A Multimedia Hearing Loss Prevention Program for Older Adults: Theoretical Basis and Development

Gabrielle H. Saunders and Susan Griest
National Center for Rehabilitative Auditory Research, Portland VA Medical Center
Oregon Health and Science University

Noise damages the auditory system and hearing, which in turn impacts communication, quality of life, interpersonal relationships, and more. There are few educational programs regarding prevention of noise induced hearing loss (NIHL) outside of the workplace, even though exposure to damaging levels of noise is prevalent through recreational and leisure activities. In this paper, we describe the theoretical basis for, and the content of, a multimedia Hearing Loss Prevention Program (HLPP) for older adults. The program is computer-based, standalone, and self-administered. It was developed using the constructs of the Health Belief Model (HBM) of Rosenstock.

Noise induced hearing loss (NIHL). There are many mechanisms by which the auditory system can be damaged by noise. The extent of the damage is dependent on the intensity of the noise (dBA), the temporal characteristics of the noise (steady state, impulse), the spectral characteristics of the noise (frequency content), and the duration of exposure (time-weighted average). Additionally, there are data regarding variations in individual susceptibility to noise damage resulting from both exogenous factors, and endogenous factors such as exposure to toluene (Fechter, 2004) and cigarette smoke (Mizoue, Miyamoto, & Shimizu,

Gabrielle H. Saunders and Susan Griest, National Center for Rehabilitative Auditory Research, Portland VA Medical Center and Department of Otolaryngology, Oregon Health and Science University.

Correspondence concerning this article should be addressed to Gabrielle H. Saunders, National Center for Rehabilitative Auditory Research, Portland VA Medical Center, 3710 SW U.S. Veterans Hospital Road, Portland, Oregon 97239. Phone: (503) 220-8262, ext. 56210. E-mail: gabrielle.saunders@va.gov

2003). The most common and insidious cause of NIHL is long-term exposure to steady state noise at levels greater than 85 dBA. Sounds greater than 85 dBA cause damage via mechanisms that are complex and not entirely understood. At least three mechanisms exist. First, noise causes mechanical destruction of the membranes of the hair cells and supporting structures of the Organ of Corti (e.g., Hawkins, Johnsson, Stebbins, Moody, & Coombs, 1976; Hunter-Duvar & Bredberg, 1974). Second, noise decreases blood flow to the inner ear causing cell damage (Axelsson, Vertes, & Miller, 1981; Santi & Duvall, 1978). Third, noise exposure results in increased metabolic activity which in turn causes production of free radicals, reduces cochlear blood flow, and causes neural swelling and necrotic and apoptotic cell death in the Organ of Corti (Henderson, Bielefeld, Harris, & Hu, 2006). For an in depth description of these mechanisms see LePrell, Yamashita, Minami, Yamasoba, and Miller (2007). Typically, NIHL is first evidenced by a temporary threshold shift, that is, an increase in thresholds at some frequencies during and immediately following exposure that disappears about 12 to 24 hr after the noise has terminated (Melnick, 1977; Mills, Gengel, Watson, & Miller, 1970). If exposure duration and/or noise level increases, permanent threshold shifts occur resulting in hearing loss between 3 and 6 kHz, with a notch somewhere around 4 or 6 kHz.

The damage caused to the cochlea by noise may not be immediately evident. That is, thresholds may not be permanently elevated, even though damage has occurred. This is evidenced by the fact that ears with past noise exposure, and thus likely cochlear damage, show greater effects of auditory aging than non-exposed ears (Gates, Schmid, Kujawa, Nam, & D'Agostino, 2000; Kujawa & Liberman, 2006). In other words, the effect of noise exposure is cumulative. Therefore, it is important that older individuals, such as veterans who have been exposed to noise during military service, or retirees who worked in noisy industries, be educated about this and about the need to protect their ears from further damage since they are especially susceptible to NIHL and tinnitus.

Noise exposure in the workplace is the most common cause of NIHL, probably because a noisy workplace results in workers being exposed on a regular basis for many hours each day, and also possibly because employees tolerate more noise in the workplace than they would elsewhere, due to the threat of unemployment (Mathur & Roland, 2007). Approximately 30 million workers are exposed to hazardous noise at work, costing the national workforce an estimated $242.4 million in disability payments (National Institute of Occupational Safety and Health [NIOSH], 2001). Berger, Neitzel, and Kladden (2006) have developed a database of levels of occupational noise. Some industries are particularly problematic, for instance, construction workers are exposed to jack hammers at 109 dBA and bulldozers at 105 dBA. In the logging industry, tree felling equipment averages 98 dBA and chain saws average 110 dBA. Underground mining equipment generates continuous noise levels of 99 to 108 dBA, while farm equipment exposes workers to levels of 103 dBA from tractors, and between 88-101 dBA from grain dryers. Other less obviously noisy occupations include police who are exposed to sirens that have been measured to be 97 dBA inside the vehicle, and night club disc-jockeys exposed to average levels of 103 dBA.

The Occupational Safety and Health Administration (OSHA; Occupational Noise Exposure, 1983) developed standards for workplace noise monitoring, audiometric testing, provision of hearing protection, training, and recordkeeping that apply to individuals in all American production industries, with the exception of those in the oil and gas drilling services, in construction, and in agriculture. However, there are many other common sources of noise to which people are exposed for long periods of time, that do not come under OSHA regulations and which often exceed safe levels. For example, Axelsson and Clark (1995) measured the Leq from a recorder located on the right shoulder of a spectator and found levels of 99.5 dBA for the 3.5 hr duration at a hockey game, and of 96.9 dBA for Game 6 of the U.S. World Series in 1987. Similarly, noise at rock and pop concerts has been shown to average 95 dBA with a range of 73 to 109.4 dBA (Mercier, Luy, & Hohmann, 2003), while personal listening devices such as iPods can reach outputs of 91 dBA to 121 dBA at maximum settings (Fligor & Cox, 2004; Portnuff & Fligor, 2006). Classical musicians are also often exposed to noise levels of greater than 85 dBA for long periods of time resulting in a high prevalence of tinnitus, and temporary threshold shifts (Laitinen, 2005). Noise levels under motorcycle helmets have been measured on the open road at between 78-90 dBA at 30 mph, to 114-116 dBA at 120 mph (Lower, Hurst, Claughton, & Thomas, 1994; McCombe, 2003), depending upon the specific motorcycle and helmet used. A recent survey of noise levels on the New York City transit system revealed maximum levels of 106, 112, and 89 dBA on subway platforms, inside subway cars, and at bus stops respectively (Gershon, Neitzel, Barrera, & Akram, 2006). Military personnel are another group exposed to dangerously loud noise. Chinook and Black Hawk helicopters register 102.5 and 106 dB respectively in the cockpit, noise levels inside an Abrams tank and in armored personnel carriers averaged 114 dBA when traveling at 30 mph and 117 dBA at 40 mph (Army Hearing Program, 2007; Berger et al., 2006).

There is an alarming lack of knowledge among the general population about the impacts of recreational noise exposure. In a study by Crandell, Mills, and Gauthier (2004), 200 adults completed a 17-item questionnaire assessing the knowledge, habits, attitudes, and perception of NIHL and use of hearing protection. In response to the question, “Can hearing loss caused by noise be cured?” 17% reported they thought it could be cured by medication, 10% by bed rest, and 4.5% by a doctor. Similarly, only 42% of respondents answered “yes” to the statement “Listening to my favorite music at very loud levels is potentially harmful to my hearing,” while as many as 34% of respondents said they would not know where to purchase hearing protection devices (HPDs).

Even when individuals are aware of the damage noise can do to the auditory system, few individuals use hearing protection. For instance, Ologe, Akande, and Olajide (2005) found that 93% of workers knew about the hazards of noise on hearing and knew of methods of protection and yet only 27% possessed hearing protectors, and of these, only 28% wore them all the time. In the study of Crandell et al. (2004) described above, 72% of respondents said they never wore hearing protection when exposed to loud sounds even though 85% were aware that noise can damage hearing. Similarly, Bogach, House, and Kudla (2005) examined the perceptions of rock concert goers to NIHL and its prevention. Two hundred four concert goers completed a survey prior to entering a concert venue. Fifty-four percent of these individuals said they attended at least four rock concerts each year and 48.5% said they preferred to stand/sit in the loudest areas of the venue. Eighty percent of respondents said they never wore hearing protection at concerts, even though 34.3% thought it was somewhat likely, and 39.8% thought it was very likely, that the level of the music at concerts would damage their hearing. Clearly, education of the public about the hazards of exposure to loud noise is necessary.

Impacts of hearing impairment. Hearing loss impairs communication, and it is consequently associated with functional disability leading to depression, social isolation, anxiety, paranoia, and poor self-esteem (Appollonio, Carabellese, Frattola, & Trabucchi, 1996; Carabellese et al., 1993; Kochkin & Rogin, 2000; Mulrow et al., 1990). Even marginal hearing loss is known to negatively affect a person's sense of independence and well-being (Scherer & Frisina, 1998). Hearing loss has also been shown to affect both partners in intimate relationships, causing feelings of frustration, anger, and antagonism between partners (Hétu, Jones, & Getty, 1993), reduced communication (Hallberg, 1996), as well as poorer social and psychological well-being on the part of the unimpaired partner (Wallhagen, Strawbridge, Shema, & Kaplan, 2004). In the workplace, hearing impaired individuals report feelings of panic, embarrassment, and incompetence (Erdman, Crowley, & Gillespie, 1984) and fear for their future employability (Morata et al., 2005). Untreated hearing impairment has also been shown to be associated with a decline in cognitive function (Cacciatore et al., 1999), health-related quality of life, and functional capacity to conduct tasks of everyday living (Dalton et al., 2003). Thus, there is a very real need to educate the public about the reality of NIHL and its psychological and social implications.

Hearing conservation programs. As noted above, OSHA has had regulations for hearing conservation in the workplace since 1983 that consist of published standards for workplace noise monitoring, audiometric testing, provision of hearing protection, training, and recordkeeping (Occupational Noise Exposure, 1983). Despite this, adherence to these guidelines is poor. For example, Daniell et al. (2006) conducted a workplace assessment of 10 foundries in Washington State. They took 7-hr duration noise measures at each site, and interviewed management and employees about noise monitoring, the availability and use of HPDs and informational materials, training on hearing conservation practices, and audiometry practices. They found that noise levels routinely exceeded 85 dBA and often were in the 90-95 dBA range. None of the 10 companies had made any effort to decrease noise levels, nor did they have plans to do so in the future. Management did not have copies of OSHA regulations for hearing conservation, nor had any of the interviewed individuals ever read them. Further, although HPDs were available to workers, little training on use and fitting was provided, 3 companies never provided annual training or audiometric testing, and training at the other 7 companies was limited to the presentation of an interactive video presented in English only. Moreover, employees whose audiogram showed a significant threshold shift were never informed of it. Reilly, Rosenman, and Kalinowski (1998) reported equally disturbing findings from a Michigan state-based surveillance program for occupational NIHL. They interviewed 1,378 individuals with NIHL about the hearing conservation practices at their workplaces. If an interview revealed no baseline or regular hearing tests at a company, state inspection was recommended. Interviews determined that 46% of the 1,378 individuals were not provided with regular hearing testing and follow-up revealed that of the 43 companies inspected, 23 had noise levels above the Michigan state OSHA regulations, and of these, 17 had no hearing conservation program, or a deficient one.

Outside of the workplace, hearing conservation programs are even more lacking. Folmer, Griest, and Martin (2002) conducted a review of hearing conservation programs in schools and found that despite recommendations from experts over many years (e.g., National Institutes of Health, 1992; Niskar et al., 2002; Roeser, 1980), “basic hearing conservation information that could prevent countless cases of NIHL remains absent from most school curricula” (p. 51). They also report that even though 29 organizations produce and disseminate hearing conservation curricula and materials targeted at school-aged children, few schools use them.

Studies examining the effectiveness of hearing conservation programs are limited, but tend to show positive findings such as increased knowledge about hearing health, and increased current and intended use of HPDs (e.g., Ewigman, Kivlahan, Hosokawa, & Horman, 1990; Knobloch & Broste, 1998; Lee-Feldstein, 1993). More specifically, Lee-Feldstein (1993) compared the thresholds of employees who worked in five noisy locations within a large automobile fabrication plant, with the thresholds of group of controls group who were not exposed to occupational noise. The noise-exposed workers all participated in a hearing conservation program. At a 5-year follow up it was found that, once the effects of presbycusis had been adjusted for, the thresholds of four of the five groups of noise-exposed employees had deteriorated to the same extent as those of the control group. The group of noise-exposed employees that worked in the noisiest location, the foundry, had thresholds that had deteriorated more than those of employees in the other groups. This is presumably because even a short exposure to the noise levels in this location caused damage. Ewigman et al. (1990) found that regular use of HPDs increased from 20% to 85% among a group of firefighters who were provided with an educational program about NIHL. Knobloch and Broste (1998) showed intended use of HPDs was greater (81%) for a group of students working in agriculture that participated in a hearing conservation program than among a control group who did not participate in the program (43%). Kerr and Hong (2008) conducted studies that show booster interventions, such as follow-up fliers mailed to participants, can be effective at maintaining HPD use. On the other hand, Lusk, Eakin, Kazanis, and McCullagh (2004) failed to show beneficial effects of a booster.

Theoretical basis of preventive health behaviors. The program we have developed aims to educate individuals about hearing loss and noise damage with the goal of changing knowledge, attitudes, and intended behaviors towards use of hearing protection in occupational and recreational settings. The target audience is veterans and other older individuals who may not be aware of hearing conservation and who do not necessarily realize the impact that recreational and leisure noise can have upon hearing ability, tinnitus, and the resultant quality of life. In particular, we want to inform users of the cumulative nature of noise damage. We chose to focus on an older population, specifically, a veteran population. We are interested in this population because veterans have almost certainly been exposed to noise during their military service, both in combat situations and when working in environments such as shipbuilding yards and aircraft maintenance. While all branches of the military have well-established effective hearing conservation programs, noise levels during combat are especially hazardous and are difficult to control because they can be unpredictable, and because military personnel have concerns that HPDs will jeopardize their safety by distorting localization cues and by attenuating important cues from other sources. Evidence that noise exposure during military service is a problem is seen in the huge numbers of veterans with service-connected hearing loss and/or tinnitus. For instance, according to the Veterans Benefits Administration Annual Benefit Report of Fiscal Year 2006 (U.S. Department of Veterans Affairs [VA], 2006) there are currently 444,583 veterans receiving compensation for defective hearing and 395,324 receiving compensation for tinnitus. Further, it is estimated that there are almost one million more veterans with service-connected hearing loss and/or tinnitus that do not meet the criteria for receiving compensation. Because damage from noise is cumulative, it is critical that the older, already noise-exposed population, be educated about the potential of further damage to the auditory system with further exposure to noise.

The program we have developed is designed based upon a combination of theoretical principles laid out in the Health Belief Model (HBM) of Rosenstock

(1966). The HBM was developed in order to explain individual differences in uptake of health services by the public. The model was initially based on four constructs:

- Perceived susceptibility – the feeling of being vulnerable to a condition and the extent to which the individual believes he/she is at risk of acquiring the condition.
- Perceived severity – the belief in the seriousness of the consequences incurred if affected by the condition both medically (death, disability, pain) and socially (effects on family life, personal relations, etc.).
- Perceived benefits – the belief that intervention will result in positive benefits.
- Perceived barriers – the barriers an individual believes he/she needs to overcome in order to effectively conduct some form of intervention. This includes costs, negative side effects, social stigma, time needed, and so on.

Two additional constructs were added later:

- Perceived efficacy – the belief in the extent to which the intervention will be effective at treating/preventing the condition.
- Cue to action – a cue that prompts an individual to take action. This could be internal such as symptoms of a health problem or external such as media communications, interpersonal communications, or information from healthcare providers.

Data show that, to varying degrees, these constructs are effective at predicting health-related behaviors, such as uptake of prenatal care visits (Zweig, LeFevre, & Kruse, 1988), breast cancer self-examination (Champion, 1987), continued enrollment in diabetes-related pharmaceutical services (Pinto, Lively, Siganga, Holiday-Goodman, & Kamm, 2006), and Hepatits B vaccination (Lin & Ball, 1997).

Lusk and colleagues have conducted a series of studies examining factors that impact the use of hearing protection. Of the constructs in the HBM, they report that the constructs of perceived self-efficacy, perceived barriers, and perceived benefits have significant impacts on use of HPDs among male automobile plant workers in the Midwest (Lusk, Ronis, Kerr, & Atwood, 1994) and male construction workers in the Midwest (Lusk, Ronis, & Hogan, 1997). They found that perceived barriers also influenced use of HPDs among farmers (McCullagh, Lusk, & Ronis, 2002), and that both perceived barriers and perceived self-efficacy influenced use of HPDs among female blue collar workers in two Midwestern manufacturing plants (Lusk, Ronis, & Baer, 1997).

The National Center for Rehabilitative Auditory Research (NCRAR) Hearing Loss Prevention Program (HLPP). The HLPP we have developed is a multimedia computer-based stand-alone self-administered program that provides education and the opportunity for users to screen their own hearing ability. It was developed to meet the following specifications:

- The educational section of the program takes less than 20 min in duration in order that it be practical for use in, for example, a hospital waiting area.
- The program is modular in design so that users can select components in which they are specifically interested. According to learning theory, this should result in optimal outcome because adults learn best when information is practical and relates meaningfully to their lives (Dirkx & Prenger, 1997).
- The program is self-administered, that is, users do not require instruction in its use from a professional.
- The program is low maintenance and does not require upkeep from a professional.
- The presentation level is adjustable because hearing impairment is so prevalent among the older population – the population this program targets. According to the National Institute on Deafness and Other Communication Disorders (2007), approximately 31% of individuals over age 65 are hearing impaired, with the percentage rising to between 40% and 50% of individuals over age 75. The program reverts back to a calibrated level for the hearing screening module.
- The program is clearly visible according to guidelines of Echt (2002) because more than 26 million people over age 40 are affected with some type of visual disorder and more than 4 million individuals in the US aged 55 or older are currently experiencing severe vision loss (VA, 1999). Echt's guidelines include use of large san serif font, light text on a dark background, and large spaces between lines of text.
- The reading level is between Grades 5 and 8 in order that the program be comprehensible to most of the adult population. More specifically, approximately 44% of people in the US over age 65 years read at 5th grade level or below, while another 30% read at approximately 5th to 8th grade level (Kirsch, Jungeblat, Jenkins, & Kolstad, 1993). Throughout the HLPP, written content is supplemented with verbal commentary. Although the two are highly correlated, verbal comprehension level is generally higher than reading level, especially in adults who have had little literacy education (Sticht, 2002).

The content of the program was developed by a team of audiological researchers, clinical audiologists, a nurse, and education specialists. The development team worked together to decide the overall content of the program, and how the content should be broken down into separate modules. Up front, it was decided that the program would consist of a combination of video clips, interactive computer modules, and animations. A professional film producer and a graphic designer were employed for the filming and for designing the computer interface. The film producer worked in tandem with the development team to prepare scripts for the individual video clips that combined humor, cultural sensitivity, and factual content. The graphic designer worked with the team to design a user-friendly interface and to select photographs and animations to be included throughout. Age-appropriate professional actors were hired for filming of the video clips. Sources of information originated from general audiological literature, Berger et al.'s (2006) *Noise Navigator® Sound Level Database,* and other scholarly works. Versions of the program were viewed by Patient Education Specialists at the Portland VA Medical Center and Dr. Elliott Berger, Senior Scientist for Auditory Research at E•A•R/Aearo Company.

The final program consists of a looping opening video to attract users' attention, a set of screens to ensure headphones are placed on the correct ears and that the signals are at a comfortable listening level, six educational modules, a hearing screening module, and a glossary of terms. Incorporated throughout are eight video clips, multiple interactive animated screens, and an American Speech Hearing Association (ASHA) animation of how the ear works

The program has been developed to permit easy addition of future modules. Module 1 is a video called "How to protect your hearing." It gives an overview of the concept of hearing protectors, how they work, and the importance of using protectors properly. It is intended to summarize key facts, so that if an individual stops using the program after this first module, he or she would have basic information about hearing protection. Module 2 is called "Which protection is right for you?" It consists of interactive computer screens accessed via a touch screen monitor and two short videos. The interactive screen provides information about different types of hearing protectors, and what each type is most suited to. The videos teach the user how to insert/fit the protectors. Module 3, "When to protect your hearing," is a video that teaches the user about typical sound levels in the environment. Module 4 is named "How loud is too loud and what to do." It is an interactive module in which the user selects specific listening situations, is shown their typical sound levels, safe exposure times, the appropriate type of hearing protection to use around those sounds. In addition, useful tips about each listening situation and type of protection recommended are provided. Module 5 is a video titled "Why protect your hearing?" It addresses some of the negative impacts of hearing loss on quality of life and interpersonal interactions. Module 6 is a multifaceted module known as "What happens when you hear?" It

Table 1

Content of the NCRAR Hearing Loss Prevention Program in Relation to Constructs of the Health Belief Model

Concept	Hearing loss prevention beliefs	How HLPP addresss it
Perceived susceptibility	Belief that exposure to noise will damage hearing	Module 3: When to protect your hearing Module 4: How loud is too loud? Module 6: What happens when you hear? These modules variously describe how the ear is damaged by noise and the levels at which damage occurs.
Perceived severity	Belief that hearing impairment has negative consequences functionally, socially, and/or psychologically	Module 5: Why protect your hearing? This module describes the ways in which hearing loss affects many aspects of quality of life.
Perceived benefits	Belief that preventing hearing loss will benefit the individual at some level, whether functionally, socially, and/or psychologically	Module 3: When to protect your hearing Module 5: Why protect your hearing? These modules contrast successful and unsuccessful communication to demonstrate the importance of good hearing during communication.
Perceived barriers	Belief that hearing protection is expensive, difficult to use, uncomfortable, ineffective, and/or has some other negative attributes	Module 2: Which protection is right for you? Module 4: How loud is too loud and what to do? These modules describe different types of hearing protectors, and how and when to use them.
Self-efficacy	The individual's belief that he/she can effectively use hearing protection and/or has the capacity to change his/her sound environment/listening habits	Throughout the program the same three simple solutions for preventing noise damage are specified: "turn it down," "move away," and "wear hearing protection."
Cues to action	Awareness of hearing difficulties, tinnitus, health-related campaigns addressing hearing protection, input from family or friends	Module 7: Test your hearing It is hoped that the hearing screening findings will provide an added cue to action if hearing loss is already-present.

Note. NCRAR = National Center for Rehabilitative Auditory Research. HLPP = Hearing loss prevention program.

provides information about the anatomy and physiology of a healthy, and a noise-damaged, auditory system via animated clips developed by ASHA; an interactive section provides an introduction to the physics of sound and it includes a glossary of terms used throughout the program. Finally, in Module 7, users can screen their hearing. The administrator can select the frequencies to be screened, the testing step-size, and the testing algorithm. In Table 1, we list each construct of the HBM, the way in which that construct could be associated with hearing and hearing protection, the module in our program that addresses that construct, and the way in which it does so.

Now that the content of the multimedia program has been developed, the next stage is placement of the system and evaluation. Initially the system will be placed in the waiting area of a busy VA hospital, but ultimately it could be located anywhere individuals might have the time available to participate. A small portable kiosk will house the computer and monitor. This kiosk will be sound-attenuating in order to provide the privacy and quiet environment needed for hearing screening. A formative evaluation will be conducted with the intent of improving the product and ensuring that the goals of the program are being met (Weston, McAlpine, & Bordonaro, 1995; Worthen, Sanders, & Fitzpatrick, 1997). The primary objective here is to educate users about the damage noise can do to the auditory system and ways this damage can be prevented. The formative evaluation will involve observation of user behavior while completing the program, informal testing of users to determine whether the program is effectively meeting its objective, and one-on-one interviewing to answer questions such as: What message did the program give? Was each module easily understood? Were there sections users found confusing? Which sections did users find interesting? Which sections did they find boring? Did users find the program informative? Did they find the program interesting or boring? Did they encounter difficulties navigating the program? What improvements and additional content areas would users like to see? Was the program of an appropriate length? Once formative evaluation is complete, a summative evaluation will occur in the form of a structured study. This study will assess whether the program changes knowledge about hearing loss and hearing protection, attitudes towards hearing and hearing protection, intended behaviors regarding use of hearing protection and avoidance of noise, and actual behaviors regarding use of hearing protection and avoidance of noise.

ACKNOWLEDGMENTS

This study was funded by the VA Rehabilitation Research and Development (RR&D) National Center for Rehabilitative Auditory Research and from the Paul B. Magnuson Award for Outstanding Achievement in the RR&D Service awarded to Dr. Stephen Fausti in 2004.

REFERENCES

Appollonio, I., Carabellese, C., Frattola, L., & Trabucchi, M. (1996). Effects of sensory aids on the quality of life and mortaliy of elderly people: A multivariate analysis. *Age and Ageing, 25*(2), 89-96.

Army Hearing Program. (2007). *Noise levels of common army equipment*. U.S. Army Center for Health Promotion and Preventive Medicine. Retrieved June 16, 2008, from http://chppm-www.apgea.army.mil/hcp/NoiseLevels.aspx

Axelsson, A., & Clark, W. (1995). Hearing conservation programs for nonserved occupations and populations. *Occupational Medicine, 10*(3), 657-662.

Axelsson, A., Vertes, D., & Miller, J. (1981). Immediate noise effects on cochlear vasculature in the guinea pig. *Acta Oto-laryngologica, 91*(3-4), 237-246.

Berger, E., Neitzel, R., & Kladden, C. (2006). *Noise Navigator® sound level database with over 1700 measurement values*. Retrieved November 14, 2007, from www.e-a-r.com/pdf/hearingcons/NoiseNavigatorDatabase.xls

Bogach, I., House, R., & Kudla, I. (2005). Perceptions about hearing protection and noise-induced hearing loss of attendees of rock concerts. *Canadian Journal of Public Health, 96*(1), 69-72.

Cacciatore, F., Napoli, C., Abete, P., Marciano, E., Triassi, M., & Rengo, F. (1999). Quality of life determinants and hearing function in an elderly population: Osservatoria Geriatrico Campano study group. *Gerontology, 45,* 323-328.

Carabellese, C., Appollonio, I., Rozzini, R., Bianchetti, A., Frisonni, G., Frattola, L., et al. (1993). Sensory impairment and quality of life in a community elderly population. *Journal of the American Geriatric Society, 41,* 401-407.

Champion, V. (1987). The relationship of breast cancer self-examination to Health Belief Model variables. *Research in Nursing and Health, 10,* 375-382.

Crandell, C., Mills, T., & Gauthier, R. (2004). Knowledge, behaviors, and attitudes about hearing loss and hearing protection among racial/ethnically diverse young adults. *Journal of the National Medical Association, 96*(2), 176-186.

Dalton, D., Cruickshanks, K., Klein, B., Klein, R., Wiley, T., & Nondahl, D. (2003). The impact of hearing loss on quality of life in older adults. *The Gerontologist, 43*(5), 661-668.

Daniell, W., Swan, S., McDaniel, M., Camp, J.E., Cohen, M., & Stebbins, J. (2006). Noise exposure and hearing loss prevention programmes after 20 years of regulations in the United States. *Occupational and Environmental Medicine, 63*(5), 343-351.

Dirkx, J., & Prenger, S. (1997). *A guide for planning and implementing instruction for adults: A theme-based approach*. San Francisco: Jossey-Bass.

Echt, K. (2002). Designing web-based health information for older adults: Visual considerations and design directives. In R. Morrell (Ed.), *Older adults, health information, and the world wide web* (pp. 61-87). Mahwah, NJ: Erlbaum.

Erdman, S., Crowley, J., & Gillespie, G. (1984). Considerations in counseling for the hearing impaired. *Hearing Instruments, 35,* 50-58.

Ewigman, B., Kivlahan, C., Hosokawa, M., & Horman, D. (1990). Efficacy of an intervention to promote use of hearing protection devices by firefighters. *Public Health Reports, 105*(1), 53-59.

Fechter, L. (2004). Promotion of noise-induced hearing loss by chemical contaminants. *Journal of Toxicology and Environmental Health, 67*(8-10), 727-740.

Fligor, B., & Cox, L. (2004). Output levels of commercially available portable compact disc players and the potential risk to hearing. *Ear and Hearing, 25*(6), 513-527.

Folmer, R., Griest, S., & Martin, W. (2002). Hearing conservation education programs for children: A review. *Journal of School Health, 72*(2), 51-57.

Gates, G., Schmid, P., Kujawa, S., Nam, B., & D'Agostino, R. (2000). Longitudinal threshold changes in older men with audiometric notches. *Hearing Research, 141*(2), 220-228.

Gershon, R., Neitzel, R., Barrera, M., & Akram, M. (2006). Pilot survey of subway and bus stop noise levels. *Journal of Urban Health: Bulletin of the New York Academy of Medicine, 83*(5), 802-812.

Hallberg, L.-M. (1996). Occupational hearing loss: Coping and family life. *Scandinavian Audiology, 25*(Suppl. 43), 25-33.

Hawkins, J.J., Johnsson, L., Stebbins, W., Moody, D., & Coombs, S.L. (1976). Hearing loss and cochlear pathology in monkeys after noise exposure. *Acta Oto-laryngologica, 81*(3-4), 337-343.

Henderson, D., Bielefeld, E., Harris, K., & Hu, B. (2006). The role of oxidative stress in noise-induced hearing loss. *Ear and Hearing, 27*(1), 1-19.

Hétu, R., Jones, L., & Getty, L. (1993). The impact of acquired hearing impairment on intimate relationships: Implications for rehabilitation. *Audiology, 32,* 363-381.

Hunter-Duvar, I., & Bredberg, G. (1974). Effects of intense auditory stimulation: Hearing losses and inner ear changes in the chinchilla. *Journal of the Acoustical Society of America, 55*(4), 785-801.

Kerr, M., & Hong, O. (2008, February). *Health communication approaches to hearing loss prevention*. Paper presented at the National Hearing Conservation Association Conference, Portland, OR.

Kirsch, I., Jungeblat, A., Jenkins, L., & Kolstad, A. (1993, May 17). *Adult literacy in America: A first look at the findings of the National Adult Literacy Survey.* Retrieved May 17, 2004, from http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=93275

Knobloch, M., & Broste, S. (1998). A hearing conservation program for Wisconsin youth working in agriculture. *Journal of School Health, 68*(8), 313-318.

Kochkin, S., & Rogin, C. (2000). Quantifying the obvious: The impact of hearing instruments on the quality of life. *The Hearing Review, 7,* 6-34.

Kujawa, S., & Liberman, M. (2006). Acceleration of age-related hearing loss by early noise exposure: Evidence of a misspent youth. *The Journal of Neuroscience, 26*(7), 2115-2123.

Laitinen, H. (2005). Factors affecting the use of hearing protectors among classical music players. *Noise & Health, 7*(26), 21-29.

Lee-Feldstein, A. (1993). Five-year follow-up study of hearing loss at several locations within a large automobile company. *American Journal of Industrial Medicine, 24,* 42-54.

LePrell, C., Yamashita, D., Minami, S., Yamasoba, T., & Miller, J. (2007). Mechanisms of noise-induced hearing loss indicate multiple methods of prevention. *Hearing Research, 226*(1-2), 22-43.

Lin, W.-C., & Ball, C. (1997). Factors affecting the decision of nursing students in Taiwan to be vaccinated against Hepatitis B infection. *Journal of Advanced Nursing, 25,* 709-718.

Lower, M., Hurst, D., Claughton, A., & Thomas, A. (1994). Sources and levels of noise under motorcyclists' helmets. *Proceedings of the Institute of Acoustics, 16*(2), 319-325.

Lusk, S., Eakin, B., Kazanis, A., & McCullagh, M. (2004). Effects of booster interventions on factory workers' use of hearing protection. *Nursing Research, 53*(1), 53-58.

Lusk, S., Ronis, D., & Baer, L. (1997). Gender differences in blue collar workers' use of hearing protection. *Women and Health, 25*(4), 69-89.

Lusk, S., Ronis, D., & Hogan, M. (1997). Test of the Health Promotion Model as a causal model of construction workers' use of hearing protection. *Research in Nursing and Health, 20,* 183-194.

Lusk, S., Ronis, D., Kerr, M., & Atwood, J. (1994). Test of the Health Promotion Model as a causal model of workers' use of hearing protection. *Nursing Research, 43*(3), 151-157.

Mathur, N., & Roland, P. (2007, May 2). *Inner ear, noise-induced hearing loss*. Retrieved November 14, 2007, from http://www.emedicine.com/ent/topic723.htm

McCombe, A. (2003). Hearing loss in motorcyclists: Occupational and medico-legal aspects. *Journal of the Royal Society of Medicine, 96,* 7-9.

McCullagh, M., Lusk, S., & Ronis, D. (2002). Factors influencing use of hearing protection among farmers. *Nursing Research, 51*(1), 33-39.

Melnick, W. (1977). Temporary threshold shift following 24-hour noise exposure. *Annals of Otology, Rhinology and Laryngology, 86*(6 pt 1), 821-826.

Mercier, V., Luy, D., & Hohmann, B. (2003). The sound exposure of the audience at a music festival. *Noise & Health, 5*(19), 51-58.

Mills, J., Gengel, R., Watson, C., & Miller, J. (1970). Temporary changes of the auditory system due to exposure to noise for one or two days. *Journal of the Acoustical Society of America, 48*(2), 524-530.

Mizoue, T., Miyamoto, T., & Shimizu, T. (2003). Combined effect of smoking and occupational exposure to noise on hearing loss in steel factory workers. *Occupational and Environmental Medicine, 60,* 56-59.

Morata, T., Themann, C., Randolph, R., Verbsky, B., Byrne, D., & Reeves, E. (2005). Working in noise with a hearing loss: Perceptions from workers, supervisors, and hearing conservation program managers. *Ear and Hearing, 26*(6), 529-545.

Mulrow, C., Aguilar, C., Endicott, J., Tuley, M., Velez, R., Charlip, W., et al. (1990). Quality-of-life changes and hearing impairment: A randomized trial. *Annals of Internal Medicine, 113,* 188-194.

National Institute on Deafness and Other Communication Disorders. (2007). *Statistics about hearing disorders, ear infections, and deafness.* Retrieved February 26, 2008, from http://www.nidcd.nih.gov/health/statistics/hearing.asp

National Institutes of Health. (1992). Noise and hearing loss. *NIH Consensus Statement, 8*(1), 1-24.

National Institute for Occupational Safety and Health. (2001). *Work-related hearing loss: DHSS (NIOSH)* Publication No. 2001-103. Retrieved February 26, 2008, from http://www.cdc.gov/Niosh/01-103.html

Niskar, A., Kieszak, S., Holmes, A., Esteban, E., Rubin, C., & Brody, D. (2002). Estimated prevalence of noise-induced hearing threshold shifts among children 6 to 19 years of age: The Third National Health and Nutrition Examination Survey, 1988-1994, United States. *Pediatrics, 108*(1), 40-43.

Occupational noise exposure: Hearing conservation amendment. Final rule. 48 Fed. Reg. 9738-9785 (1983) (to be codified at 29 C.F.R. §1910.95)

Ologe, F., Akande, T., & Olajide, T. (2005). Noise exposure, awareness, attitudes and use of hearing protection in a steel rolling mill in Nigeria. *Occupational Medicine (Lond), 55*(6), 487-489.

Pinto, S., Lively, B., Siganga, W., Holiday-Goodman, M., & Kamm, G. (2006). Using the Health Belief Model to test factors affecting patient retention in diabetes-related pharmaceutical care services. *Research in Social and Administrative Pharmacy, 2,* 38-58.

Portnuff, C., & Fligor, B. (2006, October). *Sound output levels of the iPod and other MP3 players: Is there potential risk to hearing?* Paper presented at the Noise-Induced Hearing Loss in Children at Work and Play Conference, Cincinnati, OH.

Reilly, M., Rosenman, K., & Kalinowski, D. (1998). Occupational noise-induced hearing loss surveillance in Michigan. *Journal of Occupational and Environmental Medicine, 40*(8), 667-674.

Roeser, R. (1980). Industrial hearing conservation programs in the high schools (protect the ear before the 12th year). *Ear and Hearing, 1*(3), 119-120.

Rosenstock, I. (1966). Why people use health services. *The Milbank Memorial Fund Quarterly, 44*(Suppl. 3), 94-127.

Santi, P., & Duvall, A.I. (1978). Stria vascularis pathology and recovery following noise exposure. *Otolaryngology, 86*(2), ORL354-361.

Scherer, M., & Frisina, D. (1998). Characteristics associated with marginal hearing loss and subjective well-being among a sample of older adults. *Journal of Rehabilitation Research and Development, 35*(4), 420-426.

Sticht, T. (2002, February 2). *The "scientific" understanding of reading and the "reading potential" of adults assessed by measuring listening and reading abilities.* Retrieved June 13, 2008, from http://www.nald.ca/fulltext/sticht/feb02/page1.htm

U.S. Department of Veterans Affairs. (1999). *Blind rehabilitation gold ribbon panel report.* Washington, DC: Department of Veterans Affairs Blind Rehabilitation Service.

U.S. Department of Veterans Affairs. (2006). *Veterans Benefits Administration annual benefits report fiscal year 2006.* Retrieved April 16, 2008, from http://www.vba.va.gov/2006_abr.pdf

Wallhagen, M., Strawbridge, W., Shema, S., & Kaplan, G. (2004). Impact of self-assessed hearing loss on a spouse: A longitudinal analysis of couples. *Journal of Gerontology, 59b,* S190-S196.

Weston, C., McAlpine, L., & Bordonaro, T. (1995). A model for understanding formative evaluation in instructional design. *Educational Technology Research and Development, 43*(3), 29-48.

Worthen, B., Sanders, J., & Fitzpatrick, J. (1997). *Program evaluation: Alternative approaches and practical guidelines*. New York: Longman.

Zweig, S., LeFevre, M., & Kruse, J. (1988). The Health Belief Model and attendance for prenatal care. *Family Practice Research Journal, 8*(1), 32-41.