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Research Article

# Hearing Assistive Technology: Ratings of Familiarity, Perceived Usefulness, and Expected Cost by Audiology Patients

**Authors**

- Brian M. Kreisman[1]
- Andrew B. John[2]
- Erin Sheffer[3]
- Megan Marsh[4]

[1]*Calvin College, Grand Rapids, MI*

[2]*University of Oklahoma Health Sciences Center, Oklahoma City, OK*

[3]*Fort Wainwright, US Army, Fairbanks, AK*

[4]*Center for Hearing and Speech, Houston, TX*

## Abstract

While the benefit of hearing assistive technology (HAT) is well established, ownership remain low. We report the results of a patient survey on ownership, perceived usefulness, and expected and willing-to-pay cost of 20 widely-available HAT devices. Overall results suggest low rates of ownership and low familiarity with HAT. Perceived usefulness to people with hearing loss was high. Notably, cost estimates were often higher than actual costs; furthermore, respondents indicated a willingness to pay more than actual prices for lower-cost devices.

**Key Words: Hearing Assistive Technology, Alerting Devices, Personal Listening Devices, Telecommunication Devices, Assistive Listening Devices, Hearing Loss**

## Introduction

It is well known that individuals with hearing loss may need assistive devices in addition to hearing aids to meet their communication and functional needs. Hearing assistive technology (HAT) is the most commonly used term to describe devices used to support and enhance hearing, listening, and alerting among those with hearing loss (Smaldino, Kreisman, John, & Bondurant, 2014). HAT devices include both auditory assistive devices and assistive listening devices (ALDs). HAT encompass a wide variety of technologies, including alerting devices, personal listening devices, and telecommunication devices (see Table 1). These devices are important because they can improve individuals' communication and safety beyond hearing aids or cochlear implants. The interested reader is referred to Smaldino, Kreisman, and John (2014) and Smaldino et al. (2014) for detailed reviews of HAT. The purpose of this study was to assess a variety of factors related to HAT in a sample of patients seeking hearing health care in the United States.

Previous research has suggested that certain adult populations are more likely to benefit from HAT than other adults and therefore are more likely to own HAT. For example, adults that indicate having a greater degree of handicap and poorer quality of life due to their hearing loss are more likely to use HAT (Kelly-Campbell & Lessoway, 2015; Southall, Gagné, & Leroux, 2006). Adults with additional sensory impairments (e.g., dual impairments) and those that have a greater degree of hearing loss can significantly benefit from the use of HAT in their everyday life to increase their independence and quality of life (Kricos, 2007). In addition, HAT can be beneficial for people with or without hearing loss (Hartley, Rochtchina, Newall, Golding, & Mitchell, 2010; Meyer, Larrivee, Veneziano-Korzec, & Stacy, 2017). Although research has indicated that HAT can increase quality of life for people with hearing loss, patients frequently demonstrate reluctance to try them (Aberdeen & Fereiro, 2014; Jerger, Chmiel, Florin, Pirozzolo, & Wilson, 1996; Ross, 1997).

**Table 1. Examples of different HAT devices.**

| Alerting Devices | Personal Listening Devices | Telecommunication Devices |
|---|---|---|
| Amplified alarm clock | Personal FM system | Amplified cell phone |
| Vibrating alarm clock | Infrared TV system | Amplified cordless telephone |
| Amplified CO detector w/strobe | Personal loop system | Amplified answering machine |
| Cell phone ring alerter | Personal hard-wired systems | Inline telephone amplifier |
| Door knock alerter | | Portable telephone strap amplifier |
| Amplified smoke detector w/strobe | | Telephone ringer amplifier |
| Doorbell alert system | | Teletypewriter/TTY |
| Multi-alerting system | | Vibrating pager |
| Weather alert radio | | Video conferencing |
| Strobe light phone alerter | | Facsimile (FAX) machines |
| Amplified doorbell | | Captioned telephone |

**Use of HAT by Individuals with Hearing Loss**

Use of HAT is generally low among patients with hearing loss, for several possible reasons. For example, some patients may not perceive their hearing loss as poor enough to use HAT, while other patients experience disappointment with hearing aids due to high expectations and therefore they are less likely to try additional devices (see Jorgensen and Messersmith, 2015, for a review). Perhaps not surprisingly given the low-tech and low-cost nature of many HAT devices, few recent studies have assessed patients' familiarity and comfort using these devices. However, a few studies have investigated HAT use and interest, and have identified three major obstacles to use by patients with hearing loss: low familiarity, low perceived usefulness, and high perceived cost (e.g., Harkins & Tucker, 2007; Hartley et al., 2010; Kochkin, 2002; McCarthy, Culpepper, & Winstead, 1983; Southall, et al., 2006).

**Familiarity with HAT**

One barrier to use of HAT is low familiarity with device options among patients with hearing loss. McCarthy and colleagues (1983) surveyed 44 adults with hearing loss regarding their awareness and attitudes of HAT. Specifically, the survey addressed alarm clocks, light indicators, TV/radio amplifiers, TTY/TTD, telephone amplifiers, and closed-captioned television. Almost half of the participants reported that they had no experience with HAT (48%). The majority of participants were unfamiliar with all HAT except for telephone amplifiers (McCarthy et al.,1983). Despite major advances in technological sophistication of HAT options, more recent studies have found similarly low levels of familiarity with these devices (i.e., Aberdeen & Fereiro, 2014).

**Perceived Usefulness of HAT**

McCarthy and colleagues (1983) also found that nearly half (45%) of respondents felt that they could not benefit from the use of one or more HAT. Since that study, HAT technology has improved, and a wider variety of HAT is available commercially; however, the reported use of HAT remains low (Hartley et al., 2010; Kochkin, 2002; Ross, 1997; Southall et al., 2006; Tomita, Mann, & Welch, 2001). For example, Kochkin (2002) surveyed 3000 hearing aid users regarding their usage of HAT. About one-fourth of the participants used a phone amplifier and only 10% of participants used any other HAT. Tomita and colleagues (2001) surveyed individuals with hearing loss and reported only 5.3% of their participants used HAT. Hartley et al. (2010) surveyed 2956 adults age 49 and older and found that only 4.4% of those respondents had used HAT in the past twelve months and most of those HAT users only used one device, usually technology while listening to the television or listening on the telephone. Kochkin (2002) reported that approximately one-fourth of survey respondents with hearing loss used a device to amplify the telephone. Additional situations for which respondents reported using HAT were while watching television, at the movies, or at places of worship, though usage rates remained low in these situations.

Some factors related to perceived usefulness have been identified. Southall and colleagues (2006) reported that adults with hearing loss indicated they use HAT due to: a) a desire to continue social interaction with friends, b) pressure from family members, and c) government programs that assist with the cost of HAT. In the absence of these factors, HAT could be expected to be low. Other reasons patients report low usefulness of HAT include personal factors such reduced fine-motor control, reduced visual capacity, fear, lack of confidence, and perception of the physical appearance of HAT (related to perception of hearing loss as associated with age) (Southall et al., 2006). Hartley et al. (2010) reported that individuals who are more educated, had higher HHIE scores, and had greater degrees of hearing loss were more likely to use HAT, suggesting that perceived usefulness is tied at least in part to these factors.

Perceived usefulness is also related to recommendation by hearing healthcare professionals. Southall and colleagues (2006) found that participants who reported having a strong relationship with their hearing professional were more likely to perceive HAT as useful and be willing to try HAT devices compared to participants who had a weaker relationship with their hearing professional.

### Cost of HAT

Evidence from previous research suggests that low uptake may be attributed, in part, to low levels of consumer knowledge about HAT cost. McCarthy and colleagues (1983) found that less than one-third of the participants were aware of the "minimal cost" of the devices and almost half (47%) thought that HAT were costly and time-consuming. More recent studies have also reported that the perceived cost of HAT restricted consumers' acceptance and use of HAT (Harkins & Tucker, 2007; Southall et al., 2006). In addition, unless hearing healthcare providers indicate otherwise, patients may assume that HAT has a high cost similar to that of hearing aids, which is a known barrier to hearing aid uptake (i.e., Garstecki & Erler, 1998).

### Study Purpose

The preceding studies provided significant insight into individuals' knowledge about HAT and its perceived cost and benefit. These studies suggest that HAT is useful to people with hearing loss or perceived hearing handicap and, when used, can improve their quality of life. However, obstacles remain to adoption of HAT by most adults with hearing loss. Further research is warranted examining ownership rates, familiarity and perceived usefulness of HAT, and expected costs.

With these considerations in mind, the present study assessed a variety of factors related to a broad range of HAT devices in a population of patients seeking hearing healthcare at hospital/clinic locations in the United States. Outcomes assessed include a) ownership rates of HAT, b) familiarity with HAT, c) how useful participants considered HAT for themselves, d) how useful participants considered HAT would be for people with hearing loss in general (PWHL), e) the expected cost of HAT, and f) the cost people were willing to pay for HAT. Because this range of questions have not previously been included in a single questionnaire, all outcomes were considered equally important. In addition, the relationships among demographic variables and the above outcomes were assessed.

## Methods

### Questionnaire Development

A questionnaire addressing HAT ownership, familiarity, usefulness, and cost estimates was created. The first section of the questionnaire contained demographic questions, including age, gender, highest level of education completed, whether the participant used hearing aids, whether the participant had a landline phone, and whether the participant had a mobile phone. These questions included an option for participants to indicate they preferred not to answer Questionnaires were anonymous and data were not linked to patient records or any other identifiers.

The second section of the questionnaire consisted of a picture of twenty different HAT options selected from distributor websites (see Table 2 for a list of HAT devices assessed). Pictures were selected to provide a clear and representative image of each device. Each picture was accompanied by a generic name (i.e., "amplified alarm clock" or "door knock alerter") and a short description of the device's function, derived from manufacturer descriptions and distributor advertisements. Pictures of the devices on the questionnaire had the manufacturer and model information obscured.

Next to the picture of each device, the participants were provided with three visual analog scales to rate:

a) familiarity: 1 (not at all familiar) to 10 (very familiar);

b) usefulness of HAT to self:1 (not at all useful) to 10 (very useful); and

c) usefulness of HAT to people with hearing loss in general (PWHL): 1 (not at all useful) to 10 (very useful).

Participants were also asked to indicate in provided spaces (1) how much money they expected the item to cost and (2) how much money they would be willing to pay for the item. The purpose of these two questions was to compare these answers to the actual price of the item (not provided on the questionnaire). A sample page of the questionnaire is shown in Figure 1.

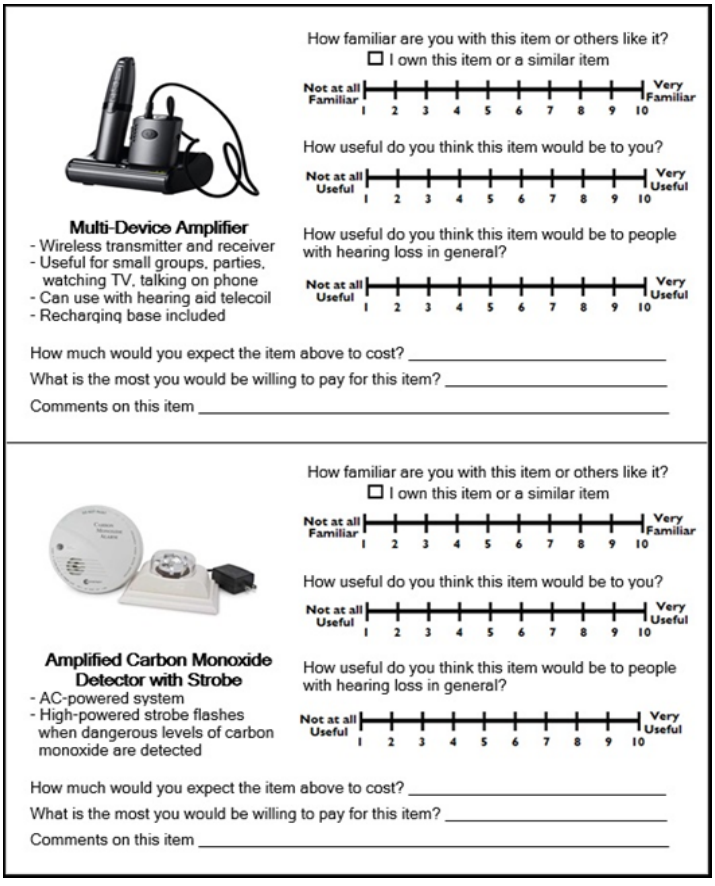


**Figure 1. A sample questionnaire page featuring two HAT devices**

### Participants and Procedure

Data were collected over a period of approximately six months from seven clinics and hospitals, located in or nearby the cities of the authors' universities, that agreed to administer the questionnaire. Approval from the respective universities' Institutional Review Boards was obtained prior to data collection. A letter describing the study from the researcher(s) in the area was included with each questionnaire. Potential participation was discussed with the patients at the time they made their appointment. Participants indicated consent by completing the survey anonymously. Participants were adults eighteen years or older who had a scheduled appointment with an audiologist to receive any hearing or hearing aid related services and who agreed to complete the questionnaire. The questionnaire was provided to the participants prior to or immediately following their scheduled appointment and participants filled out the questionnaire by themselves while in the office, so respondents were free to enter any values they chose without oversight. Because participants completed the questionnaires anonymously, their answers were not linked to any personal information such as hearing acuity. Questionnaires were collected from sites by the authors who entered into spreadsheets at each university before being compiled for analysis.

### Statistical Analysis

Data were analyzed via Statistical Packages for the Social Sciences (SPSS) version 20. Descriptive statistics (counts, mean, standard deviation, range, and interquartile range) were calculated for each response to each scale item and open-set question. Differences in scale responses (i.e., usefulness to self compared to usefulness to PWHL) were assessed using a Friedman's analysis of variance (ANOVA). Associations among responses and demographic variables were calculated using Pearson's product moment correlation coefficient ($r$). All significance tests were calculated at alpha = .05.

## Results

A total of 117 adults completed the questionnaire. Not all respondents answered every question and thus the percentages provided for each question are based on the number of respondents who answered the question.

### Demographics

The mean age of respondents was 61.1 years old (standard deviation [$SD$] = 18.2, range 20 to 93 years); 68 females (59.1%), 47 males, 2 preferring not to report gender. Of those who chose to report their education level (105 of 117), nearly all had at least a high school diploma (95.2%) and about half reported a college degree (bachelor's or higher) as the highest level of education. Educational level ranged from completion of eighth grade to completion of doctoral degrees. Almost one-fourth (23.9%) of respondents indicated they had worn hearing aids prior to completing the questionnaire. Most respondents indicated that they had a land-line phone (81.2%), used a mobile phone (87.2%), and had a television at home (99.1%). Mobile phone ownership was not significantly correlated with any other factor. Similarly, no association between landline phone ownership and any other demographic variable was observed. Television ownership was not analyzed as a predictor because nearly every respondent owned a television.

Some outcomes were predicted by demographic factors. Age was significantly negatively correlated with average device familiarity ($r$ = -.26, $p$ < .01), while ownership was significantly correlated with gender ($r$ = .25, $p$ < .01), indicating that men were more likely to own HAT than women. Level of education was significantly inversely correlated with ownership ($r$ = -.23, $p$ = .02) and perceived usefulness to self ($r$ = -.23, $p$ = .02). That is, more-educated respondents were less likely to own HAT and less likely to perceive HAT as useful to themselves. Hearing aid use was significantly positively correlated with HAT ownership ($r$ = .41, $p$ < .001), familiarity ($r$ = .20, $p$ = .03), and perceived usefulness to self ($r$ = .24, $p$ = .01), but negatively correlated with perceived usefulness to PWHL ($r$ = -.21, $p$ = .03). Landline phone ownership was significantly negatively correlated with expected cost of HAT ($r$ = -.26, $p$ < .01).

### Responses for Hearing Assistive Technologies

**Device ownership.** The majority of respondents (72.6%) reported not owning any of the items pictured on the questionnaire. Over 27% of respondents reported owning at least one of the twenty devices pictured. Specifically, 15.4% of respondents reported owning one device and the remaining 12.0% reported owning between three to eight devices. Ownership was very low for all devices individually, ranging from zero to 10.3% of respondents.

**Familiarity with devices.** On a ten-point scale, where ten indicated highest familiarity, means ranged from 1.2 ($SD$ = 1.0) for the multi-device amplifier to 4.2 ($SD$ = 3.4) for the amplified cordless phone. A significant positive correlation between ownership of devices and familiarity with devices was found ($R^2$ =0.676; $p$ < .001). Mean ratings for ownership and familiarity of all devices are shown in Table 2.

**Perceived usefulness to self and people with hearing loss.** On a ten-point scale, where ten indicated highest perceived usefulness, usefulness to self was rated from 2.3 ($SD$ = 2.6) for the teletypewriter/TTY to 5.0 ($SD$ = 3.8) for the amplified carbon dioxide detector with strobe. Ratings of perceived usefulness to PWHL ranged from 6.0 ($SD$ = 2.9) for the vibrating pager to 8.4 ($SD$ = 2.0) for the amplified smoke detector with strobe. On average across HAT devices, perceived usefulness to PWHL was rated 3.5 points higher than usefulness to self. A significant positive correlation between

perceived usefulness to self and usefulness to PWHL was found across all devices ($r$ = .36, $p$ < .001); paired correlations of usefulness to self and to PWHL within each device were also significantly positive (all $p$ < .05). A Friedman's test revealed that, for all devices, mean perceived usefulness to PWHL was significantly higher than mean perceived usefulness to self (all $p$ < .001, as determined by Tukey's tests), with rating differences ranging from 2.7 to 4.7 points. Mean ratings for all devices are shown in Table 3.

**Table 2. Mean and SD of familiarity rating for each HAT device (1 = not at all familiar, 10 = very familiar) and percentage of respondents reporting ownership of each device.**

| Device | Mean Familiarity (SD) | Device Ownership (%) |
|---|---|---|
| Amplified alarm clock | 2.2 (2.5) | 6.0 |
| Amplified answering machine | 2.7 (2.8) | 1.7 |
| Amplified CO detector w/strobe | 3.2 (3.2) | 5.1 |
| Amplified cell phone | 2.3 (2.5) | 1.7 |
| Amplified cordless telephone | 4.2 (3.4) | 10.3 |
| Amplified smoke detector w/strobe | 2.7 (2.9) | 2.6 |
| Cell phone ring alerter | 1.4 (1.4) | 0 |
| Door knock alerter | 1.5 (1.5) | 0 |
| Infrared TV system | 3.2 (3.1) | 7.7 |
| Inline telephone amplifier | 2.0 (2.1) | 3.4 |
| Multi-alerting system | 2.0 (2.3) | 2.6 |
| Multi-device amplifier | 1.2 (1.0) | 0.9 |
| Personal amplifier | 2.2 (2.4) | 2.6 |
| Personal FM system | 2.0 (2.2) | 0.9 |
| Phone and doorbell alert system | 2.3 (2.5) | 1.7 |
| Portable telephone strap amplifier | 1.5 (1.5) | 1.7 |
| Telephone ringing amp with flash | 2.6 (2.6) | 2.6 |
| Teletypewriter/TTY | 2.5 (2.5) | 0.9 |
| Vibrating pager | 1.5 (1.4) | 0 |
| Weather alert radio | 3.1 (3.0) | 6.0 |

**Table 3. Mean and SD of perceived usefulness for self and mean perceived usefulness to people with hearing loss for each HAT device (1 = not at all familiar, 10 = very familiar). Perceived usefulness to PWHL was significantly higher than perceived usefulness to self for all devices (all $p$ < .001).**

| Device | Mean Usefulness to Self (SD) | Mean Usefulness to PWHL (SD) |
|---|---|---|
| Amplified alarm clock | 3.0 (3.0) | 6.9 (2.8) |
| Amplified answering machine | 3.2 (3.0) | 7.0 (2.5) |
| Amplified CO detector w/strobe | 5.0 (3.8) | 8.0 (2.5) |
| Amplified cell phone | 4.0 (3.4) | 7.9 (2.3) |
| Amplified cordless telephone | 4.8 (3.4) | 8.1 (2.2) |
| Amplified smoke detector w/strobe | 4.7 (3.5) | 8.4 (2.0) |
| Cell phone ring alerter | 2.7 (2.7) | 6.4 (2.7) |
| Door knock alerter | 2.8 (2.9) | 6.8 (2.7) |
| Infrared TV system | 4.5 (3.4) | 7.8 (2.5) |
| Inline telephone amplifier | 3.6 (3.0) | 7.7 (2.3) |
| Multi-alerting system | 2.9 (3.0) | 7.5 (2.5) |
| Multi-device amplifier | 2.6 (2.6) | 6.3 (2.8) |
| Personal amplifier | 3.1 (2.8) | 6.8 (2.7) |
| Personal FM system | 2.8 (2.7) | 6.2 (2.8) |
| Phone and doorbell alert system | 3.1 (3.0) | 7.7 (2.4) |
| Portable telephone strap amplifier | 3.0 (2.8) | 6.9 (2.8) |
| Telephone ringing amp with flash | 3.0 (3.0) | 7.7 (2.4) |
| Teletypewriter/TTY | 2.3 (2.5) | 6.8 (3.0) |
| Vibrating pager | 2.7 (2.8) | 6.1 (2.9) |
| Weather alert radio | 4.4 (3.6) | 7.1 (2.8) |

**Device Cost.** Respondents were asked to how much they expected each item to cost and what is the most they would be willing to pay for each item. Recall that the actual cost of the devices was not provided in the questionnaire. Actual cost in each HAT category was estimated based on published prices from the same website as the images provided in the questionnaire (http://www.lssproducts.com) and were selected to represent a typical device in each category. To compare cost estimates and costs willing to pay for each HAT, cost indices were calculated in the following manner. Expected cost index was calculated as expected cost as a proportion of actual cost. An expected cost index of less than 1.0 suggests that the expected cost was below the actual cost; if it was above 1.0, the expected cost was higher than the actual cost. The willing-to-pay index was calculated as willing-to-pay cost as a proportion of actual cost. An index of less than 1.0 suggests that that the respondents were not willing to pay as much as the actual cost of the device, whereas an index of greater than 1.0 suggests that respondents were willing to pay more than the actual price. The expected and willing-to-pay costs as well as the actual cost of the device pictured in the questionnaire and a range of prices for similar devices is shown in Table 4.

Expected costs and willing-to-pay (WTP) cost were almost perfectly correlated across the devices as a group ($r$ = .98; $p$ < .001). On average, respondents were willing to pay about 80% of the expected cost of each item. For 13 of 20 devices, the actual cost was within the interquartile range (IQR; middle 50%) of expected cost estimates. For the remaining seven devices, actual cost was higher than the upper bound of the IQR; notably, this group of seven included the four devices with the highest actual cost and all seven were in the ten devices with highest actual costs. A similar pattern was seen for willing-to-pay cost. Actual cost was within the IQR of WTP cost estimates for nine of 20 devices; the remaining 11 included the ten devices with the highest actual cost (Table 4).

Expected cost index and willing-to-pay index values are shown in Table 5. Examination of these index values reveals that expected costs ranged from 48% of actual cost (infrared TV system) to 240% of actual cost (portable telephone strap amplifier). For twelve devices, the expected cost index value was 1.0 or greater, meaning that respondents expected those devices to cost more than they actually did. Index values varied inversely with actual cost, meaning that the cost of higher-price items was more likely to be underestimated and the cost of lower-price items was more likely to be overestimated.

Willing-to-pay index values showed a similar pattern. The cost respondents were willing to pay ranged from 29% (personal FM system) to 180% (amplified cordless telephone) of the actual device costs. For eight devices, the willing-to-pay cost index was 1.0 or greater, meaning that respondents were willing to pay more than the devices actually cost. Index values again varied inversely with actual cost, meaning that the proportion of actual cost that respondents were willing to pay was less for higher-priced devices than for lower-priced devices.

**Table 4. Mean, standard deviation (SD), and interquartile range (IQR) for expected costs and willing-to-pay (WTP) costs of HAT devices. Actual costs are based on published prices of pictured items at time study was conducted. All values are rounded to the nearest whole dollar.**

| Device | Expected Mean (SD) | Expected IQR | WTP Mean (SD) | WTP IQR | Actual Cost |
|---|---|---|---|---|---|
| Amplified alarm clock | $90 (99) | 35 - 100 | $54 (49) | 25 - 70 | $45 |
| Amplified answering machine | $82 (59) | 50 - 100 | $58 (47) | 30 - 75 | $100 |
| Amplified CO detector w/strobe | $93 (124) | 50 - 100 | $74 (119) | 36 - 84 | $45 |
| Amplified cell phone | $140 (126) | 70 - 200 | $110 (108) | 50 - 150 | $125 |
| Amplified cordless telephone | $109 (71) | 50 - 150 | $90 (57) | 50 - 140 | $50 |
| Amplified smoke detector w/strobe | $118 (238) | 36 - 100 | $81 (118) | 30 - 100 | $125 |
| Cell phone ring alerter | $56 (41) | 25 - 80 | $37 (33) | 10 - 50 | $55 |
| Door knock alerter | $45 (30) | 25 - 50 | $32 (24) | 15 - 50 | $30 |
| Infrared TV system | $121 (95) | 50 - 150 | $84 (64) | 40 - 100 | $250 |
| Inline telephone amplifier | $72 (91) | 30 - 96 | $57 (63) | 25 - 75 | $35 |
| Multi-alerting system | $127 (94) | 68 - 163 | $97 (125) | 40 - 120 | $175 |
| Multi-device amplifier | $175 (239) | 75 - 200 | $112 (145) | 40 - 150 | $175 |
| Personal amplifier | $98 (118) | 40 - 100 | $68 (72) | 25 - 100 | $130 |
| Personal FM system | $156 (358) | 50 - 150 | $79 (128) | 20 - 100 | $275 |
| Phone and doorbell alert system | $114 (128) | 50 - 120 | $86 (128) | 35 - 100 | $90 |
| Portable telephone strap amplifier | $72 (112) | 25 - 100 | $47 (63) | 20 - 50 | $30 |
| Telephone ringing amp with flash | $69 (57) | 30 - 100 | $50 (48) | 25 - 50 | $45 |
| Teletypewriter/TTY | $225 (248) | 100 - 300 | $127 (152) | 28 - 175 | $425 |
| Vibrating pager | $82 (80) | 35 - 100 | $49 (54) | 13 - 60 | $40 |
| Weather alert radio | $86 (60) | 40 - 100 | $61 (46) | 25 - 100 | $150 |

**Table 5. Expected cost and WTP cost indices, calculated from Table 3. Values greater than1.0 indicate higher mean expected/ WTP cost estimate than actual cost. Actual costs are based on published prices of pictured items at time study was conducted, rounded to the nearest whole dollar.**

| Device | Expected Cost Index | WTP Cost Index | Actual Cost |
|---|---|---|---|
| Amplified alarm clock | 2.00 | 1.20 | $45 |
| Amplified answering machine | 0.82 | 0.58 | $100 |
| Amplified CO detector w/strobe | 2.07 | 1.64 | $45 |
| Amplified cell phone | 1.12 | 0.88 | $125 |
| Amplified cordless telephone | 2.18 | 1.80 | $50 |
| Amplified smoke detector w/strobe | 0.94 | 0.65 | $125 |
| Cell phone ring alerter | 1.02 | 0.67 | $55 |
| Door knock alerter | 1.50 | 1.07 | $30 |
| Infrared TV system | 0.48 | 0.34 | $250 |
| Inline telephone amplifier | 2.06 | 1.68 | $35 |
| Multi-alerting system | 0.73 | 0.55 | $175 |
| Multi-device amplifier | 1.00 | 0.64 | $175 |
| Personal amplifier | 0.75 | 0.52 | $130 |
| Personal FM system | 0.57 | 0.29 | $275 |
| Phone and doorbell alert system | 1.27 | 0.96 | $90 |
| Portable telephone strap amplifier | 2.40 | 1.57 | $30 |
| Telephone ringing amp with flash | 1.53 | 1.11 | $45 |
| Teletypewriter/TTY | 0.53 | 0.30 | $425 |
| Vibrating pager | 2.05 | 1.23 | $40 |
| Weather alert radio | 0.57 | 0.41 | $150 |

## Discussion

Our study sample differs from previous research in that no other research has sought to determine the perspectives of persons in the U.S. seeking help for hearing difficulties on hearing assistive technologies (HAT). Previous data had been collected from samples of people in Australia (Hartley et al., 2010) or Canada (Southall et al., 2006), and included only participants with noted hearing loss, were current users of hearing aids, or were current users of HAT (Hartley et al., 2010, Kochkin, 2002; Southall et al., 2006; Tomita et al., 2001).

### Ownership of devices

Over 27% of respondents indicated that they owned at least one HAT device on the questionnaire. This percentage is much higher than that found in some previous research using people with reported hearing loss (Hartley et al., 2010; Tomita et al., 2001), and is more in line with the findings of reported hearing aid users (Kochkin, 2002). Our sample differed from these studies because not all of our respondents had a noted hearing loss or used hearing aids. One would think that our sample of those seeking audiology services might have a lower percentage of HAT ownership; however, this was not the case. One possible reason for our higher reported HAT ownership is that we provided pictures and descriptions of the devices in the questionnaire which may have reminded people of the devices they do own and which they may have not otherwise remembered using. In addition, Hartley et al. (2010) only asked participants about their HAT usage in the past 12 months whereas we asked about HAT ownership in general, which may help to explain the higher percentage of people reporting HAT ownership in our study.

The most commonly owned devices as reported by the respondents were the amplified cordless telephone (10.3%) and the infrared television listening system (7.7%). This finding was consistent with findings from previous studies. Hartley et al. (2010) found that those individuals who reported using HAT predominantly used technology while listening to the television and listening on the telephone. Similarly, Kochkin (2002) stated that approximately one-fourth of current hearing aid users surveyed had a device to amplify the telephone, followed by television HAT in terms of use.

Ownership of HAT significantly predicted familiarity and usefulness to self, but did not significantly predict usefulness to PWHL, expected cost or cost willing to pay. It is important to note that ownership of HAT in our sample was relatively small for group comparisons of owners vs. non-owners, so these results should be interpreted with caution.

### Familiarity with Devices

The mean familiarity ratings for all devices were all below a rating of five on a scale of one to ten. The HAT that respondents indicated being the most familiar with was the amplified cordless telephone (4.2/10). As previously mentioned, the amplified cordless phone was also one of the most commonly owned devices among respondents of this study. In general, familiarity and ownership were significantly positively correlated. In other words, one was more likely to be more familiar with HAT that one owned. The familiarity with amplified

phones also is consistent with McCarthy et al. (1983), who found that telephone amplifiers were the most familiar device to their respondents with hearing loss.

Familiarity with HAT significantly predicted perceived usefulness to self and perceived usefulness to PWHL. The more familiar the respondents were with HAT, the more likely they were to perceive HAT as useful to self and the more likely they were to perceive HAT as useful to PWHL with hearing loss. Familiarity with HAT did not significantly predict expected cost or cost willing to pay. Respondents familiar with HAT were neither better nor worse at estimating true costs of HAT. Familiarity also did not change the likelihood that a respondent would be willing to pay more (or less) than the true cost for HAT.

**Perceived Usefulness to Self and Usefulness to People with Hearing Loss**

Respondents indicated the amplified carbon monoxide detector with strobe was the most useful item to themselves, while the amplified smoke detector with strobe would be the most useful HAT to PWHL. Perceived usefulness to self was below 5.0 for all HAT except the amplified carbon dioxide detector with strobe. Perceived usefulness to PWHL for the 20 HAT devices ranged between 6.0 for the vibrating pager to 8.4 for the amplified smoke detector with strobe. On average, usefulness to PWHL was rated 3.5 points (out of ten) higher than usefulness to self. Hartley et al. (2010) indicated people who perceive a hearing handicap are more likely to use HAT. It is possible that our respondents did not perceive a hearing handicap or did not consider their hearing handicap to be as great as others with hearing loss in general. In Southall et al. (2006), respondents with hearing loss indicated they use HAT due to: a) a desire to continue social interaction with friends, b) pressure from family members, and c) government programs that assist with the cost of HAT. Recall that we did not collect information about participants' hearing acuity. A reasonable explanation as to why the HAT usefulness ratings would be judged higher for PWHL in comparison to self is that our respondents may or may not have had a hearing loss.

**Estimated Cost and Price Willing to Pay**

Expected cost index was significantly negatively correlated with actual cost. In other words, respondents were more likely to overestimate the cost of inexpensive HAT and underestimate the cost of more expensive HAT. The WTP index was also significantly negatively correlated with actual cost. Respondents were more likely to be willing to pay an equal to greater amount than the actual cost for more expensive items. McCarthy et al. (1983) also reported that their respondents were unaware of the minimal cost of some of the devices. Our respondents overestimated the cost of some of the less-expensive HAT.

**Demographic Predictors of Responses**

Some demographic variables did correlate with questionnaire response patterns. Younger respondents were more likely to be familiar with HAT devices, and men were more likely to own HAT devices. Individuals who had attained higher levels of education were less likely to own HAT devices and less likely to perceive them as useful to themselves (though not to PWHL). This last finding differed from previous research that found that people with higher levels of education were more likely to use HAT (e.g., Hartley et al., 2010). The reason for the difference in results of the two studies is unknown; however, it should be noted that our study population was relatively well educated. Of those who reported their educational level, over one-fourth of our participants had post-bachelor's education and over half were college graduates. Therefore, these results may have limited generalizability to the larger population.

Hearing aid users were more likely to own and be familiar with HAT. Hearing aid users were also more likely to perceive HAT as useful to self, but less likely to perceive HAT as useful to PWHL compared to non-hearing aid wearers. It is possible that, because the hearing aid users owned and were more familiar with HAT than non-users, they had more tempered expectations of what HAT can do (or how much HAT can help PWHL). Recall that only 23.9% of respondents indicated they wore hearing aids at the time of the survey.

One interesting finding was the negative association between landline phone use and cost estimates for HAT. Landline phone users were more likely to underestimate the cost of HAT devices compared to those respondents who did not own landline phones. It is possible that landline phone ownership in this sample was a proxy for adoption of new technology (or de-adoption of old technology) and thus this finding reflects lagging cost expectations in individuals who have been least willing to give up a landline.

**Associations among Response Factors**

**Ownership of HAT.** Ownership of HAT devices significantly predicted familiarity and perceived usefulness to self. That is, owners of HAT devices were more familiar with HAT and perceived HAT as more useful to themselves than non-owners. Ownership of HAT did not significantly predict usefulness to PWHL, expected cost of HAT, or willing-to-pay cost for HAT. Recall from our previous discussion that these group comparisons should be interpreted conservatively.

**Familiarity with HAT.** Familiarity with HAT significantly predicted perceived usefulness to self and perceived usefulness to PWHL. The more familiar a respondent was with HAT, the more likely he/she was to perceive HAT to be useful to self as well as to be useful to PWHL. Familiarity with HAT did not significantly predict expected cost of HAT or cost willing to pay for HAT.

**Perceived usefulness to self and to people with hearing loss.** Perceived usefulness of HAT to self significantly predicted perceived usefulness to PWHL. Respondents' perceived usefulness of HAT was lower for self than for PWHL; however, these ratings varied together closely. Perceived usefulness of HAT to self or to PWHL did not significantly predict expected cost or willing-to-pay cost.

**Cost Estimates**

Comparisons among expected costs, willing-to-pay costs, and actual costs of the 20 HAT devices evaluated in this study yielded some interesting results. First, both expected and willing-to-pay costs were highly variable (Table 3). For example, expected costs for the amplified smoke detector ranged from $10 to $1,000; expected costs for the TTY device ranged from $20 to $2,000. Willing-to-pay costs for the same devices were 0 to $1,000 each. The IQR values reported in Table 3 illustrate that, even within the middle 50% of cost estimates, the range was as high as $200. It seems likely that these widely-varying estimates are related to the low familiarity with HAT devices reported by respondents. Unfortunately, the low rates of ownership for each device preclude comparisons between owners and non-owners. Future studies might carry out such a comparison in samples constructed individuals who are more keenly aware of HAT.

The expected and willing-to-pay costs reported by respondents were strongly positive correlated, suggesting that willing-to-pay cost is influenced at least in part by perceived market price. Respondents tended to set willing-to-pay costs at about 80% of expected costs, though these values were highly variable across the sample.

Respondents were reasonably successful in estimating true costs of devices toward the low and middle sections of the price range of the 20 devices. The actual cost of 13 of 20 devices was within the IQR of expected costs. Devices whose true cost was outside of the IQR tended to be at the most expensive end of the price range of devices surveyed. Similarly, actual cost was within the IQR of willing-to-pay estimates for nine of 20 devices, where 10 of the 11 remaining devices were the most expensive devices surveyed.

Cost index estimates suggested that respondents were likely to overestimate the cost of inexpensive devices and underestimate the cost of expensive devices. Respondents were willing to pay true market price or more for several devices, including the amplified alarm clock, amplified carbon monoxide detector, amplified cordless telephone, door knock alerter, inline telephone amplifier, portable telephone strap amplifier, telephone ringing amplifier, and vibrating pager. The common threads among this group of devices are that they are generally low cost and that most are associated with telephone communication, which suggests that HAT acceptability may be higher for low-cost devices, and that telephone communication is prioritized by potential HAT consumers. The present study did not directly assess HAT preferences among respondents, and did not assess hearing status directly. However, previous studies have found that individuals with hearing loss prioritize telephone communication when seeking assistive devices (i.e., Hartley et al., 2010; Kochkin, 2002).

A limited number of studies have assessed WTP and other value/benefit aspects of hearing healthcare, most notably Palmer and colleagues (1995) and Newman and Sandridge (1997), who evaluated patients' valuation of hearing aid technology. It does not appear that such a study has been undertaken for HAT prior to the present investigation, however. One notable difference between the present investigation and the studies cited above is that those studies provided a range within which patients estimated value. For example, Palmer and colleagues (1995) provided a range of $0 to $700 within which patients were asked how much they would pay for hearing aids with different levels of sound quality. The present study requested cost estimates and WTP values with no boundaries, which explains the wide range of estimates. The finding that many patients greatly over- or under-estimated cost of HAT is consistent with studies that have found that consumers often perform poorly in estimating prices of goods in general (i.e., Dickson and Sawyer, 1990) and healthcare costs specifically (i.e., Greene et al., 2008).

## Limitations

This study had a few limitations worth noting. First, our population was patients being seen for any hearing or hearing aid related services and these patients completed the survey either prior to or immediately following their appointment. Therefore, no information on participants' hearing acuity were available. It is possible that some of the participants had little or no hearing loss and that some participants filling out the questionnaire following their appointment were influenced by the discussion with their audiologist. Second, our sample was also highly educated compared to the general population (about half had at least a college degree). Third, low HAT-ownership rates limited our ability to compare HAT users to non-users. Fourth, several studies have demonstrated that acceptability of HAT increases substantially following specific device training and familiarization, ideally in consultation with a healthcare provider (i.e., Aberdeen and Fereiro, 2014; Wittich, Southall, & Johnson, 2016). Because the present study did not include hands-on training with surveyed devices, responses may reflect lower perceived usefulness and, potentially, lower willing-to-pay measures than if specific devices had been demonstrated for respondents. Finally, it should be noted that there is no known validated questionnaire for this type of study. Like previous studies, our questionnaire itself was developed for this research project, meaning that all conclusions should be interpreted cautiously as our questionnaire also has not been validated.

## Conclusion

The present study utilized a questionnaire designed to measure HAT ownership, familiarity, perceived usefulness, and cost factors of a wide variety of devices. Among our sample of participants in the U.S. who were seeking hearing health care, 27.4% owned HAT. In addition, familiarity with HAT was relatively low. More HAT education and advocacy by audiologists and other hearing professionals is needed to educate the public about HAT and their potential benefits. Respondents perceived HAT as being much more useful to people with hearing loss in general than to themselves. Not surprisingly, the amount that respondents were willing to pay for more expensive HAT was generally less than the actual cost. However, responses suggest that patients may overestimate the cost for some basic HAT and be willing to purchase these devices for the actual cost. It is possible that these basic HAT could help patients recognize the benefit of HAT and be more willing to invest in other HAT. Further research might assess whether audiologists can influence patients' perceived usefulness of HAT with a hands-on demonstration, patient trial with HAT, or discussion of HAT costs and benefits. Further investigations that utilize the questionnaire developed for this study should be considered. Examples of such research include determining the test/retest reliability of the questionnaire, examining the effect of degree of hearing loss on responses, or comparing responses of patients in different stages of their audiology care.

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