

CAN YOU HEAR ME NOW: THE LEADING ARMY INJURY & DISABILITY

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USAWC CLASS OF 2011

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REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.					
1. REPORT DATE (DD-MM-YYYY) 07-03-2011		2. REPORT TYPE Strategy Research Project		3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE Can You Hear Me Now: The Leading Army Injury & Disability				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Ms. Christie P. Smith				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) COL Roberto Nang Department of Peacekeeping and Stability Operations				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army War College 122 Forbes Avenue Carlisle, PA 17013				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT Distribution A: Unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT The astounding 319 percent increase, since 2001, in disability payments for auditory dysfunction, the most prevalent individual service-connected disability, is indicative that the Army must do more to prevent and mitigate that dysfunction. Data show that 51.8 percent of combat soldiers sustain moderately severe or worse hearing loss, with the potential for handicaps like depression and impaired cognitive function. This hearing loss is attributable to blast exposure, noise-induced damage, or ototoxic medications. The strategic implications of hearing loss for the warfighter are magnified by the \$1 billion in annual cost, which jeopardizes the Army's commitments to injured soldiers. Over the next 15 years, staggering demands will be placed on hearing healthcare by these veterans as they age among the estimated 78 million people transitioning to the over 50 age group. Auditory impairment of these highly trained, educated, and experienced soldiers impacts adversely their current health and readiness, highlighting the importance of hearing conservation given the astonishing rise in blast injuries from improvised explosive devices. Auditory impairment could be used as a proxy to identify undiagnosed mild Traumatic Brain Injury.					
15. SUBJECT TERMS Auditory dysfunction, hearing loss, traumatic brain injury, tinnitus					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UNLIMITED	18. NUMBER OF PAGES 34	19a. NAME OF RESPONSIBLE PERSON
a. REPORT UNCLASSIFIED	b. ABSTRACT UNCLASSIFIED	c. THIS PAGE UNCLASSIFIED			19b. TELEPHONE NUMBER (include area code)

USAWC STRATEGY RESEARCH PROJECT

CAN YOU HEAR ME NOW: THE LEADING ARMY INJURY & DISABILITY

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ABSTRACT

AUTHOR: Ms. Christie P. Smith
TITLE: Can you hear me now: the leading Army injury & disability
FORMAT: Strategy Research Project
DATE: 07 March 2011 WORD COUNT: 5,895 PAGES: 34
KEY TERMS: Auditory dysfunction, hearing loss, traumatic brain injury, tinnitus
CLASSIFICATION: Unclassified

The astounding 319 percent increase, since 2001, in disability payments for auditory dysfunction, the most prevalent individual service-connected disability, is indicative that the Army must do more to prevent and mitigate that dysfunction. Data show that 51.8 percent of combat soldiers sustain moderately severe or worse hearing loss, with the potential for handicaps like depression and impaired cognitive function. This hearing loss is attributable to blast exposure, noise-induced damage, or ototoxic medications. The strategic implications of hearing loss for the warfighter are magnified by the \$1 billion in annual cost, which jeopardizes the Army's commitments to injured soldiers. Over the next 15 years, staggering demands will be placed on hearing healthcare by these veterans as they age among the estimated 78 million people transitioning to the over 50 age group. Auditory impairment of these highly trained, educated, and experienced soldiers impacts adversely their current health and readiness, highlighting the importance of hearing conservation given the astonishing rise in blast injuries from improvised explosive devices. Auditory impairment could be used as a proxy to identify undiagnosed mild Traumatic Brain Injury.

CAN YOU HEAR ME NOW: THE LEADING ARMY INJURY & DISABILITY

The problems of deafness are more complex if not more important than those of blindness. Deafness is a much worse misfortune because of the loss of the most vital stimulus, the sound of the voice that brings language, sets thoughts astir and helps us in the intellectual company of man.

Helen Keller

Auditory dysfunction is the most prevalent individual service-connected disability, with compensation totaling more than \$1 billion annually.¹ To complicate matters, in 2007, the hearing loss disability processing time by veterans was 789 days, which was more than two years.² Compensation by the Veterans Administration will grow unless mitigating steps are taken to treat the root causes of this dysfunction. Myriad root causes exist such as blast exposure, noise-induced damage, or ototoxic (causing hearing loss) medications. Impairment can include hearing loss, auditory processing deficits, vestibular impairment, and tinnitus which have an impact on the health and readiness of the force. This paper will highlight the biggest challenges with this impairment, explore why it continues to be a problem, define steps to mitigate it, examine what has and needs to be done and offer recommendations for the way forward.

Magnitude of the Problem

More than 31 million Americans, particularly veterans, are affected by hearing loss, one of the most common chronic health conditions affecting all age groups, ethnicities and genders.³ The estimated economic impact of these workers exposed to hazardous noise is \$242.4 million per year in disability.⁴ Data show that 51.8 percent of combat soldiers have moderately severe hearing loss or worse due to loud sounds associated with combat.⁵ Implications for the Army are great as these soldiers must be

evaluated for their ability to perform their duties safely and effectively. If they are unable to do so, they may be given the opportunity to change jobs where their hearing will not be further degraded or risk leaving the service with a medical discharge.

Hearing loss is one health condition that is 100 percent preventable. Hearing impairment associated with noise exposure can occur at any age.⁶ Physiological changes occur in the ear, including damage to delicate sensory hair cells. Military personnel are particularly vulnerable to noise-induced hearing loss which is characterized by difficulty understanding speech. With this difficulty, vowel sounds can be heard longer than consonants so words like “soap” are heard as “goad.”⁷

Each year, both occupational and environmental noises are becoming more pervasive. Within the Army, noise induced hearing loss is the most prevalent occupational health hazard.⁸ Noise induced hearing loss is on the rise among military personnel. Among soldiers returning from deployments, hearing loss is the fourth leading reason for medical referrals with one-third of them returning from Iraq and Afghanistan referred due to acute acoustic blasts. Seventy-two percent of them were determined to have hearing loss.⁹ The incidence of noise-induced hearing loss can be reduced or eliminated through the successful application of engineering controls and hearing conservation programs.¹⁰

It is prudent to prevent hearing loss rather than to provide a lifetime of disability payments. Given the already 319 percent increase in auditory dysfunction disability payments since the beginning of the Afghanistan war in 2001, compensation will rise unless mitigating steps are taken.¹¹ Each year hearing loss affects more than 10 percent of the general population and costs more than \$30 billion in lost productivity,

special education, and medical treatment. Already there are 50 million adults suffering from tinnitus, an early indicator of hearing loss.¹² Tinnitus is defined as head or ear noise lasting five or more minutes.¹³

The incidence of hearing loss increases with age and is more prevalent in men than women by a ratio of two to one.¹⁴ The disparity between men and women can be attributed to the types of occupations men pursue in heavy industry and the cumulative effects of noise over time. Of those over 75, about 40 percent are hearing impaired or deaf.¹⁵ The Healthy People 2010 Program predicts 78 million people in the United States over the next 15 years will transition to the over-50 age group, further escalating the incidence of hearing loss.¹⁶ Americans aged 65 and older will constitute 20 percent of the population in 25 years. This massive demographic shift will place unprecedented demands on all age-related healthcare and hearing healthcare in particular. In 2010, the US government predicted it would spend \$1.6 billion to rehabilitate people traumatized from the effects of noise.¹⁷

Implementing a widespread program to reduce or eliminate preventable hearing loss is a huge public health need.¹⁸ The U.S. Army is not immune to this need. Reports indicate that up to 50 percent of soldiers in combat arms branches, who have 10 or more years of service, experienced hearing loss sufficient to interfere with their job performance.¹⁹ Up to 30 percent of all Army personnel with two or more years in combat arms branches have clinically significant hearing loss. At 15 or more years of service, that percentage with significant hearing loss exceeds 50 percent.²⁰

The Auditory System

The sense of hearing is a result of changing sound waves from the air into electrical signals that the brain processes. The ear can be divided into three parts: outer ear, middle ear and inner ear. The outer ear collects sound, whose pressure is amplified through the middle ear and passed from one medium into another (air to fluid). The change from air to fluid occurs because air is contained in the ear canal and middle ear, but not within the inner ear. The hollow channels of the inner ear are filled with fluid, and lined by a sensory epithelium that is covered with sensory hair cells. These hair cells convert sound waves into nerve impulses that travel to the brainstem. The information is further processed and eventually reaches the thalamus and relayed to the portion of the cerebral cortex dedicated to sound.²¹

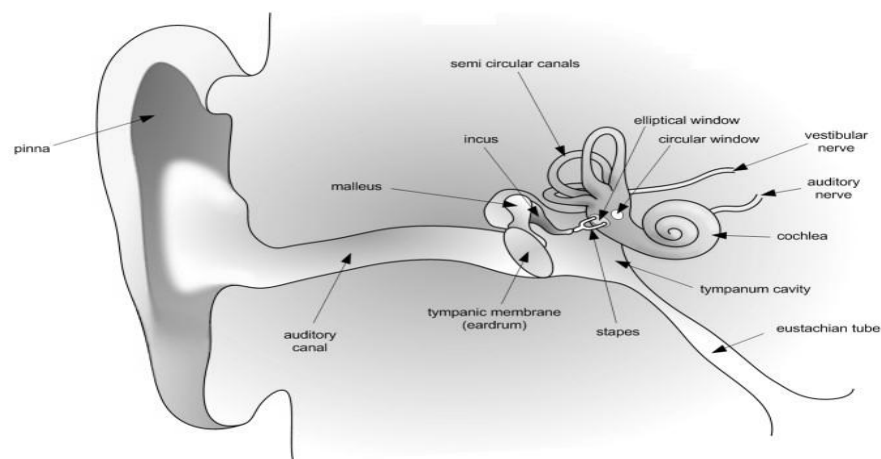


Figure 1. Human ear depicting outer (pinna), middle (auditory canal, tympanic membrane through staples) and inner (nerves and cochlea) sections.

Types of Hearing Losses and Causes

The three types of hearing loss or auditory impairment are conductive, sensorineural and central auditory processing disorders.²² Sound waves are not effectively transmitted through the outer and middle ear to the inner ear in conductive

hearing loss. Sensorineural hearing loss results from damage to hair cells in the cochlea and may result from damage within the nerve pathways between the inner ear and central auditory cortex. Typical age-related hearing loss is sensorineural.²³ With sensorineural hearing loss, higher frequencies (4000 Hz) are the first affected. When these frequencies are impaired, so goes the loss in the ability to understand oral communication. Consonants are primarily affected. High frequency impairment diminishes the ability to distinguish between similar sounding words.²⁴

Estimates are that one-third of Americans over 65 have mostly irreversible hearing loss.²⁵ Damage to the auditory centers and central auditory cortex cause central auditory processing disorders. Hearing impairment can result from age related hearing loss, noise exposure, or ototoxic medications or chemical substances. Hearing effects are cumulative; the more noise exposure heard, the more hearing may be lost.²⁶

In addition to noise and blast injuries, chemicals and drugs can also cause hearing loss. Some medications used to treat burns from blast injuries or used to treat cancers can have ototoxic effects. These medications cause damage ranging from mild imbalance to total incapacitation and from tinnitus to total hearing loss. There are over 200 medications known to affect hearing adversely. More than one million Americans suffer hearing loss annually from taking ototoxic drugs with another four million at risk.²⁷ Ototoxicity can occur in up to 70 percent of patients and can cause further impairment to those with preexisting hearing loss, putting veterans with preexisting hearing loss at an even greater risk.²⁸ Noise exposure and ototoxic medications accelerate the natural decline of normal auditory function.²⁹ Other ototoxic agents include tobacco, solvents, or heavy metals.³⁰

Chemical substances, such as solvents, alone cannot cause hearing loss; however, they exacerbate noise-related hearing loss through a process called potentiation.³¹ Chemical agents may damage any part of the auditory system.³² The synergistic interaction between these chemicals and noise create a combined biological effect of two hazards. Avoiding noise and chemical exposure is one of the best preventive measures.³³

Solvents are in paints, paint thinners, degreasers, adhesives, inks, glues, and enamel. They can affect the peripheral and central auditory system through ototoxicity, neurotoxicity or a combination of the two.³⁴

There are no guidelines or standards on hearing function for combined exposures of workers to chemicals and noise.³⁵ No specific test exists for ototoxicity other than a patient's positive history of exposure. No treatment can reverse the damage.

Regulatory Agencies and Standards

Noise exposure is quantified as the total sound energy that reaches the inner ear.³⁶ Noise is any unwanted sound or combination of sounds that creates adverse health effects.³⁷ The National Institute of Occupational Safety and Health (NIOSH) defines hazardous noise as sound that exceeds 85 decibels (dB) over a typical 8-hour day.³⁸ In a military environment, that is equivalent to the sound of a High Mobility Multipurpose Wheeled Vehicle (HMMWV) going 50 miles per hour. Normal conversation is at 60dB with a whisper being 34dB.³⁹ Military firearms produce noise between 150dB to 180dB. The probability of auditory system damage increases substantially with noise levels above 140dB.⁴⁰

The Occupational Safety and Health Administration recommends that employers: measure and monitor workplace noise; create hearing conservation programs for employees exposed to noise above 85 dBs; provide annual training; require hearing protection be worn while offering a variety of protection from which to choose; perform annual hearing tests on their employees exposed to workplace noise; compare those results to an original baseline; implement engineering controls where possible; and post a copy of the standard.⁴¹ For every 5 db increase in noise volume, exposure time should be cut in half to minimize damage. The Army uses a more stringent rate than that specified by OSHA; the Army uses a 3 db rate change.⁴² Recreational and occupational noise sources combined can create irreversible hearing damage.⁴³

Effects of Hearing Loss and Noise

People depend on their sense of hearing to provide essential cues for daily living activities.⁴⁴ Hearing impairment can restrict employment, recreational, and social activities. It can compromise an individual's safety by hindering one's ability to appropriately respond to alarms and warning signals (doorbells, smoke alarms, and sirens). Permanent hearing loss contributes to other problems resulting in job and revenue loss, depression, and social isolation.⁴⁵

Early detection of hearing loss is essential to creating behavioral change opportunities that can prevent further damage.⁴⁶ Noise-induced hearing loss is one of the most common occupational illnesses. It is often ignored since there are no visible side effects, it develops over time and generally no pain is associated. Despite few symptoms in the early stages of measureable hearing loss, the long term cumulative

effect is permanent loss.⁴⁷ A progressive loss of communication, socialization, and responsiveness to the environment occurs.⁴⁸

Excessive noise exposure can damage hair cells of cochlea by creating vascular, metabolic, and chemical changes to normal cell processes. The NIOSH reports that approximately 30 million Americans are exposed to noise likely to lead to hearing loss.⁴⁹ No branches of military service have successfully managed noise levels because noise control is not always an option in all environments.⁵⁰ Those with noise induced hearing loss report difficulty understanding speech in background noise.⁵¹ The decreased speech discrimination ability can create social and family problems and reduce a soldier's duty performance efficiency.⁵²

Noise exposure, the most prevalent occupational hazard, affects more than 40 million Americans with veterans at particular risk from military service. An additional nine million are at risk from hearing loss from other agents such as solvents and metals.⁵³ Sources of noise exposure in the Army are either continuous or impulse noise. The latter is usually at a higher peak, shorter duration and lower repetition than industrial noise.⁵⁴ The impulse noise is thought to produce greater hearing loss than continuous noise.⁵⁵ In war, some injuries related to noise-induced hearing loss cannot be easily prevented. These include traumatic brain injury, dizziness, auditory neuropathy, and central auditory processing disorders.⁵⁶

Traumatic Brain Injury (TBI), Blast Injuries, Improvised Explosive Devices (IEDs), and Hearing Loss

Traumatic brain injury, the signature wound of the Global War on Terrorism, affects an estimated 1.5 million Americans annually and results in significant disability and societal costs.⁵⁷ From 2003 through 2007, the Military Health System recorded

43,779 patients diagnosed with a traumatic brain injury and estimated that \$100 million had been spent on direct and purchased care for them with another \$10 million spent on prescription costs.⁵⁸

Due to the wicked nature of TBI, concurrent damage to the auditory system can occur anywhere from the outer ear, middle ear, inner ear to the auditory cortex, resulting in impaired function.⁵⁹ Due to its unique construction, the auditory system is extremely sensitive to blast injuries.⁶⁰ In blasts that cause TBI, ear drums are damaged and neurostructures in the brain might become stretched.⁶¹ Vestibular disturbances are common in TBI patients with tympanic membrane (eardrum) rupture being the most frequent result of blast exposure.⁶² Another potential result of TBI is damage to the central auditory system which can result in difficulty hearing in background noise, discriminating auditory patterns for speech perception and difficulty locating sound.⁶³ It takes up to a year after the traumatic event to determine whether permanent hearing damage caused by the blast injury exists.⁶⁴ Permanent sensorineural hearing loss, the most prevalent auditory impairment in blast trauma, accounts for up to 54 percent of injuries.⁶⁵

The dramatic escalation of blast exposure from IEDs has created unprecedented documentation of brain injury and associated auditory impairment. Significant acoustic injury could be used as a proxy to diagnose mild TBI. Across the spectrum of blast injuries, it is easy to see acoustic injuries. This potential proxy use raises concerns of whether additional TBI patients might be misdiagnosed or missed.⁶⁶ More than 5.3 million people, approximately 2 percent of the U.S. population, live with disabilities resulting from TBI. TBI is one of the foremost medical problems resulting from the wars

in Afghanistan and Iraq. RAND Corporation estimates about 20 percent of wounded soldiers sustained head, face or neck injuries.⁶⁷ Tinnitus is another common, but underreported, auditory dysfunction that manifests itself immediately after blast exposure.⁶⁸

Blast-induced traumatic brain injury is the signature injury of the current world conflicts due to the increased use of improvised explosive devices and rocket-propelled grenades by insurgents. Concurrent injuries to the auditory system as a result of acute blast trauma and resultant TBI accounted for one-quarter of all injuries in Operation Iraqi Freedom. Nearly 16 percent had hearing loss that impacted their combat performance.⁶⁹ In light of the high prevalence of hearing loss and tinnitus in this growing population, the U.S. Army should develop and implement improved strategies to diagnose and manage these conditions.⁷⁰

Hearing Readiness

Since the effects of hearing loss impact significantly the health and readiness of U.S. forces, there should be increased emphasis and funding of hearing readiness. Hearing readiness means that soldiers have the required hearing capabilities, protective equipment, and medical equipment for deployment in combat zones.⁷¹ Hearing readiness applies to annual audiometric testing that enables tracking of audiologic health of soldiers.⁷² Noise-induced hearing loss has been associated with poor word recognition due to an inability to temporally resolve auditory information.

Mission success in armored battle is directly linked to speech intelligibility.⁷³ Impaired hearing can lead to fatal mistakes in combat situations.⁷⁴ The value of good hearing to soldiers is apparent, as data show that performance is degraded even before

the currently accepted limit for abnormality, H3, is reached.⁷⁵ Soldiers with H1 and H2 hearing profiles are deployable.⁷⁶

H3 and H4 profiles are unique to military populations and are considered duty limiting. H3 is moderate to severe hearing loss with speech reception thresholds at less than 30dB. H4 is severe to profound hearing loss with aided speech. H4 typically disqualifies a soldier from continued service.⁷⁷ Soldiers with H3 and H4 profiles are non-deployable pending adjudication by a board. The Army hearing profiles range across the four categories seen below.

H1	Audiometer average level for each ear not more than 25 dB at 500, 100, 2000 Hz with no individual level greater than 30 dB. Not over 45 dB at 4000Hz.
H2	Audiometer average level for each ear at 500, 1000, 2000 Hz, or not more than 30 dB, with no individual level greater than 35 dB at these frequencies, and level not more than 44 dB at 4000 Hz; or audiometer level 30 dB at 500 Hz, 25 dB at 1000 and 2000 Hz, and 35 dB at 4000 Hz in better ear. (Poorer ear may be deaf.)
H3	Speech reception threshold in best ear not greater than 30 dB HL, measured with or without hearing aid; or acute or chronic ear disease.
H4	Functional level below H3.

Figure 2. Army Hearing Profiles

Preventable hearing loss deprives the Army of invaluable leadership for junior soldiers or those without combat experience.⁷⁸ Hearing directly affects mission success especially in combat environments. Normal hearing allows soldiers to detect the enemy and maintain effective communication ability and situational awareness.⁷⁹ Hearing loss can create a number of handicaps such as a poorer quality of life related to reduced social interactions, isolation, sense of exclusion, depression and potentially impaired cognitive function. Premature deterioration in auditory function will have long-term consequences.

From a public health perspective, implementing prevention strategies to alleviate hearing impairment is the responsible path to choose. Prevention can be accomplished through research on causes and treatment options, improved education and guidance on risks, noise controls and hearing protection practices.⁸⁰ One study concluded that reducing the noise level would be more cost-effective than having a comparable percentage reduction in years of exposure.⁸¹

Evolution of Military Hearing Conservation

The development and maturation of industry and military hearing conservation programs has been a slow and evolutionary process to change attitudes. In the 16th century, French surgeon, Ambroise Pare, first wrote about treating injuries sustained from firearms describing acoustic trauma in great detail.⁸² However, hearing protection would not be addressed until three centuries later when jet engines were invented. The result was policy addressing hearing loss prevention which led to the current Army Hearing Program with the aim to prevent noise-induced hearing loss in soldiers and ensure their maximum combat effectiveness.⁸³ The introduction of IEDs on the modern battlefield, as a tactic in irregular warfare, has caused the focus on hearing conservation to be even more significant. There were four distinct periods in the evolution of the Army's Hearing Program.

The first period occurred during the 1900s when it was thought that hearing loss could be prevented by building a tolerance to noise. Prior to World War I, veterans received compensation for hearing loss. From the American Civil War to World War I, occupational hazards evolved; the most prevalent was hazardous noise. Union Army Soldiers' medical records indicated 33 percent were diagnosed with hearing loss.

Soldiers with disabilities from military service were guaranteed larger pensions. By 1941, the “tolerance theory” to noise was examined at the Armored Medical Research Laboratory at Fort Knox, Kentucky. The landmark study concluded in 1944 and recommended that those regularly exposed to gunfire blasts be provided hearing protection.⁸⁴

In the second period, hearing conservation programs did not exist until the end of World War II when Army and Navy surgeons emphasized aural rehabilitation for veterans returning to their civilian lives. Congress passed the Soldiers Readjustment Act of 1944 to make services more available and efficient. The Army Air Corps became the Air Force and introduced the jet engine aircraft whose sound volume and duration had never been experienced before. It became readily apparent that exposure to jet engine noise caused permanent hearing loss which made verbal communication nearly impossible.⁸⁵

The third period started in 1952 when the Office of Naval Research requested a special investigation of noise hazards and learned that the effects of sounds from jet engines were much greater and more serious than commonly thought. These findings spurred the creation of the Armed Services Committee on Hearing and Bioacoustics to address the mechanisms of hearing and auditory standards. By 1953, a study known as the Biological Effects of Noise Exploratory Study concluded on the effects of high intensity noise on the human body. The study recommended monitoring prevention of noise induced hearing loss activities and establishment of a database to track hearing loss. Prevention was deemed the best solution to noise induced hearing loss. An Air Force Hazardous Noise Exposure regulation became the basis of the first

comprehensive hearing conservation program.⁸⁶ This document included all the essential components of a hearing conservation program by today's standards.

In the fourth period, the Army acquired its first audiologists between 1965 and 1967 with an additional 25 to follow in 1970.⁸⁷ However, it was not until 1974 that the Army Hearing Conservation Program was introduced against a backdrop of the Health and Safety Act of 1974.⁸⁸ A decline in hearing loss during this period was directly attributable to the hearing conservation program.

The military knew since 1953 that prevention was the best solution to noise induced hearing loss. Yet today, there is a 319 percent increase in disability payments for acoustic dysfunction. One might conclude that the Army did not and has not done enough to mitigate that dysfunction.⁸⁹ Challenges abound.

Preventing and Mitigating Hearing Injuries

Multiple strategies to prevent auditory impairment must be used. Identifying education strategies to delay or prevent the onset of noise-induced hearing loss and raise levels of awareness between modifiable risk factors and hearing loss will have important effects on Americans.⁹⁰ The greatest exposure to high-intensity noise occurs during a soldier's initial years in the service.⁹¹ Noise is not a new hazard, but a constant threat since the industrial revolution. Repeated exposures can lead to permanent incurable hearing loss or tinnitus. Tinnitus is known to produce discomfort in social life, work performance and family relationships.⁹² NIOSH recommended removing hazardous noise from the workplace and using hearing protection where dangerous noise exposures are not controlled or eliminated.⁹³

The U.S. Army could implement the following strategies as a means to prevent auditory impairment. 1) Increase emphasis on hearing protection and hearing conservation standards to protect soldiers. Some noise induced hearing loss is unavoidable despite the availability and use of hearing protection. Some exposures are so extreme that they exceed the capability of hearing protection devices.⁹⁴ 2) Improve protective head gear in combination with ear protection to minimize auditory system damage. Many factors prevent the proper use of existing personal hearing protection. These include communication difficulties, discomfort and impracticality of use in certain circumstances. Studies show that the most effective hearing protection devices are those that are most comfortable.⁹⁵ 3) Implement hearing conservation strategies, hearing loss early detection and monitoring programs to reduce the number who experience hearing impairments. Attitudes towards prevention of hearing loss are influenced mostly by personal experience not what is taught during training.⁹⁶

The US Army is taking steps to conserve hearing. Hearing protection can be in the form of limiting exposure time to hazardous noise or wearing hearing protection devices. The military generally relies on the latter. Noise levels in combat are hazardous and difficult to control given that the sources are unpredictable, and that personnel have concerns that hearing protection devices will jeopardize their safety by distorting sound cues critical to their survival. Studies have shown that between 30 to 50 percent of troops do not optimally use hearing protection as they should.⁹⁷ Commanders are providing better education about hearing protection. Use of hearing protection was unlikely when not enforced, often because protectors were hot, uncomfortable, caused ear infections, or impeded communication.⁹⁸

Medical staffs are performing more testing in war zones to detect hearing problems.⁹⁹ An acute onset of noise induced hearing loss should be treated as an emergency. Prompt management of improving the blood flow to the inner ear has proved to be effective.¹⁰⁰ All blast injuries should be referred to audiology for evaluation. If acoustic injuries are present, then they could be used as a proxy to determine whether mild traumatic brain injury exists. Future research should be targeted on acute acoustic trauma.¹⁰¹ The Army Hearing Conservation Program (AHCP) reflected a recognition that something needed to be done, but it was not enough. The risk of noise-induced hearing loss in soldiers is at its highest rate in 30 years.¹⁰² Hearing conservation programs in the military did not adequately protect the hearing of military service members. This inadequacy had important human health, personnel readiness and financial implications that additional staff, training and noise controls could remedy.¹⁰³

The Army Hearing Program, which evolved from AHCP, provides hearing services to soldiers in training and operational environments. The program consists of four elements: hearing readiness, clinical hearing services, operational hearing services, and hearing conservation. The goal of military hearing programs is improving the health and readiness of the force through hearing readiness. Hearing readiness means increasing soldiers' hearing awareness and maintaining good hearing for situational awareness and voice communication in any environment.¹⁰⁴ Active surveillance programs give better visibility of military personnel hearing protection use and provide military personnel information on risk factors for noise exposure and hearing loss.¹⁰⁵

The Army issued its soldiers the high-tech ear protection device QuietPro to moderate sound entering the ear. These earplugs filter hazardous noise while allowing normal hearing. They contain microphones that work with radios, allowing squad members to talk to one another.¹⁰⁶ These earplugs enable effective situational awareness while protecting from hazardous impulse noises by allowing soldiers to monitor environmental sounds, communicate, gauge auditory distance accurately, and localize sound sources. In 2004, the Marines first issued these earplugs because they saw their units' strength decreasing as a result of hearing loss.¹⁰⁷

In 2007, the tactical communications and protective systems (TCAPS) were introduced to the Army. TCAPS provide protection and allow soldiers to monitor environmental sounds, communicate and gauge sound distance. Additionally, these light and rugged earplugs allow radio connections to be processed without signal interruption.¹⁰⁸

Proper size and fit are crucial for all earplugs.¹⁰⁹ Improper use of hearing protection can be associated with excessive noise-induced hearing loss. When combat arms earplugs were introduced at the start of the Afghanistan War (Operation Enduring Freedom), they were shunned for operational use and considered too expensive at \$6 per pair.¹¹⁰ In practice, hearing protection is not worn in tanks when giving fire orders.¹¹¹ Infantry soldiers have concerns with communication when using earplugs.¹¹² Artillery soldiers typically do not wear hearing protection in active combat.¹¹³ Hearing protection, although beneficial, is viewed as a nuisance.¹¹⁴

Hearing protection utilization should be encouraged at recruitment. The most commonly granted accession medical waiver is for hearing deficiency. Army recruits

had a lower retention rate than their other service counterparts.¹¹⁵ This lower retention rate meant that the Army had to strengthen its recruitment efforts to compensate for those individuals who could not be retained on active duty due to hearing impairment. The general public is uninformed about the damage recreational noise can cause. Even when they become aware that noise can damage hearing, few choose to wear protective devices; although when informed about the potential for permanent hearing loss, studies show use of hearing protection usage increased. Educating the public, targeting younger generations and young veterans about loud noise exposure habits is needed so that they can change their behaviors towards using hearing protection in their civilian lives.¹¹⁶

Clinical trials are underway with the National Institutes of Health to explore combinations of antioxidants to restore hearing or preserve it before it is lost. Use antioxidants to alleviate cochlear damage caused by noise and ototoxicity; supplements could provide an additional layer of protection.¹¹⁷ Resveratrol, which is found in grape skins and over 70 other fruits, has many beneficial properties such as free-radical scavenging.¹¹⁸ Resveratrol is demonstrated to have antioxidant properties that serve as a protective agent against noise-induced hearing loss.¹¹⁹ There are numerous studies on various compounds used for hearing protection ranging from antioxidants that scavenge free radicals to agents that increase blood flow. Effective therapies may require a combination of compounds.¹²⁰

Never underestimate the power of vitamins. Glutathione helps eliminate foreign substances, making it one of the body's major antioxidant defense systems. L-carnitine reduces noise-induced threshold shifts. Magnesium, D-methionine, and resveratrol

increase glutathione levels.¹²¹ Vitamin combinations (A, B9, B12, C, E, selenium, and zinc) after noise exposure may be effective at reducing cell damage. Beta carotene, vitamins C and E, and magnesium when administered prior to exposure prevented temporary and permanent hearing loss in tests.¹²² Vitamin E has been shown to prevent cell death and permanent noise-induced hearing loss even when treatments were delayed up to three days after noise exposure. Studies have shown promise that applying Riluzole locally within the first 24 hours after acoustic trauma can be a remedy to restore hearing loss. Unfortunately it is invasive and not without risk.¹²³

Strategic Impact on Readiness

Hearing loss has tremendous strategic implications for the warfighter, especially in terms of readiness, costs, and whether the U.S. Army can keep its commitment to take care of soldiers and their families when the soldiers are injured or even after their service to the nation has ended. The U.S. Army can focus its efforts on mitigating noise induced hearing loss in light of the rise in exposures to traumatic brain injuries and the resultant acute acoustic trauma. Protecting veterans with past noise exposures is critical. Studies show that general officers/executives had the highest rate of noise-induced hearing loss over time, followed by enlisted personnel in training, scientists and professionals.¹²⁴

Hearing loss is associated with functional disability that can lead to depression, social isolation, anxiety, paranoia, and poor self-esteem. Marginal hearing loss has been shown to negatively affect a person's sense of independence. Hearing impaired individuals report feelings of panic, embarrassment, incompetence and fear for their future employability. Untreated hearing impairment is associated with cognitive

functional decline, diminished quality of life, and reduced capability to perform the tasks of everyday living.¹²⁵

Hearing loss prevention can start by instilling risk awareness through individualized training which has shown to motivate employees to defend their own hearing. Enforcement is not a good motivator; however instilling risk awareness is by motivating others to take action in defense of their own hearing.¹²⁶

Health, Costs and the Social Contract

To prevent hearing loss and mitigate acoustic insults or injuries, take preventive measures targeting modifiable risk factors to minimize negative effects of loud noise exposure. Use hearing protection. Avoid tobacco.¹²⁷ Get regular exercise. Eat a healthy diet and use nutritional supplements. It has been reported that high cholesterol and triglyceride levels are major risk factors for developing occupational hearing loss.¹²⁸ Restoration of hearing loss and tinnitus relief is possible by changing eating habits and reducing cholesterol levels.¹²⁹ Maintain good oral health.

Standard operating procedure should be that the U.S. Army provides all its inpatient TBI admissions with auditory consultation services as symptoms can be mistaken for posttraumatic stress disorder, mental-health issues, and cognitive deficits. Additionally, patients who have been treated with ototoxic medications should be evaluated using conventional and high-frequency audiometry on initial examination and monitored for changes in auditory sensitivity every 5-days throughout their antibiotic therapy.¹³⁰

Noise induced hearing loss remains a leading health hazard for Army personnel. Military personnel continue to suffer hearing impairment due to noise.¹³¹ The large

numbers affected are highly-trained, educated, and experienced soldiers. Preventable hearing loss deprives the Army of invaluable leadership for junior soldiers or those without combat experience.¹³² These soldiers' inability to properly perform their duties results in underperformance, retraining and transfer, or in early medical retirement. All impact negatively on the Army's Force Readiness, not to mention the tremendous costs in job inefficiencies, retraining, or disability payments.

America's national security depends on well-trained soldiers on the battlefield.¹³³ The ability for the U.S. Army to keep its commitment to take care of its soldiers and their families, as it relates to hearing, will likely be cost-prohibitive. Vitamin therapies, a low cost effective option, combined with risk awareness, and evaluation of all TBI patients for acoustic trauma are the best the Army can do now. In the event that our soldiers suffer acoustic trauma, as a result of a blast injury, that acoustic injury should be used as a proxy to evaluate the potential for mild traumatic brain injury.

As we progress to more complex operations in which clear battle lines will not be demarcated with combatants and noncombatants, technology disadvantaged enemies will turn more to terrorism and IEDs. The strength of U.S. firepower means that few enemies will confront the U.S. using conventional means. Instead they will use alternate ways to neutralize the U.S. advantage.¹³⁴ We see that now in Iraq and Afghanistan. This trend will continue in the years to come. The terrorists events of the 2004 Madrid, Spain train bombing, 2005 London, England underground train bombing, and 2011 Moscow, Russia airport bombing are evidence of that trend. It is even more important for the U.S. Army to rely on hearing conservation programs to keep its

commitments to its soldiers, ensuring their health and maintaining a high state of health readiness without compromising soldier effectiveness.

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