Wireless Telephones and Hearing Aids: 
An Overview

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Abstract
Wireless telephones are becoming increasingly common and will be more so in the future. Unfortunately, many are unusable with hearing aids and may actively interfere with the normal use of hearing aids because of the electromagnetic interference (EMI) generated by wireless telephones. The EMI generated by digital wireless telephones is much greater than that of analog wireless telephones. More research and design work needs to be done before wireless telephones can be considered accessible to people who use hearing aids.

Key Words: Hearing aid, telecoil

Abbreviations: CDMA = code division multiple access, EMI = electromagnetic interference, FCC = Federal Communications Commission, GSM = Global System for Mobile Communications, PCS = personal communication service, SHHH = Self Help for Hard of Hearing People, TDMA = time division multiple access

More than 100 million people in this country now use a wireless telephone, and all of the evidence suggests that this number will increase substantially in the years to come. Wireless telephones are extremely popular since they can be used almost anywhere—in a restaurant, on a train, or while walking on the street or on a beach. More and more people, in all kinds of situations, are using wireless telephones. It is quite a common occurrence to sit next to someone on a train or bus who is talking to someone else miles away. Like it or not, it is becoming increasingly apparent that life in the 21st century will require wireless telephone communication as a prerequisite for normal social and vocational functioning. Further, digital wireless communication systems are rapidly replacing analog wireless systems because of the enormous capabilities of digital systems.

Much more is involved in this brave new world of wireless communication than voice transmission. In addition to providing voice communication, modern handheld communication devices can serve as an all-in-one office, combining a personal organizer, scheduler, spreadsheet, and word processor and operating as a high-speed data terminal with access to electronic mail and, eventually, to almost any database in the world. Furthermore, these devices can also function as a personal pager and include such routine wireline operations as access to voice mail, caller ID, call forwarding, and call waiting. It may not be too long before handheld communication devices will be able to transmit and receive visual images or even function as a global positioning system. Mobile devices providing some of these functions already exist. In fact, the industry has come up with a new term to describe the multiplicity of operations of these new units; they are no longer just “telephones” but personal communication services (PCS) or devices. Ultimately, people will probably be assigned a single personal identification number that they can use to make and receive calls and conduct business from anywhere in the world.

The efficient operation of these new devices requires that the signals, including voice signals, be encoded digitally. This digital encoding and decoding of the information transmitted via PCS devices permit a much more efficient use of the radio spectrum than an analog system. Through various time- or code-sharing techniques, the same radio frequency used digitally can carry up to six or eight messages simultaneously, whereas an analog system can convey only one. The
economic implications of this one attribute alone are enormous, not to mention the fact that many of the operations of PCS devices would simply not be possible without digital encoding. So what is the problem?

The problem is that many people who wear hearing aids will hear a loud buzzing sound when they attempt to use these telephones. This interference will occur whether they use the microphone or telecoil input to the hearing aid. The buzzing noise may be so loud as to make it impossible to comprehend speech through the wireless telephone.

Interference from wireless telephones can be subdivided into two basic types: user and bystander interference. User interference refers to the interference generated in a hearing aid when someone nearby is using a digital wireless telephone. This problem could occur in trains, buses, cars, restaurants, offices, etc. Of the two types of interference, user interference is much more severe than bystander interference and is the primary problem that needs to be addressed.

The interference is produced by the nature of the digital encoding and radio transmission. There are two basic types of digital encoding used in wireless telephony. One type is termed time division multiple access (TDMA). This type of radio transmission requires that the carrier be turned on and off many times per second. The most common TDMA systems interrupt the transmission either at 50 or 217 times per second. The frequency of this interruption rate, which is in the audio frequency range, is demodulated by hearing aids and produces an audible interference with a periodicity (heard as a buzz) equal to the rate of interruption and a very large number of harmonics covering the entire audio frequency range.

The TDMA principle operates by dividing the available telephone channels in the radio frequency spectrum into recurring groups of nonoverlapping time slots, with each slot carrying a portion of one of six simultaneous conversations. These conversations take turns accessing all of the available information in the spectrum but for only one-sixth of the time. As a consequence, each radio frequency channel can carry six times as many telephone conversations as a conventional analog telephone channel.

Another method of coding is known as code division multiple access (CDMA). This method of coding uses what is termed “spread-spectrum” techniques, in which the bandwidth occupied by the carrier signal is much wider than the bandwidth of the information signal being transmitted. For example, a 3-kHz voice bandwidth would be spread over 1 MHz or more of the radio frequency spectrum. The 3-kHz voice signal, however, occupies only a small number of time frequency slots within the much broader bandwidth of the carrier signal. The remaining time frequency slots are filled by other 3-kHz voice signals. The CDMA system thus allows for multiple conversations to share the available spectrum in both time and frequency. Each voice signal is distinguished by the transmitter employing a unique spreading code, one that is also known by the receiver that decodes the signal appropriately for each telephone channel. Since there is no periodic interruption of the carrier wave, the nature of the electromagnetic interference (EMI) is different from that of TDMA. The interference produced by CDMA does not have a strong periodic component but it does have a broad frequency spectrum. The amount of EMI also depends on how busy the network is. The busier the network is (i.e., the greater the number of simultaneous telephone conversations), the greater the interference is. It is thus very difficult to compare CDMA interference with TDMA interference. Under certain conditions, CDMA interference will be less, but under other conditions, it may exceed TDMA interference.

In the history of events, consumers were first alerted to the problem of EMI in hearing aids by the purveyors of a CDMA system since this form of coding produces less EMI (under certain conditions) than TDMA systems. This group took the lead in forming a coalition, termed “Hear-It Now,” with a membership that included Self Help for Hard of Hearing People (SHHH) and the Alexander Graham Bell Association for the Deaf and Hard of Hearing. The consumer groups were and are “technology neutral.” They did not, and do not, favor one technology over another. All they want is equal access to telephone communication no matter what technology is being employed.

Unlike other countries in which Global System for Mobile Communications (GSM) telephones had been deployed, consumer groups in the United States were quite active in expressing their fears about the potential impact of this technology. Their very vocal concerns soon reached the Federal Communications Commission (FCC) via a petition. Then-Chairman Reed Hundt personally met with consumer representatives, and in a June 1995 address, he reaffirmed the FCC’s commitment to the inclusion
of people with hearing losses (and other disabilities) in the telecommunication revolution that was taking place. As a matter of policy, he pointed out that the FCC did not favor one technology over another, and he did not want to see the introduction of new systems delayed. He felt that having the various systems meet in open competition in the marketplace would ultimately best serve the interests of the entire public. At the same time, he stressed that the various groups involved urgently needed to meet and determine whether they could come up with a solution to the EMI problems faced by hearing aid users (Hundt, 1995).

The result of this call for a cooperative effort was the “summit” meeting in January 1996 in Washington, DC. This meeting brought together representatives from the FCC, Food and Drug Administration, telecommunications industry, hearing aid industry, and consumer organizations. This was a historic occasion. It was the first time that all of the various interests involved were brought together to focus on a common mission: ensuring communication accessibility for people with hearing loss. Various working groups were formed to conduct research and address specific problem areas. In a very important sense, it was this proactive stance taken by the FCC that was responsible for the progress that has been made, and will continue to be made, on this issue.

What makes this current situation particularly ironic is that just when all conventional telephones are required to be hearing aid compatible, the rules of the game have changed. It seems that we have to start all over again, but with a much more severe problem.

We knew about the phenomenon of EMI in hearing aids long before digital wireless technologies were introduced in the United States. Digital wireless telephones were being used in Europe and were adopted in other countries such as Australia, India, and Thailand before they made their way here. The operating system they employed is termed GSM and it is the standard for European digital wireless systems. GSM employs the TDMA method of coding.

After the system was deployed in Europe, researchers discovered that GSM devices created an electromagnetic disturbance that not only produced interference in hearing aids but could also affect other electronic devices such as cash registers, electronic weighing machines, car electronics, and gasoline pump meters. There have even been reports that cardiac pacemakers could be affected.

There were no villains in this process; we all operate with different agendas, and no one was maliciously trying to deny telephone access to people wearing hearing aids. The telephone industry did not intend that the new generation of digital wireless telephones would be inaccessible to people wearing hearing aids, and the hearing aid companies had no idea that they had to build EMI immunity in their hearing aids. Although there were no villains, there were a few heroes; special tribute should be paid to Brenda Battat of SHHH and Donna Sorkin (formerly with SHHH but now with the Alexander Graham Bell Association for the Deaf and Hard of Hearing) for the diligence, intelligence, and tenacity with which they pursued this issue. Without their efforts, it is doubtful that we would be as far along as we are. At bottom, consumer concerns have driven the process to where we are now.

It was clear from the beginning of the summit process that the interference problem would require that both the wireless telephone industry and the hearing aid industry address possible solutions. On the one hand, the wireless industry would have to find ways to reduce or shield the radiated signal from digital wireless telephones and make the telephones more hearing aid compatible. On the other hand, the hearing aid industry would have to determine the exact locations within the various types of hearing aids that were most sensitive to EMI and work on ways to increase their immunity, either through shielding, circuit modifications, or both.

Concurrent with this effort, one of the objectives of the research programs at the University of Oklahoma, Etymotic Research, Inc., and Rehabilitation Engineering Research Centers at Gallaudet University and the Lexington Center for the Deaf is to determine an “acceptable” level of interference. This would be the highest level of interference that permits adequate telephone communication for people wearing some kind of listening device. Based on the results of the above-mentioned research, an American National Standard is being prepared that would allow for the pairing of wireless telephones and hearing aids so as not to exceed the acceptable level of interference (American National Standards Institute, 2001). For example, wireless telephones that generate a high level of EMI should be paired with hearing aids that are the most immune to EMI, whereas hearing aids that are the most susceptible to EMI can be paired with wireless telephones that produce little EMI (see Berger, 2001).
“Universal design” is an approach whose goal is to make products of all types usable by the widest possible audience. Often, a design intended for a particular population is useful to all. For example, curb ramps, initially meant to ensure wheelchair access, were found to be useful for people with strollers, bicyclists, etc. Another example is the vibrating pagers initially designed for people with hearing losses that are now found to be useful and desirable for the general population. An analogous condition for wireless telephones would be where the reduction of EMI emissions would also be advantageous for normal-hearing people.

Ensuring that hearing-impaired people are able to effectively communicate by means of wireless digital telephones is going to be one of the major audiologic challenges of the future. Although currently there are analog wireless telephones that are hearing aid compatible and other wireless telephones that can provide optional analog or digital encoding, it is probable that this option, for economic reasons, will soon be phased out. Considering the rapidity with which wireless digital telephones are being deployed, hearing aid dispensers should currently be evaluating how to match a newly dispensed hearing aid with a modern digital wireless telephone.

Less than 10 years ago, the Hearing Aid Compatibility Act of 1988 mandated that virtually all telephones manufactured or imported in the United States be hearing aid compatible. Although there were some exemptions, it seems clear that the intent of the law was to ensure that hearing-impaired people would be able to communicate effectively through a telephone. In 1990, another law was passed: the Americans with Disabilities Act. Among other requirements, this law emphasizes the need to ensure communication access for people with hearing losses. Now we have the Telecommunications Act of 1996, which, in the proposed implementing guidelines, states that “new products shall not cause interference to hearing technologies (including hearing aids, cochlear implants, and assistive listening devices) of the user or bystanders.” There are qualifying statements included here and there in these laws, such as “readily achievable” or “without undue burden,” but overall is not the intent of Congress pretty clear? Is it not apparent that these laws are intended to express a societal value that full communication access is a right that all of our citizens should enjoy?

Still, laws and intentions do not solve technical problems. That is up to the scientists and engineers and to the organizations they represent. The articles in this issue represent the first attempts at education on this issue of wireless telephones and hearing aids. Moreover, it is clear that the education we will be getting is the current state of the art. These conference papers bring together all of the major interests involved in this issue, from the academic researchers to hearing aid and telephone industry representatives, the government agencies involved, and the clinicians and the consumers.

The bottom line has to be full communication access for people with hearing loss, comparable to what we have now with wireline phones. Conceptually and technologically, our society has come a long way in the past 10 to 20 years. The concept that people with disabilities should be part of the mainstream, insofar as this is possible, is an accepted cultural value. So would it not be a rather perverse consequence of telecommunication developments if these served to further isolate, rather than admit, hard-of-hearing people from full participation in our society?

Acknowledgment. This work was supported by grant # H133E30015 from the National Institute on Disability and Rehabilitation Research. The opinions expressed here are those of the author and not the NIDRR.

REFERENCES

