Dispensing Rates of Four Common Hearing Aid Product Features: Associations With Variations in Practice Among Audiologists

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Abstract

The purpose of the study was to develop and examine a list of potential variables that may account for variability in the dispensing rates of four common hearing aid features. A total of 29 potential variables were identified and placed into the following categories: (1) characteristics of the audiologist, (2) characteristics of the hearing aids dispensed by the audiologist, (3) characteristics of the audiologist's patient population, and (4) evidence-based practice grades of recommendation for each feature. The potentially associative variables then were examined using regression analyses from the responses of 257 audiologists to a dispensing practice survey. There was a direct relation between price and level of hearing aid technology with the frequency of dispensing product features. There was also a direct relation between the belief by the audiologist that a feature might benefit patients and the frequency of dispensing that feature. In general, the results suggested that personal differences among audiologists and the hearing aids audiologists choose to dispense are related more strongly to dispensing rates of product features than to differences in characteristics of the patient population served by audiologists. An additional finding indicated that evidence-based practice recommendations were inversely related to dispensing rates of product features. This finding, however, may not be the result of dispensing trends as much as hearing aid manufacturing trends.

Keywords

hearing aid, product features, dispensing rates, variability, audiologists

The Institute for Healthcare Optimization, initiated by the Boston University Management of Healthcare Variability Program (2009), indicates there is substantial “natural” variability in the process of health care delivery. This natural variability arises from three primary sources:

1. *patient demand variability* (patients arrive for treatment randomly over time);
2. *clinical variability* (patients differ in the type and severity of their diseases, and similar patients respond differently to treatment); and
3. *professional variability* (different providers treat similar patients in different ways).

These variables also are expected to affect the delivery of hearing aids and the product features of hearing aids, such as digital noise reduction processing, digital feedback reduction processing, directional processing, and the telecoil. Because the effects of patient demand variability are minimal with regard to hearing aid product feature selection, if audiologists are allowed enough time in their schedules to conduct a comprehensive hearing evaluation and hearing aid

selection, patient demand variability should not affect hearing aid product feature selection decisions. Clinical and professional variability, therefore, are expected to have the greatest impact on hearing aid product feature delivery in typical audiology practice settings. For these reasons, the current study examined the characteristics of the patient population served by audiologists (clinical variability) and the characteristics of audiologists (professional variability) to determine whether either variable is affecting the dispensing of common hearing aid product features.

Evidence-based practice (EBP) guidelines, based on recent research, have been developed to assist clinicians with making clinical decisions. In a guideline made widely available to audiologists (Valente et al., 2006), varying grades of

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recommendation, designated by letters A to D, were assigned to specific product features. Presumably, those with higher grades of recommendation (e.g., A) would be dispensed more often than those with lower grades of recommendation (e.g., D). Use of such grades of recommendation by audiologists might also be expected to minimize practice variability in the selection of product features among audiologists.

The study of the natural variability involved in the dispensing rates of hearing aid features was prompted by the variability observed in the dispensing rate of product features. Among 367 audiologists, E. E. Johnson (2007a) found the average dispensing rate of digital noise reduction processing was 85%, digital feedback suppression processing was 87%, and directional processing and telecoil were 77% and 67%, respectively. There was substantial variability noted, however, among audiologists in the individually reported dispensing rates of each feature (i.e., digital noise reduction processing, 16%; digital feedback suppression processing, 15%; directional processing, 21%; and telecoil, 29% as reflected in the measure of standard deviation). The average dispensing rates of the various features were also not consistent with EBP guideline recommendations of each feature's expected benefit(s) (e.g., Valente et al., 2006). Specifically, the features with lower grades of recommendations were dispensed more often than features with higher grades of recommendations and vice versa.

Rationale for the Selection of Product Features Examined for Explanations of Underlying Dispensing Variability

The identification of individual product features within a hearing aid device is becoming, arguably, difficult in recent product releases as these devices are becoming more fully integrated. That is, most all modern hearing aids now attempt to seamlessly transition between multiple memory listening programs that engage product features with various degrees of implementation. Nonetheless, these products can be subdivided into smaller discretely identifiable components both in the manufacturing stage of development and by individual audiologists responsible for dispensing hearing aids to patients.

Product features were selected for inclusion in this study based on two major criteria. The first criterion for inclusion was that the feature had previously demonstrated "marked" variability in its dispensing rate among audiologists. Second, product features examined should be readily available on hearing aids manufactured by all major brands to alleviate variability in dispensing rates that might arise due to audiologist preference for a brand that does not offer a particular product feature. This is important because previous research has shown that 93% of audiologists rely heavily on one preferred brand, dispensing it 71% of the time on average to patients (E. E. Johnson, 2007b). Therefore, product features

such as ear-to-ear wireless communication between two hearing aids and antireverberation algorithms were excluded as each was available from only a small subset of manufacturing brands at the time of this study's completion.

A review of product feature offerings from major hearing aid brands indicated that digital feedback suppression processing, digital noise reduction processing, directional processing, and the telecoil were universally available. By focusing on these common features, it is expected that study findings are salient to the highest number of hearing aid dispensing audiologists. In addition, numerous research studies have demonstrated benefits of dispensing three of these features (e.g., *directional processing*, Cord, Surr, Walden, & Dyrland, 2004; Killion, 2004; Kochkin, 2003; Ricketts & Henry, 2002; Ricketts, Henry, & Gnewikow, 2003; Ricketts & Hornsby, 2003; Ricketts, Hornsby, and Johnson, 2005; Walden, Surr, Cord, & Dyrland, 2004; *digital feedback suppression processing*, Chung, 2004; Freed & Soli, 2006; Greenberg, Zurek, & Brantley, 2000; E. E. Johnson, Ricketts, & Hornsby, 2007; Kates, 1999; Kiessling, Brenner, Jespersen, Groth, & Jensen, 2005; and the *telecoil*, Pettersson, 1987; Stoker, French, & Lyons, 1986). Another feature, digital noise reduction processing, has equivocal findings to date about its effectiveness as shown in a meta-analysis of research, particularly regarding speech recognition improvement (Bentler, 2005). Other more recent studies have demonstrated, however, that some types of digital noise reduction processing improve sound quality and comfort when listening to speech in the presence of background noise despite the absence of improved speech recognition (Mueller, Weber, & Hornsby, 2006; Ricketts & Hornsby, 2006).

Variability in Health Care Practices

Determining explanations for practice variability has been examined repeatedly in the field of medicine germane to the specialty areas of physicians and their respective treatment decisions (e.g., Blair, O'Shea, & Orr, 1998; Cheng, DeWitt, Savageau, & O'Connor, 1999; Green and Wheeler, 2003; Green, Wheeler, & LaPorte, 2003; Sable, Schwartz, Kelly, Lisbon, & Hall, 2006; Smith, Martin, Langefeld, Miller, & Freedman, 1995; Tamayo-Sarver, Dawson, Cydulka, Wigton, & Baker, 2004; Tamblyn et al., 1998). A past hearing aid EBP guideline suggests that the inclusion versus exclusion of a hearing aid product feature can have significant effects on patient outcomes (Valente et al., 2006). For this reason, understanding the factors underlying differences in dispensing rates among audiologists are of clear importance.

As an example of differences in patient outcomes relative to hearing aids, consider the speech intelligibility differences that two comparable hearing impaired listeners (one with and one without a directional microphone on his or her hearing aid) would experience when listening to speech in the presence of a spatially separated background noise. Alternately,

consider the communication differences of a telephone conversation when a hearing aid has an appropriately functioning telecoil as compared with no telecoil with possible acoustic feedback subsequent to changes in the dynamic feedback pathway.

Despite research evidence and high grades of recommendation, not every patient will receive benefit from treatment interventions shown to be effective and efficacious for a group of patients (McQuay & Moore, 1997); the same is true of hearing aid product features. Concomitantly, determining the individual characteristics of patients who respond favorably to many medical treatments is a major shortcoming of applying research evidence to clinical practice (McQuay & Moore, 1997). Likewise, it has not been possible to predict on an individual basis the patients that will benefit from certain hearing aid product features (Ricketts & Mueller, 2000). The ultimate decision regarding treatment and intervention still lies with the medical service provider and has been referred to as a gap that still exists between empirical evidence and end-clinical decisions (Tonelli, 2001). Applying this reasoning to hearing aid fittings, the decision regarding inclusion or exclusion of product features on a patient's hearing aid(s) is that of the audiologist serving the patient. Thus, the question of clinical and research study interests is "What is responsible for variability in dispensing rates of hearing aid product features among audiologists?"

In response to the demonstrated variability in reported dispensing rates of product features among audiologists observed in hearing aid dispensing surveys, it was the aim of this endeavor to identify sources of and correlations with dispensing rate variability. There are likely an enormous number of specific characteristics that might be expected to contribute to the variability observed in dispensing rates of product features. To identify characteristics that best account for hearing aid product feature dispensing variability, the first stage of this research endeavor, referred to as the Preliminary Study, identified potential predictive variables using focus group and literature review techniques. In the second stage of this research project, referred to as the Main Study, audiologists were surveyed with regard to the variables identified in the Preliminary Study; the survey responses were then analyzed for correlations among the variables and dispensing rates.

Preliminary Study: Identification of Predictor Variables

Method

Suitable predictor variables expected to best account for the variability in hearing aid dispensing rates were determined via two methods. The first method included researcher-developed hypotheses regarding the most likely predictors of dispensing rates. These hypotheses were developed based on

a review of literature, personal clinical experience, and 3 years of experience analyzing data from annual dispenser surveys that had a subsection devoted to dispensing rates (E. E. Johnson, 2007a, 2008a; Kirkwood, 2006).

The second method involved focus group discussions with other audiologists. Four focus group discussion sessions were held with a total of 16 audiologists. These focus group participants consisted of eight audiologists from the Vanderbilt University Bill Wilkerson Center located in Nashville, Tennessee, and eight audiologists who participated in the 2006 American Academy of Audiology AudiologyNow! conference. Of these participants, 10 (62.5%) were female and 6 (37.5%) were male. Overall, 87% held a state license and certification from the American Speech-Language-Hearing Association, 2 participants (12.5%) held certification from the American Board of Audiology, and 1 participant (6.3%) held certification from the International Hearing Society. In terms of education, a master's degree, doctor of audiology, or doctor of philosophy was held as the highest degree relevant to the field of audiology by 18.7%, 75%, and 6.3% of participants, respectively. The participants were also employed in a variety of work environments and states. The work environments included privately owned clinics, outpatient hospitals/clinics, universities, both public and private hospital systems, including the U.S. Department of Veterans Affairs, and hearing aid companies. States of practice included Arizona, Florida, Illinois, Michigan, Minnesota, and Tennessee. The average age of the participants was 35 years ($SD = 9$ years). Reported work experience in the field of audiology averaged 10 years ($SD = 10$ years), of which, on average, 8.5 years ($SD = 8$ years) was spent fitting hearing aids. This diversity of the focus group participants was consistent with the goal of examination of potential predictor variables from the viewpoints of several audiologists with broad and varied perspectives.

Prior to discussion of the variables that might account for the variability in dispensing rates, data from the 2007 *The Hearing Journal/Audiology Online* (THJ/AO) dispenser survey were presented to the focus group participants to demonstrate that variability among audiologists does indeed exist. Participants were then asked to provide information on why this variability might occur, given the following two lead-in questions:

1. What leads you to select or not select product features for your patients?
2. What information might best predict the dispensing rates of product features in a group of audiologists?

The focus group results were tabulated based on the number of times potential predictor variables were mentioned by participants across the four groups. For example, the most often a particular topic could be reported was four times (in every focus group session) to the least often (in only one

focus group session). In general, the potential predictor variables fell under two “umbrella” categories: *Characteristics of an audiologist* and *Characteristics of an audiologist's patient population*. A total of 38 potential predictor variables were mentioned in the first category and 11 potential predictor variables in the second category.

Results and Discussion: Selection of Predictor Variables

An initial challenge experienced often by researchers designing studies using multiple regression as a statistical tool is deciding how many predictor variables to include in the study. The challenge is rarely having too few variables to evaluate; rather, the challenge is that too many predictor variables exist than is reasonable or practical to evaluate (Howell, 2001).

However, the number of variables evaluated needs to be limited to ensure sufficient reliability and validity of study-developed regression models and is dependent on the number of study participant responses for each predictor variable examined. In other words, multiple regression statistics require multiple responses for each predictor variable examined (Tabachnick & Fidell, 2001). Resultantly, it is vital to limit the number of predictor variables well below the number of respondents expected.

A list of 56 potential predictor variables was ultimately trimmed to a list of 29. The 29 predictor variables chosen as a result of focus group participants (FG), researcher-developed hypotheses (R), and mutual agreement (M) between the focus group participants and researcher are listed in Table 1. The count of variables by each of these three sources are as follows: FG, 15; R, 7; M, 7.

The 15 variables that were uniquely identified by the focus group participants and chosen for inclusion were mentioned in at least three of the four focus group sessions with the exception of three potential predictor variables mentioned only twice. Those mentioned twice were ease of engaging features in the product software, completion of verification measures, and completion of validation measures. The first of these three variables was chosen because of its clinical relevancy related to ease of use and the latter two because they are recommended by EBP (Mueller, 2005; Valente et al., 2006), but their use is quite varied among audiologists (e.g., Mueller, 2003). Audiologists who use verification and validation measures of hearing aid performance may have dispensing rates that are more consistent with EBP recommendations.

Seven predictor variables were included because of researcher-developed hypotheses; however, these seven were not mentioned in any of the focus group sessions. That is, variables regarding personally held beliefs about product feature benefit were included as clinicians have been reported to rely on tradition, recent experiences, and sometimes long

ago graduate training when making clinical decisions (Eisenberg, 2001). In addition, beliefs are generally regarded as the foundation for behavioral actions as supported by the theory of reasoned action (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975). Such notions were thought worthwhile to include as potential predictor variables of dispensing rate behavior. Seven more potentially predictive variables were deemed important to both the researcher and by those participating in the focus groups (in three out of the four sessions).

The final list of 29 variables chosen for inclusion in the Main Study was organized into four categories labeled as follows:

1. *Characteristics of the audiologist*
2. *Characteristics of the audiologist's patient population*
3. *Characteristics of the hearing aids dispensed by the audiologist*
4. *Evidence-based practice grades of recommendation*

Although these categories do not have entirely clear boundaries, most variables included under the category headers were deemed to cluster together. *Characteristics of the audiologist* included items related to the audiologist's professional experience, work setting, and clinical techniques (e.g., likelihood validation procedures were completed). *Characteristics of the audiologist's patient population* included items such as patient age, socioeconomic status, technology savviness, severity of hearing loss, amount of perceived handicap, payment source (private or third-party), and so on. *Characteristics of the hearing aids dispensed by the audiologist* included items such as style, level of digital technology, price, and so on. *Evidence-based practice grades of recommendation* were A to D alphabetical letters from the 2006 American Academy of Audiology EBP guideline.

Main Study: A Survey of Audiologists Examining Variables With a Potential Relationship to Hearing Aid Product Feature Dispensing Rates

Method

Survey design. A survey was developed for the Main Study to assess potential relationships between variables identified in the Preliminary Study and hearing aid product feature dispensing rates. Each predictor variable shown in Table 1 was first written in question format to obtain responses from survey participants. Four survey questions were also included, which asked respondents to indicate the percentage of time each of four features was dispensed during the prior 3-month period corresponding to approximately the summer of 2007. These four features were digital feedback suppression processing,

Table 1. Selected predictor variables of dispensing rates. The “Source of the Variable” column refers to whom suggested the variable for inclusion in the Main Study [FG – Focus Groups, R – Researcher, and M - Mutual (both Focus Groups and Researcher)]

Number of Predictor Variables	Description of the Predictor Variables	Source of the Variables	Response Choices on the Survey Questionnaire
<i>Category 1 - Characteristics of the Audiologist</i>			
1	Gender (Categorical) • Male gender relative to female gender	[M]	Male, Female
2	Primary practice setting (Categorical) Relative to Private Practice • Physician's office employee	[M]	Private Practice, Physician's office, Public/Private Hospital, Outpatient Clinic, Veterans Affairs Hospital, Government – Non-Veterans Affairs affiliated, University
3	• Hospital employee (Public, private, or an outpatient clinic)		
4	• Government employee (VA and non-VA)		
5	• University employee Educational degree (Categorical)	[M]	Master's, Doctor of Audiology, Doctor of Education, Doctor of Science, Doctor of Philosophy, Other
6	Relative to a Master's Degree • AuD		
7	• All other doctorates		
8	Years of work experience	[M]	0 – 100 years
9	Amount of continuing education units per year	[FG]	0-100 – Average number of CEU hours each year
10	Audiologist's patient candidacy criterion for a feature based on the magnitude of patient need: <i>Directional processing and digital noise reduction processing</i> – Patient difficulty communicating in challenging listening environments without hearing aids (e.g., cocktail party, restaurant, bar/pub, etc.) <i>Telecoil</i> - Patient difficulty communicating on the telephone without hearing aids <i>Digital feedback suppression processing</i> – Likelihood of acoustic feedback with hearing aid fit based on ear geometry or hearing aid fitting characteristics (e.g., high gain requirements, problems with occlusion, or open canal fittings)	[R]	11 point rating scale 0 (No difficulty at all) – 10 (Extreme difficulty)
11	How often verification measures of hearing aid performance are completed (i.e., real-ear probe microphone measures)?	[FG]	Or 0 (Feedback very unlikely) – 10 (Feedback very likely) 0-100% of the time
12	How often validation measures of hearing aid performance are completed (i.e., an outcome assessment questionnaire)?	[M]	0-100% of the time
Number of Predictor Variables	Description of the Predictor Variables	Source of the Variables	Response Choices on the Survey Questionnaire
<i>Category 1 Continued – Characteristics of the Audiologist</i>			
	Audiologist's beliefs regarding product feature benefit based on their...	[R]	11 point rating scale
13	Educational training		0 (Strongly disagree) –
14	Clinical experience		10 (Strongly agree)
15	Interpretation of lab research data published in journals		
16	Interpretation of real world data published in journals		
<i>Category 2 - Characteristics of the Audiologist's Patient Population</i>			
17	Age	[M]	Old-old adults 85+, Old adults 75-84, Young-old adults 65-74, Adults 18-64, Children 3-17, Young children/infants 0-2
18	Severity of hearing loss	[M]	Mild, moderate, moderately-severe, severe, profound
19	Hearing loss handicap	[M]	No handicap, mild handicap, moderate handicap, severe handicap

(continued)

Table 1. (continued)

20	Hearing aid payment source	[FG]	Third-party payer, Private party payer
21	Socioeconomic status – Yearly household income	[FG]	\$0-\$20,000 \$20,001-\$40,000 \$40,001-\$60,000 \$60,001-\$80,000 \$80,001-\$100,000 \$100,001-Above
22	Lifestyle	[FG]	11 point rating scale 0 (Not at all active) – 10 (Extremely active)
23	Savvy with technology	[FG]	11 point rating scale 0 (Not at all savvy) – 10 (Extremely savvy)
24	Magnitude of Patient Population's Feature-Specific Need: <i>Directional microphones and digital noise reduction</i> – Ability to communicate in challenging listening environments without hearing aids (e.g., cocktail party, restaurant, bar/pub, etc.) <i>Telecoil</i> - Ability to communicate on the telephone without hearing aids <i>Digital Feedback Suppression</i> – Likelihood of acoustic feedback based on ear geometry or hearing aid fitting characteristics (e.g., high gain requirements, problems with occlusion, or open canal fittings)	[M]	11 point rating scale 0 (No difficulty at all) – 10 (Extreme difficulty) or 0 (Feedback very unlikely) –10 (Feedback very likely)
Number of Predictor Variables	Description of the Predictor Variables	Source of the Variables	Response Choices on the Survey Questionnaire
<i>Category 3 - Characteristics of the Hearing Aids Dispensed by the Audiologist</i>			
25	Level of technology	[M]	Analog, Low-end digital, Mid-level digital, High-end digital
26	Style	[M]	CICs, ITCs, ITEs, Mini-BTEs with an open canal, BTEs with traditional earmold
27	Price – Manufacturer suggested retail price	[M]	\$1-\$500 \$501-\$1000 \$1001-\$1500 \$1501-\$2000 \$2001-\$2500 \$2501-\$3000 \$3001-\$3500 \$3501-\$4000
28	Ease of engaging/configuring product features in the hearing aid programming software	[FG]	11 point rating scale 0 (Not easy at all) – 10 (Extremely easy)
<i>Category 4 –Evidence-based Practice Guideline Recommendations</i> Used to analyze underlying differences in the dispensing rates of all four product features			
29	2006 AAA EBP grades of recommendation • Analyzed in a general linear model analysis with all previous predictor variables	[R]	A (Strongest Rating), B, C, D (Weakest Rating)

digital noise reduction processing, directional processing, and the telecoil. A shorter time interval of 3 months was used because past research has shown these intervals, relative to yearly intervals, increase the likelihood that respondents provide more absolute estimates (Blair & Burton, 1987). In addition to the questions related to dispensing rates and the variables that might explain differences among audiologists, several other questions were included that were aimed at examining audiologists' exposure to EBP and their attitudes toward it; the results of which were published previously in *Audiology Today* (E. E. Johnson, 2008b). The complete survey is shown in the appendix.

In an attempt to reduce the likelihood of misinterpretation of questionnaire wording and the biases it may introduce, the questions were peer-reviewed by two PhD-trained professors at Vanderbilt University with individual specialty areas in hearing aid and marketing research. Before large-scale release of the survey to actual participants, the survey was piloted on five PhD students in the Vanderbilt University Hearing and Speech Sciences Department who had worked previously as audiologists. This peer-review process was intended to avoid problems with wording choice and semantics (Lessler & Forsyth, 1996; Schwarz, 1999).

The mode of survey participation was via the Internet with assisted survey hosting and maintenance through a commercial online survey development and management company (SurveyMonkey, Portland, OR). Well-regulated Internet surveys aimed at a particular group of individuals that have routine access to the Internet lead to at least comparable and sometimes less selection or response bias than conventional mailed or telephone surveys (Weisberg, 2005). These days, a predominant method for gathering information from particular special interest groups (e.g., audiologists) is via the well-regulated Internet survey. In 2007, more than 99% of audiologists had access to high-speed Internet at either their place of employment or home; 80% of audiologists had high-speed access at both home and their place of employment (unpublished data THJ/AO Dispenser Survey, 2007).

Survey participants. In all, 2,000 audiologists were contacted with postal mailing addresses purchased from the American Academy of Audiology (AAA) as potential survey participants. These audiologists were randomly selected from AAA members that self-reportedly dispense hearing aids. In an attempt to maximize the response rate for this study, these audiologists were mailed an initial invitation letter followed by a reminder letter 2 weeks later. Additionally, \$100 incentives were distributed to 5 randomly selected survey participants in an attempt to help improve response rate.

A total of 306 individuals began the Main Study survey, which yielded a response rate of 15.3%. This response rate is in the typical range observed by researchers studying audiologists and other health care professionals. For example, a 2006 survey of audiologists by AAA regarding, "Ethical Issues in Hearing," yielded a response rate 18.1%, as

calculated by the number of respondents, 1,633 (Hawkins, Hamill, & Kukula, 2006) divided by the number of AAA professional members at that time, 9,008 (personal communication, Ed Sullivan, 2007). Likewise, personal experience indicates that response rate to the annual THJ/AO dispenser survey is typically around 15%. Other response rates to surveys of audiologists range from approximately 9.1% to greater than 30% (American Speech-Language-Hearing Association, 2003; Hawkins, Hamill, Vliet, & Freeman, 2002; C. E. Johnson, Danhauer, Reith, and Latiolais, 2007; Sullivan, 2006; Tharpe, Fino-Szumski, & Bess, 2001). Response rates of higher than 15% were typically only seen in surveys related to compensation and benefits. Regardless of low response rates, surveys of medical professionals can be regarded as representative based on demographics of the survey participants (Green, Wheeler, et al., 2003; Menachemi, Hikmet, Stutzman, & Brooks, 2006). Accordingly, demographics of participants in this study are reported shortly hereafter.

Although 306 individuals began the survey for this study, two participant screening questions slightly reduced the number of individuals completing the questionnaire in its entirety. Six respondents were not audiologists and 14 audiologists indicated they did not dispense hearing aids as part of their employment. Thus, the data from these 20 individuals were excluded from data analysis because this study was designed to only assess the behavior of hearing aid dispensing audiologists. An additional 24 hearing aid dispensing audiologists who met the screening requirements discontinued the survey at some point prior to completion. The "Others" work category had a sample size of only 5 and was therefore deemed too small to retain and be considered representative. In total, 257 hearing aid dispensing audiologists remained and served as the sample population.

Adequate sample size for the multiple regression analyses. As a first indicator of sample size adequacy, the 257 audiologists met the requirement for regression modeling as determined by Tabachnick and Fidell (2001). That is, $N \geq 104 + m$, where m is the number of predictor variables and N the number of required subjects. For models of a single product feature's dispensing rates, m was equal to 28, resulting in a required N of at least 132. Additionally, the adequacy of sample size was examined using the number of respondents per predictor variables considered in the models. At a minimum, there should be five respondents per predictor variable (Tabachnick & Fidell, 1996), whereas another source suggests a ratio of 10:1 (Harris, 1985). In this study, the 257 participants provide 9.2 participant responses for each of the 28 predictor variables used in the four product feature-specific regression models.

A calculation of sample size adequacy was also based on anticipated effect sizes and statistical power as recommended by Cohen (1988). The four individual feature-specific regression models with a sample size of 257 audiologists and use

Table 2. Demographics of the survey respondents

General Demographics	Survey Response Choices	% of Study Sample	% of AAA Membership Demographics in 2007
Gender	Male	21.8%	23%
	Female	78.2%	77%
Educational Degree	Master's	30.0%	55.7%
	Doctor of Audiology	63.8%	34.2%
	Other Doctorate	6.2%	9.6%
			Not Reported: <1%
Workplace Environment	Private Practice	41.6%	Private Practice: 28.4%
	Physician's Office	32.3%	ENT/Physician's Office: 20.6%
	University	5.4%	University: 6.7%
	Hospital/Clinic	10.9%	Hospital: 10.8%
	Government Employee	9.7%	Clinic: 9.4%
	Other	0.0%	Military: 0.7%
			VA: 3.4%
			School: 4.6%
			Corp Group AuD: 0.5%
			Government: 0.5%
			Manufacturer: 3.8%
			Other: 2.6%
			Not Reported: 7.6%
Mean (Standard Deviation)			
Years of Work Experience		14.2 years (9.9)	Under 3 years: 5.4%
			3-5 years: 7.6%
			6-10 years: 13.6%
			11-15 years: 12.2%
			Over 15 years: 46%
			Not Reported: 15.1%

of only 28 predictor variables had the ability of demonstrating a small to medium effect size of 0.1 with statistical power of 0.80 (Cohen, 1988). In other words, the sample size allowed for 80% likelihood of identifying overall regression models with an R value greater than .3 or an R^2 value greater than .09 with statistical significance at $p < .05$.

Demographics of the 257 dispensing audiologists who comprised the analyzed study population are summarized in Table 2. The study participants' state of residence is shown in Figure 1 to describe the participants by geographical location. Chi-square analysis indicated no significant difference between the study sample and AAA membership in terms of gender, $\chi^2(1, 257) = 0.213$, $p = .645$. Proportionally more individuals with AuDs (Doctor of Audiology degree) participated in the survey than are reportedly members of AAA (63.8% vs. 34.2%), whereas proportionally fewer individuals with a Master's degree participated (30% vs. 57%), $\chi^2(1, 257) = 98.1$, $p < .001$. Further comparisons between workplace environment and years of work experience were not completed via chi-square analysis, as the categorical choices between the two samples were quite dissimilar. That is, AAA divides workplace environment into 12 categories whereas responses to this survey divided the workplace environment into fewer categories, similar to the annual THJ/AO dispenser survey. Likewise, years of work experience was collected as interval data for this study, but is collected categorically by AAA as seen in Table 2.

Preparation of data for analysis. Responses that involved entering the percent of an audiologist's patient population having given characteristics (e.g., age, amount of hearing loss, etc.) or characteristics of the hearing aids they dispensed (e.g. style, level of technology, price, etc.), were transformed into a single value on an interval scale. The endpoints for each scale were consistent with the lowest and highest endpoints of the examined categories. That is, hearing loss was represented by the five categories of mild, moderate, moderately severe, severe, and profound, and thus, the scale ranged from 1 to 5. A transformed score of 1 indicated that 100% of the patients seen by an audiologist had a mild hearing loss, whereas a score of 5 would indicate that 100% of his or her patients had a profound hearing loss. However, mixtures of the categories within a patient population were much more common. For example, the patient population of an audiologist might consist of 20% mild hearing losses, 10% moderate, 30% moderately severe, 20% severe, and 20% profound. Thus, scores between 1 and 5 were calculated as follows:

$$1(0.20) + 2(0.10) + 3(0.30) + 4(0.20) + 5(0.20) = 3.1.$$

In other words, those audiologists seeing more patients with more severe to profound hearing losses generally had higher scores whereas those seeing more patients with milder hearing losses generally had lower scores.¹ In the

Figure 1. States of residence for the survey respondents

case of hearing loss severity, audiologists generally serve a broad range across the continuum of mild to profound hearing impairment except for those specializing in the service of those with severe-to-profound hearing impairment.

Other questions requiring a similar transformation and the specific procedure applied are described below:

Characteristics of the audiologist's patient population

- Age (scale of 1 to 6): (1) young children/infants 0 to 2 years, (2) children 3 to 17 years, (3) adults 18 to 64 years, (4) young-old adults 65 to 74 years, (5) old adults 75 to 84 years, (6) old-old adults 85+ years
- Handicap experienced as a result of hearing loss (scale of 1 to 4): (1) no handicap, (2) mild handicap, (3) moderate handicap, (4) severe handicap
- Payment source for hearing aids (scale of 1 to 2): (1) third-party payer, (2) private party payer

- Socioeconomic status: Yearly household income (in \$, scale of 1 to 6): (1) 0 to 20,000, (2) 20,001 to 40,000, (3) 40,001 to 60,000, (4) 60,001 to 80,000, (5) 80,001 to 100,000, (6) 100,001 and above

Characteristics of the hearing aids dispensed by the audiologist

- Level of technology (scale of 1 to 4): (1) analog, (2) low-end digital, (3) mid-level digital, (4) high-end digital
- Style (scale of 1 to 5): (1) completely in-the-canal or CICs, (2) in-the-canal or ITCs, (3) in-the-ear or ITEs, (4) mini-behind-the-ear, or mini-BTE, with an open canal, (5) behind-the-ear, or BTE, with traditional earmold
- Price (in \$; scale of 1 to 8): (1) 1 to 500, (2) 501 to 1,000, (3) 1,001 to 1,500, (4) 1,501 to 2,000, (5) 2,001 to 2,500, (6) 2,501 to 3,000, (7) 3,001 to 3,500, (8) 3,501 to 4,000

The second type of transformation required was an arcsine transformation (e.g., Cohen, Cohen, West, & Aiken, 2003; Wheater & Cook, 2000) for percent measures regarding how often product features were dispensed and how often real-ear verification and outcome validation measures were completed. Arcsine transformed values of percentage values were obtained by using the following formula:

Arcsine value = arcsine[square root(% dispensing rate/100)].

Data analysis. Despite the ordinal nature of rating scales, it is common to treat such data as interval in nature for regression analysis, particularly, if at least five or more categories are available (Berry, 1993; Labovitz, 1970; O'Brien, 1979; Zumbo & Zimmerman, 1993). Response choices to questions were generally developed to be answered on eleven point rating scales ranging from 0 to 10 with various anchor points (e.g., *no difficulty at all* to *extreme difficulty*, *feedback very unlikely* to *feedback very likely*, *not savvy at all* to *extremely savvy*, *no likelihood at all* to *extremely likely*, etc.) or where categorical in nature (e.g., gender of the audiologist, primary practice setting, educational degree, style of hearing aid, level of hearing aid technology, etc.) Responses to questions for other predictor variables, however, required the transformations described earlier.

Multiple regression analyses were used as a means of determining the magnitude of independent predictor variables' effects on dispensing rates of each product feature (i.e., the dependent variable). Four regression models, one for each of the four product features, were used to evaluate each of 28 predictor variables. Note that the 29th predictor variable, EBP grades of recommendation, was not used when creating a regression model for a single product feature, as the grade of recommendation does not vary for a *single* product feature. However, a grand analysis, using a general linear model statistical approach, incorporated the dispensing rates of all four product features and their respective EBP grades of recommendation in combination with the other 28 variables. This grand analysis allowed for determination of whether grades of recommendation or the other predictor variables best accounted for differences in the dispensing rates among the four product features.

The four product feature-specific regression models. The method of analysis was stepwise linear regression whereby all independent variables were considered on the first iteration of the statistical analysis with entry priority given to the variable accounting for the most amount of dispensing rate variability. A statistical significance parameter for entry into the model was set at $p < .002$, whereas for removal it was at $p < .1$. This removal value allowed for the elimination of variables that had been identified as significant by chance of likelihood on previous iterations of the analysis (Howell, 2001).

For entry into the model, each predictor variable's beta coefficient (β_j) was tested for statistical significance at $p < .002$.

Figure 2. Average dispensing rates of the product features. Letters to the right of the product feature represent the grade of recommendation assigned to that feature by the 2006 AAA Guidelines for the Audiology Management of Adult Hearing Impairment. Grades ranged from A to D, however, B was the highest grade assigned to a product feature. Denoted by an asterisk, a significant increase in the mean dispensing rate of directional processing was noted from the year 2006 to the summer of 2007.

This conservative p -value was used to correct for the multiple statistical comparisons conducted as a result of individually examining each of the 28 predictor variables (.05/28). The structure of the first-order regression model evaluated for each product feature was

$$\text{Dispensing rate of the product feature} = \beta_0 (\text{Y-intercept}) + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_{28} x_{28}.$$

Results

The dispensing rates of the four product features are shown in Figure 2 and reveal the average percentage of time each feature was reportedly dispensed during the summer of 2007 by the 257 participating audiologists. To examine the stability of these dispensing rates, these data were compared with a 2007 survey conducted by THJ/AO regarding dispensing rates during the 2006 year (Table 3). Four independent samples t -tests indicated that with the exception of one product feature, directional processing, the mean dispensing rate did not statistically differ ($p < .05$) between the year 2006 and the summer of 2007. Directional processing was slightly more popular in the summer of 2007 as its mean dispensing rate increased from 77% to 83%.

Comparisons of dispensing rate variability in the two data sets were also examined. Levine's test for equality of variance revealed slightly greater variability in the summer of 2007 data for digital feedback suppression processing and the telecoil than evident in the year 2006 (Table 3). For visualization of dispensing rate variability, variability for the telecoil during the summer of 2007 is shown in Figure 3.

The stepwise regression procedure indicated overall R values (multiple correlation coefficients) were of a high

Table 3. Dispensing rate variability among audiologists from the two time periods

	Standard Deviation	
	Percent Scores (Arcsine Units)	
	Year 2006	Summer of 2007
Digital Feedback Suppression System Processing*	14.8% (0.24)	17.5% (0.27)
Digital Noise Reduction System Processing	16.0% (0.25)	16.4% (0.25)
Directional Processing	21.1% (0.28)	20.9% (0.30)
Telecoil*	26.5% (0.35)	29.1% (0.38)

An asterisk indicates significantly more variability in the summer of 2007 as compared to the year of 2006.

* Indicates significantly more variability in the summer of 2007 as compared with the year of 2006.

Figure 3. Scatter plot of the percentage of time a telecoil was dispensed by audiologists in the summer of 2007: mean = 63.65; SD = 29.41; N = 257**Table 4.** Overall regression results, multiple correlation coefficients, and variability accounted for by the four product feature-specific regression models

	F-statistics	R value (Multiple Correlation Coefficient)	Adjusted R ² (Proportion of Variability Accounted for)
Digital Feedback Suppression Processing	$F(4,252) = 24.972, p < .001$	0.533	0.272
Digital Noise Reduction Processing	$F(4,252) = 34.192, p < .001$	0.599	0.348
Directional Processing	$F(4,252) = 33.522, p < .001$	0.589	0.337
Telecoil	$F(3,253) = 50.719, p < .001$	0.613	0.368

Table 5. Independent variables accounting for variability in the dispensing rates of digital feedback suppression processing

Importance Ranking (Semipartial Correlation)		Unstandardized Beta Coefficients (Std. Error)	T value (Significance)	R ² Change
	(Constant)	0.149 (0.157)	0.953 (0.342)	
1 st (0.315)	Level of Hearing Aid Technology (LT)	0.200 (0.038)	5.262 (<0.001)	0.132
2 nd (0.268)	Audiologist's Belief in the Feature Based on Educational Training (ABET)	0.039 (0.009)	4.410 (<0.001)	0.084
3 rd (0.213)	Audiologist's Feature Candidacy Criterion (AFCC)	-0.020 (0.006)	-3.454 (0.001)	0.037
4 th (0.204)	Ease of Engaging and Configuring Product Features in the Programming Software (EOE/CPS)	0.034 (0.010)	3.302 (0.001)	0.031

magnitude (i.e., >0.5) in comparison to usual studies of human behavior (Cohen, 1988). Accordingly, a sizeable amount of dispensing rate variability was accounted for by each of the developed models, that is, between 27.2% and 36.8% based on adjusted R^2 values (Table 4). These analyses revealed that each model only used a few of the predictor variables examined. Only 3 of the 28 variables related to and accounted for the variability in dispensing rates of the telecoil, whereas 4 variables related to the

features of directional processing, digital noise reduction processing, and digital feedback suppression processing (Tables 5 through 8).

Within each regression model, predictor variables were also ranked in terms of their relative importance to one another through calculation of a semipartial correlation, as recommended by Howell (2001) and Darlington (1990), and are shown in Tables 5 through 8. Semipartial correlations describe the relationship between each independent variable and the

Table 6. Independent variables accounting for variability in the dispensing rates of digital noise reduction processing

Importance Ranking (Semipartial Correlation)		Unstandardized Beta Coefficients (Std. Error)	T value (Significance)	R ² Change
	(Constant)	0.399 (0.117)	3.407 (0.001)	
1 st (0.419)	Level of Hearing Aid Technology (LT)	0.244 (0.033)	7.323 (<0.001)	0.208
2 nd (−0.306)	Audiologist's Feature Candidacy Criterion (AFCC)	−0.029 (0.006)	−5.101 (<0.001)	0.076
3 rd (0.224)	Doctor of Audiology Degree Relative to a Master's Degree (AuD)	0.098 (0.027)	3.650 (<0.001)	0.041
4 th (0.220)	Audiologist's Belief in the Feature Based on Clinical Experience (ABCE)	0.023 (0.006)	3.582 (<0.001)	0.033

Table 7. Independent variables accounting for variability in the dispensing rates of directional processing

Importance Ranking (Semipartial Correlation)		Unstandardized Beta Coefficients (Std. Error)	T value (Significance)	R ² Change
	(Constant)	−0.118 (0.190)	−0.622 (0.535)	
1 st (0.361)	Level of Hearing Aid Technology (LT)	0.166 (0.027)	6.140 (<0.001)	0.080
2 nd (0.312)	Hearing Aid Style (S)	0.207 (0.040)	5.219 (<0.001)	0.071
3 rd (−0.302)	Audiologist's Feature Candidacy Criterion (AFCC)	−0.037 (0.007)	−5.028 (<0.001)	0.158
4 th (0.234)	Magnitude of Patient Population's Feature-Specific Need (MPPFSN)	0.036 (0.009)	3.818 (<0.001)	0.038

Table 8. Independent variables accounting for variability in the dispensing rates of a telecoil

Importance Ranking (Semipartial Correlation)		Unstandardized Beta Coefficients (Std. Error)	T value (Significance)	R ² Change
	(Constant)	0.433 (0.091)	4.739 (0.069)	
1 st (−0.304)	Audiologist's Feature Candidacy Criterion (AFCC)	−0.040 (0.008)	−5.072 (<0.001)	0.057
2 nd (0.271)	Audiologist's Belief in the Feature Based on Clinical Experience (ABCE)	0.049 (0.011)	4.483 (<0.001)	0.286
3 rd (0.242)	Audiologist's Belief in the Feature Based on Real-World Research (Effectiveness) Data (ABEBP- EFV)	0.046 (0.013)	3.660 (<0.001)	0.033

dependent variable with all other independent variables partialled out. Darlington (1968), cited in Howell (2001), refers to this measure as the “usefulness” of a predictor in a developed model. The semipartial correlation squared represents the decrement in R^2 that results from the elimination of the i th predictor variable from the model or its increment based on its addition to the model (Howell, 2001). These results determined the ordering of variables in Tables 5 through 8.

As seen in Table 5, the digital feedback suppression processing dispensing rate was predictable based on the level of hearing aid technology dispensed by the audiologist (LT), an

audiologist's belief regarding its potential benefit to patients based on educational training (ABET), an audiologist-specific feature candidacy criterion for when to recommend the feature to a patient based on the likelihood of feedback (AFCC), and the audiologist's rated ease of engaging/configuring product features in hearing aid programming software (EOE/CPS), as described in the following equation:

$$\begin{aligned} \text{Digital feedback suppression processing} \\ \text{dispensing rate} = & 0.149 + 0.20(\text{LT}) + 0.039(\text{ABET}) \\ & + -0.02(\text{AFCC}) + 0.034(\text{EOE/CPS}). \end{aligned}$$

The digital noise reduction processing dispensing rate was predictable based on the level of hearing aid technology dispensed by the audiologist (LT), an audiologist-specific feature candidacy criterion for when to recommend the feature to a patient based on the amount of communication difficulty in challenging listening environments (AFCC), the educational degree of the audiologist (AuD), and the audiologist's belief regarding its potential benefit to patients based on clinical experience (ABCE; Table 6).

$$\begin{aligned} \text{Digital noise reduction processing dispensing} \\ \text{rate} = 0.399 + 0.244(\text{LT}) + -0.029(\text{AFCC}) \\ + 0.098(\text{AuD}) + 0.023(\text{ABCE}). \end{aligned}$$

Directional processing dispensing rate was predictable based on the level of hearing aid technology dispensed by the audiologist (LT), the style of hearing aid dispensed (S), an audiologist-specific feature candidacy criterion for when to recommend the feature to a patient based on the amount of communication difficulty in listening environments (AFCC), and the magnitude of the audiologists' patient population's feature-specific need for the feature based on the amount of their communication difficulty in challenging listening environments (MPPFSN; Table 7).

$$\begin{aligned} \text{Directional processing dispensing rate} = \\ -0.118 + 0.166(\text{LT}) + 0.207(\text{S}) + -0.037(\text{AFCC}) \\ + 0.036(\text{MPPFSN}). \end{aligned}$$

Dispensing rate of the telecoil was predictable based on an audiologist-specific feature candidacy criterion for when to recommend the feature to a patient based on the amount of communication difficulty on the telephone (AFCC), the audiologist's belief regarding its potential benefit to patients based on clinical experience (ABCE), and the audiologist's belief regarding its potential benefit to patients based on interpretations of real-world effectiveness data published in peer-reviewed journals (ABEBP-EFV; Table 8).

$$\begin{aligned} \text{Telecoil dispensing rate} = 0.433 + -0.040(\text{AFCC}) \\ + 0.049(\text{ABCE}) + 0.046(\text{ABEBP-EFV}). \end{aligned}$$

In summary, these analyses indicated that audiologist-specific patient candidacy criterion for when to recommend the feature based on the amount of communication difficulty in listening environments or likelihood of acoustic feedback (AFCC) was significantly related to dispensing rate for all four product features. Similarly, at least one of the questions pertaining to an audiologist-specific held belief regarding potential product benefit was important for three of the four product features. Likewise, the level of hearing aid technology (LT) was related to dispensing rates of three of the product features. In contrast, several variables were related to

dispensing rates of only a single feature. Specifically, ease of engaging/configuring product features in the hearing aid programming software (EOE/CPS) was related to dispensing rate of digital feedback suppression processing. In addition, audiologists with an AuD degree dispensed digital noise suppression processing 10% more often than those with a master's degree. Hearing aid style (S) and the magnitude of the audiologist's patient population's feature-specific need based on their communication difficulty in challenging listening environments (MPPFSN) were related to dispensing rates of directional processing.

Factor analysis of the predictor variables and its potential influence on study regression results: A confirmatory finding. From the large correlation matrices generated as a result of the four regression models some of the predictor variables were shown to moderately correlate with one another. The variables most highly related to one another were responses to questions regarding each audiologist's belief in the potential benefit of a feature based on his or her educational training, clinical experience, and interpretation of published evidence from lab research (efficacy data) as well as real-world research (effectiveness data). Such correlation coefficients were approximately 0.6. In addition, this was also confirmed separately by a measure of internal consistency known as Cronbach's alpha using responses to the four belief questions. A calculated value of 0.86 indicated strong covariance among the variables. These analyses suggest that the belief question responses might group as a statistical factor; therefore, a factor analysis was also completed.

The primary purpose of factor analysis was to determine whether variables identified as significantly predictive of the dispensing rates in the earlier developed regression models might have similarity to other variables that were not significantly predictive. For example, the earlier regression analyses identified only beliefs based on clinical experience as significantly predictive of digital noise reduction and telecoil dispensing rates. However, it could have been that all beliefs had some relation to dispensing rates. That is, stepwise regression analysis technique first indicates as significantly predictive those variables that account for *most of the variance* in a dataset followed by those variables that account for *additional* variability. Therefore, variables accounting for similar variance can be overlooked as significantly predictive.

For the factor analysis, questions with responses collected on an interval scale or transformed to an interval scale were included. Those questions with responses not on an interval scale were excluded, such as demographic characteristics of the audiologists (categorical data). That is, factor analysis is not possible with both categorical and interval scaling types of data at once. A principal component analysis method of factor analysis identified existence of seven statistical factors, the same for each of the four product features, accounting

Table 9. Primary loading values of the variables on the statistically-derived factors

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
Belief based on clinical experience	0.80						
Belief based on real-world research data	0.86						
Belief based on lab research data	0.83						
Belief based on educational training	0.81						
Activity level of the patient population		0.77					
Savviness of the patient population		0.62					
Patient population household income		0.51					
Level of hearing aid technology			0.73				
Price of the hearing aid			0.59				
Patient population age				0.53			
Patient population handicap				0.44			
Patient population hearing loss				0.64			
Patient population payer source for a hearing aid:				0.49			
Private pay or third party							
How often do you complete validation (formal outcome) measures?					0.54		
How often do you complete verification (real-ear) measures?					0.68		
Audiologist criterion for when to dispense hearing aid product features based on the magnitude of patient need						0.62	
Patient population product feature-specific need question							0.46
Hearing aid style			No loading score greater than 0.4				
Ease of configuring the product feature in programming software			No loading score greater than 0.4				

for, on average, 63% of the variance. In addition, loading values were generated for each question item (variable) ranging from 0.0 to 1.0 for each factor (Table 9).

Factor 1, for example, included all question items regarding personal beliefs held by audiologists with regard to product feature effectiveness based on their (a) educational training, (b) clinical experience, (c) interpretation of lab research publications, or (d) interpretation of real-world research publications. On Factor 1, these four belief-related items had a high average weighting of 0.82. Only two of the variables examined in the factor analysis did not load on any factor with weightings of 0.4 or less. These two regarded the ease of engaging/configuring the product feature in programming software (EOE/CPS) and the styles of the hearing aids dispensed by the audiologist (S). All other variables with a stronger factor loading, that is, >0.4, were assigned to one of the seven statistical factors using each item's highest loading value, that is, the primary loading. Based on these variable groupings, the factors were accordingly named as follows:

1. Audiologist's Beliefs Regarding Each Feature's Potential Benefit

- 2. Activity Level and Savviness of the Patient Population*
- 3. Hearing Aid Price and Level of Technology of the Hearing Aids Dispensed*
- 4. General Patient Population Characteristics (e.g., demographics, magnitude of hearing loss, etc.)*
- 5. Audiologist's Use of Verification and Validation Measures*
- 6. Audiologist's Feature Candidacy Criterion Based on the Magnitude of Patient Need*
- 7. Magnitude of Patient Population's Feature-Specific Need.*

Scores for each of these factors were calculated by averaging across the responses obtained from the survey participants to the variables loading on each factor. Then, the seven factor scores, along with the two variables (EOE/CPS and S) not loading onto any one of the seven factors, as well as all remaining variables not included in the factor analysis were used to redevelop the regression models.

Results of four regression analyses produced findings similar to the original regression analyses completed without the identification of factors. That is, predictive relationships were

Table 10. Grades of recommendation for each product feature (A - Strongest D - Poorest)

Product Feature	Grade of Recommendation
Digital Feedback Suppression Processing	B
Digital Noise Reduction Processing	D
Directional Processing	B
Telecoil	C

of similar magnitude and ranking; however, instead of only identifying one of the belief questions as significantly predictive, the category of *Audiologist's Beliefs Regarding Each Feature's Potential Benefit* factor itself was significantly predictive. Additionally, the *Hearing Aid Price and Level of Technology of the Hearing Aids Dispensed* factor suggested that not just level of technology was related to dispensing rates, but that price also shared a similar relationship (i.e., the two were somewhat redundant variables). Also, similar to the previous regression models, the two factors, *Audiologist's Feature Candidacy Criterion Based on the Magnitude of Patient Need* and *Magnitude of Patient's Feature-Specific Need* (e.g., the patient's communicative difficulty or likelihood of feedback), were significantly predictive. This was not surprising as these factors were only composed of one item and was the exact same variable that had been used in the earlier regression analyses. Factors named *Activity Level and Savviness of the Patient Population*, *Audiologist's Use of Verification and Validation Measures*, and *General Patient Population Characteristics* were not significantly predictive of dispensing rates akin to earlier regression results where the individual variables that comprise these factors were also not significantly predictive.

Simply stated, the factor analysis indicated any variables regarding a belief were predictive of dispensing rates despite its origination source (e.g., clinical experience, educational training, lab research, or real-world research). Similarly, when the level of hearing aid technology was significantly predictive of dispensing rates (i.e., for all features except the telecoil), price of the hearing aid was also interrelated and accounted for similar but less variance in the dispensing rates. This redundancy of price and level of technology makes sense given the relationship between the two that exist in brand pricing strategies (Nowlis & Simonson, 1996). That is, higher priced products include higher levels of technology and vice versa.

A grand analysis including evidence-based practice grades of recommendation: A general linear model statistical design. This grand analysis examined the respective grades of recommendation for each of the four product features as taken from the *AAA Guideline for the Audiologic Management of Adult Hearing Impairment* (Valente et al., 2006) for their

relationship to dispensing rates. In regard to EBP, the three grades of recommendation assigned to the four product features are shown in Table 10; note that no product feature was assigned the highest strength rating of an "A." Use of a general linear model statistical design stemmed from the between-subject and within-subject nature of the 29 variables as well as the categorical and interval scales on which the data was collected. Those survey questions with responses that applied to all four product features were referred to as between-subject variables, whereas those predictor variables that required multiple questions, one for each product feature, were considered within-subject variables. For example, the four questions regarding belief in product feature benefit were asked four times each, once for each product feature. Other within-subject variables included the *Magnitude of Patient's Feature-Specific Need* and *Audiologist's Feature Candidacy Criterion Based on the Magnitude of Patient Need*.

In this model, the overall R^2 value was .68, meaning that 46% of the variance in dispensing rates of the four product features could be accounted for with several of the predictor variables, $F(261, 766) = 6.37, p < .001$. Each of the variables with a significant relationship is shown in Table 11. Similar to the earlier product feature-specific regression models, the regression coefficients indicate the direction of a variable's effect on dispensing rates. For example, the positive coefficient for the *Hearing Aid Price and Level of Technology* factor indicates that audiologists who dispense more of their hearing aids at higher prices and with higher levels of technology dispense hearing aid product features more often.

The most pertinent finding of this analysis was the demonstrated relationship between the grades of recommendation and dispensing rates. Specifically, in contrast to the EBP grades of recommendation, digital noise reduction processing with a grade of "D" was dispensed significantly more often than the other product features with a "B" or "C" grade. However, the telecoil was appropriately dispensed less often, based on its grade of recommendation, than those product features with a "B" grade.

Other variables that were shown to relate to differences in the dispensing rates of the four features were consistent with those earlier identified by the product feature-specific regression models (i.e., the audiologist-specific feature candidacy criterion, an audiologist's personal belief in the potential benefit of a product feature, and level of hearing aid price/technology). Additionally, the magnitude of patient population's feature-specific need and hearing aid style, which were responsible for predicting directional processing dispensing rates only, were significantly predictive of the overall dispensing rates of the four features. Two new predictor variables also emerged, the audiologist's gender and his or her patient population's age as reported by the audiologists. In essence, female

Table 11. Variables with associations to dispensing rates of all four product features as evidenced by the general linear model analysis

	F-statistics	Regression Coefficient
Hearing Aid Price and Level of Technology Factor (HAP/LT)	$F(1,235) = 12.99, p < 0.001$	0.573
Audiologist's Feature Candidacy Criterion (AFCC)	$F(1,235) = 81.11, p < 0.001$	-0.041
Audiologist's Beliefs Factor (AB)	$F(1,235) = 113.03, p < 0.001$	0.074
2006 AAA EBP grades of recommendation (GOR) (Categorical)	$F(2,235) = 123.89, p < 0.001$	
<i>D relative to B</i>		0.100
<i>C relative to B</i>		-0.205
Magnitude of Patient Population's Feature-Specific Need (MPPFSN)	$F(1,235) = 19.13, p < 0.001$	0.003
Hearing Aid Style (S)	$F(1,235) = 23.29, p < 0.001$	0.07
Audiologist's Gender (AG) (Categorical)	$F(1,235) = 15.80, p < 0.001$	-0.501
<i>Male gender relative to female gender</i>		
Patient Population's Age (PPA)	$F(1,235) = 18.56, p < 0.001$	-1.183

audiologists reported dispensing product features more often than males. Additionally, those audiologists with reportedly younger patient populations dispensed features more often than audiologists serving older patient populations.

Discussion

An examination of the average dispensing rates and the variability among audiologists in this study sample (i.e., dispensing rates in the summer of 2007) revealed similarities to THJ/AO 2007 survey of dispensing rates in the year 2006. Specifically, audiologists demonstrated considerable variability in dispensing rates (i.e., standard deviations in the percentage of time dispensed) for digital feedback suppression processing, digital noise reduction processing, directional processing, and the telecoil (14.8%, 16.0%, 21.1%, and 26.5%, respectively). Collectively, this was viewed as strong evidence that differences in the practice behavior of audiologists in regard to product feature dispensing do exist.

Other medical researchers have also noted variability in regard to patient care by physicians and other health care providers in their respective fields (e.g., Blair et al., 1998; Cheng et al., 1999; Green & Wheeler, 2003; Green, Wheeler, et al., 2003; Hellerstein, 1998; Sable et al., 2006; Smith et al., 1995; Tamayo-Sarver et al., 2004; Tamblyn et al., 1998). Smith et al. (1995) revealed that a physician's practice patterns accounted for most of the variation in a physician's productivity, as opposed to clinic or patient characteristics. Hellerstein (1998) reported that variability in the dispensing of generic versus brand name drugs by physicians was largely unexplained by patient characteristics; yet physician characteristics were very important. In addition, physician management of pain via dispensing medication assessed through the use of clinical vignettes has been shown to rely heavily on the individual physician's goals for pain relief and how often pain medications are prescribed by a physician in the real-world

rather than patient characteristics (Green & Wheeler, 2003; Green, Wheeler, et al., 2003). Simultaneously, some patient characteristics such as ethnicity and race have been shown to inappropriately relate with the pain management (Green, Anderson, et al., 2003).

In this study of hearing aid product feature dispensing rates, overall regression coefficients for the developed models were considered large/high for human behavior research, meaning that a sizeable portion of the variability in dispensing rates was accounted for by the predictor variables (Cohen, 1988). However, most of the variability was accounted for by only a few of the variables with the vast majority of potential predictor variables having no relation to dispensing rates. Further utility of these study results is possible via use of the product feature-specific regression model equations that allow for predictions of other audiologists' dispensing rates not included in this study sample. That is, instead of obtaining responses to all of the questions in this study's developed survey, only those questions pertaining to the significantly predictive variables are needed to make such predictions.

In general, the three most important and commonly occurring variables accounting for the variation in dispensing rates of the product feature were (a) the price/level of hearing aid technology dispensed by the audiologists, (b) an audiologist-specific feature candidacy criterion for when to recommend a product feature based on patient need, and (c) an audiologist's personal belief in the potential of a product feature. Several other variables accounting for some of the variance were dependent on the specific product feature examined. That is, the ease of engaging digital feedback suppression processing in the programming software was related to its dispensing rate. In addition, audiologists with an AuD degree dispensed digital noise suppression processing more often than those with a master's degree by 10% on average. Those audiologists dispensing directional processing frequently reported dispensing larger hearing aid styles and having a

patient population with greater need for the product feature based on their patient populations' communication difficulty in challenging listening environments.

In interpreting these study findings in terms of the categories in which the variables were placed, variables from two of the categories were of most importance. These categories were characteristics of the audiologists and characteristics of the hearing aids dispensed by the audiologist. Variables in the category labeled characteristics of the audiologist's patient population were least often responsible for dispensing rate variability. That is, the only relationship between a variable in this category and dispensing rates of a single feature occurred between directional processing and the magnitude of the patient population's feature-specific need based on communication difficulty in challenging listening environments. This suggests that current differences in the dispensing rates of product features among audiologists are not explained by differences in the patient populations served by those same audiologists.

The category with the strongest relationship to dispensing rates was characteristics of the hearing aids most commonly dispensed by an audiologist, that is, it was ranked as the best predictor in three of the four product feature regression models by the semipartial correlation. It is proposed that the positive relationship between increased level of hearing aid technology/price and size of hearing aid style with higher dispensing rates reflect realities of hearing aid manufacturing and the distribution system. For example, completely-in-the-canal or CIC style hearing aids have faceplates that are generally too small for inclusion of directional microphones, and the typical placement of the faceplate (recessed within the ear canal) makes directional separation unlikely even if the instrument could be fitted with a directional microphone (Ricketts, 2001). In addition, an examination of the hearing aid models in a brand's product line offering shows that additional product features are more likely to be included on high-end hearing aid models, whereas low-end product models may require incremental price increases for the addition of product features or may not allow for the addition of product features. In comparison, the price/level of technology relationship to the dispensing rates of product features is somewhat similar to the pricing of prescription medications that has been shown to effect the dispensing of generic label or brand name drugs (Lexchin, 2004).

Within the second category, characteristics of the audiologists, the primary variables with a relationship to dispensing rates were

1. an audiologist-specific candidacy criterion for when to dispense a feature (AFCC), and
2. a personally held belief by the audiologist regarding a product feature's potential benefit (AB).

The strength of the relationship between the AFCC variable and dispensing rates was unexpected. Survey questions pertaining to the patient candidacy were actually written with the expectation that audiologists would report similar criterion at which they dispensed product features based on patient need. However, the audiologists' responses to the questions indicated otherwise. The feature candidacy criterion did vary among audiologists and those having lower criterion levels reported higher dispensing rates while those with higher criterion levels reported lower dispensing rates for each product feature.

One might argue that the audiologist-specific feature candidacy criterion (AFCC) should be considered a patient population characteristic, while we believe it is in fact a characteristic of the audiologist. That is, although the criterion is based on patient need, it was *not* the absolute magnitude of the patient population's need for a product feature (i.e., predictor variable, MPPFSN) that related to dispensing rates for all features except directional processing. Rather, it was the criterion held by the audiologist regarding how much patient need was necessary prior to dispensing the product feature that related to dispensing rates. In other words, some audiologists had a more stringent criterion for when to dispense a product feature based on patient need, whereas others had a more lax criterion. Accordingly, differences in dispensing rates of digital feedback suppression processing, digital noise reduction processing, and the telecoil did not arise as a result of differences in the magnitude of patient population need for the feature, but rather the audiologist-specific feature candidacy criterion based on need for a feature. In the case of directional processing, variability was accounted for by both the AFCC and MPPFSN variables.

The general finding that personal beliefs held by the audiologist had a strong relationship to dispensing rates suggests audiologists have differing views on the benefits of product features. This finding is theoretically supported by the theory of reasoned action (Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980). This theory suggests that a person's behavior is often based on his or her attitudes that are founded on his or her personal beliefs. Thus, variations in the magnitude of a belief would give rise to differences in attitude and behavior. Specifically, relative to this study's findings, those audiologists who had less belief in a product feature's effectiveness dispensed it less often than those who had more belief in the feature and vice versa.

With regard to characteristics of the audiologists that affected dispensing rates, other professional health care occupations have similar influences on their decision choices. The fact that an audiologist's belief in a product feature relates to his or her dispensing rate of that feature is similar to the findings of other researchers. Sable et al. (2006) found that attitudes toward emergency contraceptives

affected the dispensing frequency of those medications by physicians. Likewise, Epstein, Read, and Winickoff (1984) found that physicians' beliefs regarding anti-inflammatory drugs affected dispensing of the drugs.

Regarding the management of pain (i.e., how much pain is acceptable), treatment goals of the individual physician have also been shown to relate with pain reliever drug dispensing (Green, Wheeler, et al., 2003). This is very much akin to the audiologist-specific feature candidacy criterion for when to dispense a product feature (i.e., how much listening difficulty is needed before an audiologist recommends directional processing).

With reference to patient population characteristic effects on health care practices, several studies have noted that provision and outcomes of health care may be influenced by patient age, ethnicity, and gender (e.g., Bernabei et al., 1998; Bonham, 2001; Fichtenbaum & Gyimah-Brempong, 1997; Hicks et al., 1997; McCulloch, 1992). although this study did not evaluate whether ethnicity and gender differences of the patient population might affect dispensing rates, it seems clear that many potential characteristics of the patient population that could have affected dispensing rates did not. The two exceptions to this statement were in regard to the magnitude of patient population's feature-specific need (MPPFSN) variable, which related to dispensing rates of directional processing only and patient population's age relation to the overall dispensing rates of the four product features. Logically, the patient population age effect may be because of decline in cognitive or dexterity skills of older patient populations that cause audiologists to dispense additional product features less often. However, despite the fact that older patients may have more trouble understanding and making use of features, older patients can derive benefit from their use (C. E. Johnson, Danhauer, & Krishnamurti, 2000). This is particularly true as product features are now more automatic, requiring less patient involvement than ever before. This finding definitely warrants further follow-up studies, and according to these study results, patient population age may not be predictive of dispensing rates for any single product feature, but rather for a general collection of product features.

When examining differences in the dispensing rates of all four product features among audiologists, the general linear model statistical design revealed EBP grades of recommendation did not appropriately relate to how often the features were dispensed relative to one another. Specifically, the *average* dispensing rate of digital feedback suppression processing and directional processing, both product features with a grade recommendation of "B," was less than that for digital noise reduction processing with a grade recommendation of "D." Likewise, the telecoil was dispensed less often than digital noise reduction processing despite its higher grade of recommendation. In other words, the high dispensing

rates of digital noise reduction processing were inversely related to its grade of recommendation.

In general, other variables with an identified relationship in grand general linear model analysis were also responsible for dispensing rate differences of a single product feature. However, two additionally predictive variables of the overall dispensing rates, not demonstrated in product feature-specific models, were the gender of the audiologist and age of the patient population served. This finding was likely based on the increased sample size of 1,028 obtained by combining all four product features into one grand analysis compared with the single product feature sample size of only 257. Regardless, the gender finding, with men dispensing fewer product features than women, was consistent with a previous study, which showed gender differences in dispensing rates of features (E. E. Johnson, 2007a). Meanwhile, the effect of patient population's age was unexpected, as it was not significantly predictive for any single product feature. Nonetheless, interpretation of this result would indicate that audiologists with younger patient populations dispense more product features in general than those with older patient populations.

With regard to audiologists' use of EBP to make clinical decisions, it should be made clear that this study did not examine whether EBP is used at the level of the individual patient. Therefore, these study results are unable to be interpreted as such. That is, this study did not analyze individual patient characteristics and the frequency of product feature dispensing rates by that patient's audiologist. Rather, on the whole, audiologists' overall dispensing rates of the four product features were inconsistent with the amount of existing evidence for each feature's use. Additionally, these study results cannot be extrapolated as any indication that other practice behaviors of audiologists are inconsistent with EBP; these study results only apply to dispensing rates of hearing aid product features.

Reasons underlying the variability of audiologists regarding the dispensing of hearing aid product features are relatively similar to those that influence the practice of other medical professions. From this, audiologists should acknowledge such potential effects on their own daily practices and seek ways to reduce unwarranted ones. A few specific recommendations to reduce unwarranted effects are offered in a latter section of this article devoted to the matter.

Possible study limitations. In any discussion of study results, possible study limitations should be included. Relevant to the undertaken study, the potential effects of multicollinearity and residual data points on the developed product feature-specific regression models were analyzed to demonstrate the integrity of those models. Multicollinearity is a statistical expression of whether two or more variables evaluated for placement in a regression model are highly related to one another (Howell, 2001). The effects of

multicollinearity should be examined as high correlation between the independent variables can lessen their joint contribution to a predictive model (Howell, 2001). Thus, less, as opposed to more, multicollinearity between the independent variables is desired in a “good” regression model. As two measures of possible multicollinearity effects on the data set, tolerance and the variance inflation factor (VIF) were calculated.

For the models developed to describe the study data, the tolerance values were at least 0.541 for all variables, with greater than 90% of the variables having tolerance values greater than 0.90. Concomitantly, no VIF value exceeded 1.85, and greater than 90% of the VIF values were less than 1.1, where 1.0 is the minimum VIF value theoretically possible. This was viewed as strong evidence that multicollinearity did not adversely affect the developed regression models as it is considered problematic when tolerance values are less than 0.1 and reciprocal VIF values exceed 10.0 (Armitage, Berry, & Matthews, 2002; Wetherill, Duncombe, Kenward, Paul, & Vowden, 1986).

The influence of residual data points on the developed regression models was also assessed. The impact of outlying data points of both the independent and dependent variables, referred to respectively as measures of distance and leverage, were represented in a single measure called Cook's *D* (Howell, 2001). No case observations approached values of concern, that is, close to 1; therefore, data outliers were not considered to adversely affect developed coefficients in the regression models.

Other possible study limitations could stem from the lack of an ability to identify variables that might have had a better relationship to dispensing rates than those assessed. That is, as with any study using predictor variables, results are limited to only those variables chosen for examination. Future studies should certainly consider other variables not examined by this study. For the variables examined in the study, it is conceivable that question wording and response choices have the potential to affect the study outcomes.

When interpreting the audiologist-specific feature candidacy criterion (AFCC) finding, for example, two contrary viewpoints emerge. One viewpoint is that the question and its generic, 0 to 10 rating scale response represents an important domain on which audiologists decide to dispense each product feature to a patient, and, as the results suggest, the criterion for when to do so is different among audiologists. A secondary viewpoint is that a design flaw surrounding the survey question pertaining to the AFCC variable or its rating scale anchors were the cause of such a finding. Namely, the rating scale may have oversimplified the complex decision regarding whether a product feature should be dispensed. The rating scale may have also not been interpreted similarly by the respondents and not used consistently. That is, if

audiologists were to say they would dispense directional processing to a patient having moderate difficulty hearing in challenging listening environments, what number on a 0 to 10 scale constitutes moderate difficulty? As a solution, perhaps more audiological anchors regarding hearing difficulty in noise would have been more suitable for the rating scale such as, signal-to-noise ratio (SNR) loss. However, the use of such a test is not commonplace by audiologists; thus, using the SNR loss measure as rating scale anchor points seemed inappropriate.

With regards to the low dispensing rate of the telecoil, this may have been due to various causes. First of all, the telecoil is dispensed for better access to induction loop hearing assistance systems, however, the presence of such systems in the United States is less common than in European countries. Resultantly, few telecoils are dispensed for this reason only in the United States. Instead, the telecoil is most often dispensed for better access to telephone technology, particularly those on local area network (LAN) lines. A second reason for the low dispensing rate of the telecoil may be the advent of the acoustic telephone listening program which has offered a substitute for the telecoil. That is, this listening program now offers less occurrence of feedback as a result of better, more effective digital feedback suppression systems (Freed & Soli, 2006; E. E. Johnson et al., 2007) and rolls off the frequency response of the hearing aid greater than ~3 kHz (i.e., typical high-frequency bandwidth of a LAN line telephone). This roll-off of the frequency response helps to prevent feedback particularly when a telephone comes in normal proximity to the ear. That is, the peak of the feedback loop response, unchanged by the presence of a telephone headset, occurs in the vicinity of 4 to 5 kHz for a vented earmold, whereas the peak for the unvented earmold occurs in the vicinity of 2.5 to 4.0 kHz (Kates, 1999). A telephone placed near the ear in a normal listening position will increase the amplitude of the feedback loop response by about 10 dB and, concomitantly, makes feedback more likely than without the telephone near the ear (Kates, 1999).

Conceivably, combining the two product features of a telecoil and acoustic telephone listening program that serve the same purpose through different modes, i.e., one through induction and one acoustic, dispensing rates of a more generalized telephone program would have probably been higher. However, because the 2006 AAA EBP guideline did not include the acoustic telephone program specifically in its review of product features, its dispensing rates were not evaluated in this study in conjunction with those of the telecoil. That is, without such a review, the major focus of this study on examining whether dispensing rates were consistent with EBP recommendations was unachievable with the acoustic telephone program.

Recommendations to minimize dispensing rate variability. With regards to variability arising from professional decision

making in other medical professions, a number of recommendations have been proposed. To minimize variability in the dispensing of pain medications among physicians, for example, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), a regulatory organization of health care facilities, has developed focused standards to address the issue (Gallagher, 2003). Furthermore, in an attempt to better align physician behavior with practice guidelines, several methods have been employed. To change physician behavior, physicians have been provided with their own clinical outcomes as means of monitoring the effectiveness of their clinical decisions as well as engaging in a process known as academic detailing. This process typically includes peer review of a physician's practice behavior followed by suggestions for improvement (Schuster, Terwoord, & Tasosa, 2006). Additionally, financial incentives have also been studied and used clinically to modify physician behavior (Greco & Eisenberg, 1993; Hillman, Pauly, & Kerstein, 1989; Kahn et al., 1990).

Further analysis of data in this study suggests that some audiologists better reflect EBP in their dispensing rates of product features than others. That is, a lower mean dispensing rate of digital noise reduction processing, the feature having the poorest grade of recommendation, was reported by audiologists with exposure to the 2006 AAA EBP guideline compared to those audiologists reporting no exposure. This suggests the notion that continued dissemination of these guidelines and ways to reflect their recommendations in clinic can promote change, albeit minimal, in dispensing behavior. Additionally, as an indication of their acceptance to change, audiologists expressed a general willingness to modify their daily practice behavior to better reflect EBP recommendations (E. E. Johnson, 2008b).

There are probably several ways, therefore, to reduce individual, audiologist-specific influences on the dispensing of product features. One might be self-evaluation, where audiologists individually ask themselves whether their beliefs regarding product feature effectiveness are consistent with sources external to themselves, the most preferable, of course, being peer-reviewed journal articles and EBP guidelines. Through alignment of audiologists' beliefs with such sources, practice behavior will begin to reflect research findings and EBP recommendations.

Second, given that audiologists seem to have a differing criterion for when to dispense product features based on patient need, we must find a way to standardize such a criterion across audiologists. This is an area that research should address for EBP to provide a more specific recommendation than an overall strength of evidence rating for a product feature. One already proposed criterion for when to dispense directional processing is a hearing impaired individual's measured SNR loss as measured by the QuickSIN test (Killion, Niquette, Gudmundsen, Revit, & Banerjee, 2004).

Anchor points based on this measure were considered for this study; however, the QuickSIN lacks widespread use (i.e., only 8% of audiologists have access to the QuickSIN test, Killion, 2004). Therefore, SNR loss as defined by the QuickSIN was deemed an inappropriate criterion for use in this study, as presumably, many audiologists surveyed would have been unfamiliar with the test. For this reason, a more generalized rating scale anchor was used in this study (i.e., *no difficulty to extreme difficulty*). Perhaps a first step toward standardizing a criterion for patient candidacy is standardizing the use of clinical tests at various clinical sites. Such standardization attempts are becoming more commonplace, as evidenced by the U.S. Department of Veterans Affairs, which will soon use the International Outcomes Inventory for Hearing Aids (IOI-HA; Cox & Alexander, 2002; Cox, Alexander, & Beyer, 2003; Cox, Stephens, & Kramer, 2002) as a validation measure for all hearing aid fittings.

Lastly, as evidenced by this study, price of the hearing aid and the level of technology within the hearing aid itself impacted or influenced the dispensing rates of product features. Again, although a reasonable sales model, such an impact is grossly misaligned with goals of EBP. In extreme cases of a sales model, the distinctions between low- and high-end product models is whether the audiologist has access to additional product features via the programming software. EBP would encourage the use of only specific interventions (in the case of hearing aids, product features) with effectiveness and efficacy research data to address particular patient needs or insufficiencies. One way to address such an undue influence on product feature dispensing is the offering of product features in an à la carte manner by hearing aid manufacturers. This would allow the audiologist full discretion over the inclusion/exclusion of hearing aid product features and in turn eliminate dispensing of product features the manufacturer chooses to make available for a given hearing aid product model based on its level of technology and price. Hence, product feature availability would not be constrained by product feature bundling within a hierarchy of product models.

Summary

This study demonstrated that differences in broad characteristics of audiologists' patient populations were not primarily responsible for dispensing rate variability of four hearing aid product features. Instead, characteristics of the hearing aids dispensed by audiologists and characteristics of the audiologists themselves accounted for most of the variance in dispensing rates. Furthermore, average dispensing rates of the four product features were not consistent with recommendation for their use as taken from a 2006 AAA EBP guideline.

Appendix

Survey Developed for the Main Study

Participant Screening Questions													
<p>1. Are you an audiologist?</p> <p>☐ Yes</p> <p>☐ No</p>													
<p>2. Do you dispense hearing aids?</p> <p>☐ Yes</p> <p>☐ No</p>													
Characteristics of your patient population													
<p>INSTRUCTIONS: PLEASE ANSWER THE FOLLOWING QUESTIONS ABOUT THE PATIENT POPULATION TO WHOM YOU DISPENSE HEARING AIDS.</p> <p>PLEASE ENTER ALL PERCENTAGES AS WHOLE NUMBERS.</p>													
<p>3. What percent of your patient population falls into the following age categories? (Entered values must total 100%.)</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 80%;">Old-old adults 85+</td> <td style="width: 20%; text-align: center;"><input style="width: 100%;" type="text"/></td> </tr> <tr> <td>Old adults 75-84 years</td> <td style="text-align: center;"><input style="width: 100%;" type="text"/></td> </tr> <tr> <td>Young-old adults 65-74 years</td> <td style="text-align: center;"><input style="width: 100%;" type="text"/></td> </tr> <tr> <td>Adults 18-64 years</td> <td style="text-align: center;"><input style="width: 100%;" type="text"/></td> </tr> <tr> <td>Children 3-17 years</td> <td style="text-align: center;"><input style="width: 100%;" type="text"/></td> </tr> <tr> <td>Young children/infants 0-2 years</td> <td style="text-align: center;"><input style="width: 100%;" type="text"/></td> </tr> </table>		Old-old adults 85+	<input style="width: 100%;" type="text"/>	Old adults 75-84 years	<input style="width: 100%;" type="text"/>	Young-old adults 65-74 years	<input style="width: 100%;" type="text"/>	Adults 18-64 years	<input style="width: 100%;" type="text"/>	Children 3-17 years	<input style="width: 100%;" type="text"/>	Young children/infants 0-2 years	<input style="width: 100%;" type="text"/>
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Young children/infants 0-2 years	<input style="width: 100%;" type="text"/>												
<p>4. What percent of your patient population falls into the following hearing loss categories? (Entered values must total 100%.)</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 80%;">Mild</td> <td style="width: 20%; text-align: center;"><input style="width: 100%;" type="text"/></td> </tr> <tr> <td>Moderate</td> <td style="text-align: center;"><input style="width: 100%;" type="text"/></td> </tr> <tr> <td>Moderately-severe</td> <td style="text-align: center;"><input style="width: 100%;" type="text"/></td> </tr> <tr> <td>Severe</td> <td style="text-align: center;"><input style="width: 100%;" type="text"/></td> </tr> <tr> <td>Profound</td> <td style="text-align: center;"><input style="width: 100%;" type="text"/></td> </tr> </table>		Mild	<input style="width: 100%;" type="text"/>	Moderate	<input style="width: 100%;" type="text"/>	Moderately-severe	<input style="width: 100%;" type="text"/>	Severe	<input style="width: 100%;" type="text"/>	Profound	<input style="width: 100%;" type="text"/>		
Mild	<input style="width: 100%;" type="text"/>												
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Severe	<input style="width: 100%;" type="text"/>												
Profound	<input style="width: 100%;" type="text"/>												

(continued)

Appendix (continued)

5. What percent of your patient population falls into the following hearing handicap categories? (Entered values must total 100%.)

No handicap	<input type="text"/>
Mild handicap	<input type="text"/>
Moderate handicap	<input type="text"/>
Severe handicap	<input type="text"/>

6. What percent of the hearing aids you dispense are paid for via a private party versus a third party payer? (Entered values must total 100%.)

Private party payer	<input type="text"/>
Third party payer	<input type="text"/>

7. What percent of your patient population has a household income in the following ranges? (Entered values must total 100%.)

\$0-\$20,000	<input type="text"/>
\$20,001-\$40,000	<input type="text"/>
\$40,001-\$60,000	<input type="text"/>
\$60,001-\$80,000	<input type="text"/>
\$80,001-\$100,000	<input type="text"/>
\$100,001-Above	<input type="text"/>

8. In general, how active are your patients in their daily lives?

	Not active at all - 0	1	2	3	4	5	6	7	8	9	10 - Extremely active
Activity level	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

9. In general, how savvy are your patients in their daily lives with technology, not including hearing aids?

	Not savvy at all - 0	1	2	3	4	5	6	7	8	9	10 - Extremely savvy
Savvy	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

10. In general, how much hearing difficulty do your patients report experiencing in challenging listening environments (e.g. cocktail party, restaurant, bar, etc.)?

	No difficulty at all - 0	1	2	3	4	5	6	7	8	9	10 - Extreme difficulty
Difficulty level	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(continued)

Appendix (continued)

11. In general, how much hearing difficulty do your patients report experiencing when using the telephone?

	No difficulty at all - 0	1	2	3	4	5	6	7	8	9	10 - Extreme difficulty
Difficulty level	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

12. In general, when wearing their hearing aids, how likely is acoustic feedback to occur for your patients?

	Feedback very unlikely - 0	1	2	3	4	5	6	7	8	9	10 - Feedback very likely
Feedback likelihood	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Characteristics of dispensed hearing aids

INSTRUCTIONS: PLEASE ANSWER THE FOLLOWING QUESTIONS REGARDING THE HEARING AIDS YOU DISPENSE TO PATIENTS.

PLEASE ENTER ALL PERCENTAGES AS WHOLE NUMBERS.

13. What percent of the hearing aids you dispense fall into the following technology categories? (Entered values must total 100%.)

Analog	<input type="text"/>
Low-end digital	<input type="text"/>
Mid-level digital	<input type="text"/>
High-end digital	<input type="text"/>

14. What percent of the hearing aids you dispense fall into the following style categories? (Entered values must total 100%.)

CIC	<input type="text"/>
ITC	<input type="text"/>
ITE	<input type="text"/>
BTE with traditional earmold	<input type="text"/>
Mini-BTE with open canal	<input type="text"/>

(continued)

Appendix (continued)

15. What percent of the hearing aids you dispense fall into the following retail price ranges? (Entered values must total 100%.)

Notes:

1) Please report based on the price of a single hearing aid, not two.

2) If you dispense in a third party payer system (e.g. Department of Veterans Affairs, etc.), do not enter the amount you charge your patients, but rather the manufacturer suggested retail price (MRSP).

\$1-\$500	<input type="text"/>
\$501-\$1,000	<input type="text"/>
\$1,000-\$1,500	<input type="text"/>
\$1,501-\$2,000	<input type="text"/>
\$2,001-\$2,500	<input type="text"/>
\$2,501-\$3,000	<input type="text"/>
\$3,001-\$3,500	<input type="text"/>
\$3,501-\$4,000	<input type="text"/>

16. What percent of the hearing aids you dispense are produced by the following brands? (Entered values must total 100%.)

GnReSound	<input type="text"/>
Oticon	<input type="text"/>
Phonak	<input type="text"/>
Siemens	<input type="text"/>
Starkey	<input type="text"/>
Unitron	<input type="text"/>
Widex	<input type="text"/>
Other brands	<input type="text"/>

17. In general, how easy is it for you to configure hearing aid product features in the programming software application(s) you use?

	Not easy at all - 0	1	2	3	4	5	6	7	8	9	10 - Extremely easy
Ease of Configuring	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(continued)

Appendix (continued)**Dispensing Rates of Product Features**

INSTRUCTIONS: ATTEMPT TO REFLECT THE MOST ACCURATE PERCENTAGES POSSIBLE RELATIVE TO YOUR DISPENSING BEHAVIOR FOR THE FOLLOWING QUESTIONS. IF NECESSARY, PLEASE REFER BACK TO YOUR RECENT HISTORY OF DISPENSED HEARING AID PRODUCTS.

PLEASE ENTER ALL PERCENTAGES AS WHOLE NUMBERS.

18. What percent of the hearing aids you dispensed in the last three months had directional microphone technology activated (either manual, automatic, or adaptive)?

19. What percent of the hearing aids you dispensed in the last three months had digital noise reduction processing activated?

20. What percent of the hearing aids you dispensed in the last three months had digital feedback suppression processing activated?

21. What percent of the hearing aids you dispensed in the last three months had a telecoil activated (either manual or automatic)?

(continued)

Appendix (continued)

Personal beliefs regarding hearing aid product features

INSTRUCTIONS: THE FOLLOWING QUESTIONS ARE RELATED TO YOUR EDUCATIONAL AND CLINICAL EXPERIENCE.

PLEASE INDICATE THE EXTENT TO WHICH YOU AGREE OR DISAGREE WITH THE STATEMENTS.

22. Based on my educational training (e.g specifically what you learned in graduate school or via continuing education), I believe the following will benefit my patients.

	0 - Strongly disagree	1	2	3	4	5 - Neutral	6	7	8	9	10 - Strongly agree
A telecoil	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Digital noise reduction processing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Directional microphone technology	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Digital feedback suppression processing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

23. Based on my clinical experience, I believe the following will benefit my patients.

	0 - Strongly disagree	1	2	3	4	5 - Neutral	6	7	8	9	10 - Strongly agree
Digital noise reduction processing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Directional microphone technology	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
A telecoil	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Digital feedback suppression processing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(continued)

Appendix (continued)

Personal beliefs continued...

INSTRUCTIONS: THE FOLLOWING QUESTIONS ARE RELATED TO HOW YOU USE PUBLISHED RESEARCH TO DETERMINE PATIENT BENEFIT FROM HEARING AID PRODUCT FEATURES.

Lab data (efficacy data) - research findings from participants evaluated in a laboratory setting

Real-world data (effectiveness data) - research findings from participants evaluated in their real-world, everyday listening environments

Please indicate the extent to which you agree or disagree with the following statements.

24. Based on lab research published in peer-reviewed journals, I believe the following will benefit my patients.

	0 - Strongly disagree	1	2	3	4	5 - Neutral	6	7	8	9	10 - Strongly agree
Digital noise reduction processing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Digital feedback suppression processing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
A telecoil	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Directional microphone technology	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

25. Based on real-world research published in peer-reviewed journals, I believe the following will benefit my patients.

	0 - Strongly disagree	1	2	3	4	5 - Neutral	6	7	8	9	10 - Strongly agree
Directional microphone technology	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
A telecoil	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Digital feedback suppression processing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Digital noise reduction processing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(continued)

Appendix (continued)

Audiologist Characteristics

26. In general, you usually recommend directional microphone technology once your patients report _____ in challenging listening environments (e.g. cocktail party, restaurant, bar, etc.)?

	0 - No difficulty at all	1	2	3	4	5	6	7	8	9	10 - Extreme difficulty
Difficulty level	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

27. In general, you usually recommend digital noise reduction processing once your patients report _____ in challenging listening environments (e.g. cocktail party, restaurant, bar, etc.)?

	0 - No difficulty at all	1	2	3	4	5	6	7	8	9	10 - Extreme difficulty
Difficulty level	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

28. In general, you usually recommend a telecoil once your patients report _____ hearing on the telephone?

	0 - No difficulty at all	1	2	3	4	5	6	7	8	9	10 - Extreme difficulty
Difficulty level	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

29. In general, you usually recommend digital feedback suppression processing when acoustic feedback is _____ to occur?

	0 - Very unlikely	1	2	3	4	5	6	7	8	9	10 - Very likely
Feedback likelihood	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

30. When dispensing a new hearing aid, on what percent of patients do you complete real-ear probe microphone measures?

31. What percent of the time do you complete formal, standardized outcome assessment measures (e.g. questionnaires) of your patients' hearing aid performance?

(continued)

Appendix (continued)

Evidence-based practice knowledge

32. Have you ever read or been exposed to an evidence-based practice guideline before?

- ☐ Yes
☐ No

Evidence-based practice knowledge and opinion

33. Prior to this survey, were you aware of the American Academy of Audiology's 2006 evidence-based practice guideline entitled, "Guidelines for the Audiologic Management of Adult Hearing Impairment?"

- ☐ Yes
☐ No

34. Have you read this evidence-based practice guideline?

- ☐ No, not at all
☐ Only read the title
☐ Glanced through it
☐ Read it once
☐ Read repeatedly, studying it thoroughly

35. In your opinion, how credible are evidence-based guidelines as a helpful tool for clinicians to use when making decisions about the care of patients?

	0 - Very Incredible	1	2	3	4	5 - Neutral	6	7	8	9	10 - Very credible
Credibility	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

36. Do you believe your practice behavior is consistent with current evidence-based practice information?

	0 - Very inconsistent	1	2	3	4	5 - Neutral	6	7	8	9	10 - Very consistent
Consistency	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(continued)

Appendix (continued)

37. Would you be willing to modify your practice behavior based on recommendations from an evidence-based guideline maintained by the American Academy of Audiology?

	0 - Very unwilling	1	2	3	4	5 - Neutral	6	7	8	9	10 - Very willing
Willingness	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Audiologist Demographics

38. What is your gender?

- ☐ Male
☐ Female

39. How many years have you been dispensing hearing aids?

40. What is the highest professionally relevant educational degree that you hold (please select one)?

- ☐ Master's
☐ Doctor of Audiology
☐ Doctor of Education
☐ Doctor of Science
☐ Doctor of Philosophy
☐ Other (please specify)

41. In what setting do you primarily practice (please select one)?

- ☐ Independent private practice
☐ Private practice affiliated with a larger retail hearing aid brand
☐ Physician's office
☐ University
☐ Public/private general hospital
☐ Outpatient clinic
☐ Veterans Affairs system
☐ Government - Non-Veterans Affairs affiliated
☐ Other (please specify)

(continued)

Appendix (continued)

42. How many continuing education hours do you complete each year in the area of hearing aid dispensing?

43. In which state do you primarily practice?

State:

Thank you

We appreciate your participation in this survey and your contributions to the field of Audiology and individuals with hearing impairment.

If you would like to be entered in a random drawing for one of five \$100 dollar prizes given to the survey participants, please enter your first and last name in the text box below.

Remember at no time will the results be analyzed in accordance to the names of survey participants. Instead these names are collected for the sole purpose of giving away prize money to survey participants as a means of improving response rate.

If you win, the prize will be mailed to the same address as the invitation letter to participate in the study.

44. If you would like to be entered in the random drawing for one of five \$100 prizes, please type your first and last name below. (not required)

Authors' Note

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Note from page 8

1. One potential problem with this data transformation would be the case where an audiologist reported having a patient population consisting of 50% mildly hearing impaired individuals and 50% profoundly hearing impaired individuals. Such an audiologist's patient population would be represented as a 3, that is, $1(0.50) + 5(0.50)$, halfway between mild and profound scores of 1 and 5. However, no audiologist in this study sample reported such divergent patient population characteristics for the question regarding hearing loss or other remaining questions requiring a similar transformation. This might be expected as audiologists rarely serve two distinct patient populations at opposite ends of a continuum exclusively (e.g., only infants and old-old adults). Rather, audiologists typically serve a particular range of the age continuum (e.g., infants or old-old adults).

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