Consumer survey on hearing aid benefit and satisfaction

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Abstract

Purpose: There is unexplained variability in self-reported hearing aid outcomes. The aim of this study was to evaluate determinants of hearing aid benefit and satisfaction ratings using a large-scale customer survey and to analyze the relation between demographic variables, hearing aid attributes, benefit, and satisfaction.

Method: The study used a retrospective design wherein 2,109 hearing aid users, recruited by Hearing Tracker and Hearing Loss Association of America, completed an online survey. The survey included questions about demographics, perceived hearing loss, devices, service delivery, cost, benefit, and satisfaction. The analytic approach included descriptive summaries and regression models to evaluate potential determinants of hearing aid benefit and satisfaction ratings.

Results: Hearing aid sound quality, fit and comfort, and battery life were related to both benefit and satisfaction. Respondents who rated these outcomes favorably were also likely to benefit from, and be satisfied with, their hearing aids. Benefit was also related to degree of hearing loss, hearing aid experience, and cost. Hearing aid users with greater self-perceived hearing loss, more hearing aid experience, and more expensive hearing aids reported more benefit. Satisfaction was also related to age, employment status, and brand. Younger respondents, those who were students, and those using certain brands reported more satisfaction.

Conclusion: The results highlight importance of good hearing aid outcomes (quality, fit/comfort, battery life) for benefit and satisfaction ratings. Professionals who fit hearing aids should strive to focus on achieving these outcomes and researchers should strive to explain the remaining variability in ratings of benefit and satisfaction.

Introduction

There exists significant unexplained variability in self-reported hearing aid benefit and satisfaction outcomes among adults who use hearing aids (e.g., Cox, Alexander, & Gray, 2007; Jerram & Purdy, 2001; Wong, Hickson, & McPherson, 2003). Exploring the determinants of benefit and satisfaction ratings can provide information useful in helping practitioners refine their clinical practice and in helping manufacturers develop interventions which increase benefit and satisfaction. This ultimately aids in the improvement of patient-centered care, because self-reported hearing aid benefit and satisfaction are positively correlated with better hearing healthcare outcomes (e.g., McCormack & Fortnum, 2013; Ng & Loke, 2015). There exists audiologic and non-audiologic determinants of benefit and satisfaction ratings. Audiologic determinants include hearing aid experience, duration of hearing loss and self-reported hearing difficulties. Non-audiologic determinants include demographic variables (e.g., age, gender, income, employment status), device-related factors (e.g., how many hearing aids, technology level, brand, accessories), service delivery factors (e.g., who fit hearing aids, follow up services), and cost (e.g., cost of the device, insurance coverage, discount network used).

While hearing aid benefit and satisfaction are strongly related, they are two separate constructs (e.g., Wong et al., 2003). Hearing aid benefit can be defined as improvement in hearing function and communication ability as a result of hearing aid performance. Hearing aid satisfaction can be defined as a hearing aid user's positive emotional appraisal of their hearing aid experience in the context of their expectations (Convery, Keidser, Hickson, & Meyer, 2019; Cox & Alexander, 1999). There are several ways hearing aid benefit and satisfaction can be assessed. One of the most common measures of hearing aid benefit is the Abbreviated Profile of Hearing aid Benefit (APHAB; Cox & Alexander, 1995), a self-report inventory divided into four

subscales assessing a patient's experience with and without hearing aids in daily life (Turan, Unsal, & Kurtaran, 2019). One of the most common measures of hearing aid satisfaction is the Satisfaction with Amplification in Daily Life (SADL), a self-report inventory divided into four subscales addressing determinants ratings of hearing aid satisfaction; these subscales include positive effects, service and cost, negative features and personal image (Cox & Alexander, 1999). In the following, benefit and satisfaction will be considered separately.

Benefit

Several possible audiologic and non-audiologic determinants of hearing aid benefit ratings have been discussed in the literature. For example, Cox et al. (2007) found that hearing aid experience, expectations for hearing aids, and self-reported hearing loss (without hearing aids) were all related to success measured with the APHAB. They found that better APHAB scores were reported by participants who were new hearing aid users, had higher expectations, and had less self-reported hearing loss (Cox et al., 2007).

Non-audiological factors also play a significant role in the hearing aid users' perceived benefit. For example, service-related factors have been related to hearing aid benefit, such as setting (e.g., private practice, socialized healthcare; Cox et al., 2007) and the inclusion of pre-fitting counseling (Kemker & Holmes, 2004). In addition, fitting strategy has been related to benefit; Abrams, Chisolm, McManus, and McArdle (2012) indicated that fitting with a verified prescription yields better APHAB scores than fittings with the manufacturer's initial fit. Additionally, certain personality traits (e.g., low neuroticism; Cox, Alexander, & Gray, 2007), high hearing aid self-efficacy (Campos, Bozza, & Ferrari, 2014), and positive pre-fitting attitudes and expectations towards hearing aids (Ferguson, Woolley, & Munro, 2016; Hickson, Hamilton,

& Orange, 1986; Hickson, Timm, Worrall, & Bishop, 1999; Jerram & Purdy, 2001) have all been related to hearing aid benefit.

Interestingly, there is some discrepancy in the literature regarding the importance of device-specific factors for hearing aid benefit. More expensive, more advanced, or more sophisticated devices (e.g., premium-level hearing aids) might be expected to increase hearing aid benefit, given the additional features (e.g., advanced signal processing, adaptive beamforming technology) and added expense of such devices. Yet, support for this idea in the literature is limited. For example, Johnson, Xu, and Cox (2016) found that device differences between basic-feature and premium-feature hearing aids explained very little variability in benefit scores. However, one device factor, bilateral fittings, is related to benefit. Boymans et al. (2009) compared a group of subjects fit bilaterally with a group of subjects fit unilaterally; this survey of hearing aid users in Switzerland found that the bilaterally fit group had higher scores of perceived benefit but did not differ from the unilaterally fit group in terms of satisfaction.

In contrast to the determinants mentioned, there are factors that have been found to have no relation to perceived hearing aid benefit. Some of these factors are demographic in nature, such as age (Uriarte et al., 2005) and gender of the hearing aid user (Aurélio, da Silva, Rodrigues, & Kuniyoshi, 2012; Gatehouse, 1994; Mondelli, Rocha, & Honório, 2013). Furthermore, results demonstrating the relationship between hearing acuity and hearing aid benefit reveal that audiometric thresholds, along with word recognition in quiet and speech perception in noise, are only weakly related to benefit ratings (Dornhoffer, Meyer, Dubno, & McRackan, 2020).

Satisfaction

As with hearing aid benefit, there are numerous audiological and non-audiological variables that have been examined as potential determinants of hearing aid satisfaction ratings. Audiologically, speech-in-noise abilities (Davidson, Marrone, Wong, & Musiek, 2021) and length of hearing aid usage have been reported to be highly correlated with the level of hearing aid satisfaction (Convery et al., 2019; Saunders & Jutai, 2004). In the study previously mentioned, Cox et al. (2007) reported that greater self-reported hearing loss without hearing aids corresponded with higher satisfaction scores on the SADL (Cox et al., 2007). In terms of non-audiologic variables, personality (e.g., low neuroticism and high extraversion; Cox et al., 2007), high social support (Singh, Lau, & Pichora-Fuller, 2015), patient-reported self-management skills (Convery et al., 2019), and positive pre-fitting attitudes and expectations toward hearing aids (Gatehouse, 1994; Wilson & Stephens, 2003) have all been shown to be predictors of satisfaction.

Previous large-scale consumer surveys have also identified numerous determinants of hearing aid satisfaction ratings. MarkeTrak surveys, for example, have provided insight into the consumer's perspective and contributed to the understanding of factors that relate to hearing aid satisfaction. In 2010, a summary of previous MarkeTrak surveys indicated that benefit, sound quality and value were the leading indicators of perceived hearing aid satisfaction. At this time, consumers had reported advanced signal processing improved hearing aid satisfaction in relation to feedback, wind noise, comfort with loud sounds, etc. (Kochkin, 2010). More recently, Picou (2020) reported five important overall factors contributing to hearing aid satisfaction: hearing aid performance and sound, hearing care professional effectiveness, hearing aid physical qualities, hearing aid maintenance, and costs (upfront and ongoing).

Results of EuroTrak surveys spanning from 2009 to 2015 (in Germany, France, and the United Kingdom) show similar results, as reported by a review by Bisgaard and Ruf (2017). From 2009 to 2015, these surveys showed an increase in satisfaction over the prior 6 years in relation to hearing aid features along with product performance, with the largest increase shown in telephone use. This likely confirms that the addition of the Bluetooth streaming feature created a positive impact on hearing aid satisfaction. Additionally, this review reported a higher satisfaction with bilateral hearing aid fittings, as benefits include localization, spatial hearing, binaural summation, release of masking, etc. (Bisgaard & Ruf, 2017). A similar finding had been shown in a previous study by Bertoli, Bodmer, and Probst (2010), where a bilateral fit yields more frequently reported satisfaction. The results from both of these studies conflict with other reports that those with a bilateral fit do not differ in satisfaction from those fit unilaterally (Boymans et al., 2009), and is another example of the variability that exists among determinants.

Several factors have been found to have weak or no relation to hearing aid satisfaction. While perceived hearing loss was shown to be a contributing factor to hearing aid usage, hearing acuity has not been found to be a determinant in satisfaction (Bertoli et al., 2010; Dillon, James, & Ginis, 1997; Gatehouse, 1994; Jerram & Purdy, 2001). Age, gender and socioeconomic status have also not been found to have any relation to hearing aid satisfaction (Gatehouse, 1994; Hickson et al., 1999; Jerram & Purdy, 2001).

Benefit versus Satisfaction

Although benefit and satisfaction are closely associated constructs, they are not always affected by the same determinants. For example, hearing aid self-efficacy has been related to hearing aid satisfaction, but not benefit (Ferguson et al., 2016). Extraversion was related to reported satisfaction, but not benefit (Cox et al., 2007). According to Convery et al. (2019),

hearing aid satisfaction is also driven by factors such as physical appearance of the hearing aid, cost, and frequency of issues encountered with the device. While Cox et al. (2007) reported that new users perceive the most benefit, various studies have found that new users are generally less satisfied than those with previous experience (Wong et al., 2003). Additionally, greater self-perceived hearing loss (hearing difficulty without hearing aids) has previously been indicated by Cox et al. (2007) to be related to satisfaction but inversely related to benefit, further supporting the dissociation between benefit and satisfaction.

Purpose

While there exists a variety of studies which contribute to the understanding of hearing aid benefit and satisfaction ratings, many of these studies have relatively small sample sizes. In addition, much of this information has also been derived from laboratory studies, which can only include participants willing to come to the lab. The data collected from such studies might be affected by a social desirability bias, which might be reduced through processes which create anonymity such as online surveys (Larson, 2019), such as with direct-solicitation consumer surveys. Although the large-scale surveys, such as MarkeTrak and EuroTrak have been well-established for several decades and include large sample sizes, their findings are primarily descriptive in nature, and the range of factors contributing to hearing aid benefit and satisfaction are still not fully understood. By analyzing a large-scale customer survey related to the hearing aid purchase process and experience, this study aims to examine potential determinants of hearing aid benefit and satisfaction ratings. In better understanding the determinants of hearing aid benefit and satisfaction ratings, the results of the analyzed data collected may help patient-centered strategies to improve outcomes of audiological care.

Method

The study used a retrospective design. The consumer survey data were gathered by the HearingTracker.com during the year 2018. HearingTracker.com is an independently-owned informational resource for hearing aid consumers. The website contains information for current and prospective hearing aid owners, but does not sell hearing aids. People typically end up on the website after performing an Internet search for hearing aid information or insight into some specific brand or model. Some HearingTracker.com visitors sign up to be on the email mailing list. The survey was sent electronically using the Formstack platform to those who have signed up for the email mailing list. The Hearing Loss Association of America also sent the survey to their newsletter mailing list. The Hearing Loss Association of America is an organization representing consumers with hearing loss through efforts in education, support, and advocacy. Members of both mailing lists received an invitation to participate and a link to the survey. The specific instructions in the invitation were:

> "Have you ever purchased a hearing aid? If so, please take a moment to complete our hearing aid survey. We will ask about where you purchased your hearing aid(s), what sort of costs were involved, how satisfied you are, etc. Note: This survey is intended for US-based hearing aid purchasers. If are outside of the United States, or your hearing aids were obtained through the Veterans Affairs (VA), or were paid for by another government entity, please do not complete this survey. Additionally, if your hearing aids were given to you by a friend or family member for free, please do not complete this survey."

Participants were not compensated for their participation. The chair of the Institutional Review Board at Lamar University confirmed that this study does not require ethical approval as

we used anonymized retrospective data with the permission of the company who owned the data. Data were not pre-processed by the company before they were analyzed for the purpose of the current study.

Survey

All participants completed the online survey (included in full in the Supplemental Digital Content) which included questions on demographic factors (e.g., age, gender, income, employment status), audiological factors (e.g., hearing aid experience, duration of hearing loss, self-reported hearing difficulties), device-related factors (e.g., how many hearing aids, technology level, brand, accessories), service delivery factors (e.g., who fit hearing aids, follow up services), cost (e.g., cost of the device, insurance coverage, discount network used), hearing aid features, benefit and satisfaction (see Table 1).

The measure of hearing aid benefit was the response to a single question, "How would you rate your overall hearing with your current hearing aid(s)?" Response options were "vast improvement in hearing ability," "good improvement in hearing ability," "fair improvement in hearing ability," "no improvement in hearing ability," and "I heard better without my hearing aid(s). The latter response was taken as an indication of no hearing aid benefit, whereas the former was interpreted as maximum hearing aid benefit.

The measure of hearing aid satisfaction was the response to a single question, "How likely is it that you would recommend your hearing aid(s) to a friend or family member?" Response options ranged from 0 to 10, where 10 would indicate a high likelihood someone would recommend a hearing aid (i.e., consumer's loyalty), indicative of high satisfaction. Despite not including the word 'satisfaction' in the question, responses to the single question

Table 1. Summary of independent variables entered into the full regression model, in addition to the wording of the question on the survey. The full survey, including response options, is included in the Supplemental materials.

Type	Category	Variable	
Independent	Demographic	Age	How old are you?
		Gender	Are you male or female?
		Household pre-tax income	What is your pretax household income, approximately?
		Employment	What is your current employment status?
	Audiologic	Reported degree of hearing loss	How much hearing loss do you have? (Check all that apply)
		Duration of loss before hearing aids	From the time you first learned you had a hearing problem, how long did you wait before purchasing your first hearing aids?
		Hearing aid experience	How many years have you worn hearing aids, in total?
	Device characteristics	How many hearing aids (1 or 2)	How many hearing aids did you purchase?
		Hearing aid brand	What brands did you purchase?
		Level of technology	What level of technology did you purchase?
		Insurance coverage	Did your healthcare insurance cover all or part of the cost of your hearing aids?
		Professional who did the fitting	Who fitted your hearing aids?
		Cost	What was the total cost of your hearing aid(s) (in US dollars)?
	Device outcomes	Rated sound quality	How would you rate the overall sound quality of your hearing aid(s)?
		Rated fit and comfort	How would you rate the fit (comfort) of your current hearing aid(s)?
		Rated battery life	How would you rate the battery life of your current hearing aid(s)?
Dependent		Benefit	How would you rate your overall hearing with your current hearing aid(s)?
		Satisfaction	How likely is it that you would recommend your hearing aid(s) to a friend or family member?

were interpreted as reflecting satisfaction, consistent with established work in healthcare settings (Hamilton et al., 2014).

Data Analysis

All analyses were conducted with the R language for statistical computing (v 4.1.0; R Core Team, 2022). The characteristics of the study sample were summarized descriptively, including participant demographics, audiometrics, hearing device characteristics, and hearing aid fitting outcomes. Dependent variables were ratings of benefit or satisfaction. Independent variables included those described in Table 1 with data summarized in Tables 2-5; specifically, independent variables included those related to demographics (age, gender, household pre-tax income, employment), subjectively reported audiologic background (reported degree of loss, duration of loss before hearing aids, hearing aid experience), device characteristics (how many hearing aids, hearing aid brand, level of technology, insurance coverage, the professional who did the fitting, cost), and device outcomes (rated sound quality, rated fit and comfort, rated battery life).

Given the large number of potential independent variables, backwards stepwise ordinal regression was used to evaluate potential factors related to benefit and satisfaction scores. For each dependent variable (i.e., benefit or satisfaction), full models with all variables of interest were constructed with the ***polr*** function of the **MASS** package (Ripley et al., 2013). The ***polr*** function fits a proportional odds logistic regression for an ordered factor response, such as ratings of benefit or satisfaction in the current study. For benefit, the dependent variable was ordinal response to the benefit question (response options were "heard better without hearing aids," "no benefit," "fair benefit," "good benefit," "vast benefit"). For satisfaction, the dependent variable was ordinal response to the satisfaction question (response options from 1 to 10). The

final model for each outcome was selected in a backward stepwise fashion based on the Akaike Information Criteria (AIC) using the ***stepAIC*** function of the **MASS** package.

Initial attempts to analyze the benefit or satisfaction data revealed the models did not meet the assumptions necessary for analysis, primarily due to the low number of respondents who indicated limited benefit or satisfaction. As a result, both dependent variables were modified to reduce the number of categories in the response options. For benefit scores, responses of "heard better without hearing aids," "no benefit," and "fair benefit" were grouped together to create a single category of "limited benefit" for regression analyses. For satisfaction scores, responses from 0 to 4 were grouped to create a category of "not satisfied." Responses of 5, 6, and 7 were grouped to create a category of "somewhat satisfied" and responses of 8, 9, and 10 were grouped to create a category of "very satisfied." This step of creating satisfaction categories had additional benefit of facilitating comparison between benefit and satisfaction scores to each other as the data became similarly structured (i.e., three categories each). Model fits were assessed using the Lipsitz goodness of fit test for ordinal logistic models using the ***lipsitz.test*** function of the **generalhoslem** package (Jay & Jay, 2013). The ***emmeans*** function of the **emmeans** package (Lenth, 2019) was used to conduct pairwise comparisons explore significant main effects using pairwise comparisons and controlling for false discovery rates (Benjamini & Hochberg, 1995).

Results

Study Sample Characteristics

Participants

Adults with reported history of hearing aid ownership (n = 2,109) responded to the survey questions. Table 2 displays demographic data reported by the participants. As indicated in the table, most participants were 55 years old or older. There were slightly more female

Table 2. Demographic characteristics of study sample

Characteristic	N = 2,109[1]
Age	
Under 18 years old	63 (3.0%)
18 to 34	86 (4.1%)
35 to 54	290 (14%)
55 to 74	1,121 (53%)
75 or older	514 (24%)
I prefer not to say	35 (1.7%)
Gender	
Female	1,148 (54%)
Male	936 (44%)
I prefer not to say	25 (1.2%)
Household Pre-Tax Income	
$<25k	134 (6.4%)
$25-49k	327 (16%)
$50-$99k	549 (26%)
$100-149k	281 (13%)
>$150k	222 (11%)
I prefer not to say	596 (28%)
Employment	
Employed or homemaker	624 (30%)
I prefer not to say	74 (3.5%)
Out of work or looking for work	36 (1.7%)
Retired	1,090 (52%)
Self-employed	171 (8.1%)
Student	70 (3.3%)
Unable to work	44 (2.1%)

[1] n (%)

participants than males. Most participants were located in the United States (n = 2087, 99%). Other countries with more than one participant included Canada (n = 7, 0.3%) and the United Kingdom (n = 2, <0.1%). Table 3 displays the audiologic details participants reported. Most participants (52.8%) reported using hearing aids for 10 years or more. Participants represented a range of self-reported hearing losses, with most participants (69.2%) reporting hearing losses in the moderate to severe range. Note, the survey question for degree of hearing loss indicated participants should 'check all that apply,' resulting in reported combinations of degrees (e.g., mild moderate) that were not explicitly listed as response options, which were single words (e.g., moderate).

Hearing aids

Device characteristics are summarized in Table 4. Most participants (84%) reported purchasing two hearing aids. The most common dispensing site was a clinic or private practice setting (57%). Other settings, not represented in the table and accounting for fewer than 1% of respondents, included primary care doctor (n = 12, 0.6%), pharmacy hearing center (e.g., CVS; n = 2, <0.1%), Veterans Affairs (n=4, 0.2%), Kaiser Permanente (n = 9, 0.4%), and a professional at the residence (n = 7, 0.3%). Among those who purchased hearing aids at a store, the most common stores were MiracleEar (n = 31, 19%), Beltone (n = 30, 19%), Connect Hearing (n = 21, 13%), Audibel (n = 16, 9.9%), and HearUSA (n = 14, 8.6%). Among those who purchased hearing aids online, the common websites were ebay (n = 24, 31%), buyhear (n = 8, 10%), eargo (n = 6, 7.7%), hearingplanet (n= 4, 5.1%), MDhearingaid (n = 4, 5.1%), and Amazon (n = 4, 5.1%). Among those that purchased hearing aids from a discount warehouse, the most popular warehouse store for hearing aid purchase was Costco (n = 220, 96%), followed by Sam's Club (n = 9, 3.6%).

Table 3. Reported audiologic characteristics of study participants

Characteristic	N = 2,109[1]
Reported Degree of Loss	
Mild	59 (2.8%)
Mild Moderate	56 (2.7%)
Moderate	610 (29%)
Moderately Severe	195 (9.2%)
Severe	646 (31%)
Severe Profound	128 (6.1%)
Profound	374 (18%)
Not sure / I prefer not to say	41 (1.9%)
Duration Loss Before Hearing Aids	
I waited less than one year	888 (42%)
I waited 1 year or more	222 (11%)
I waited 2 years or more	183 (8.7%)
I waited 3 years or more	147 (7.0%)
I waited 4 years or more	78 (3.7%)
I waited 5 years or more	133 (6.3%)
I waited 6 years or more	38 (1.8%)
I waited 7 years or more	38 (1.8%)
I waited 8 years or more	22 (1.0%)
I waited 9 years or more	27 (1.3%)
I waited 10+ years	243 (12%)
I'm not sure	90 (4.3%)
Hearing Aid Experience	
Less than one year	153 (7.3%)
1-2 years	137 (6.5%)
2-4 years	170 (8.1%)
4-6 years	234 (11%)
6-10 years	306 (15%)
10-15 years	248 (12%)
15+ years	855 (41%)
I'm not sure	6 (0.3%)

[1] n (%)

Table 4. Device characteristics of hearing aids participants reported purchasing

Characteristic	N = 2,109[1]
Total Cost	
Median cost per aid in USD (interquartile range)	4000 (2500, 5737)
Missing	82
How Many	
I purchased a pair of hearing aids	1,774 (84%)
I purchased a single hearing aid	335 (16%)
Where	
Local hearing clinic / private practice	1,206 (57%)
Discount Warehouse (Costco, Sams, etc.)	250 (12%)
Ear, nose, and throat doctor	177 (8.4%)
Hospital or university clinic	177 (8.4%)
Name brand stores (Miracle Ear, Audibel, Beltone, Connect Hearing)	162 (7.7%)
I purchased my hearing aids on the internet	80 (3.8%)
Other	23 (1.1%)
Hearing Aid Brand	
Phonak	529 (25%)
Oticon	392 (19%)
ReSound	296 (14%)
Widex	183 (8.7%)
Starkey	165 (7.9%)
Signia / Siemens	135 (6.4%)
Other	352 (16.8%)
Not sure	78 (0.4%)
Missing	15
Level of Technology	
Low-end (least expensive)	78 (3.7%)
Mid-range	721 (34%)
Top end (most expensive)	1,136 (54%)
Not sure	165 (7.9%)
Missing	9
Insurance Coverage	
My insurance covered the full cost	117 (5.5%)
My insurance covered part of the cost	444 (21%)
My insurance did not cover my hearing aid purchase	1,548 (73%)
Professional	
Audiologist	1,581 (75%)
Hearing Instrument Specialist	432 (20%)
None	53 (2.5%)

	Not sure	43 (2.0%)

[1] n (%)

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Under 18 years old	63 (3.0%)
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Self-employed	171 (8.1%)
Student	70 (3.3%)
Unable to work	44 (2.1%)

[1] n (%)

Table 5. Fitting outcome ratings from study participants

Characteristic	N = 2,109[1]
Hearing aid sound quality	
Poor	128 (6.1%)
Acceptable	429 (20%)
Good	726 (35%)
Very good	812 (39%)
Missing	14 (<1%)
Hearing aid fit and comfort	
Poor	79 (3.8%)
Acceptable	313 (15%)
Good	662 (32%)
Very good	1,043 (50%)
Missing	12 (<1%)
Hearing aid battery life	
Poor	176 (8.4%)
Acceptable	656 (31%)
Good	757 (36%)
Very good	504 (24%)
Missing	16 (<1%)

[1] n (%)

Most of the hearing aids were reportedly "top end" hearing aids (n = 1136, 54%) with a median price of $4000 (USD; interquartile range: $2500 – 5737). The median year of acquisition was 2016 (interquartile range: 2014 - 2018). Most participants reported using Phonak, Oticon, or Resound hearing aids. Other brands with used by more than 1% of respondents include Kirkland Signature (n = 73, 3.5%), Rexton (n = 58, 2.8%), Signia (n = 38, 1.8%), Beltone (n = 36, 1.7%), Unitron (n = 36, 1.7%), Miracle Ear (n = 32, 1.5%).

Participant ratings of their fittings are displayed in Table 5. These data demonstrate few participants rated their hearing aid sound quality, fit/comfort and battery life to be poor. Most commonly, participants rated their hearing aid sound quality to be good or very good (74%), their hearing aid fit/comfort to be very good (50%), and the hearing aid battery life to be good (36%).

Benefit

Ten participants did not respond to the hearing aid benefit question. The number and percent of respondents who reported each category of benefit are displayed in Figure 1, which demonstrates "good" or "vast" benefit for most participants (i.e., 40 and 37.5%, respectively). Very few participants indicated hearing aids made listening more difficult or reported no benefit (0.6 and 2.4%, respectively). After removing responses from participants with missing data in any of the independent variables of interest, 1951 responses remained for regression analyses. After collapsing the benefit scores into the three categories, among the 1951 respondents, 38% reported 'vast benefit (n = 742), 40% reported 'good benefit (n = 783), 22% combined reported 'limited benefit (n = 426). The three category assignment allowed for the retention of two of the original benefit categories, yet reduced the number of categories with few respondents, resulting in three generally similarly sized participant groups.

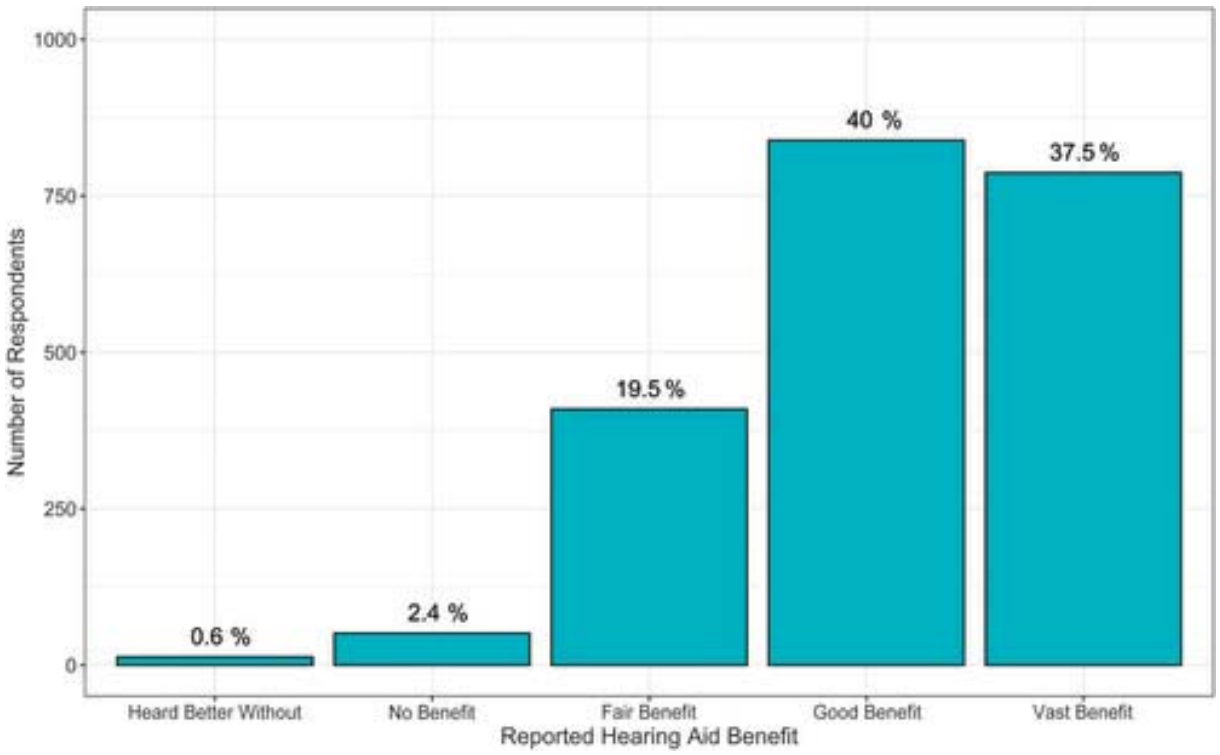

Figure 1. Number of responses and percent of respondents (values) for each category of benefit.

Prior to analysis, responses of 'unable to work' and 'unemployed' were combined into a single category ('not working'). The final model selected from the backwards stepwise procedure included age, self-reported degree of hearing loss, hearing aid experience, total hearing aid cost, hearing aid sound quality, hearing aid fit/comfort, and hearing aid battery life. The model was not a poor fit, as indicated by non-significant Lipsitz test (LR statistic = 8.85, df = 9, $p = 0.451$). Analysis of variance of the model revealed statistically significant main effects of most of the predictors on the hearing aid benefit ratings (see Table 6). The exception is age, which was not statistically significant, despite being included in the final model. On the basis of these results, there is not sufficient evidence to indicate that the predictors hearing aid benefit ratings included gender, household pre-tax income, employment, duration of loss before hearing

aids, how many hearing aids, hearing aid brand, level of technology, insurance coverage, or the professional who did the fitting.

Table 6. Results of the analysis of variance of the model of benefit ratings. Significant predictors are indicated by **bold** typeface.

Variable	$\chi 2$	df	*p*
Age	10.86	5	0.054
Degree of hearing loss	**29.90**	**7**	**<0.001**
Hearing aid experience	**33.74**	**7**	**<0.001**
Total cost (USD)	**8.15**	**1**	**0.004**
Sound quality	**375.54**	**3**	**<0.001**
Fit and comfort	**24.37**	**3**	**<0.001**
Battery life	**10.68**	**3**	**0.014**

Figure 2 displays the percent of respondents in each benefit category based on reported degree of hearing loss (top panel). Follow-up pairwise comparisons reveal ratings of benefit were different across each degree of hearing loss, except ratings of benefit were not different between people with reported moderate and profound hearing loss, moderate and severe hearing loss, and moderately-severe and severe hearing loss (all $p > .1$). Combined, these findings reveal people with severe-profound hearing loss were most likely to report 'vast' hearing aid benefits and people with mild hearing loss were least likely to report 'vast' benefits.

Figure 2 (bottom panel) reveals the percent of respondents who reported each category of benefit based on their hearing aid experience. Follow-up comparisons revealed the groups were significantly different from each other ($p < 0.01$), except people with 1-2 years of experience reported similar benefits as those with less than 1 year of experience and similar to those who were not sure how much experience they had ($p > .05$). In addition, people with 10-15 and 15+ years of experience reported similar benefits to each other ($p > .05$). Combined, these findings

reveal people with more hearing aid experience were generally more likely to report ‘vast’ benefits than were people with fewer years of hearing aid experience.

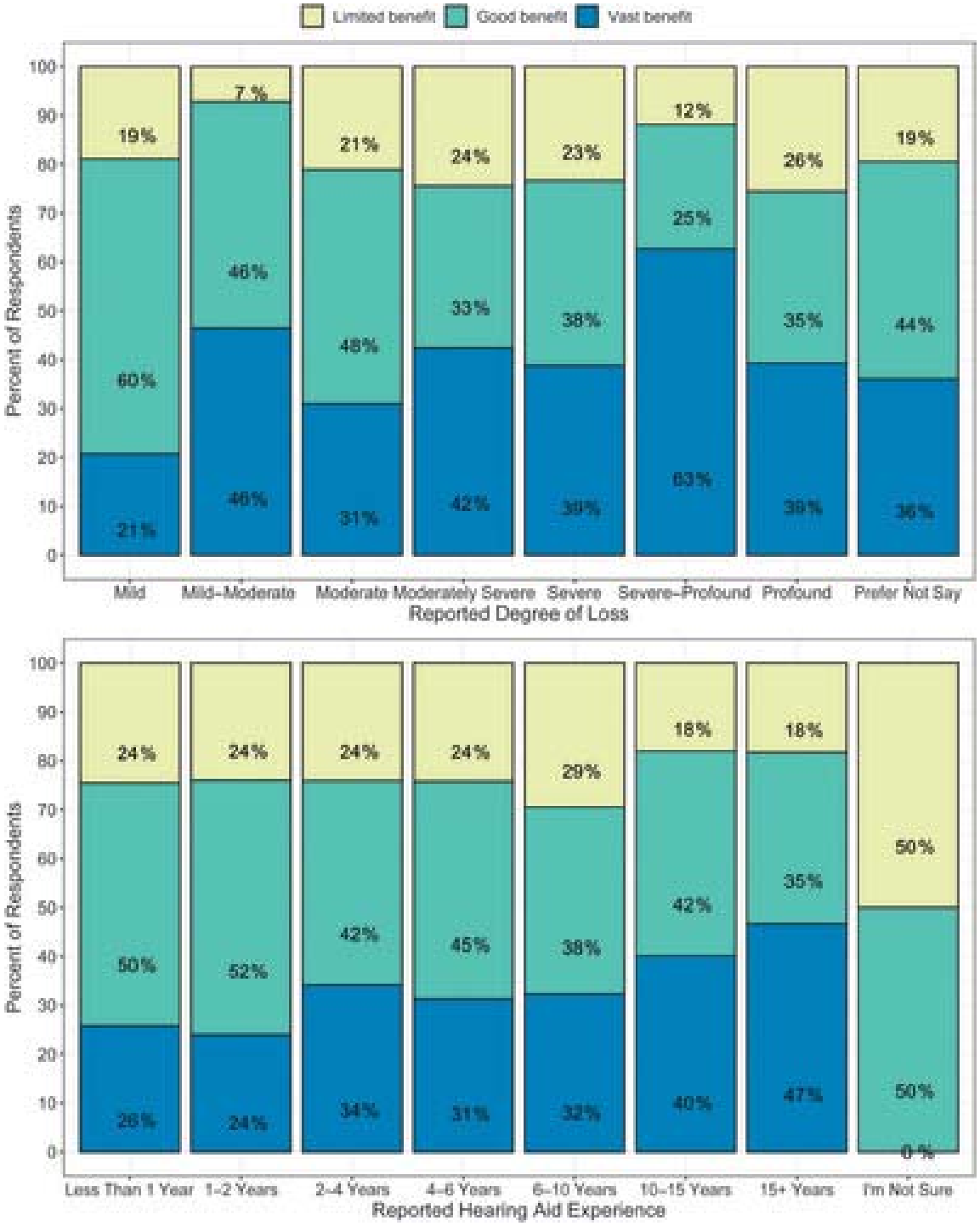

Figure 2. Audiologic factors related to benefit. Panels display the percent of respondents in each category of hearing loss (top panels) and hearing aid experience (bottom panels) who reported fair, good, and vast benefit.

Figure 3 displays the median reported cost of hearing aids for respondents in each category of benefit. A follow-up test with a linear model (cost as a dependent variable and reported benefit as the independent variable) revealed statistically significant differences in cost based on reported benefit ($F(2, 2017) = 8.25$, $p < .001$). Follow-up testing revealed people who reported vast benefit reported paying more than people who reported good benefit (*M* difference = $321, 95% CI: 82 to 559, $p < .01$) and more than people who reported limited benefit (*M* difference = $427, 95% CI: 146 to 708, $p < .0001$). However, people who reported good and limited benefit paid similar amounts for their hearing aids (*M* difference = $106, 95% CI: -172 to 384, $p = .36$).

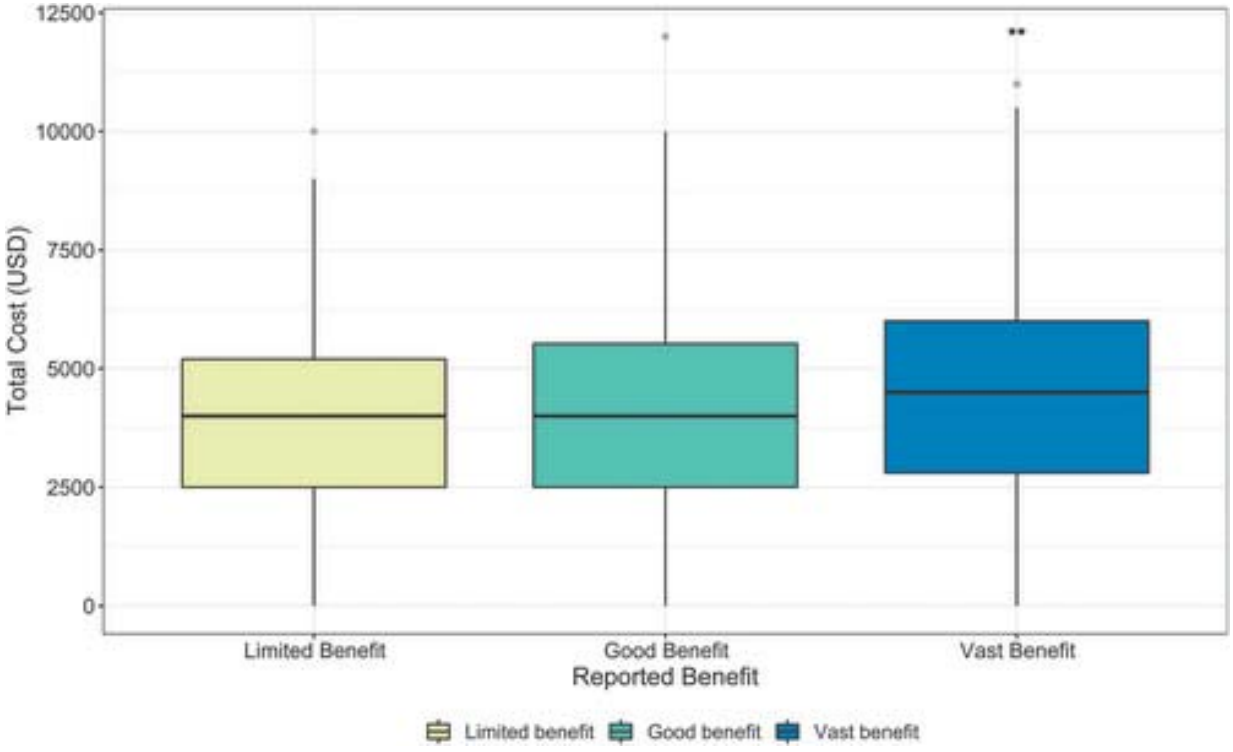

Figure 3. Median cost for respondents who reported limited, good, or vast benefit. ** indicates reported cost was higher for respondents who reported vast benefit than the other benefit categories ($p < .01$).

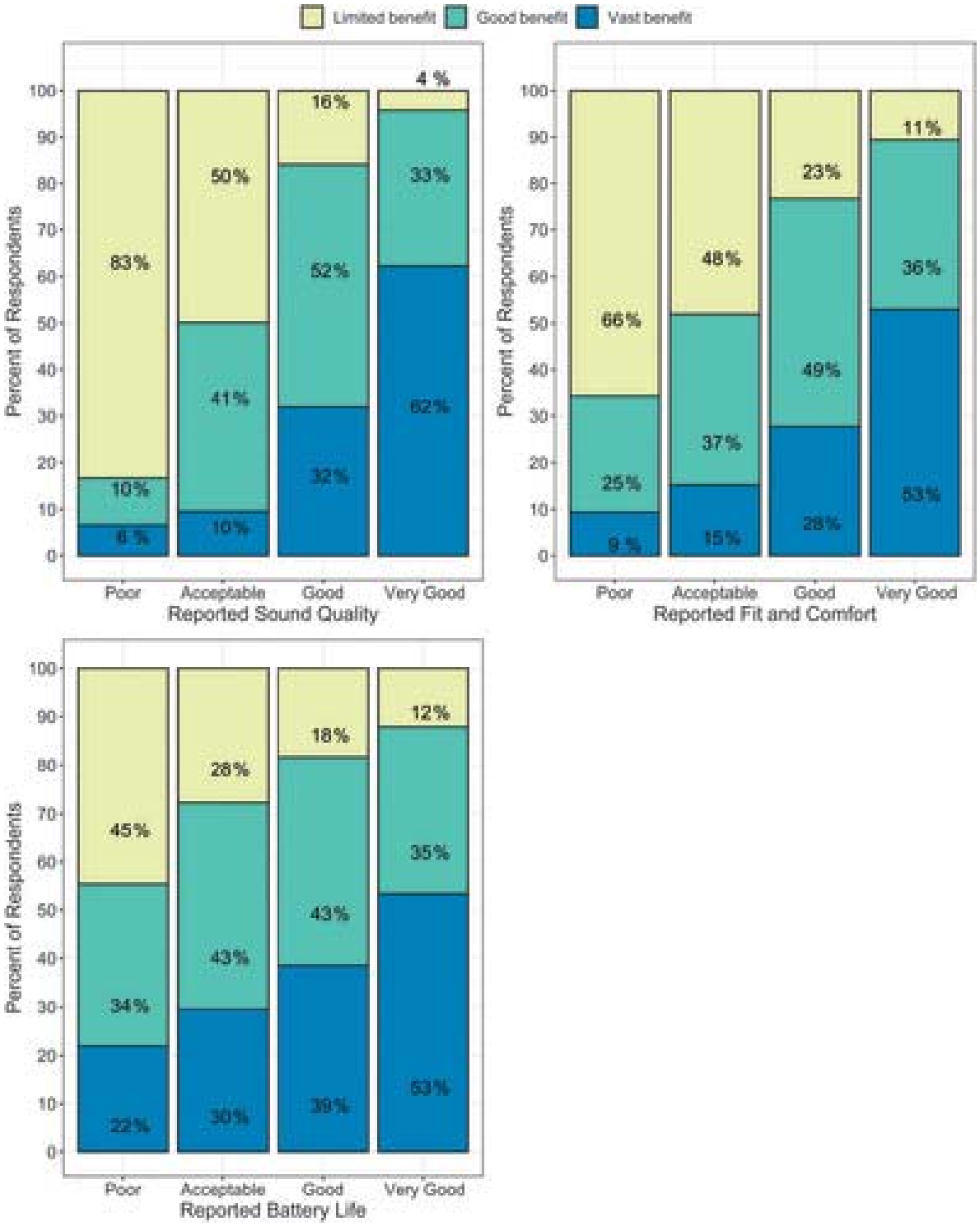

Figure 4. Fitting factors related to benefit. Panels display the percent of respondents in each category of sound quality rating (top left) and fit/comfort rating (top right) and battery life (bottom left) who reported limited, good, and vast benefit.

Figure 4 displays the relationship between reported fitting outcomes and reported hearing aid benefit. Follow-up testing revealed that ratings of benefit differed across all ratings of sound quality ($p < .05$); respondents who reported better sound quality were more likely to report 'vast' hearing aid benefit (top left panel of Figure 4). Similarly, respondents who reported better fit and comfort were more likely to report more hearing aid benefit ($p < .05$), except respondents who reported acceptable and good fit/comfort had similar ratings of benefit (top right panel of Figure 4). Respondents who reported better battery life were also more likely to report more hearing aid benefit ($p < .05$; bottom panel of Figure 4), except people who reported good and acceptable battery life had similar benefit ratings ($p = .14$), as did people who reported good and very good battery life ($p = .16$).

Satisfaction

Forty-nine people did not answer the satisfaction question; Figure 5 displays the responses to the satisfaction question, where higher ratings are indicative of higher satisfaction. After removing responses from participants who did not answer all the questions of interest, 1955 responses remained for regression analyses. After collapsing the satisfaction scores into three categories, among the 1955 respondents, 64.3% reported they were 'very satisfied' (n = 1257), 25.6% reported they were somewhat satisfied (n = 501), and 10.1% were not satisfied with their hearing aids (n = 197).

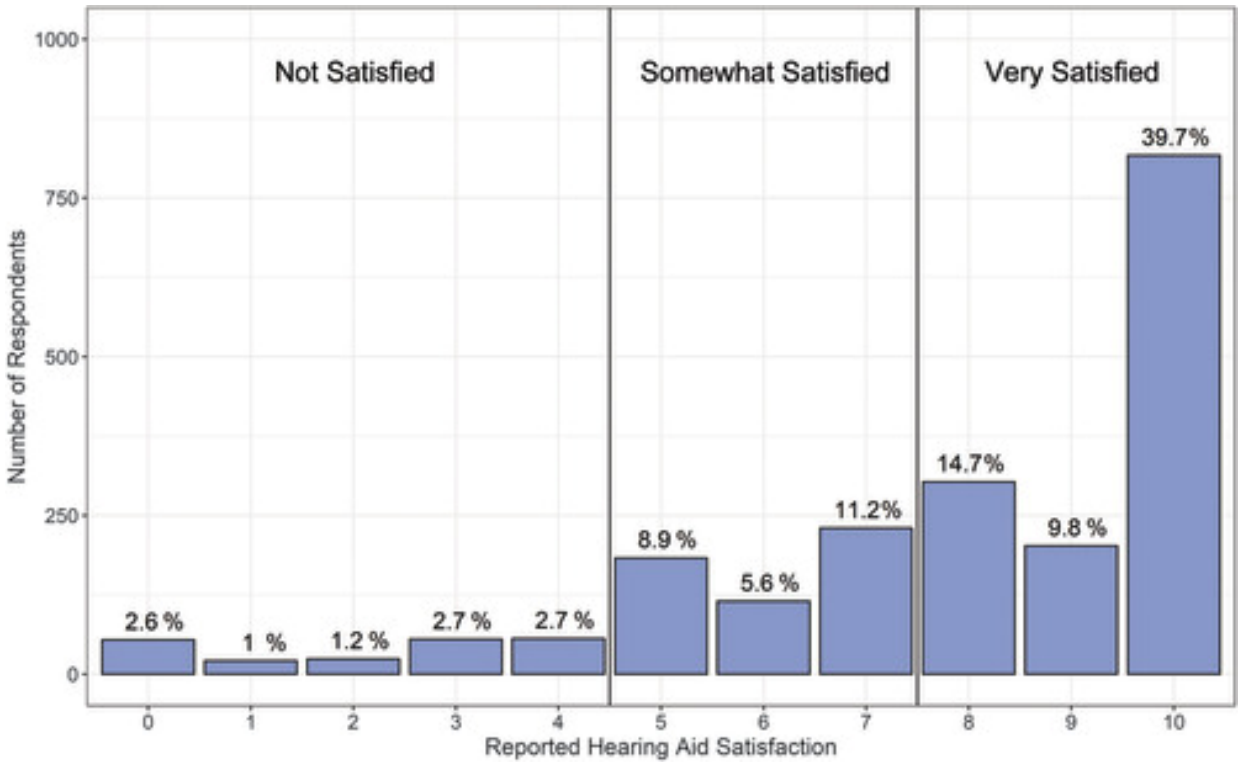

Figure 5. Number of respondents (and percent) for each satisfaction score, in addition to the assigned satisfaction category (i.e., not satisfied, somewhat satisfied, or very satisfied).

The result of the backwards stepwise procedure was a regression model with age, employment, income, brand, cost, hearing aid sound quality, hearing aid fit and comfort, and hearing aid battery life. The variables gender, duration of hearing loss, duration of hearing aid experience, purchase location, number of hearing aids, level of technology, health insurance, and fitter did not survive the stepwise procedure. Table 7 displays the results of the analysis of variance of the regression model. Briefly, all factors were significantly related to satisfaction, except pre-tax household income. In addition, follow-up regression analysis with cost as the dependent variable and satisfaction rating as the independent variable revealed cost was not different between respondents with different satisfaction ratings ($p > .05$). Combined, these data indicate age, employment, brand, and fitting outcomes were related to ratings of satisfaction.

Table 7. Results of the analysis of variance of the model of satisfaction ratings. Significant predictors are indicated by **bold** typeface.

Variable	$\chi 2$	df	*p*
Age	**16.18**	**5**	**0.006**
Employment	**14.53**	**5**	**0.013**
Household income	10.30	5	0.067
Brand	**14.86**	**6**	**0.021**
Cost	**7.09**	**1**	**0.008**
Sound quality	**353.58**	**3**	**<0.001**
Fit and comfort	**51.91**	**3**	**<0.001**
Battery life	**16.70**	**3**	**0.001**

Figure 6 displays the relationship between ratings of satisfaction and age (top left panel), employment (top right panel), and brand (bottom left panel). Follow-up analysis revealed decreasing likelihood of high satisfaction ratings with increasing age; younger respondents were more likely to be satisfied with their hearing aids than were older participants ($p < .05$). The exception is ratings of satisfaction were similar for 18-34 year olds and 55-74 year olds ($p = 0.82$). Analysis also revealed all groups reported different satisfaction based on employment, except those who are retired and employed/homemakers, who reported similar levels of satisfaction to each other ($p = 1.0$). Finally, follow-up analysis revealed significant differences in brand satisfaction; respondents reporting owning brands D, E, and F were more likely to be satisfied than respondents using other brands ($p < .05$). Satisfaction ratings were statistically similar across those three brands ($p > .05$).

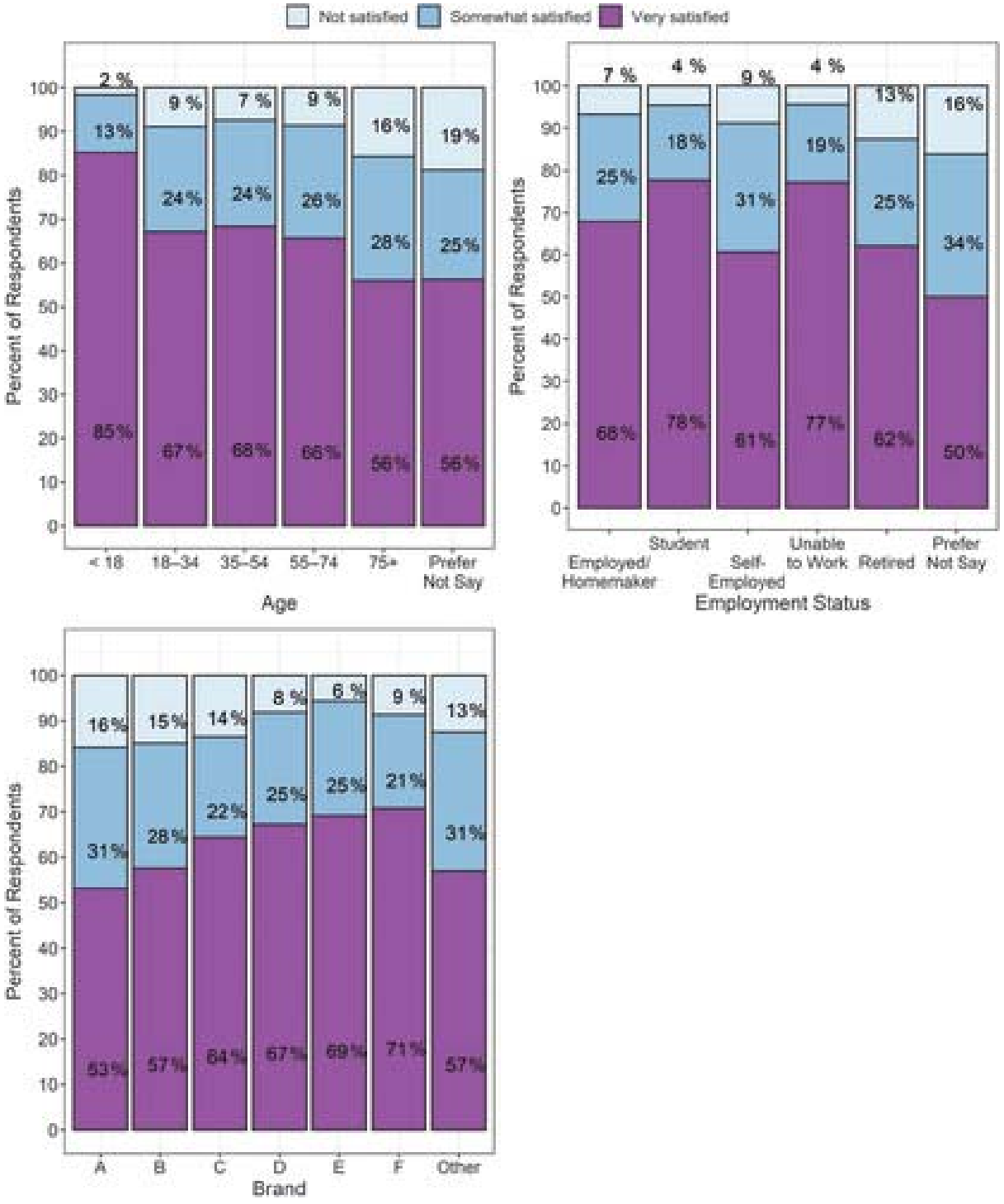

Figure 6. Factors related to satisfaction. Panel displays the percent of respondents in each age bracket (top left), each employment status (top right), and each brand (bottom left) who reported they were not satisfied (ratings of 0-4), somewhat satisfied (ratings of 5-7), or very satisfied (ratings of 8-10).

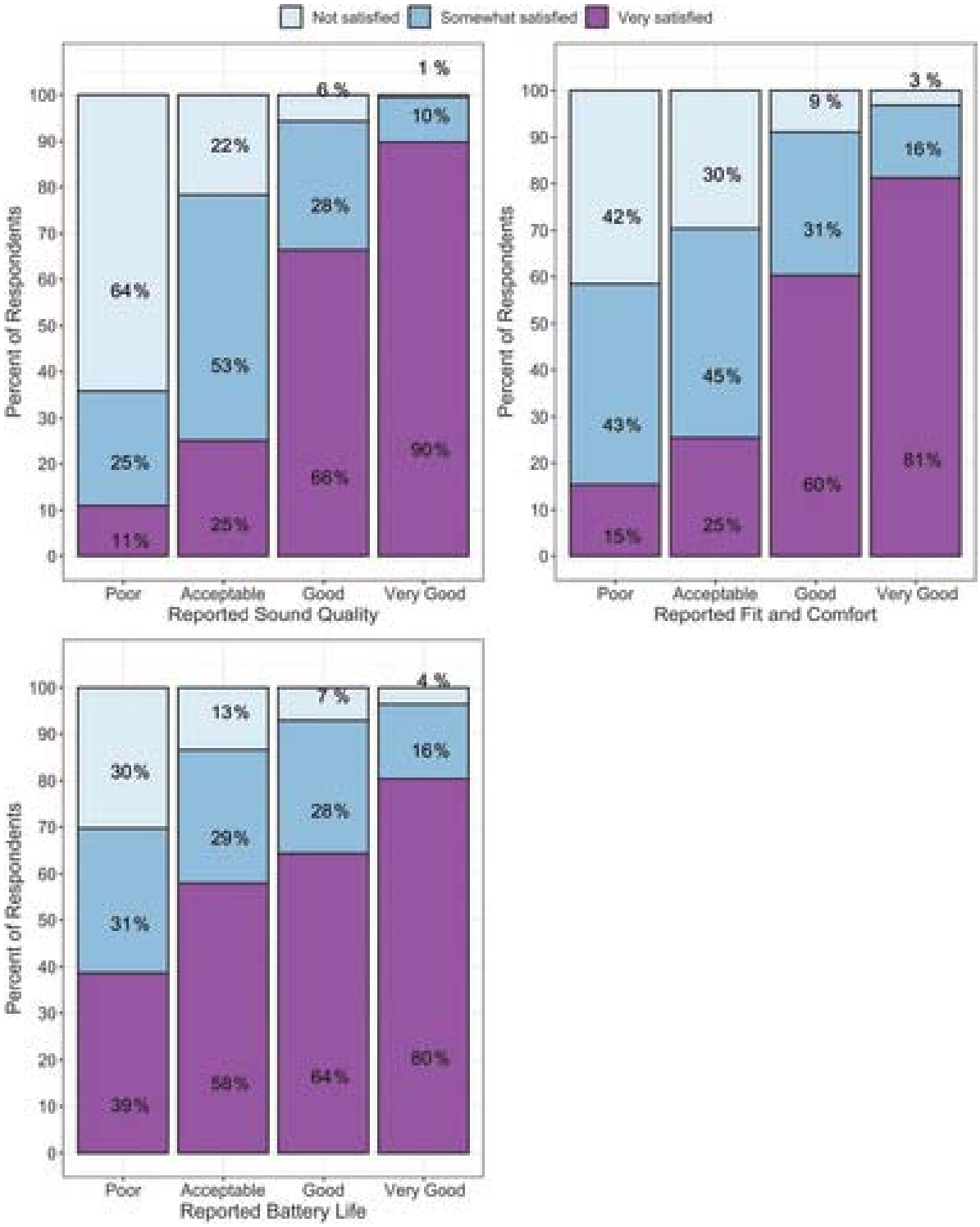

Figure 7. Fitting factors related to satisfaction. Panels display the percent of respondents in each category of sound quality rating (top left), fit/comfort rating (top right), and battery life (bottom left) who reported they were not satisfied (ratings of 0-4), somewhat satisfied (ratings of 5-7), or very satisfied (ratings of 8-10.

Figure 7 reveals the relationship between satisfaction and fitting outcomes (sound quality in the top left panel, fit and comfort in the top right panel, and battery life in the bottom left panel). Follow-up analysis revealed that satisfaction ratings were more likely to be high with higher ratings of sound quality, fit and comfort, and battery life ($p < .05$). The exception is battery life, where respondents with ratings of 'acceptable' and 'good' reported satisfaction ratings similar to each other ($p = .26$). Combined, these data indicate better fitting outcomes were more likely to be related to high ratings of satisfaction.

Relation between Benefit and Satisfaction

Figure 8 displays the relationship between benefit and satisfaction. Although people who reported 'vast' benefit were more likely to also be 'very satisfied' (621/742, 84%), there is variability in the satisfaction ratings of people who reported only 'limited' benefit. Nearly one third (126/426, 30%) of people who reported 'limited benefit' reported they were also not satisfied with their hearing aids. Yet, the majority (42%) of participants who reported only limited benefit also reported they were 'somewhat' (181/268, 42%) or 'very' satisfied (119/426, 28%). These data indicate that satisfaction and benefit are related, but different, constructs and that predicting satisfaction based on perceived benefit would be difficult, especially for people who report limited benefit.

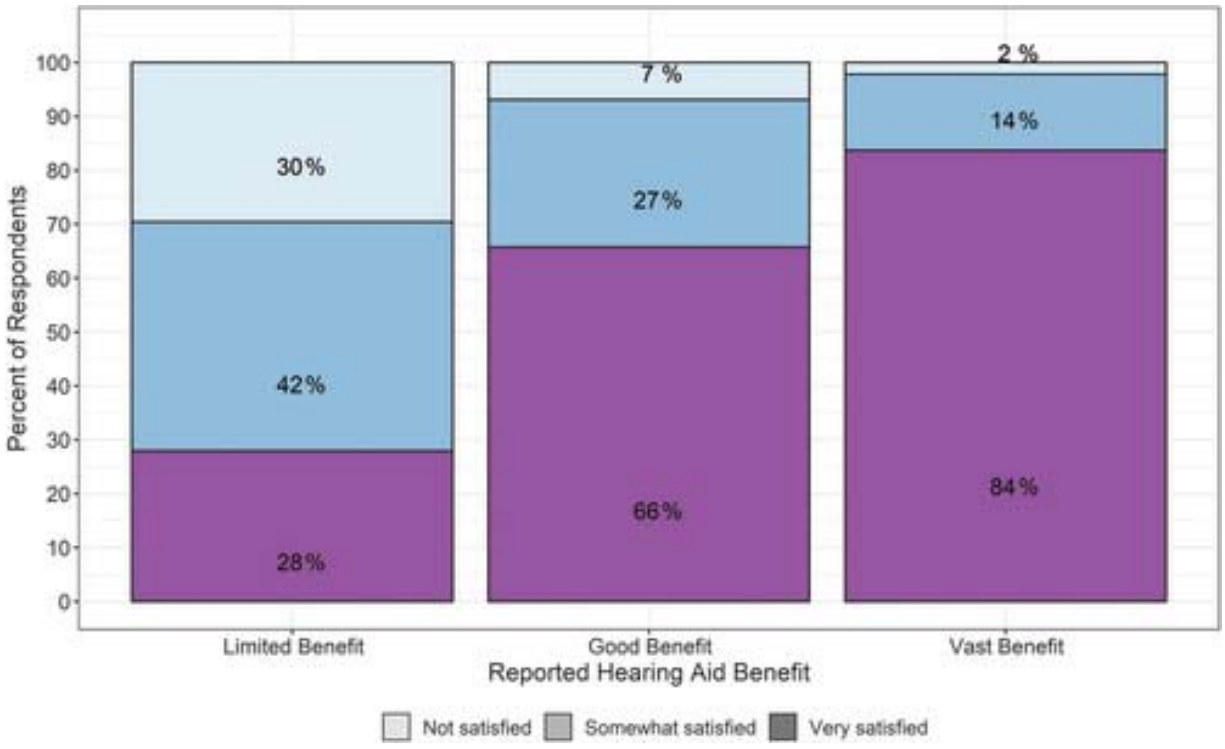

Figure 8. Relationship between reported hearing aid benefit and satisfaction. Panel displays the percent of respondents in each benefit category who they were not satisfied (ratings of 0-4), somewhat satisfied (ratings of 5-7), or very satisfied (ratings of 8-10).

Discussion

The purpose of this study was to examine potential determinants of hearing aid benefit and satisfaction ratings in a large sample of hearing aid users. The results of this survey revealed different determinants for benefit and satisfaction, consistent with previous work supporting differentiation between benefit and satisfaction (Boymans et al., 2009; Cox et al., 2007; Ferguson et al., 2016). Although good fitting outcomes (sound quality, fit and comfort, battery life) are related to both benefit and satisfaction, in the current data set, it would be difficult to predict how satisfied someone with limited benefit would be (see Figure 8) and the factors that

are statistically related to benefit and satisfaction are different. As a result of the dissociation between benefit and satisfaction, each will be considered separately.

Benefit

There are several key findings regarding hearing aid benefit. 77.5% of respondents, as shown in Figure 1, reported "good" or "vast" benefit, with 19.5% reporting only limited benefit. With 97% of respondents reporting degrees of benefit, it can be inferred that the established hearing aid users who participated in this study perceived benefit from their devices. The three fitting outcomes (sound quality, fit/comfort, battery life) were significantly related to reported benefit. These findings with a large study sample showing the importance of hearing aid fit agrees with work by Abrams et al. (2012) in which a verified prescription fit yields greater perceived benefit. Also, a recent large-scale study has shown that sound quality (i.e., ability to hear friends and family in quiet and noisy settings) and physical comfort of hearing aids seem to be the most desirable hearing aid attributed by consumers shopping for hearing aid (Manchaiah, Picou, Bailey, & Rodrigo, 2021). Taken together, these findings highlight the importance of a well-fit hearing aid for maximizing reported hearing aid benefit

In addition to the fitting outcomes, the determinants of benefit ratings include reported degree of hearing loss, hearing aid experience, and hearing aid cost. The relationship between degree of hearing loss is inconsistent with studies previously reporting only weak relationship between hearing acuity and reported hearing aid benefits (Dornhoffer et al., 2020). However, recall the current study used *perceived* hearing loss, which is a better predictor generally for hearing aid outcomes than *measured* hearing acuity (Vestergaard Knudsen et al., 2010). Hearing aid experience also shows to have a positive correlation with perceived benefit, as more experienced users (>2 years) reported greater benefit. These results conflict with those of Cox et

al. (2007) whose results indicated that higher success (related to benefit) was driven by new hearing aid users (less experience). This could be due, in part, to the use of several different measures of benefit which can potentially yield different results. Additionally, out of the 205 participants in said study, 139 were patients of the VA and the majority of subjects received hearing aids at no cost to themselves (Cox et al., 2007).

In the current study, cost was associated with benefit ratings; respondents who reported more benefit also paid more for the hearing aids (median price = 4500 USD; 25% quantile = 2800 USD; 75% quantile = 6000 USD) than people who reported good (median price = 4000 USD; 25% quantile = 2500 USD; 75% quantile = 5525 USD) or limited to no benefit (median price = 4000 USD: 25% quantile = 2500 USD; 75% quantile = 5200 USD). It is possible the more expensive hearing aids included more advanced features or processing. However, benefits of advanced features which are beneficial in laboratory settings, have not been similarly beneficial in field studies (Johnson et al., 2016; Wu et al., 2019). In addition, 'levels of technology' was not a significant predictor of benefit ratings in the current study, suggesting it is not (only) advanced processing associated with additional costs that affect benefit. Instead, cost might be related to expectations, rather than to device differences. It is possible that respondents who paid more for their hearing aids expected more benefits from their hearing aids, resulting in higher reported benefits; expectations have been related to reported benefits (Cox et al., 2007; Ferguson et al., 2016).

Satisfaction

There are several key findings regarding hearing aid satisfaction. Among 1,296 respondents, only 9.1% (n=118) reported no satisfaction with their hearing aids (scores of 0 through 4 on the 10 point satisfaction scale). The other 1,178 (90.9%) respondents reported

scores of 5 or higher on the satisfaction scale. This high level of satisfaction among hearing aid users is consistent with MarkeTrak data and similar across other studies, where consistently ~80% of hearing aid users are satisfied (Bertoli et al., 2009; Kochkin, 2010; Picou, 2020; Picou, 2022). This indicates that adequate comparisons can be made between these large-sample surveys.

As with ratings of benefit, ratings of satisfaction were related to hearing aid fitting outcomes (sound quality, fit/comfort, battery life). These results are consistent with those of MarkeTrak, with sound quality being one of their top determinants of hearing aid satisfaction (Kochkin, 2010; Picou, 2020), and consistent with previous reports of the sound quality predictor (Kapteyn, 1977). Combined with the benefit data, these findings highlight that good fitting outcomes increase the likelihood of high benefit and satisfaction ratings.

In addition to these fitting outcomes, age, employment status, and brand were associated with ratings of satisfaction. The relationships between age, employment status, and ratings of satisfaction could be interrelated. It is reasonable to assume that there are similar underlying factors related to both age and employment status. For example, younger respondents and students were more likely to report higher ratings of satisfaction than were older respondents and retired people. It could be that those in school (who are younger) have more demanding auditory lifestyles (e.g., school, social events) than those who are retired. Older adults tend to have quieter lifestyles than younger adults (Wu & Bentler, 2012). Hearing aids have been implicated in increased social participation (Holman, Drummond, & Naylor, 2021), so it is possible the younger adults are more satisfied with their hearing aids and their performance in these social situations. It is also possible there are additional variables, related to both age and employment, not measured here that affect these relationships, such as social support or general health.

It is not clear what is driving the relationship between brand use and ratings of satisfaction. It is possible brand differences are related to feature differences, and hearing aid features have been linked to satisfaction rates (Picou, 2020; Picou, 2022). It might also be driven by sound quality differences between brands. Previous evidence suggests some hearing aid users prefer the sound quality of one brand over another (e.g., Marcrum et al., 2018), but differences between brands are often proprietary and complex. It is not clear what other brand-related aspects are contributing to this relationship and further research should be done to address this.

Study Limitations

One limitation of the study is the use of single item questions to index benefit and satisfaction. While the satisfaction question is an established measure of satisfaction in marketing research (Van Doorn, Leeflang, & Tijs, 2013), it does not include the word 'satisfaction.' Thus, the face validity of the question as a measure of satisfaction is somewhat limited. It is also possible respondents are very satisfied with their hearing aids, but feel unlikely to recommend them to others based on their friends' or families' personal situations, rather than their own satisfaction. Conversely, the rating of benefit has good face validity, explicitly including response options that indicate benefit (e.g., "vast improvement in hearing ability" or "good improvement in hearing ability"). However, the relationship between this single question of benefit and the validated benefit questionnaires (e.g., APHAB) has not been established.

Furthermore, a few things should be taken into consideration regarding the participant sample. The majority of respondents reported owning top-end (n=1,136) and mid-level (n=721) hearing aids. Hearing aids with these higher levels of technology allow for more extensive programming adjustments by hearing healthcare professionals and are also likely to have additional features that could impact the benefit perceived by users (e.g., directionality, wireless

streaming). While the nature of this study helps to eliminate the social desirability bias seen in many laboratory studies (Larson, 2019), all respondents participated in the study by completing an e-mailed survey, imposing a different bias. Specifically, respondents were hearing aid users who were not only internet proficient, but likely highly informed consumers. This could imply these hearing aid users are more likely to utilize smartphone apps, actively participate in hearing healthcare decisions, and engage with the additional features available to customize their hearing aid experience.

In addition to internet proficiency and high-end hearing aids, the group is homogeneous in other dimensions. For example, more of the respondents lived in the United States, were fit by an audiologist in a local clinic, and did not have insurance coverage for their hearing aids. It is not clear how these findings will generalize to new hearing aid users, who are less likely to report benefit or satisfaction (Cox et al., 2007; Wong et al., 2003) or to other countries with different hearing aid uptake (e.g., Bisgaard, Zimmer, Laureyns, & Groth, 2021) or different service-delivery models. The participants in the current study were homogeneous in terms of service delivery, with most of them being fitted bilaterally by an audiologist in a local clinic. This combination was a common service delivery model in 2018, but the role of hearing healthcare professional is rapidly evolving (Carr & Kihm, 2022; Edwards, 2020).

Additionally, the retrospective design of this study does not allow for all confounding variables to be measured, and a causal relationship cannot be confirmed. Another limitation of this study is the unexplained variability that remains. Despite the large number of predictive factors included, only ~ 40% of the variability in benefit or in satisfaction ratings has been explained, which suggests that these are complex, multi-faceted constructs. It is possible that

qualitative research methods would be helpful to identify factors that are not captured in questionnaires and are important to hearing aid users' benefit and satisfaction.

Future Research

In addition to the exploration of unexplained variables, future research is warranted to investigate determinants of hearing aid benefit and satisfaction in a group of users with more low-end and direct-to-consumer hearing aids. This would be helpful in further understanding current and future delivery models. It would also be beneficial to consider the lower cost of these devices in the analysis. As this study shows that fitting outcome variables relate to satisfaction, it would also be beneficial to examine the relationship between hearing aid satisfaction and service satisfaction to gain further insight into the entire fitting experience. Some variables have not been thoroughly examined as determinants of benefit and satisfaction ratings and may be useful to explore in future work. These include variables related to pre-fitting (e.g., general health attitude, social interaction), fitting (e.g., first impression of hearing aid, counseling), post-fitting (e.g., activity of daily living, major life events, medication use) along with variables that relate across the range of an individual's hearing aid experience (e.g., support systems, emotions, self-efficacy). Although some investigations have included some of these additional variables, such as overall health (Gussekloo et al., 2003), general health attitude (Humes, Wilson, & Humes, 2003), and activities of daily living (Wade & Collin, 1988), additional work is warranted to construct models of benefit and satisfaction that include many of these variables simultaneously with large data sets.

Conclusions

Most of the consumers in this survey reported good hearing aid benefit and high satisfaction. Results of this study highlight the importance of good hearing aid fitting outcomes

(sound quality, comfort, battery life) for benefit and satisfaction ratings, in addition to a dissociation between benefit and satisfaction. Ratings of benefit were also related to reported degree of hearing loss, hearing aid experience, and cost. Ratings of satisfaction were also related to age, employment status, and brand. Professionals who fit hearing aids should strive to focus on achieving positive outcomes while taking into consideration the potential role of these additional factors for benefit and satisfaction. Future work is warranted to further explore the unexplained variability in both outcomes and to evaluate the generalizability of these findings to a more heterogenous population of hearing aid users.

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Data Availability Statement

The datasets analyzed and the analysis scripts used during the current study are available from the corresponding author on reasonable request.

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Supplemental Material Description

Full questionnaire completed by study participants, including questions and response options.