for all other items the most common response was satisfied. Examination of the percentage of participants who responded very dissatisfied, dissatisfied, or neutral to each item, revealed the four listening situations that participants were least satisfied with. In order, beginning with the worst, these were: (1) listening in large groups, (2) in the workplace, (3) in restaurants, (4) on the telephone. Less than half of respondents were satisfied in these situations.

Table 2 summarizes the satisfaction scores for 12 hearing aid attributes. Again, the most common score was satisfied, however some areas of dissatisfaction were evident. For example, 23% of participants said they were dissatisfied with loud sounds and only 50% were satisfied. Other items with low satisfaction scores were: ease of adjusting the volume control (60% satisfied), whistling/feedback or buzzing (55% satisfied), and ability to locate sounds (57% satisfied). Highest satisfaction scores were obtained for overall fit/comfort of the hearing aid/s and reliability.

Table 3 shows the distribution of scores to the seven items about the hearing service provider. Very high levels of satisfaction were reported for all items with very satisfied the most common score.

Factors associated with mean IOI-HA score

The mean IOI-HA score and its relationship to demographic/hearing aid variables and satisfaction with listening situations and hearing aid attributes was analysed using multiple regression. An exploratory analysis of the mean IOI-HA data distribution identified seven outliers. Approximate normality of the distribution of IOI-HA scores was ensured by removing those outliers. Before running the regression model, multi-collinearity was examined with no potential predictor associated with another one at an alarming level. To accommodate categorical variables (with more than two categories) in the regression model, appropriate dummy variables were created for each category of the potential predictive variables. For example, satisfaction about fit/comfort with the hearing aid (question 13 from the EARTrak survey, coded as q13a in the data set) was measured using three recoded categories: (1) very dissatisfied/ dissatisfied/ neutral, (2) satisfied, and (3) very satisfied. Considering the first category (1) as a reference group, two dummy variables were created: (i) q13a_2 equals 1 if q13a = 2 and 0 otherwise, (ii) q13a_3 equals 1 if q13a = 3 and 0 otherwise. The initial regression model was run with the six hearing aid satisfaction items, the seven listening situation satisfaction items, and the eight demographic/hearing-aid factors detailed in the data analysis section.

A stepwise regression algorithm was used to develop the first model, and there were six satisfaction items and four demographic/hearing-aid factors significantly associated with IOI-HA scores. In the ordinary least-square (OLS) regression model with only significant items, the overall relationship was significant ($F_{24,1035} = 48.84$, $p < 0.0001$) and the fitted model explained about 52% of the total variability in the IOI-HA scores ($R^2_{adj} = 0.5202$). At this stage, we examined regression diagnostics of the fitted model. Multivariate outliers were identified using Cook's D with the conventional cut-

Table 1. Distribution of responses to the items asking how satisfied participants were with their current hearing aid(s) in a range of different situations. The most prevalent response to each item is highlighted in bold.

		Percentage of respondents in each category					
Listening situation	*Total number of respondents*	*Very satisfied*	*Satisfied*	*Neutral*	*Dissatisfied*	*Very dissatisfied*	*Not relevant*
Conversation with one person*	1612	36.4	**48.5**	9.4	2.5	0.7	2.5
In small groups*	1604	16.9	**49.8**	21.5	8.2	2.4	1.2
In large groups*	1598	6.5	27.0	**30.0**	24.9	9.4	2.2
Outdoors*	1581	15.4	**49.6**	23.6	6.3	1.8	3.2
Concert/movie*	1522	15.2	**41.3**	21.3	7.8	4.0	10.4
Church/lectures	1488	13.1	**38.5**	22.0	9.0	3.6	13.8
Watching TV*	1597	23.6	**47.3**	15.3	8.7	2.8	2.3
In a car	1582	12.4	**45.4**	25.3	10.7	2.6	3.6
Workplace	1329	10.9	**32.5**	18.4	4.1	1.4	32.8
Telephone*	1566	10.5	**33.8**	25.5	14.3	8.3	7.5
Restaurant	1544	7.4	**35.8**	27.8	17.9	6.6	4.4

*Listening situation included in regression analysis.

Table 2. Distribution of responses to the items asking how satisfied participants were with attributes of the hearing aid. The most prevalent response to each item is highlighted in bold.

		Percentage of respondents in each category					
Hearing aid attribute	*Total number of respondents*	*Very satisfied*	*Satisfied*	*Neutral*	*Dissatisfied*	*Very dissatisfied*	*Not relevant*
Overall fit/comfort*	1598	32.0	**51.1**	9.7	5.9	1.3	0.1
Ease of adjusting volume control	1439	22.8	**36.9**	17.7	6.8	2.4	13.3
Visibility of hearing aid*	1588	29.5	**48.0**	17.1	3.5	0.6	1.3
Frequency of cleaning required	1569	20.1	**57.3**	17.4	4.0	0.6	0.6
Ongoing expense	1553	26.1	**47.1**	17.8	4.2	0.8	4.0
Battery life	1576	20.4	**48.5**	19.8	8.6	1.8	0.8
Reliability	1569	31.2	**53.0**	10.6	2.6	1.1	0.5
Clarity of tone and sound*	1581	21.4	**51.4**	18.9	6.6	1.5	0.2
Sound of own voice*	1581	19.7	**50.5**	21.5	5.8	1.6	0.9
Ability to tell location of sounds	1572	12.6	**44.5**	28.7	10.7	3.1	0.4
Comfort with loud sounds*	1581	10.8	**39.1**	27.3	17.6	4.6	0.6
Whistling/feedback/buzzing*	1581	18.2	**36.4**	25.2	13.7	4.4	2.1

*Hearing aid attribute included in regression analysis.

off point of 4/n. We reran the regression model without the multivariate outliers and this new model explained about 56% of the total variability ($R^2_{adj} = 0.5559$). The residuals of the revised model were found to be approximately normally distributed and degrees of collinearity, examined by the variance inflation factor, were within the admissible limits of 5.0. However, the assumption of homoscedasticity or constant variance was violated (Breusch-Pagan/Cook-Weisberg test: $chi^2(1) = 52.31$, $p < 0.0001$). This meant that the OLS estimates were still unbiased and consistent, but no longer had minimum variance and were not efficient. Using these estimates in hypothesis testing may lead to wrong conclusions. This concern of heteroscedasticity was addressed by using Huber-White sandwich estimates of robust standard errors (SEs) of the regression coefficients (Chen et al, 2003). In addition, to deal with heteroscedasticity, such robust SEs may effectively deal with minor problems of normality. This revised regression model with robust SEs was found to be significant ($F_{24,1021} = 59.86$, $p < 0.0001$) and explained 57% of the variability.

The final regression model with factors significantly associated with the average IOI-HA scores is presented in Table 4. In general, the satisfaction with listening situations and hearing aid attributes had greater effects on IOI-HA scores than the demographic/hearing aid factors. Satisfaction with the hearing aid fit/comfort, clarity, and loud sounds were significantly and positively associated with IOI-HA scores when other variables held constant. The extent of the association is evident from the regression coefficient in Table 4. As an example of how to interpret this result, the adjusted regression coefficient of $\beta_{Fit/comfort} = 0.1635$ ($p < 0.0001$) indicates that the expected IOI-HA average score for participants who reported being 'very satisfied' with fit/comfort of the hearing aid was 0.16 units higher than the average score of participants who were 'very dissatisfied, dissatisfied, or neutral' with fit/comfort. The hearing aid attribute that had the greatest effect on IOI-HA scores was 'clarity of tone or sound'. The expected IOI-HA average score for participants who reported being 'very satisfied' with clarity of the aid was 0.32 units higher than the average score of participants who were 'very dissatisfied, dissatisfied, or neutral'.

All of the seven listening situation satisfaction items included in the analysis were significantly associated with IOI-HA scores. These

Table 3. Distribution of responses to the items asking how satisfied participants were with features of the hearing service provider. The most prevalent response to each item is highlighted in bold.

		Percentage of respondents in each category				
Hearing service provider feature	*Total number of respondents*	*Very satisfied*	*Satisfied*	*Neutral*	*Dissatisfied*	*Very dissatisfied*
Professionalism of clinician	1611	**74.5**	23.0	1.7	0.3	0.5
Friendliness of staff	1623	**78.3**	20.1	1.1	0.1	0.4
Patience of clinician	1608	**76.8**	21.6	1.1	0.2	0.3
Explanations given to you	1617	**69.1**	27.4	2.5	0.7	0.4
Amount of time spent with you	1613	**72.7**	25.4	1.3	0.2	0.4
Cleanliness and appearance of the office	1619	**74.7**	23.2	1.5	0.2	0.3
Quality of service after purchase	1595	**70.9**	24.1	4.1	0.5	0.3

Table 4. Factors associated with IOI-HA scores using multiple regression.

Variables	*Regression coefficient*	*Robust Standard error*	*t-value*	*p-value*
Satisfaction with hearing aid attributes:				
Aid fit/comfort[#]				
Satisfied	0.0893	0.0438	2.04	0.042
Very satisfied	0.1635	0.0465	3.52	<0.0001
Aid clarity of tone and sound[#]				
Satisfied	0.1898	0.0371	5.12	<0.0001
Very satisfied	0.3255	0.0492	6.61	<0.0001
Aid comfort with loud sound[#]				
Satisfied	0.0915	0.0287	3.18	0.001
Very satisfied	0.1614	0.0443	3.65	0.0001
Satisfaction with listening situations:				
Conversation with one person[#]				
Satisfied	0.1537	0.0537	2.86	0.004
Very satisfied	0.2864	0.0599	4.78	<0.0001
In small groups[#]				
Satisfied	0.1760	0.0397	4.43	<0.0001
Very satisfied	0.2030	0.0563	3.61	<0.0001
In large groups[#]				
Satisfied	0.0949	0.0322	2.94	0.003
Very satisfied	0.1698	0.0579	2.93	0.003
Outdoors[#]				
Satisfied	0.1871	0.0345	5.43	<0.0001
Very satisfied	0.2302	0.0484	4.76	<0.0001
Movie/concert[#]				
Satisfied	0.0666	0.0317	2.1	0.036
Very satisfied	0.0793	0.0460	1.72	0.085
Watching TV[#]				
Satisfied	0.0888	0.0367	2.42	0.016
Very satisfied	0.1410	0.0452	3.12	0.002
Telephone[#]				
Satisfied	0.0593	0.0278	2.13	0.034
Very satisfied	0.0973	0.0422	2.31	0.021
Audiogram[1]				
Type 1 bilateral or type 1 with types 2,7	−0.0471	0.0301	−1.56	0.118
Type 4 or 5 in either ear	−0.0354	0.0434	−0.81	0.415
Type 3 or 6 in either ear	0.0940	0.0360	2.61	0.009
Fitting status group[2]				
Return group	0.1187	0.0257	4.61	<0.0001
Constant	2.9586	0.0575	51.43	<0.0001

[#]'Very dissatisfied/dissatisfied/neutral'.
[1]Type 0,2 7 only in one or both ears.
[2]New fitting.

were: satisfaction with conversation with one person, in small groups, in large groups, outdoors, movie/concert, watching TV, and workplace. Strongest effects with p values of .003 or less were evident for the following situations: conversation with one person, in small groups, in large groups and outdoors. The strongest effect was evident for satisfaction with conversation with one person. After adjusting for the effects of other significant factors, the expected IOI-HA average score for participants who reported being 'very satisfied' in conversation with one person was 0.29 units higher than the average score of participants who reported being 'very dissatisfied, dissatisfied, or neutral'. Similarly, participants who reported being 'very satisfied' with outdoor listening had 0.23 unit higher average in IOI-HA average score than their counterparts who were 'very dissatisfied, dissatisfied, or neutral'.

Only two of the eight demographic/hearing aid factors were found to make a significant contribution in the regression analysis. These were audiogram type and fitting status (new versus return clients). Having a type 3 or 6 audiogram in either ear (see Figure 2), indicative of a severe to profound hearing loss, was significantly and positively associated with average IOI-HA scores ($p = 0.009$). Compared to first time hearing aid users, the return clients had 0.12 unit higher IOI-HA score on an average ($p < 0.0001$).

Discussion

The first aim of this study was to describe the outcomes of hearing aid fitting for a large sample of clients fitted in private clinics in Australia. There were no significant differences between IOI-HA results obtained here and those obtained previously by Cox and Alexander (2002) using the English version of the assessment (see Figure 3). Some differences were evident in comparison to results from the Netherlands (Kramer et al, 2002) and Germany (Heuermann et al, 2005) and the reasons for this are not clear. There were some differences in the nature of the populations tested, the response rates, and also there were differences in the measure itself, as both were translated versions. In addition, there are differences in hearing health care delivery systems in different countries. The findings obtained here suggest the need for normative data for different populations and/or for different translations of the IOI-HA.

In addition to the IOI-HA, outcomes were measured using a range of satisfaction items similar to those used in MarkeTrak. These items covered (1) general satisfaction, (2) satisfaction in specific listening situations, (3) satisfaction with hearing aid attributes, and (4) satisfaction with aspects of service. Test-retest reliability of the single items in each of these categories was not evaluated. As each item assesses a particular aspect of the experience of hearing aid fitting, rather than psychological constructs, it is likely that the items are unidimensional and, in this context, testing single-item reliability is less relevant. Nevertheless, it may be valuable in future research to investigate test-retest reliability of the individual items.

First, 78% of participants were either satisfied or very satisfied with their hearing aid(s), a result that is in the mid-range of reported satisfaction when compared with other published reports using the same question. Published figures of hearing aid satisfaction range from 68% to 92% (Bille et al, 1999; Cox & Alexander, 2001; Hickson et al, 1999; Parving, 2003; Spitzer, 1998) with the most recent large scale study by Kochkin (2005) reporting that 71% of 1511 respondents were somewhat satisfied, satisfied, or very satisfied. Only 49% of respondents in Kochkin's study were satisfied or very satisfied, but this difference with the present study may have occurred because of the seven-point response scale he used rather than the five-point response scale employed here. It is possible however that it reflects actual lower satisfaction levels, a possibility that is supported by the fact that only 79% of participants in Kochkin's survey said they would recommend a hearing aid to a friend, compared to 92% in the present study.

Second, examination of the satisfaction ratings for the different listening situations showed that participants were generally satisfied with performance, with the exception of listening in large groups where only 34% were either very satisfied or satisfied. This was the listening situation with the lowest satisfaction, and Kochkin (2005) reported a very similar result of 37% of respondents satisfied with hearing aid performance when listening in large groups. This is despite the vast majority of participants in the present study having amplification that is designed to assist them in such environments, that is, bilateral digital hearing aids with multiple microphone technology and more than one listening program (Dillon, 2001; Preves, 2000). Although Kochkin's (2005) study included a similar proportion of bilateral hearing aid users (i.e. 74% compared to 78% in the present study), there were reported differences in other hearing aid attributes. Only 47% of Kochkin's group were reported as having digital devices (compared to 81% here) and only 25% had directional microphones (compared to 72% here). The fact that Kochkin's participants reported similar levels of satisfaction in large groups to our sample is therefore surprising, although there is a question over the validity of the descriptions of hearing-aid features in that study which may explain this. In the present study, clinicians reported on the hearing aid details, whereas Kochkin relied on participant report which is highly likely to be less accurate. However, regardless of such comparisons, the results do highlight that participants continue to be very dissatisfied with the performance on their hearing aid(s) in large groups and this is an area that warrants greater attention. Only 2% of participants said this situation was not relevant to them, indicating that almost all of them find themselves in this situation and the majority experience difficulty. Ways to address this include providing education about the specific features of their hearing aids that may help them in large group situations (e.g. directional microphones, alternate listening programs), the use of hearing assistance technology, and counselling and communication education to enable the use of appropriate communication strategies in this environment.

Third, the ratings of satisfaction with hearing aid attributes revealed some problematic issues. The attributes with the lowest levels of satisfaction were comfort with loud sounds, ease of adjusting volume control, whistling/feedback, and ability to locate sounds. Kochkin (2000a, 2005) reported similar problems with all of these issues associated with less satisfaction. The subsequent analysis of the factors associated with IOI-HA scores highlighted the particular importance of improving satisfaction with comfort with loud sounds in particular as this is associated with improved average IOI-HA scores.

Finally, participants rated satisfaction with various service aspects and, as has been found in numerous other studies (see Wong et al, 2003 for a review), these ratings were uniformly high. For all items, 95% or more of respondents said that they were either satisfied or very satisfied and 69% or more were very satisfied with all aspects. Although it may be that these results reflect the reality (i.e. that service is almost always very satisfying), it may also be a limitation of the measure being used. Ceiling effects limit the usefulness of the measure and more sensitive measures may be necessary to tap variations in service that certainly must exist. Perhaps a visual analog scale from outstanding to poor would yield more variation in results, or clients could be asked to think about the best health service they have ever received and then to compare that service with their experience in the hearing clinic (e.g. was it much better, better, the same, worse, or much worse?).

The second aim of this study was to investigate factors that significantly influence IOI-HA scores with a view to understanding what issues should be the focus of clinical attention to improve outcomes. Factors most strongly associated with more positive outcomes were higher levels of satisfaction with the following hearing aid characteristics: (1) overall fit/comfort, (2) clarity of tone and sound, and (3) comfort with loud sounds. The strongest factor was clarity, with small but significant increases to the total IOI-HA score with higher levels of satisfaction with clarity of tone and sound (see Table 4). These findings indicate the importance of ensuring client satisfaction with these aspects of the hearing aid(s). For example, clarity of sound and comfort with loud sounds could be optimized by careful verification that audibility targets are met and that maximum loudness comfort levels are not exceeded. The relationships between satisfaction with these hearing aid attributes and the IOI-HA have not previously been reported, however other studies have indicated

that some aspects of satisfaction with specific hearing aid attributes relate to overall hearing aid satisfaction, which is in line with the findings here. For example, Bentler et al (1993) reported that 21.2% of the variance in satisfaction could be accounted for by ratings of sound quality characteristics, and Spitzer (1998) found a significant correlation between naturalness of sound and satisfaction ($r = .46$, $p < .01$). Also, Kochkin (2000b) listed the 10 most common reasons that clients gave for not using hearing aids, and amongst these were hearing aid fit and comfort and poor sound quality.

The analysis of the effect of the demographic/hearing aid factors on IOI-HA scores showed small but significant effects of audiogram type and fitting status (new versus return clients). Audiogram type was essentially reflective of degree of loss and those with greater degrees of loss reported better outcomes. Better IOI-HA scores for those with greater hearing loss would be expected to some extent because it is highly likely that such individuals would use their hearing aids more than those with better hearing, and usage is one of the dimensions measured in the IOI-HA. Cox et al (2003) reported that those who reported more hearing problems in everyday life used their aids significantly more. However, the relationship to other dimensions of the IOI-HA is less clear and warrants further investigation. For example, in Cox et al's study, those with moderate to severe self-reported hearing problems reported lower scores on item 3 of the IOI-HA (residual activity limitations), higher scores on item 4 (satisfaction), and lower scores on item 6 (impact on others), compared to those with mild to moderate hearing problems. However, Wong et al (2003) reported on 14 studies that examined relationships between degree of hearing loss and hearing aid satisfaction; nine studies found no significant relationships, and the remaining five reported low to moderate correlations only. In contrast, the finding that experienced hearing aid users report better outcomes is in agreement with a number of other research studies (e.g. Cox & Alexander, 2000; Hosford-Dunn & Halpern, 2001; Kochkin, 2000a).

Of the demographic/hearing aid factors that were not correlated with IOI-HA scores (i.e. age, funding source, unilateral versus bilateral fitting, microphone technology, etc.), the most surprising was unilateral/bilateral fitting. Heuermann et al (2005) also found no effect of two hearing aids, however Kramer et al (2002) and Stephens (2002) both reported that those with two hearing aids had higher IOI-HA scores than those with one hearing aid. There are a number of possible explanations for the findings obtained here. First, it may be that bilateral fittings do not yield superior outcomes to unilateral fittings. Although the benefits of bilateral fitting are well established in laboratory settings, the self-report benefits of everyday life are less convincing. For example, Metselaar et al (2008) recently used the hearing handicap and disability inventory (van den Brink et al, 1996) and the abbreviated profile of hearing aid benefit (Cox & Alexander, 1995) and found that those fitted bilaterally did not report any significant advantages over those fitted unilaterally. Second, it may be that the IOI-HA is simply not sensitive to the localization and sound quality benefits of bilateral fitting and another measure such as the speech, spatial and qualities of hearing scale (SSQ) (Gatehouse & Noble, 2004) should be used to measure outcomes. Finally, a limitation of the data collected in the present study is that it is not known whether or how often participants actually wore the two hearing aids they were fitted with. Participants were classified as receiving either one or two hearing aids by the clinician they saw and the IOI-HA item about usage does not specify how much they wore both hearing aids. A number of those fitted with two aids may only have used one in everyday life. For example, Dillon et al (1999) found that 20% of those fitted bilaterally as part of a national hearing rehabilitation program in Australia reported using only one aid three months post-fitting.

Conclusions

Outcomes measurement is the cornerstone of evidence based practice. This study describes hearing aid outcomes at six months post-fitting for a large sample of adults in Australia and, as such, the findings serve as a benchmark for future Australian studies and for research in other parts of the world where different types of services may be offered. In addition, the large sample size allowed us to identify a number of factors having a significant influence on outcomes of hearing-aid fitting, as measured by the IOI-HA. Factors that were most strongly associated with positive changes in IOI-HA scores were greater satisfaction with the hearing aid attributes of aid fit/comfort, clarity of tone, and sound and comfort with loud sounds, and greater satisfaction in the listening situations of conversation with one person, in small groups, in large groups, and outdoors. Consideration of these factors, and modification of procedures to enhance satisfaction in a range of listening situations and with key hearing aid attributes should allow clinicians to improve outcomes for their clients. The measurement and analysis of outcomes at one point in time is, after all, just one step towards quality improvement.

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