HEARING AID TELECOILS: CURRENT NUMBERS IN THE U.S. MARKET

A Thesis

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ABSTRACT

The Americans with Disabilities Act (ADA) of 1990 requires all public facilities to provide assistive listening systems to allow communication access for patrons with hearing loss. To establish appropriate guidelines, the ADA used an advisory panel to make recommendations for the most effective means of increasing accessibility for patrons with hearing loss. Recommendations submitted by the advisory panel on assistive listening systems in 1999, indicated that of the three major assistive technologies—FM, infrared, and induction loop—induction loop systems were the least practical to choose. Induction loop systems are most effective when coupled directly to a personal hearing aid through the telecoil feature. The advisory committee reported that only "30% of modern hearing aids in the United States include a telecoil" and there was a "trend towards smaller and smaller hearing aids" that would not accommodate a telecoil. Personal communications with the researchers on the advisory panel revealed that these statements were not based on research data but were "educated guesses" based on annual hearing aid market reports published in trade journals. To obtain a more accurate estimate of the number of telecoils sold in the United States market, a survey was distributed to the top six hearing aid manufacturers requesting data on their sales of hearing aids with telecoils for the 2002 sales year. Data from the survey indicated that
48% of hearing aids sold in 2002 contained a telecoil. Sales trends for each hearing aid style were also analyzed through published market reports and indicated that smaller styles were gaining popularity, however, larger hearing aid styles still accounted for 65% of the market's sales.
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CHAPTER 1

INTRODUCTION

The Americans with Disabilities Act (ADA) of 1990 established the first comprehensive civil rights legislation for individuals with disabilities, including the disability of hearing impairment. The ADA regulations were derived from the Rehabilitation Act of 1973 that prohibited discrimination based on disability in federal agencies or institutions receiving federal funds (Williams & Carey, 1995). Today, the Americans with Disabilities Act includes Accessibility Guidelines for Buildings and Facilities (ADAAG), requiring all existing, newly constructed, and altered assembly facilities to provide assistive listening systems, either fixed or portable, to allow communication access for patrons with hearing loss (ADAAG, § 4.1.3). The guideline further states that a “portion” of the assistive listening devices must be hearing aid compatible (ADAAG, § A4.33.7).

In order to establish appropriate guidelines, the ADA uses an advisory panel to examine accessibility issues and to make recommendations from their findings ("How the Board Develops Guidelines and Standards", 2002; Appendix A). In 1999, the advisory committee outlined current assistive listening technology, discussed the pros and cons of each system, and made recommendations for assisting hard of hearing individuals. The final recommendations of that report indicated that of the three major
assistive technologies—FM, infrared, and induction loop—induction loop systems were the least practical for businesses to choose (Bakke, Levitt, Ross, & Erickson, 1999). This statement was made because induction loop systems are most useful when coupled to personal hearing aids using a special hearing aid feature, the hearing aid telecoil. The panel stated that only “30% of modern hearing aids in the United States include a telecoil” and with “the trend towards smaller and smaller hearing aids, it seems unlikely that this 30% figure will increase in the future” (Bakke et al., 1999, p. 7). These two factors—that only approximately one-third of hearing aids include telecoils and the trend toward smaller hearing aid styles—were used to make the argument that induction loop systems were the least practical means of accommodating patrons with hearing loss.

The major sources of hearing aid sales data for the United States are The Hearing Journal and Hearing Review, both of which report market trends annually. While both periodicals analyze sales of hearing aids based on style and signal processing strategies, they rarely assess additional hearing aid features such as directional microphones or telecoils. In light of this lack of definitive data, it is reasonable to ask how was the statement that “30% of modern hearing aids in the United States include a telecoil” determined?

Matthew Bakke, Ph.D., one of the researchers contributing to the ADA recommendations on large area assistive listening systems, was contacted to clarify how the advisory committee arrived at this figure. Bakke stated that Mark Ross, Ph.D., a colleague contributing to the recommendations, estimated the 30% figure based on the supposition that only behind-the-ear (BTE) and in-the-ear (ITE) styles would provide enough space for the telecoil (M. Bakke, personal communication, March 26, 2003). In a
later personal communications, Ross (personal communication, August 29, 2003) indicated that he examined published sales data for hearing aid styles. The 30% estimate is based on the fact that BTE hearing aids account for approximately 20% of the current market. Due to their large size, all BTE hearing aids are able to accommodate a telecoil and a telecoil is usually included as a standard feature. ITE hearing aids account for a much larger percentage of the current market, ranging from 40-50% (Kirkwood, *The Hearing Journal annual statistical reports 1994-2003*), however, Ross estimated that only a portion of ITE hearing aids would house a telecoil, accounting for the other 10% of compatible hearing aids.

Although the rationale behind the 30% value in the report is logical, no data were collected by Bakke or Ross to support their assumptions. Consequently, it is reasonable to question the accuracy of the statement that 39% of the hearing aids in the U.S. contain telecoils. Because ADA accessibility guidelines (and the potential expansion of the market for induction loop systems) are dependent on accurate data, further study on the number of telecoils included in hearing aids is warranted.

The current study was designed to collect data on the percentage of hearing aids that include the telecoil feature. Specifically, the goals of this study were to provide data, which would either support or refute the statements made in the Bakke et al. (1999) report by asking the following research questions:

- What percentage of hearing aids sold in the United States in 2002 contained a telecoil?
- Is there a trend toward smaller hearing aids styles that will not accommodate telecoils?
CHAPTER 2

REVIEW OF THE LITERATURE

2.1 Current Accessibility Guidelines

The regulations established by the Americans with Disabilities Act (ADA) include Accessibility Guidelines for Buildings and Facilities (ADAAG). These regulations require all existing, newly constructed, and altered assembly facilities to provide assistive listening systems, either fixed or portable, for use by their patrons with hearing loss. For assembly areas that accommodate at least 50 persons, the minimum number of assistive devices required is 4% of the seating capacity but no less than two devices. The regulations further state that a “portion” of these devices must be hearing aid compatible (ADAAG, § 4.1.3 and A4.33.7). The specific “portion” of compatible devices is not defined in the guidelines. Assistive listening systems are defined as devices “intended to augment standard public address and audio systems by providing signals which can be received directly by persons with special receivers or their own hearing aids” (ADAAG, § 4.33.7, p. 64). These assistive devices are necessary to overcome adverse listening situations that may not be remedied by traditional hearing aids.

2.2 Hearing Aids

A hearing aid is a “wearable sound-amplifying device that is intended to compensate for impaired hearing” (Williams & Carey, 1994). These devices consist
of a microphone, an amplifier, and a receiver that boost and shape the incoming signal to fit within the wearer's residual hearing range. The frequency response of a hearing aid typically extends between 200 Hz and 5000 Hz (Davidson, 1995). One difficulty with conventional omni-directional hearing aids is that they amplify all incoming sound within this range, including background noise. In order to better accommodate hearing aid wearers in noisy situations, additional hearing aid features have been developed.

Directional microphones are one option for overcoming adverse listening environments. Directional microphones allow for maximum amplification of sounds coming from directly in front of the listener and suppress sound arriving from other directions, i.e., from the sides or from behind. Directionality is created by varying the microphone's electrical output levels in proportion to the amplitude and direction of the sound source (Madafiuri & Stanley, 1996). This variation in microphone output can be created through numerous strategies such as using a single microphone with dual inlet ports to adaptive signal processing strategies in advanced digital hearing instruments.

Most often directional microphones are preferred in noisy environments because the signal of interest, the conversational partner, is usually in front of the listener where the microphone is most sensitive (Dillon, 2001). In order for directional microphones to be most beneficial, the signal of interest and the noise source must be separated in space.

The next innovation to be used to increase speech understanding in noise has been to develop digital signal processing (DSP) strategies. The processing strategies are designed to minimize noise through Wiener filtering, spectral subtraction, spectrum shaping, adaptive noise cancellation, and beam forming microphone arrays (Weiss & Neuman, 1993).
Wiener filtering, spectral subtraction and spectrum shaping are accomplished using single microphones. Wiener filtering adjusts gain depending on the signal-to-noise ratio (SNR) at each frequency. Mathematically, the gain at each frequency equals the signal power divided by the sum of the signal power and the noise power (Dillon, 2001). This strategy is difficult to accomplish because the signal and noise characteristics must be known and statistically stationary in order for the filter to be beneficial at overcoming noise (Weiss & Neumann, 1993). The other two single microphone strategies are very similar in their approach to noise reduction. Spectral subtraction and spectrum shaping estimate the noise amplitude and subtract the amplitude from the spectrum of the signal and noise combined (Weiss & Neumann, 1993).

Multiple microphone strategies include adaptive noise cancellation and beam forming microphone arrays. Adaptive noise cancellation reduces noise by creating a noise correlated to the input noise. The correlated noise is subtracted from the primary signal, reducing or “canceling” the original noise. This strategy has been shown to reduce noise by 18-60 dB (Weiss & Neumann, 1993). Beam forming microphone arrays employ 2 or more microphones whose outputs are summed then subtracted from one another in an attempt to cancel or reduce noise (Weiss & Neumann, 1993).

While these strategies are able to reduce noise in certain situations, they are not effective at completely reducing or overcoming noise, particularly in difficult listening environments. Unfortunately, unwanted background noise can arrive from all directions due to room reverberation and the possibility of multiple sources of noise. Although directional microphones are intended to be less sensitive to sounds arriving from behind or to the side of the listener, this approach fails to work when the noise is not localized in
space. Noise reduction processing strategies, while more sophisticated, can sometimes reduce gain in order to reduce noise. If the signal and the noise occur at the same time and frequency, they cannot be separated unless they are spectrally different (Lewis, 1995). In this situation, noise will not only be reduced but level of the intended signal, most often speech, will be reduced as well.

2.3 Assistive Listening Devices and Systems

In order to address the issues of decreased speech intelligibility caused by adverse listening environments, assistive listening devices and systems have been developed to be used by themselves or in conjunction with personal hearing aids. These devices are able to overcome reverberation, background noise, and distance from the intended signal through the use of remote microphones, signal transmitters, and specialized receivers. Currently three main technologies exist for assistive devices and systems: frequency modulation (FM), infrared (IR), and induction loop (IL).

Frequency modulation systems (FM) use radio waves to broadcast acoustic signals to the listener. Until 1982, the government restricted FM systems to classroom use only (Telecommunications for the Disabled Act of 1982; as cited in Davidson, 1995b). Now these systems are available for commercial and personal use. Currently 40 narrowband and 10 wideband channels are designated for FM assistive listening device use (Lewis, 1995). FM systems function by broadcasting signals over radio carrier frequencies that are decoded by specialized receivers. A remote microphone (placed on a table top, worn on a lapel or hanging around the neck) and transmitter send the desired signal over a specific radio carrier frequency. The receiver can be either a separate, body-worn unit used with earbuds or headphones or coupled to personal hearing aids.
through direct audio input (DAI), hardwire connections, or inductive coupling. The receiver may also be a small snap-on FM boot used with behind-the-ear (BTE) style hearing aids (e.g. MicroLink). FM systems are popular because they provide excellent sound quality, are highly versatile, can transmit a signal around obstacles, and can broadcast several hundred feet (Davidson, 1995b). The downside to these systems is that they are more expensive than other technologies and are susceptible to FM interference. The frequencies designated for assistive listening use are also reserved for emergency call box services, pagers, and cellular phones (Lewis, 1995). FM receivers respond to the strongest transmitted signal, which may not be the desired signal.

Infrared systems (IR) were first designed in Europe, where laws prohibited the use of FM systems. IR systems transmit acoustic signals via modulated light waves. The transmission process begins with an acoustic signal that frequency modulates a radio frequency sub-carrier that in turn amplitude modulates a 95 kHz light wave. The double modulated signal is then emitted by light emitting diodes to a photo detector diode present in the receiver. The receiver then demodulates the signal (Bakke, Levitt, Ross, & Erickson, 1999). The infrared receiver is typically used with headphones or can be coupled to a personal hearing aid using inductive coupling (Davidson, 1995). IR systems may be preferred over other technologies because they provide confidential transmission. The IR signals, as with other light waves, cannot penetrate walls or transmit around obstructions. The drawback to IR systems is that they are susceptible to interference from other infrared emitting sources such as fluorescent lights and cannot be used outdoors. In addition, the transmitter must have a direct line of sight with the receiver in order for the signal to be received by the listener (Davidson, 1995).
Induction loop (IL) systems are the oldest form of wireless technology, first created by British inventor Joseph Poliakoff in 1937 (Lederman & Hendricks, 2003). IL systems were popular in the United States for use in school classrooms until the 1960s. IL systems provided the simplest and most cost-effective hearing assistance until more advanced FM and infrared technology was developed (Lederman & Hendricks, 2003). IL systems operate on the principle of electromagnetic induction. In an IL system, an electrical current is amplified and passed through a loop of coiled wire placed around a designated listening area. The electric current flowing through the wire creates an electromagnetic field around the looped area that varies in proportion to the current flowing through the loop. When another coil of wire is placed near the electromagnetic field, an electrical current is "induced" in the coil of wire (Davidson, 1995b). In the case of IL systems, the induced coil of wire is a telecoil in the listener’s personal hearing aid. Induction loop systems have a distinct advantage over the other types of technology in that induction systems do not require any additional receivers; auditory signals can be sent directly to the hearing impaired person’s personal hearing aid if equipped with a telecoil. This results in less need for management of system components and an increase in acceptance and motivation for use. Fewer receivers and headsets would need to be provided and maintained by businesses and patrons would be spared the embarrassment of having to wear an additional headset and receiver (Ross, 2002).

Despite the relative advantage to induction loop technology, current opinion focuses on the unpredictability of signal integrity. Induction loop systems are susceptible to electrical interference and spillover from adjacent loop systems and other devices emitting electromagnetic signals. Fluorescent lights, power lines, and computer
monitors, if located near the IL area, can introduce an electrical buzz into the loop signal (Lederman & Hendricks, 2003). In addition, the strength of the IL magnetic field may vary with position inside the loop, resulting in null points or particularly noisy regions of interference (Gilmore, 1995).

2.4 Telecoils

Electromagnetic induction, the principle behind the induction loop assistive listening system, is accomplished by placing a coiled wire near an electromagnetic field. The electromagnetic field will induce a current in the coiled wire that varies in proportion to the current supplying the electromagnetic field. The hearing aid component that makes inductive coupling possible is the telecoil. Telecoil, which is short for “telephone induction coil” is a small coil of wire wrapped around a metal rod and placed within the hearing aid case along with the sound processing circuitry. When the hearing aid wearer is in the presence of an electromagnetic field, an electric current will be induced in the telecoil (Davidson, 1995b). The strength of the current varies with the number of coils of wire around the metal rod and the orientation of the telecoil in relation to the electromagnetic field (Gladstone, 1985).

The first documented induction coil appeared in the Multitone VPM hearing aid in 1938 (Lederman & Hendricks, 2003). Telecoils became a more popular feature of hearing aids in the late 1940s, following the discovery and useful application of stray magnetic signals emanating from telephone receivers (Yanz & Preves, 2003). When the telecoil is placed within an electromagnetic field generated by a telephone handset, an electric current (analogous to the electric signal delivered to the hearing aid receiver) is induced in the telecoil. The telecoil, then, replaces the hearing aid microphone as the
input transducer to the hearing aid. When used with a telephone, inductive coupling helps to overcome the effects of background noise and feedback that can be problematic with microphone inputs (Yanz & Preves, 2003). However, the telecoil must be sufficiently large and positioned appropriately in the hearing aid case to produce an optimal signal (Davidson, 1995a).

Recent research conducted on telecoils focuses on the output characteristics of standard and programmable coils and the preferences of hearing aid wearers using the method of inductive coupling with assistive devices (Gladstone, 1985; Hawkins & Schum, 1985; Rodriguez, Holmes, & Gerhardt, 1985; Davidson & Noe, 1994; Davidson & Noe, 1996; Noe, Davidson, & Mishler, 1997). The result of this research has shown telecoils to adversely affect the hearing aid's frequency-gain characteristics when activated, often diminishing the effectiveness of the telecoil and the assistive devices being coupled (Davidson & Noe, 1996). The negative impact revealed in such research has contributed to some disappointment and discouragement of telecoil use among audiologists and hearing professionals (Van Vliet, 2001). Newer telecoil technology is now being developed such as pre-amplified or programmable telecoils in order to address the research concerns. The addition of a pre-amplifier allows for increased gain from a standard telecoil when activated by the hearing aid switch. Programmable telecoils allow the dispenser to adjust the output characteristics of the telecoil independently from the primary microphone response or to designate a specific program/memory to specified telecoil response properties (Davidson & Noe, 1996).

In spite of the variable frequency and output responses of telecoils, they still have die-hard supporters of their use. In the July 2001 issue of The Hearing Journal,
columnist Dennis Van Vliet discussed the disappointment with telecoil performance and attempted to address why audiologists are less than enthusiastic about recommending them to patients (Van Vliet, 2001). The October 2001 issue featured a few of the letters sent in from readers with views both for and against Van Vliet's comments. Most comments suggested that audiologists and dispensers need more training on telecoil usage and how to effectively prescribe them for patients (“Letters to the Editor,” October 2001). The advocacy group Self Help for Hard of Hearing People (SHHH) is strongly in favor of the use of telecoils and for design improvement by manufacturers (“SHHH Position Statement,” 1996). Mark Ross, Ph.D., the provider of the 30% ADA statistic, is also a strong proponent of telecoils. Dr. Ross has written numerous articles addressing the need for increased awareness of the benefits of telecoils for coupling with assistive listening devices, the most recent being featured in the American Speech-Language-Hearing Association’s (ASHA) newsletter, *The ASHA Leader*, of May 25, 2004. Dr. Ross recommends the use of telecoils to increase the acceptance and usage of assistive devices to help hard-of-hearing individuals access more community services without “advertising” their hearing loss (Ross, 2004, p. 30).

2.5 Limited data

While the practical uses of telecoils are debated in research literature, the number of telecoils dispensed and in use is of particular interest as it may affect the Americans with Disabilities Act Accessibility Guidelines (ADAAG) for accommodating patrons with hearing loss in public places. In a personal communication with Matthew Bakke, Ph.D. (March 26, 2003), one of the contributors to the Access Board review of assistive listening systems, he stated that the reported 30% telecoil statistic included in the review
and recommendations was an "educated guess" based on the sales numbers for styles that would accommodate the addition of a telecoil, such as behind-the-ear (BTE) and in-the-ear styles (ITE). Dr. Bakke and his colleagues did not collect any data to determine the percentage that was reported. In addition, Dr. Bakke and his colleagues felt that the size of hearing aids was decreasing (i.e., moving towards smaller ITC and CIC styles) and that these smaller styles would not be large enough to accommodate a telecoil as an additional feature. Both suppositions were used to argue against the use of induction loop systems by businesses to comply with the ADA regulations. The advisory committee concluded that induction loop systems would not provide assistance to the majority of patrons that are hard-of-hearing.

Since the assistive listening system recommendations of Dr. Bakke and colleagues, limited data have been published discussing the number of telecoils that have been sold in the United States hearing aid market. A dispenser survey published in The Hearing Review, June 2003 issue, published data stating 44% of hearing aids being dispensed contained telecoils (Strom, 2003). The data for this survey was provided by 750 hearing care professionals selected at random from The Hearing Review's mailing list of current subscribers (Strom, 2003). The participants included dispensing audiologists, hearing instrument specialists, and medical doctors from 49 states, the District of Columbia, (D.C.), and Puerto Rico (Strom, 2003). This is the closest to an actual study of telecoil sales trends that has been published.

Data assessing hearing aid satisfaction with usage was collected in 2000 and included limited data on telecoils. The MarkeTrak V survey, in the January 2000 issue of The Hearing Journal, sought to assess consumer satisfaction with hearing aids based on
style of the hearing aid, special features, and performance in specific listening
environments (Kochkin, 2000). The survey determined that customer satisfaction was
significantly higher on eight attributes when the hearing instrument contained a telecoil
(Kochkin, 2000). Some of the attributes surveyed were use of hearing aids outdoors,
quality of life, whistling/feedback, telephone use, and recommendation of hearing aids to
others. Each of these attributes showed improvement with inclusion of a telecoil within
the hearing aid purchased (Kochkin, 2000).

Interest in the actual number of telecoil-equipped hearing aids has been sparked
recently by the initiative in Holland, Michigan to “loop America” (Myers, 2002).
Following a trip to the United Kingdom, David Myers, Ph.D., started the campaign to
introduce induction loop systems into all public buildings in his hometown. Induction
loop systems are extremely popular in Europe due to the fact that 65% of hearing aids
dispensed are behind-the-ear (BTE) styles in which telecoils are standard (“Sales expand
in Europe,” 2002). National public health care in the United Kingdom and Scandinavia
has made hearing aids more accessible and currently provides devices for 1.8 million
people in the United Kingdom alone (Telecomworldwire, 2003). Because of the
popularity of BTE hearing aids and the availability of the telecoil feature, induction loop
systems are mandated by the United Kingdom’s Disability Discrimination Act of 1995 to
be installed in all public buildings, the subway system, as well as private taxicabs
and the mandate of induction loop systems for public facilities have the telecoil well
established in the European market.
2.6 United States' Hearing Aid Sales Market

In October 2002, Carnegie Securities, a stockbroking, investment banking, and asset management company, published a hearing aid industry report. The Carnegie Securities report analyzed investment trends, areas of potential market growth, and current risks in the hearing aid industry, such as the threat of implantable hearing devices and advances in biotechnology (Clemens & Sorensen, 2002). Within this report, six companies were named as currently dominating the hearing aid sales market (listed alphabetically): GN ReSound, Oticon Inc. (William Demant Holding), Phonak, Siemens, Starkey Laboratories, and Widex. Market share for each company was provided and indicated that these 6 manufacturers contributed to 90% of the current market. This data is provided in an adapted format in Figure 1.

2.6.1 Siemens

Founded 125 years ago by Werner von Siemens, the Siemens Corporation not only represents hearing instruments but also is highly diversified to include electronics, real estate sales, personal finance, industrial automation, power generation, transportation, appliances, and computers (www.siemens.com, 2004, About us: Our businesses).

2.6.2 Oticon Inc.

Founded in Denmark in 1904 by Hans Demant, Oticon is driven by the desire to “help people live the life they want with the hearing they have” (www.oticon.com, 2003, About Oticon: Founded on care, ¶ 4). The long term mission of the company is “to become the United States market leader in high performance hearing solutions reflecting the most advanced technical designs, an understanding of human needs, and dedication to

2.6.3 GN ReSound

GN ReSound is one of two core businesses within the Great Nordic Group. The Great Nordic Group includes the Resound, Danavox, Beltone, Philips, and Vienatone hearing instrument brands. The company, also headquartered in Denmark, was founded in 1869 with the mission to provide high-tech hearing solutions for faster, more secure, and more comfortable communication (www.gnresound.com, 2004, GN Great Nordic Profile, ¶ 4). The Great Nordic Group currently distributes to 60 countries and has subsidiaries in nineteen of them (www.gnresound.com, 2004, GN Great Nordic Profile, ¶ 6).

2.6.4 Widex

Widex, also headquartered in Denmark, is a relative newcomer to the hearing aid market. Widex was founded in 1956 in Vaerloese, Denmark and currently promotes digital and programmable technologies. Widex is represented in 85 countries worldwide (www.widex.com, 2004, About Widex, ¶ 2).

2.6.5 Phonak

Founded in Switzerland in 1947, The Phonak Group represents two hearing instruments divisions, Phonak and Unitron Hearing. Phonak currently offers hearing instruments and FM assistive devices and is introducing the NemoTech/eShell earmold material. NemoTech is a new, biocompatible material mimicking the texture of human
skin. The material is more durable, with a more uniform shell thickness

2.6.6 Starkey Laboratories

Starkey Laboratories, the newest of the six manufacturers and the only company
founded in the United States, was created by the merger of Professional Hearing Aid
Service, an all-make hearing aid repair company, and Starkey Laboratories, an earmold
manufacturer (www.starkey.com, 2004, About Starkey, ¶ 1). Since the creation of
Starkey Laboratories in 1971, the company has been known for a number of industry
firsts. Starkey is recognized for introducing the no obligation trial period and warranty as
well as a battery recycling program. In 1983, Starkey Laboratories gained further fame
for fitting President Reagan with their CE-5 in-the-canal style hearing aids. In 1989
Starkey Laboratories diversified to include Omni Hearing Systems and Nu-Ear
Electronics.
Figure 1: Company market share for each of the top 6 hearing aid manufacturers. To maintain anonymity of study participants, manufacturer company names will not be associated with their respective market share. Each participant will be indicated with a capital letter. Adapted from Carnegie Securities Research, October 2002 Report (Clemens & Sorensen, 2002).
CHAPTER 3

METHODS

3.1 Study Design

The current study was designed to a) collect data on the percentage of hearing aids that include the telecoil feature, and b) to determine if, over the past ten years, there has been a trend toward smaller hearing aid styles that will not accommodate telecoils. The methods used to collect the data to answer these two questions are described below.

3.2 Determination of the Percentage of Hearing Aids that Include the Telecoil Feature

3.2.1 Selection of Participants

Six hearing aid manufacturers were contacted for participation in this study. Manufacturers were chosen based on company reputation and the need to represent a majority of the hearing aid sales market in order to ensure the most representative data. The participating companies were GN Resound, Oticon Inc., Phonak, Siemens, Starkey Laboratories, and Widex.

3.2.2 Procedures Used to Obtain Data.

Contact names for each company were obtained through personal communication with David Kirkwood, editor of The Hearing Journal (January 8, 2003) (Appendix B).
David Kirkwood was contacted based on his connection to the hearing aid market through *The Hearing Journal* and his access to the Hearing Industries Association (HIA) annual statistical reports. Market share for each company (Figure 1) was verified using the Carnegie Securities Research October 2002 hearing aid industry report, which confirmed that the 6 companies selected represented 90% of the hearing aid market within the United States (Clemens & Sorensen, 2002).

A cover letter and a one-page, 6-question survey (Appendix C) were mailed to the 6 hearing aid manufacturers. Each company's contact person was phoned prior to the mailing of the questionnaire in order to ensure their participation and cooperation with the study. The phone conversation verified the contact name, mailing address, and further clarified the basic purpose of the study. The cover letter requested completion of the survey and reiterated the nature of the study. All participants were guaranteed anonymity of data contributed to this study. The information requested in the survey was limited to percentages of total sales and percentage of sales by style. This information requested was limited in order to maintain the confidentiality of the participants and their businesses. Exact sales figures are not reported to the general public and are considered proprietary information.

3.2.3 *Data Analysis*

All 6 manufacturers agreed to participate in the survey and returned completed questionnaires. The data received were compiled and a weighted average of sales was calculated to determine telecoil representation in the overall market. Each company's percentage of total sales containing telecoils was multiplied by the company's
respective market share. All six companies' figures were then added together to achieve
the average total sale (Appendix D). For example:

\[ \sum_{i=1}^{6} P_i M_i \]

\( P \) = telecoils as a percentage of total sales by manufacturer
\( M \) = market share for the manufacturer

This average represents 90% of the hearing aid sales market. In order to estimate
100% of the sales market, the same formula was used with the exception that the
remaining 10% market share was included in the calculation. The sales contribution of
the remaining 10% was assumed to match the previously calculated market average. It is
unlikely that the remaining 10% market share would not contribute hearing aids equipped
with telecoils to the current market, especially if the remaining companies sell behind-
the-ear (BTE) or in-the-ear (ITE) styles.

3.3 Sales of Hearing Aids by Style

3.3.1 Procedures Used to Obtain Data

Trends in hearing aids styles for the past 10 years were determined through
compilation and analysis of annual reports published by The Hearing Journal. The
annual articles report on data collected by The Hearing Industries Association (HIA).
Each article includes a breakdown of sales by product type, reporting the percentage of
the market each style represents. To maintain consistency across sales years, data was
divided into four major style categories: behind-the-ear, in-the-ear, in-the-canal, and
completely-in-the-canal styles. These style labels were determined to be the most
uniform across sales years and the most concise categories to report. In some instances,
two or more hearing aid types listed in a sales year (half-shell, full-shell, and low profiles) had to be combined in order to place data into the appropriate category.
CHAPTER 4

RESULTS

4.1 Research Questions

The present study was designed to answer the following two questions: a) what percentage of hearing aids sold in the United States in 2002 contained a telecoil? and b) is there a trend toward smaller hearing aids styles that will not accommodate telecoils? The results obtained for each question will be described separately below.

4.2 The Percentage of Hearing Aids that Include the Telecoil Feature

Responses were received from all six manufacturers. Figure 2 shows the percentage of hearing aids that include telecoils for each manufacturer. This is the overall percentage reported across all hearing aid styles. As can be seen, the percentages are quite different across manufacturers, ranging from 78% of hearing aids sold for Company A to 29% of hearing aids sold for Company E. Of the six manufacturers, three companies reported that more than half of their hearing aids were sold with telecoils. The other three companies reported that about one-third of their hearing aids were sold with telecoils.

Figure 3 shows the percentage of hearing aids sold with telecoils for each manufacturer as a function of hearing aid style (BTE hearing aids are represented by the solid black bar, ITE hearing aids, including low profile hearing aids and half shells, are
represented by the solid gray bar, and ITC hearing aids are represented by the unfilled/white bar). As expected, the vast majority of BTE hearing aids are sold with telecoils (80% to 100% across manufacturers). Five of the six companies surveyed also include telecoils in their canal and mini canal styles, ranging from 2-16% of ITC sales.

To obtain an estimate of the percentage of hearing aids with telecoils sold in the current market, a weighted average, incorporating company market share and percentage of total sales that include telecoils, was calculated (Calculation 1; Appendix D). The estimate was calculated by taking the sum of each company’s market share multiplied by their report of the percentage of total hearing aid sales featuring telecoils. This showed that, for the manufacturers surveyed, the percentage of hearing aids sold with telecoils is 44%. This statistic represents sales figures for the 90% of the U.S. hearing aid sales market that was included in the survey. This percentage does not account for telecoils that may be included in the 10% of the market that was not included in the survey. To better estimate telecoil representation in the total hearing aid market (100% of hearing aids sold) an additional calculation was made. Because the percentage of telecoils in the remaining 10% of the U.S. market is unknown, a reasonable estimate for that percentage is 44% (the percentage known to be true for 90% of the market). When the calculation is repeated (Calculation 2; Appendix D) it indicates that 48% of hearing aids sold in the U.S. contain telecoils.

4.3 Sales of Hearing Aids by Style

Figure 4 shows the sales trends for the past 10 years for each hearing aid style. Data were compiled from annual The Hearing Journal market reports. Data were not published for the 1998 and 1999 sales years. Data for the 1999 sales year were obtained

The overall trend is one of relative market stability. In-the-ear (ITE) hearing aids consistently held the largest market share with completely-in-the canal (CIC) style hearing aids representing the smallest market share. While CIC hearing aids do show a slight increase in sales from 1992 to 2000, they have been consistent since then, accounting for a relatively small (14%) percentage of the market. Both BTE and ITC sales have remained flat, or slightly increasing, at approximately 20% of the market, over the past 10 years. The ITE sales have shown the largest change over the past 10 years, decreasing by more than 10%. ITE sales have been replaced by a combination of BTE, ITC, and CIC hearing aids.
Figure 2: The percentage of hearing aids (all styles) that include telecoils for each of the six manufacturers surveyed. Market share for each company indicated in parentheses.
Figure 3: The percentage of each hearing aid style that includes telecoils for each of the six manufacturers surveyed. The black bars represent BTE hearing aids, the grey bars represent ITE hearing aids, and the white bars represent ITC hearing aids.
Figure 4: Ten year sales trends by hearing aid style. Behind-the-ear (BTE) hearing aids are represented by the squares, in-the-ear (ITE) hearing aids (including full shell and low profile styles) are represented by the triangles, in-the-canal (ITC) hearing aids (including the mini canal style) are represented by the circles, and completely-in-the-canal (CIC) hearing aids are represented by the diamonds. See text for details.
CHAPTER 5

DISCUSSION

5.1 Goals of the Study

The primary purpose of the study was to determine an accurate estimate of the percentage of hearing aids sold with telecoils in the United States. A secondary goal of the study was to assess sales trends by hearing aid styles to determine if smaller style hearing aids were dominating the market. These two issues were the primary arguments against the use of induction loop assistive listening systems stated by Bakke et al. (1999), in their report to the ADA Access Board regarding accommodations for the hard of hearing. Low telecoil sales and smaller hearing aid styles that would not accommodate the telecoil feature were offered as drawbacks to the use of induction loop systems.

5.2 Overall Telecoil Sales

The results from this study showed that 48% of the hearing aids sold in the United States contain telecoils. This data is in agreement with data reported in The Hearing Review’s dispenser survey of 2003. In The Hearing Review’s survey, dispensing audiologists reported that they prescribed telecoils in 44% of their hearing aid fittings (Strom, 2003). The fact that both manufacturers and dispensers are independently reporting similar figures lends validity to the data. Both reports indicate that telecoils are
more popular than the 30% figure proposed by Dr. Bakke and his advisory committee (Bakke et. al., 1999).

5.3 Sales of Hearing Aids by Style

An analysis of published sales trends has shown hearing aid styles to remain somewhat stable over the last ten years. Throughout the 1980s, hearing aid technology was rapidly moving towards smaller styles due to advancement in miniaturization of electronic circuitry. However, this trend has slowed through the 1990s. Published sales data from 1992 to the present (Figure 4) have primarily shown a decrease in the number of ITE hearing aids in favor of a combination of CIC, ITC, and BTE hearing aids. CIC hearing aids gained in popularity in the 1990s, but appear to have stabilized at about 14% of the market. This data, compiled from The Hearing Journal sources, agrees with data recently published by The Hearing Review. A survey of hearing instrument dispensers published by The Hearing Review in 2004 also reported data showing similar trends over the last 10 years (Strom, 2004).

Hearing aid sales by style of instrument have remained relatively consistent in contrast to the prediction that smaller styles (ITC and CIC hearing aids) would quickly begin to dominate the market. In the last year for which data are available (2003), CIC and ITC styles made up approximately 35% of the market. The remaining 65% of the market continues to be made up of larger styles that can easily incorporate telecoils. Even if the trend towards decreasing ITE hearing aids continues, five of the six surveyed companies also include telecoils in their canal and mini canal styles, despite the size constraints of the custom hearing aid shell.
5.4 Limitations of the Study

Although the results of this study have now established a better estimate of the percentage of hearing aids with telecoils in the United States, an obvious limitation of the study is that data were only collected for one sales year. Data reported in this study represent the year from January 2002 through December 2002. In order to ensure participation in this study, only a small set of data was requested from each company. Actual company sales numbers (rather than percentages) were not requested because they are not released to the general public. Sales percentages for more than one year were not requested in order to ensure maximum participation from manufacturers surveyed; it was hoped that making the survey less onerous would encourage participation. Due to the limited data collected, this survey may not be representative of the percentage of telecoils that are currently being worn, as these hearing aids would have been fit over several years. As previously stated, telecoils have been a feature of hearing aids for over 50 years and are likely to have been a feature of hearing aids sold in the last 5 to 10 years. However, the analysis of hearing aid style trends over the last 10 years and the present manufacturer survey data would suggest that the current estimate of 48% telecoil representation is likely to be reasonable for previous years sales as well and may well represent the percentage of telecoils actually worn.

A second limitation of the study is that data were only collected on 90% of the market. Given this limitation, boundaries on the actual number can be created. Ten-percent of the market is still unaccounted for by this study. The initial 44% figure obtained (Calculation 1; Appendix D) assumes that the 10% of the hearing aid market that was not surveyed did not contribute to telecoil sales (i.e., 0% of the remaining
hearing aids incorporated telecoils). This percentage (44%) serves as the lower boundary on sales. If, on the other hand, we assume that the remaining 10% of the market all included telecoils (Calculation 3; Appendix D), the upper boundary on sales would be 54%. As stated in Chapter 4, it is probably most reasonable to project the true figure as 48%, which was calculated assuming the remaining 10% of manufacturers contribute 44% of their total hearing aids sales to instruments with telecoils. In addition, advances in telecoil technology such as automatic, pre-amplified, and programmable telecoils may contribute to an increase in telecoil sales in the future. However, of the manufacturers surveyed, only one indicated that they expected their telecoil sales to increase in the coming years due to advances in automatic telecoil technology.

Another potential limitation to consider is the issue of telecoil usage. The hearing aid may be equipped with the feature, yet we do not know how many telecoils are actually used by the wearer. Some patients may find that using the telecoil is troublesome because of having to change programs, flip switches, or because their hearing loss is not sufficiently severe to cause difficulty conversing on the phone. Other hearing aid wearers simply may not have been told that the feature was available in their hearing aid. Additionally, recent research into telecoil performance has created negative attitudes towards their usefulness. As reviewed in Chapter 2, studies have shown that telecoils reduce gain and frequency response when activated unless the hearing aid contains a telecoil preamplifier. Even when placed in a larger hearing aid style, in the most sensitive position, the average output of a telecoil is still nearly 7 dB less sensitive than the manufacturer's reported specifications (Gladstone, 1985). ANSI standards permit only a 6 dB difference (Gladstone, 1985). Because of this significant difference,
patients may experience decreased word intelligibility during inductive coupling (Rodriguez, Holmes, & Gerhardt, 1985, Noe et al., 1997).

5.5 ADA Reaction

The data obtained from this study was presented to the ADA Access Board on March 29, 2004 at a meeting between Marsha Mazz (the technical assistance coordinator), her colleagues, and me. Individuals on the Access Board, while receptive to the data collected, reported that they would not be able to incorporate it into any current legislation. The latest revisions to the ADA Accessibility Guidelines were ready for publication and were not subject to further revisions at the time of our visit. In addition, the percentage of telecoils obtained by the survey was not, in their estimation, different enough to change the current recommendation that a “portion” of assistive devices must be compatible with hearing aids (ADAAG, § 4.1.3). The ADA Access Board members did acknowledge that the higher telecoil estimate made induction loop systems a more viable option for businesses complying with their regulations.
BIBLIOGRAPHY


APPENDIX A

HOW THE BOARD DEVELOPS

GUIDELINES AND STANDARDS
How the Board Develops Guidelines and Standards

The Board develops guidelines and standards under a process common to most Federal regulations. Since this process involves various steps outside the Board’s control, it is often difficult to specify with any certainty the likely publication date for upcoming proposed or final rules. Here’s a rundown of the steps involved and where various rules are in the process so you can get a rough idea of what might be published when. This is the typical process the Board follows in developing rules.

1. Create an advisory committee to develop recommendations on the requirements of a rule.

2. Develop proposed rule based on committee recommendations, add preamble (discussion), figures, and commentary and prepare regulatory assessment.

3. Submit rule and assessment to the Office of Management and Budget (OMB) for clearance; OMB has 90 days to complete its review.

4. Publish proposed rule in the Federal Register for public comment; the comment period usually lasts 30 – 120 days starting from publication. Public hearings may be held during this period.

5. Review comments and make changes to the rule as necessary.

6. Resubmit rule to OMB along with final regulatory assessment; OMB has 90 days to complete its review.

7. Publish final rule in the Federal Register.

Under the ADA, the Board’s final rules serve as the basis for enforceable standards issued by the departments of Justice and Transportation, which follow a similar rulemaking process. Sometimes, the Board’s rulemaking is done jointly with the departments. It is the standards, not the Board’s guidelines, that are used to enforce the ADA’s design requirements. Guidelines issued last year for State and local government facilities and for building elements designed for children’s use are not yet part of the Department of Justice’s ADA standards.
APPENDIX B

CONTACT NAMES/QUESTIONNAIRE RECIPIENTS
Contact Names/Questionnaire Recipients

Giselle Matsui, Director of Product Management
GN ReSound
1-800-248-4327
gmatsui@gnresound.com

Preben Brunved
Oticon Inc.
29 Schoolhouse Rd.
Somerset, NJ 08873
1-800-526-3921
pbb@oticonus.com

Stephanie Monsees, Product Manager
Phonak
1-800-777-7333
Stephanie.mONSEes@phonak.com

Thomas A. Powers, Director of Audiology
Siemens Hearing Instruments
10 Constitution Ave.
Piscataway, NJ 08854
1-732-562-6637
tpowers@siemens.com

Gary Anderson, Director of Customer Service
Starkey Laboratories
6700 Washington Ave. S
Eden Prairie, MN 55344
1-800-328-8602
gary_anderson@starkey.com

Francis Kuk, Director of Audiology
Widex Hearing Aid Company
2300 Caot Drive, Suite 415
Lisle, IL 60532
1-800-221-0188
fkuk@aol.com
APPENDIX C

COVER LETTER AND QUESTIONNAIRE
Contact Name
Company
Street
City, State Zip

Date

Dear ,

Thank you for your interest in my research survey. As I mentioned in our phone conversation, the goal of my research is to determine the percentage of hearing aids sold in the US market that contain a telecoil. An accurate estimate of the percentage of hearing aids with telecoils is needed so that reasonable recommendations can be made regarding the style and quantity of assistive devices available to patrons of public buildings and businesses. Accurate estimates of the number of hearing aids with telecoils will ultimately result in improved accessibility for individuals with hearing loss because regulations regarding the style and number of devices will take into account the percentage of individuals who can couple the devices to their personal hearing instruments. Accurate estimates may also allow businesses to provide assistive devices more cost effectively because listeners with telecoils will not need an additional receiver as a means of coupling to the assistive listening system.

Enclosed is the questionnaire. Please return the survey in the accompanying stamped envelope. If you need to contact me, I am reachable via e-mail or phone listed below. Thank you very much for your participation.

Best regards,

Rebecca Blaha
614-296-7155
blaha.15@osu.edu
Research Questionnaire

1. Of the total number of hearing aids sold by your company last year, what percentage contained telecoils? _________

2. Please indicate the 12 month period over which these data were obtained (for example, Jan 1, 2002 – Dec 31, 2002). _________

For each major hearing aid style, please indicate the percentage that contain a telecoil (for example 100% of BTEs, 80% of ITEs, etc.)

BTE (includes mini-BTEs) _________

ITE (includes full shell, half shell, and low profiles) _________

ITC (includes canal and mini canal styles) _________

Other (please specify) _________

Do you expect these numbers to change over the next year? If so, why?

5. Does your company manufacture its own telecoils or do you purchase them as a separate component?

6. Are telecoils built into your custom products whether or not the feature is ordered (i.e. is a telecoil in place even if the consumer does not have access to it via a switch)?

NOTE: This information is for research purposes only and any information that you submit will be kept confidential. Please provide contact information for the purpose of clarification of questionnaire answers only.

Company ______________________

Name/Title ______________________

Contact e-mail or phone __________
Calculations

Formula:

\[ \sum_{i=1}^{6} P_i M_i \]

- \( P = \) telecoils as a percentage of total sales by manufacturer
- \( M = \) market share for the manufacturer

Calculation 1: Covers 90% of the U.S. Market; Includes only manufacturers surveyed.


Calculation 2: Covers 100% of the U.S. Market by assuming that 44% of the remaining 10% of hearing aids include a telecoil.


Calculation 3: Covers 100% of the U.S. Market by assuming that 100% of the remaining 10% of hearing aids include a telecoil.

APPENDIX E

HEARING AID STYLE DATA FOR 1999 SALES YEAR
From: David H. Kirkwood <daviddkirkwood@rcn.com>
Sent: Tuesday, May 4, 2004 1:12 PM
To: Rebecca Ilaha <holycow1147@hotmail.com>
Subject: Re: Market research in 1999

Rebecca:

I found the HIA statistics from 1999. As I understand it, you want to know the number and percentage of hearing aid style sold in the U.S. Here is that information for 1999:

CIC hearing aids: 193,800 (12.2% of all 1,591,250 hearing aids sold in 1999)
In-the-canal aids: 384,554 (25.9% of total)
ITE hearing aids: 919,634 (65.7% of total)
BTE hearing aids: 371,045 (19.6% of total)
Eyeglass/baby aids: 2217 (0.1% of total)

Please let me know if you need anything further.

David

on 4/28/04 12:39 PM, Rebecca Ilaha at holycow1147@hotmail.com wrote:

Mr. Kirkwood,

I spoke with my advisor and we would like the style data if you still have it. I am trying to verify that there hasn’t been a significant trend towards smaller styles in the last 10 years. I would appreciate any information you can provide.

Thank you for all of your help,

Rebecca Ilaha

> From: "David H. Kirkwood" <daviddkirkwood@rcn.com>
> To: Rebecca Ilaha <holycow1147@hotmail.com>
> Subject: Re: Market research in 1999
> Date: Thu, 23 Apr 2004 09:13:03 -0400
> 
> Dear Rebecca:
> 
> I don’t remember now why I did not include the breakdown by hearing aid style in my 2000 cover story, but it was probably because I devoted so much space to marketing issues. As you have probably noticed, ever since the CIC style hit its zenith, there has been relatively little change from year to year in the relative popularity of styles. BTEs continue to gain a little market share, but nothing dramatic has happened.
> 
> I know that HIA collected the statistics for 1999 on the percentage of
> Instruments sold in each state, though I don’t know if I still have the data around. How significant are the 1999 data for your study? I suspect that if you look at the figures for 1998 and 2000 that they will be pretty similar to each other and to 1999. If you really need the data, let me know and I may be able to come up with them.

> David

> on 4/22/04 7:31 AM, Rebecca Blaha at holycow1147@hotmail.com wrote:

> > Mr. Kirkwood,

> > Sorry for not being specific enough in my last email. I was referring to the reporting of sales by hearing aid style. In other years you reported the percentage of BTEs, ITEs, etc. In 1999 this data was not included with the other overall trends. I was curious as to why this was omitted in this particular year. The topic of my thesis is to confirm or revise the current ADA stat referring to 30% of US hearing aids containing telecoils or being large enough to accommodate the feature. They are using the 30% to advocate against the use of induction loop systems for ADA accessibility. It will be graduating with my MA in audiology this summer, so the race is on to write this thesis! I appreciate all of your help.

> > Best regards,

> > Rebecca Blaha

> > >From: “David H. Kirkwood” <davidkirkwood@iron.com>
> > >To: Rebecca Blaha <holycow1147@hotmail.com>
> > >Subject: Re: Market research in 1999
> > >Date: Tue, 13 Apr 2004 17:46:25 -0400
> > >
> > >Hi, Rebecca

> > > The January 2000 story did report on 1999 sales, and January 1999’s cover story was about 1998. If you are missing one of those issues, please let me know what specific information you need. Also, remind me, what is the topic of your thesis and what is your field – audiology or business?

> > > David

> > > on 4/13/04 4:54 PM, Rebecca Blaha at holycow1147@hotmail.com wrote:

> > > >

> > > > Mr. Kirkwood,

> > > > This is Rebecca Blaha again. You have been very helpful to me in my thesis research but I have another question. I am reviewing past issues of the Hearing Journal, looking at your market research. I have data from 1992 to the present except for 1999. Did you conduct a report for this year in another month’s issue or did you not research this particular year? I couldn’t locate the traditional January issue with the cover story on sales trends in 1999. Any information would be helpful.

> > > >

> > > > Best regards,

> > > > Rebecca Blaha

> > > The Ohio State University