J Am Acad Audiol 31:87–95 (2020)

Predictors of Hearing Aid Use in the Advanced Digital Era: An Investigation of Benefit, Satisfaction, and Self-Efficacy

DOI: 10.3766/jaaa.18036

Anna Marie Jilla*
Carole E. Johnson*
Jeffrey L. Danhauer†
Michael Anderson‡
Jenna N. Smith*
James C. Sullivan*
Kristin R. Sanchez*

Abstract

Background: Untreated sensorineural hearing loss (SNHL) has been linked to depression, social isolation, anxiety, and a reduction in health-related quality of life (QoL), and is independently associated with cognitive decline. Only one in five persons with SNHL pursues amplification; 76–97% of those having hearing aids report regular or occasional use. Although hearing aid use during all waking hours is advocated for children, recommendations for adults are not as clear. Treatment outcomes, including benefit, satisfaction, and self-efficacy with hearing aids, may be predictors of self-reported hearing aid use, which is useful in clinical practice.

Purpose: The aim of this study was to determine average hours of self-reported daily hearing aid use by adults and if treatment outcome measures of benefit, satisfaction, and self-efficacy with hearing aids can predict self-reported daily hearing aid use in adults.

Research Design: The present study was a prospective cross-sectional survey with retrospective chart review.

Study Sample: The study sample consisted of 152 experienced adult advanced digital technology (ADT) hearing aid users between 18 and 90 years of age who were patients in a two-office private practice in California.

Data Collection and Analysis: A postal survey was sent to 500 experienced adult ADT hearing aid users. Participants completed the Visual Analog Scale for Daily Use of Hearing Aids (VASuse) and validated measures of (1) self-efficacy, (2) satisfaction, and (3) benefit. Retrospective data were collected for all respondents via chart review. Multivariable linear regression was used to explore relationships between treatment outcomes and hearing aid use.

Results: Experienced hearing aid users wore their hearing aids an average of 12.0 h/day. Daily hearing aid use was significantly associated with residual participation restriction (RPR) on the International Outcome Inventory for Hearing Aids (IOI-HA) item 5 ($p = 0.02$). The VASuse was significantly associated with the IOI-HA factor 1, "Me and My Hearing Aids" ($p = 0.03$), an aggregate measure of satisfaction, benefit, and QoL.

*Hearing Evaluation, Rehabilitation, and Outcomes Laboratory, Department of Communication Sciences and Disorders, College of Allied Health, University of Oklahoma Health Sciences Center, Oklahoma City, OK; †Department of Speech and Hearing Sciences, University of California Santa Barbara, Santa Barbara, CA; ‡Department of Biostatistics and Epidemiology, College of Public Health, University of Oklahoma Health Sciences Center, Oklahoma City, OK

Corresponding author: Anna Marie Jilla, Hearing Evaluation, Rehabilitation, and Outcomes Laboratory, Department of Communication Sciences and Disorders, College of Allied Health, University of Oklahoma Health Sciences Center, Oklahoma City, OK 73117; Email: anna.jilla@gmail.com

This study is funded by the University of Oklahoma Health Sciences Center, College of Allied Health Student Research and Creativity Grant: Tier II.

Portions of this research were presented at the 2015 American Auditory Society Scientific and Technical Conference, March 2–4; the XXXIII World Congress of Audiology, September 21–23, 2016, Vancouver BC, Canada; and the American Academy of Audiology Annual Conference, AudiologyNow!, April 14–16, 2016.

Conclusions: Participants reported wearing their hearing aids an average of 12.0 h/day. Self-reported daily hearing aid use was associated with a combination of satisfaction, benefit, and increased QoL, and with RPR. The interconnectedness of satisfaction, benefit, and QoL positively affected hearing aid use, and greater levels of RPR seemed to discourage hearing aid use. If hearing aid owners are inconsistent or nonusers, then counseling and outcome measures should be used in the domains of satisfaction, benefit, and QoL. Future research should involve additional ADT hearing aid users with different experience levels across various study sites.

Key Words: adults, benefit, hearing aids, quality of life, satisfaction, self-efficacy, usage

Abbreviations: ADJ = adjustment; ADT = advanced digital technology; AH = advanced handling; AL = aided listening; BEN = benefit; BH = basic handling; DHAU = self-reported daily hearing aid use; FFPTA = four-frequency pure-tone average; IO = impact on others; IOI-HA = International Outcome Inventory for Hearing Aids; IQR = interquartile range; MARS-HA = Measure of Audiologic Rehabilitation Self-Efficacy for Hearing Aids; NF = negative features; NIDCD = National Institute on Deafness and Other Communication Disorders; PE = positive effect; PI = personal image; QoL = quality of life; RAL = residual activity limitations; RPR = residual participation restriction; SADL = Satisfaction with Amplification in Daily Life; SC = service and cost; SD = standard deviation; SDS = satisfaction with devices and services; SNHL = sensorineural hearing loss; VASuse = Visual Analog Scale for Daily Use of Hearing Aids

INTRODUCTION

Hearing loss is a global health concern with significant public health implications, and it affects about 37.5 million persons in the United States, or ~15% of the population (National Institute on Deafness and Other Communication Disorders [NIDCD], 2016). Moreover, the prevalence of hearing loss is ~25% for adults between 65 and 74 years and 50% for those ≥75 years (NIDCD, 2016). Untreated sensorineural hearing loss (SNHL) can negatively impact health-related quality of life (QoL) (e.g., Weinstein and Ventry, 1982; National Council on the Aging, 1999; Chisolm et al, 2007). Furthermore, untreated SNHL is often associated with social isolation, increased rates of depression and anxiety, and lessened self-efficacy and mastery (Chisolm et al, 2007). Importantly, recent research has shown that SNHL is independently associated with accelerated cognitive decline and impairment in noninstitutionalized elderly adults (Lin et al, 2013; Lin and Albert, 2014).

Although hearing aids are the most common treatment for SNHL (Chisolm et al, 2007), the hearing aid uptake rate (e.g., the percentage of people who are candidates for hearing aids who actually obtain them) continues to hover at 20–30%, despite the advent of advanced digital technology (ADT) devices (Davis et al, 2007; Bainbridge and Ramachandran, 2014; Abrams and Kihm, 2015). This low uptake rate indicates that about 70–80% of those with hearing impairment remain at risk for the insidious effects of untreated SNHL. Furthermore, it is important to know whether the 20–30% of persons who acquire hearing aids actually use them. Previous studies have revealed that ~25% of hearing aid owners report that they never use their devices (Hartley et al, 2010) and 35% use them ~4 h/day (Kaplan-Neeman et al, 2012). Hickson et al (2014) defined successful hearing aid use as 4–8 h/day and moderate to significant perceived benefit in a nominated troublesome listening situation. Unfortunately, they reported that many hearing aid owners are inconsistent or nonusers who do not reap the benefits of amplification that might help stave off the insidious effects of SNHL (e.g., depression, social isolation, and cognitive decline).

Several lines of studies showed that audiologic variables can influence patients' successful use of hearing aids, some of which are related to factors that are inherent to audiometrics (e.g., pure-tone averages, configurations, and word recognition scores in quiet and in noise) and others are associated with patient-related (e.g., magnitude of hearing impairment as estimated by the degree of self-reported unaided hearing difficulty and marital status), device-related (e.g., lifetime hearing aid experience, cost, and level of technology), and treatment outcomes (e.g., satisfaction, benefit, self-efficacy with hearing aids, and experience with amplification) (Uriarte et al, 2005; Cox et al, 2007; Kaplan-Neeman et al, 2012; Dullard, 2014; Aazh et al, 2015). Knowing which factors influence patients' hearing aid outcomes is important for the development of holistic treatment plans, given the high prevalence of hearing loss among older adults (NIDCD, 2016). Treatment via hearing aids has recently been shown to lessen the impact of the insidious and cascading effects of SNHL, including cognition (Karawani et al, 2018; Maharani et al, 2018). The present study focused only on the relationship between magnitude of hearing impairment and treatment outcomes to increase the likelihood of providing an in-depth reflection of what causes inconsistent outcomes and hearing aid usage among owners. Few studies have monitored daily hearing aid usage as a criterion for determining compliance (i.e., users) and noncompliance (i.e., inconsistent or nonusers) with treatment recommendations. For example, Gaffney (2008) and Laplante-Lévesque et al (2014) found that the average daily hearing aid use was between 10.5 and 11.15 h, respectively, and that slight overestimations occurred with self-reported values when compared with data logging. A study is warranted to assess what patient- and device-related factors and treatment outcomes predict the use of ADT hearing aids. The primary goals of the present study were to determine (a) the predictive value of outcomes (i.e., hearing aid satisfaction, benefit, and self-efficacy) on self-reported daily hearing aid use as a continuous variable and (b) average daily wear times for patients seen in a single private practice.

METHODS

Study Design

The present study involved a prospective cross-sectional survey of patients seen in a single private practice. A retrospective chart review was also conducted on patients who responded to the survey.

Practice Setting

The private practice used in the present study has two offices in Santa Barbara County, California. Hearing aid selection, evaluation, fitting, and verification were performed by licensed hearing health-care professionals using evidence-based clinical procedures, including electroacoustic analysis for quality control and real-ear probe microphone measurement to assure appropriate gain within ±5 dB from 250 to 4000 Hz, using National Acoustic Laboratories: Nonlinear, Version 2 targets (Valente et al, 2006; Keidser et al, 2011; Dillon, 2012; Acoustical Society of America, 2014). Appropriate follow-up procedures were conducted for all patients at weekly intervals throughout the minimum 45-day trial period (Valente et al, 2006).

Participant Recruitment and Inclusion/Exclusion Criteria

Participants were recruited from a convenience sample of hearing aid users from the two-office private practice in Santa Barbara, California, who met the following inclusion criteria: (a) 18–90 years of age and (b) received their hearing instruments within six weeks to five years from the start date of the investigation. Patients were excluded from participation if they (a) were under contract from a Veteran's Affairs medical center, (b) returned their hearing aid(s) during the trial period, (c) had specialty CROS or BICROS amplification configurations, and/or (d) were incarcerated at the time of the study.

The search of the patient database focused on the most recent hearing aid(s) purchased and resulted in a pool of 838 patients eligible to participate in the study. Of the 838 patients, 500 were selected randomly to participate in the present study and were mailed a packet containing (a) an informational letter about the study which was approved by the University of Oklahoma Health Sciences Center's Institutional Review Board (IRB#: 5744); (b) a coupon redeemable for two packages of hearing aid batteries, even if they did not participate in the study; and (c) the separate questionnaires for the outcome measures. The order of the questionnaires was counterbalanced across participants to minimize order effects. The surveys were mailed to the perspective participants during the week of August 31, 2015, and completed outcome measures were accepted for three months from the original send date.

Materials and Measures

The audiologic factors chosen for the present study included four-frequency pure-tone averages (FFPTAs) and word recognition scores in quiet. The best FFPTA (i.e., average of 500, 1000, 2000, and 4000 Hz) was used to determine the degree of hearing loss. Patient-related (i.e., age, gender, living arrangement, and marital status), device-related (i.e., level of hearing aid technology, device cost, and private or insurance/third party payment method), and treatment outcome (i.e., self-reported daily hearing aid use, satisfaction, benefit, and hearing aid self-efficacy) factors were examined in the present study. Participants prospectively completed the (a) patient information form, (b) Visual Analog Scale for Daily Use of Hearing Aids (VASuse: Jilla, 2016), (c) International Outcome Inventory for Hearing Aids (IOI-HA; Cox and Alexander, 2002), (d) Measure of Audiologic Rehabilitation Self-Efficacy for Hearing Aids (MARS-HA; West and Smith, 2007), and (e) Satisfaction with Amplification in Daily Life (SADL; Cox and Alexander, 2001). Audiometric data and hearing aid characteristics were obtained through retrospective chart review of each participant's records.

The patient information form queried demographic information (i.e., participants' ages, gender, marital status, and number of people in the household) and factors pertaining to hearing aid ownership (i.e., h/day of hearing aid use, experience with current devices, lifetime experience with hearing instruments, and self-reported degree of unaided difficulty). The questions about experience with current and lifetime hearing aid use were adapted from the SADL (Cox and Alexander, 2001) to demarcate time periods when patients typically have mastered advanced handling (AH) skills for hearing instruments at 18 mo (Meyer et al, 2014). The VASuse (Jilla, 2016) was presented as item 5 in the patient information form using the question "How many hours per day do you wear your hearing aids?" An example was provided with instructions on the first visual analog scale. Then, participants were asked to mark an "X" on the second visual analog scale corresponding to their response (see Figure 1).

The IOI-HA (Cox and Alexander, 2002) is an 8-item post–hearing aid fitting questionnaire focusing on self-reported daily hearing aid use (DHAU), benefit (BEN), residual activity limitations (RAL), satisfaction with devices and services (SDS), residual participation restriction (RPR), impact on others (IO), QoL, and self-reported unaided hearing difficulty. This outcome measure yields a global score and two subscale scores. The Me and My Hearing Aids subscale consists of responses from the items on DHAU, BEN, SDS, and QoL and pertains to introspection about the hearing aids, whereas the Me and the Rest of the World subscale consists of responses from the items concerning RAL, RPR, and IO and evaluates the influences of hearing aids on activities in the outside world. The MARS-HA (West and Smith, 2007) is a 24-item questionnaire used to assess self-efficacy with hearing aids. This measure yields a global score and four subscale scores: basic handling (BH), AH, adjustment (ADJ), and aided listening (AL). The SADL (Cox and Alexander, 2001) is a 15-item self-assessment tool that measures patient satisfaction with hearing aids. The questionnaire yields a global score and scores for four subscales: positive effect (PE), negative features (NF), service and cost (SC), and personal image (PI).

Data Collection and Analysis

Because the subscales contributed to the composite scores of the outcome measures used here, it was preferable to split the analysis into two models so that measure scores were not intercorrelated. Accordingly, Model 1 used composite scores from the SADL and MARS-HA, and item scores from the IOI-HA as independent variables with the VASuse values as the dependent variable. For the IOI-HA, instead of using the global score, each question was treated as a separate factor (e.g., RPR, QoL, etc.). Similarly, Model 2 included the subscales of the MARS-HA (i.e., AH, ADJ, AL, and BH), IOI-HA (i.e., Me and My Hearing Aids, and Me and the Rest of the World), and the SADL (i.e., PE, NF, SC, and PI) as independent variables with the VASuse as the dependent variable. Each independent variable was assessed for normality using the Shapiro–Wilk test and modeled using multivariable linear regression or multivariable robust regression, as appropriate for the distribution. Both models controlled for patient-related and device-related covariates, which included age, gender, FFPTA, hearing loss group (i.e., mild, moderate, severe, or profound), hearing aid cost, level of technology, current and lifetime experience with hearing aids, and self-reported unaided degree of communication difficulty.

A power analysis was conducted using pilot data from a previous study, which used the SADL and the IOI-HA. Pilot data were unavailable for the MARS-HA. The power analysis indicated that 63 and 35 participants were needed for Models 1 and 2, respectively, to obtain 80% power to detect significant associations between dependent and test variables in these models with 5% type I error.

Three of the authors (AMJ, CEJ, and JNS) from the University of Oklahoma Health Sciences Center traveled to the clinical sites in Santa Barbara, California, to conduct the retrospective patient chart review. Participants' age, gender, audiometric thresholds, and specifics about their hearing aids (i.e., hearing aid make/model, style, cost, method of payment, and weeks since fitting) were extracted from patients' files. Scoring error was minimized using two independent judges. The data analysis for the present study was

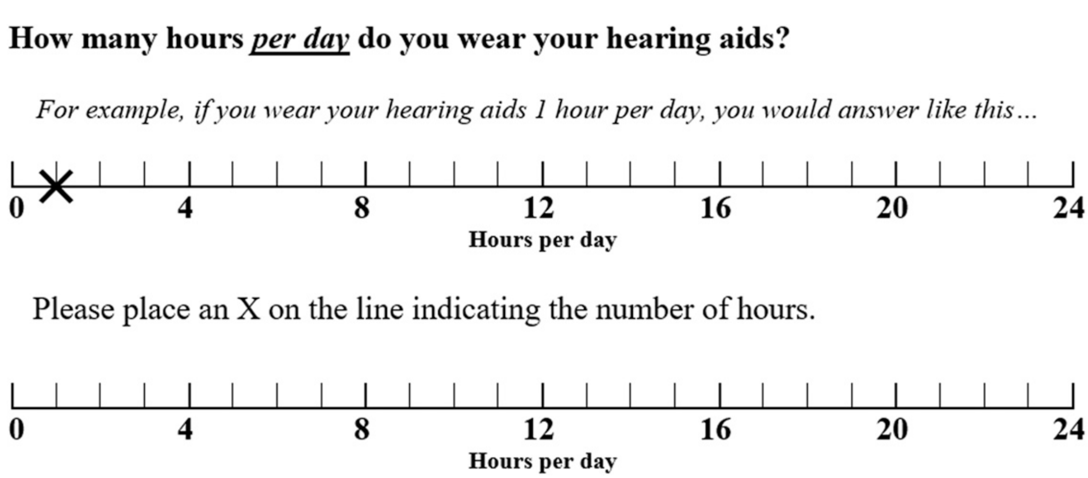

Figure 1. Visual Analog Scale for Daily Use of Hearing Aids (VASuse).

generated using SAS software (version 9.4; SAS Institute Inc., 2013).

Descriptive statistics were computed for all demographic and clinical variables (i.e., audiometric data, FFPTAs, degree of hearing loss, self-rated unaided hearing difficulty, monaural or binaural fitting type, level of hearing aid technology, lifetime hearing aid experience, and experience with current hearing aids). Categorical variables are reported here as frequencies, while rounded percentages and continuous variables were assessed for normality using the Shapiro–Wilk test and reported as mean, standard deviation (SD), or median, interquartile range (IQR), as appropriate. Because self-reported daily use (as measured by h/day) was not normally distributed, robust regression models (i.e., PROC ROBUSTREG in SAS; Holland and Welsch, 1977; Chen, 2002) were used for the multivariable regression modeling. These models tested the independent effects of SADL, IOI-HA, and MARS-HA scores on daily use while controlling for other variables such as age, gender, hearing aid cost, and experience with hearing aid use. Stepwise addition of variables was not performed because the contribution of each variable to the model's r-square value depends heavily on the order in which the variable is entered into the model. The purpose of the present study was to use an overall model to test independent effects of covariates while controlling for others.

RESULTS

Of the 500 surveys mailed to perspective participants, 16 were returned to the sender. Of the remaining 484, 152 surveys were completed within the three-month response period (31.4% response rate) and used in the data analysis. Table 1 provides frequencies and rounded percentages for patient- and device-related characteristics of the study sample.

The sample included 78 females and 74 males with a median age of 75.0 years (N = 152; IQR: 68.0, 83.0). Their hearing aids were primarily binaural fittings (79.5%) which used varying levels of ADT. Their

Table 1. Frequency Data for Patient- and Device-Related Characteristics

	N	Percent
Group loss	152	
Mild	56	36.8
Moderate	71	46.7
Severe	20	13.2
Profound	5	3.3
Self-rated unaided communication difficulty	151	
None	0	0
Mild	17	11.3
Moderate	49	32.5
Moderate–severe	59	39.1
Severe	26	17.2
Fitting type	152	
Monaural	28	18.4
Binaural	124	81.5
Level of hearing aid technology	149	
Entry level	19	12.8
Mid level	52	34.9
Advanced level	37	24.8
Premium level	41	27.5
Lifetime hearing aid experience	149	
<6 mo	3	2.0
7–12 mo	7	4.7
13–18 mo	14	9.4
19–24 mo	13	8.7
2–10 years	60	40.3
>10 years	52	34.9
Experience with current hearing aids	152	
<6 mo	20	13.2
7–12 mo	18	11.8
13–18 mo	28	18.4
19–24 mo	18	11.8
>24 mo	68	44.7

hearing aid styles included receiver-in-the-canal and receiver-in-the-ear (74.8%), standard behind-the-ear (13.7%), and other in-the-ear options (e.g., in-the-canal, in-the-ear; 10.5%). Participants had varying levels of lifetime experience with hearing aids: >10 years (34.9%), 2–10 years (40.3%), 19–23 mo (8.7%), 13–18 mo (9.4%), 7–12 mo (4.7%), and <6 mo (2.0%).

Participants' ratings of unaided communication difficulty ranged from mild to severe. Most of the participants self-reported greater degrees of hearing difficulty without their devices (mild: N = 17; 11.3%; moderate: N = 49; 32.5%; moderate–severe: N = 59; 39.1%; and severe: N = 26; 17.2%). Participants had varying degrees of SNHL as demonstrated by FFPTAs in their better ears: mild hearing loss = 0- to 40-dB HL, moderate = 41- to 60-dB HL, severe = 61- to 80-dB HL, and profound ≥81-dB HL. Most of the participants had moderate (N = 71; 46.7%) or mild (N = 56; 36.8%) hearing losses, whereas a smaller proportion of the sample had severe (N = 20; 13.2%) or profound (N = 5; 3.3%) losses. Means and SDs for audiometric data are presented in Table 2.

Average Self-Reported Hearing Aid Use

The present study found an average of 12.0 self-reported h/day usage (IQR = 8.00, 16.00). It is important to note that these data were for experienced users of varying levels of ADT hearing aids who had used their devices for ≥6 mo.

Regression Results

Results from multivariate regression analyses for satisfaction, benefit, and self-efficacy are presented in Table 3. Models 1 and 2 rendered r-square values of 0.43 and 0.45, respectively, which indicated that more than 43% of the variance of the VASuse was accounted for by the covariates in the regression model. Using Cohen's criteria, these results are considered to be medium (good) to large (excellent) effect sizes (Cohen, 1992).

Satisfaction, Benefit, and Self-Efficacy

Model 1 revealed that global hearing aid satisfaction was not a predictive factor for daily self-reported hearing aid use. Model 2 found no significant relationship between hearing aid use and the satisfaction subscales of PE, SC, NF, or PI. Model 1 included analysis of each IOI-HA question as a separate domain of hearing aid outcomes (e.g., BEN, RAL, SDS, RPR, IO, and QoL). From Model 1, the VASuse was significantly associated with question 5 on the IOI-HA ($p = 0.02$), which measures RPR after hearing aid fitting and asked, "Over the past two weeks, with your present hearing aid(s), how much have your hearing difficulties affected the things you can do?" Specifically, for every unit increase of RPR (1 = very much . . ., 5 = none), self-reported usage decreased by 1.50 h. From the model, daily usage was predicted to decrease as lower RPR is reported.

Model 2, which included analyses of the two subscales from the IOI-HA: Me and My Hearing Aids, and Me and the Rest of the World, revealed that the VASuse was significantly associated with the Me and My Hearing Aids subscale of the IOI-HA ($p = 0.03$). Specifically, for every one unit increase on this subscale, self-reported usage increased by 2.22 h. The Me and My Hearing Aids subscale measures patients' perceptions of the postfitting impact on ameliorating the effects of SNHL and

Table 2. Descriptive Statistics for Audiometric Data

	N	Median (25th%,75th%)	Mean (SD)
Right ear			
PTA	146	50.6 (40.0, 58.8)	50.6 (15.4)
250 Hz	149	**30.0 (15.0, 45.0)**	33.2 (20.2)
500 Hz	149	**35.0 (25.0, 50.0)**	38.3 (20.7)
1000 Hz	149	**45.0 (35.0, 60.0)**	46.5 (20.3)
2000 Hz	148	**55.0 (45.0, 65.0)**	54.3 (18.6)
4000 Hz	147	**65.0 (55.0, 75.0)**	65.3 (17.0)
8000 Hz	128	**75.0 (65.0, 85.0)**	72.0 (17.8)
Left ear			
PTA	147	**51.3 (40.0, 60.0)**	50.8 (16.2)
250 Hz	148	**30.0 (15.0, 45.0)**	32.8 (20.7)
500 Hz	148	**35.0 (20.0, 50.0)**	37.2 (20.9)
1000 Hz	149	**45.0 (30.0, 56.0)**	45.8 (20.4)
2000 Hz	149	**55.0 (45.0, 65.0)**	55.0 (18.7)
4000 Hz	148	**65.0 (55.0, 75.0)**	66.8 (17.5)
8000 Hz	134	**75.0 (65.0, 85.0)**	73.2 (17.6)

Note: Mean and median values are in boldface, where appropriate, to indicate the preferred descriptive data based on the normality of the distribution of that variable. PTA = pure-tone average of 500, 1000, 2000, and 4000 Hz.

Table 3. Results from Multivariate Regression Analysis

		Beta (SE)	p-Value
Model 1			
SADL composite		0.05 (0.93)	0.9564
IOI-HA: BEN		0.03 (0.67)	0.9628
IOI-HA: RAL		0.01 (0.66)	0.9852
IOI-HA: SDS		1.59 (0.88)	0.0728
IOI-HA: RPR		−1.50 (0.63)	0.0171*
IOI-HA: IO		1.01 (0.60)	0.0949
IOI-HA: QOL		0.89 (0.77)	0.2456
MARS-HA composite		0.01 (0.04)	0.8153
	r^2 = 0.4300		
Model 2			
SADL: PE		0.17 (0.77)	0.8268
SADL: SC		−0.24 (0.56)	0.6766
SADL: NF		0.70 (0.37)	0.0583
SADL: PI		0.03 (0.52)	0.9484
IOI-HA (Me and My Hearing Aids)		2.22 (1.02)	0.0294*
IOI-HA (My Hearing Aids and the World)		−0.97 (0.79)	0.2180
MARS-HA: BH		0.04 (0.05)	0.3718
MARS-HA: AH		0.01 (0.03)	0.6773
MARS-HA: ADJ		−0.04 (0.05)	0.4505
MARS-HA: AL		−0.03 (0.04)	0.5085
	r^2 = 0.4473		

*Statistically significant at an alpha level of 0.05.

includes the following items: DHAU, BEN, SDS, and QoL. It should be noted that item 1 was omitted from this analysis because the VASuse would be highly correlated with DHAU. No significant relationship was found between the VASuse and hearing aid self-efficacy for Models 1 or 2.

DISCUSSION

In hearing health care, treatment adherence is defined as compliance with recommendations (in this case, for hearing aid uptake and consistent use). Recall that about 25–35% of hearing aid owners report either occasional or nonuse of their devices (Hartley et al, 2010; Kaplan-Neeman et al, 2012). Although hearing aid usage during all or most waking hours is a reasonable goal for many patients, the criterion for regular usage is inconsistent across the literature (e.g., Perez and Edmonds, 2012). Monitoring hearing aid use can help identify patients who need additional counseling about the care and use of their hearing instruments. The median value for self-reported daily hearing aid use of 12.0 h (IQR = 8.0, 16.0) reported here is consistent with other findings in the ADT era by Gaffney (2008) and Laplante-Lévesque et al (2014) who found that hearing aids were worn 10.5 and 11.15 h/day, respectively. This also indicates acceptable criterion validity of the VASuse when compared with results from studies using data logging.

The use of the SADL global satisfaction score as a predictor of hearing aid use has been equivocal in the literature. For example, Hosford-Dunn and Halpern (2001) found it to be a poor predictor, whereas Uriarte et al (2005) found it to be a significant predictor. However, when using ranges for values of daily hearing aid use, some studies have found significant relationships between self-reported daily wear time and SADL subscales (e.g., Uriarte et al, 2005 on PE, SC, BN, and PI; Kaplan-Neeman et al, 2012 on PE and SC). Findings of the present study indicated that satisfaction, as measured by the SADL, did not significantly influence these patients' self-reported daily hearing aid use. It is possible that the continuous measure (i.e., 0–24 h) of hearing aid use used here made it more difficult to detect such associations.

Our findings for global MARS-HA scores, and AL, AH, and ADJ subscales were consistent with Dullard's (2014) results where composite scores from the MARS-HA also did not correlate significantly with self-reported h/day usage on a continuous scale (i.e., 0–24 h). It is likely that the poor predictive power of self-efficacy was due to the experience level of the participants considering that Meyer et al (2014) found that persons with >18 mo of hearing aid ownership/use often reported more confidence in BH and AH than peers having lesser experience. Our lack of findings for the AH subscale of the MARS-HA supported Meyer and colleagues' 18 mo benchmark for AH skills, considering that 118 of our participants reported more than one year of hearing aid use. It is likely that self-efficacy is not a significant determinant of hearing aid use, particularly among experienced users.

Only one study was identified that specifically examined IOI-HA composite scores using ranges of hearing aid use. Aazh et al (2015) found that composite IOI-HA scores increased with increased hearing aid use when using IOI-HA scores of the nonuser group as a baseline for comparison. The present results indicated that the multidimensional composite measure was not useful for predicting hearing aid use measured as a continuous variable. No previous studies were identified that examined relationships between hearing aid use and the IOI-HA questions as separate subscale domains. Some studies have found that benefit was significantly associated with QoL (e.g., Chisolm et al, 2007) and SDS (e.g., Uriarte et al, 2005) separately. The literature reflects an interconnectedness of the domains of benefit, satisfaction, and quality of life improvement. Thus, it is not surprising that the aggregate values of these domains on the Me and My Hearing Aids subscale were found to be significant predictors of self-reported daily hearing aid use. The Me and My Hearing Aids subscale pertains to introspection about how patients interact with their hearing aids, whereas the Me and the Rest of the World measures how hearing aids influence functioning in the outside world. Results indicate that our sample's hearing aid use was more heavily influenced by internal than external factors. The RPR domain was also significantly associated with daily usage, indicating that lower levels of RPR negatively influence hearing aid use. It is likely that as RPR increases, patients feel the need to wear their devices regularly with the goal of reducing their higher levels of RPR. The results of the present study indicated that satisfaction, benefit, and self-efficacy were not tell-all factors for daily hearing aid usage. Most of the previous studies, except for Dullard (2014), measured hearing aid use in intervals. The present study sought to measure hearing aid use as a continuous variable, thereby providing a more theoretically precise value that is amenable to data analysis and subsequent clinical recommendations. However, it is possible that as the scale for daily usage changed, it may have been more difficult to detect associations among satisfaction, benefit, and self-efficacy. This possibility was previously documented by Wong et al (2003).

Limitations of the present study include those associated with having a single study site and possible response bias. That is, participants who returned the surveys may have inherently had better outcomes and those who were dissatisfied with or inconsistent users of their hearing aids may have simply elected not to participate (Wong et al, 2003). The results suggest that data logging values may have also been helpful in assessing criterion validity of the VASuse as a clinical tool. Furthermore, the present study sample of hearing aid users consisted mainly of experienced users, and previous studies have noted that they are at lower risk for inconsistent usage (e.g., Bertoli et al, 2009).

A premise of the present study was that focusing on ways to enhance patients' benefit, satisfaction, and quality of life with amplification should increase daily wear time of hearing aids. Thus, it was somewhat surprising that no other variables (i.e., self-efficacy or satisfaction) predicted values on the VASuse. A similar study should be conducted with new or inexperienced hearing aid users having varying types and degrees of hearing loss to determine their average usage values and if other variables may influence treatment adherence with hearing aids. However, the significant findings noted here for the IOI-HA should provide audiologists with further evidence for using this measurement tool in clinical practice, while paying specific attention to outcomes in the domains of RPR, BEN, SDS, and QoL. Our results suggest that patient responses can also facilitate communication about holistic treatment plans and alert practitioners to particular patients who might be at risk for noncompliance with treatment recommendations for daily wear times. Our median values for self-reported usage of 12.0 h/day (IQR = 8.00, 16.00) are encouraging and may help show that users who wear their devices during most waking hours can provide guidance in determining consistent usage patterns for other adult hearing aid users.

Acknowledgments. The authors would like to extend their gratitude to Kim and Tate Danhauer, Nate Smith, Joanne Ryu, Jessica Huddleston, and Kortney Bush for their contributions to this project.

REFERENCES

Aazh H, Prasher D, Nanchahal K, Moore BCJ. (2015) Hearing-aid use and its determinants in the UK National Health Service: a cross-sectional study at the Royal Surrey Country Hospital. *Int J Audiol* 54:152–161.

Abrams HB, Kihm J. (2015) An introduction to MarkeTrak IX: a new baseline for the hearing aid market. *Hear Rev* 22:16.

Acoustical Society of America. (2014) *ANSI S3.22-2014: Specification of Hearing Aid Characteristics*. New York, NY: American National Standards Institute.

Bainbridge KE, Ramachandran V. (2014) Hearing aid use among older U.S. adults: the National Health and Nutrition Examination Survey, 2005–2006 and 2009–2010. *Ear Hear* 35:289–294.

Bertoli S, Staehelin K, Zemp E, Schindler C, Bodmer D, Probst R. (2009) Survey on hearing aid use and satisfaction in Switzerland and their determinants. *Int J Audiol* 48:183–195.

Chisolm TH, Johnson CE, Danhauer JL, Portz LJP, Abrams HB, Lesner S, McCarthy PA, Newman CW. (2007) A systematic review of health-related quality of life and hearing aids: final report of the American Academy of Audiology Task Force on the

Health-Related Quality of Life Benefits of Amplification in Adults. *J Am Acad Audiol* 18:151–183.

Chen C. (2002) Robust regression and outlier detection with the ROBUSTREG procedure. Proceedings of the Twenty-Seventh Annual SAS Users Group International Conference. Cary, NC: SAS Institute Inc.

Cohen J. (1992) A power primer. *Psych Bull* 112:155–159.

Cox RM, Alexander GC. (2001) Validation of the SADL questionnaire. *Ear Hear* 22:151–160.

Cox RM, Alexander GC. (2002) The International Outcome Inventory for Hearing Aids (IOI-HA): psychometric properties of the English version. *Int J Audiol* 41:30–35.

Cox RM, Alexander GC, Gray GA. (2007) Personality, hearing problems, and amplification characteristics: contributions to self-report hearing aid outcomes. *Ear Hear* 28:141–162.

Davis A, Smith P, Ferguson M, Stephens D, Gianopoulos I. (2007) Acceptability, benefit and costs of early screening for hearing disability: a study of potential screening tests and models. *Health Technol Assess* 11:1–294.

Dillon H. (2012) *Hearing Aids*. 2nd ed. New York, NY: Thieme.

Dullard B. (2014) A comparison of general and task-specific measures of self-efficacy in adult hearing aid users. DigitalCommons@UConn. http://digitalcommons.uconn.edu/cgi/viewcontent.cgi?article=6753&context=dissertations. Accessed June 12, 2017.

Gaffney P. (2008) Reported hearing aid use versus datalogging in a VA population. *Hearing Review*. http://www.hearingreview.com/2008/06/reported-hearing-aid-use-versus-datalogging-in-a-va-population/. Accessed March 24, 2016.

Hartley D, Rochtchina E, Newall P, Golding M, Mitchell P. (2010) Use of hearing aid and assistive listening devices in an older Australian population. *J Am Acad Audiol* 21:642–653.

Hickson L, Meyer C, Lovelock K, Lampert M, Khan A. (2014) Factors associated with success with hearing aids in older adults. *Int J Audiol* 53:S18–S27.

Holland P, Welsch R. (1977) Robust regression using interactively reweighted least squares. *Commun Stat Theor Methods* 6: 813–827.

Hosford-Dunn H, Halpern J. (2001) Clinical Application of the SADL Scale in private practice II: predictive validity of fitting variables. *J Am Acad Audiol* 12:15–36.

Jilla AM. (2016) *Visual Analog Scale for Daily Use of Hearing Aids: VASuse*. Oklahoma City, OK: University of Oklahoma Health Sciences Center.

Kaplan-Neeman R, Muchnik C, Hildesheimer M, Henkin Y. (2012) Hearing aid satisfaction and use in the advanced digital era. *Laryngoscope* 122:2039–2036.

Karawani H, Jenkins K, Anderson S. (2018) Restoration of sensory input may improve cognitive and neural function. *Neuropsychologia* 114:203–213.

Keidser G, Dillon H, Flax M, Ching T, Brewer S. (2011) The NAL-NL2 prescription procedure. *Audiol Res* 1:88–90.

Laplante-Lévesque A, Nielsen C, Jensen LD, Naylor G. (2014) Patterns of hearing aid usage predict hearing aid use amount (data logged and self-reported) and overreport. *J Am Acad Audiol* 25: 187–198.

Lin FR, Albert M. (2014) Hearing loss and dementia – who is listening? *Aging Ment Health* 18:671–673.

Lin FR, Yaffe K, Xia J, Xue QL, Harris TB, Purchase-Helzner E, Satterfield S, Ayonayon HN, Ferrucci L, Simonsick EM, Health ABC Study Group. (2013) Hearing loss and cognitive decline in older adults. *JAMA Intern Med* 173:293–299.

Maharani A, Dawes P, Nazroo J, Tampubolon G, Pendleton N. (2018) Longitudinal relationship between hearing aid use and cognitive function in older Americans. *J Am Geriatr Soc* 66: 1130–1136.

Meyer C, Hickson L, Fletcher A. (2014) Identifying the barriers and facilitators to optimal hearing aid self-efficacy. *Int J Audiol* 53:S28–S37.

National Council on the Aging. (1999) *The Consequences of Untreated Hearing Loss in Older Persons*. Washington, DC: National Council on the Aging.

National Institute on Deafness and Other Communication Disorders (NIDCD). (2016) *Quick Statistics about Hearing*. https://www.nidcd.nih.gov/health/statistics/quick-statistics-hearing. Accessed February 22, 2018.

Perez E, Edmonds BA. (2012) A systematic review of studies measuring and reporting hearing-aid usage in older adults since 1999: a descriptive summary of measurement tools. *PLoS One* 7: e31831.

SAS Institute Inc. (2013) *SAS/ACCESS® 9.4 Interface to ADABAS*. Cary, NC: SAS Institute Inc.

Uriarte M, Denzin L, Dunstan A, Sellars J, Hickson L. (2005) Measuring hearing aid outcomes using the Satisfaction with Amplification in Daily Life (SADL) Questionnaire: Australian data. *J Am Acad Audiol* 16:383–402.

Valente M, Abrams H, Benson D, Chisolm T, Citron D, Hampton D, Loavenbruck A, Ticketts T, Solodar H, Sweetow R. (2006) Guidelines for the audiologic management of adult hearing impairment. *Audiol Today* 18:1–44.

Weinstein BE, Ventry IM. (1982) Hearing impairment and social isolation in the elderly. *J Speech Hear Res* 25:593–599.

West RL, Smith SL. (2007) Development of a hearing aid self-efficacy questionnaire. *Int J Audiol* 46:759–771.

Wong LLN, Hickson L, McPherson B. (2003) Hearing aid satisfaction: what does research from the past 20 years say? *Trends Amplif* 7:117–161.