2018

Retrospective Policy Analysis on the Efficacy of the Army Hearing Program

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Dr. Corrine Williams, Director of Graduate Studies
Retrospective Policy Analysis on the Efficacy of the Army Hearing Program

CAPSTONE PROJECT PAPER

A paper submitted in partial fulfillment of the requirements for the degree of Master of Public Health in the University of Kentucky College of Public Health

By
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Final Examination
Lexington, Kentucky
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ABSTRACT

The present study (1) examined the Army Hearing Program (AHP) and (2) provided a retrospective policy analysis on several of the policies embedded within the AHP, more specifically the hearing readiness policy, to determine their efficacy and impact regarding noise-induced hearing loss (NIHL). The Beaufort Longest Framework was the analytic framework for this project. It was also used to structure the writing and formatting of this report. An extensive literature review of Army Medical Department (AMEDD) journals and Public Health journals were used in addition to several published Army Regulations and Pamphlets for guidance within conducting the Methods section of this paper. NIHL was discussed and the four elements of the AHP (i.e., Hearing Readiness, Clinical Hearing Services, Operational Hearing Services, and Hearing Conservation) were compared and contrasted regarding its impact on mitigating NIHL. Data were used from literature as well as from the Army Public Health Center (APHC). The results revealed that rates of significant threshold shifts (STS) and hearing loss decreased tremendously during the timeframe following implementation of the hearing readiness policy in 2007 and the Army Hearing Program in 2008.
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<th>Description</th>
<th>Definition</th>
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<tbody>
<tr>
<td>AHP</td>
<td>Army Hearing Program</td>
<td></td>
</tr>
<tr>
<td>AC</td>
<td>Air-conduction</td>
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</tr>
<tr>
<td>BC</td>
<td>Bone-conduction</td>
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</tr>
<tr>
<td>CHL</td>
<td>Conductive Hearing Loss</td>
<td>Hearing loss caused by an impedance of the conduction of sound through the outer and middle ear. This type of hearing loss is not associated with noise.</td>
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<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
<td>A codification of the general and permanent rules published in the Federal Register by the Executive departments and agencies of the Federal Government. The Occupational Safety and Health Administration’s regulations are found in Title 29 (Regulations Related to Labor).</td>
</tr>
<tr>
<td>dB</td>
<td>Decibel</td>
<td>The unit used to express the intensity of sound (sound pressure level). The decibel scale is a logarithmic scale in which 0 dB approximates the threshold of hearing in the middle frequencies for young adults. The threshold of discomfort is usually noted between 85 and 95 dB and the threshold for pain is between 120 and 140 dB.</td>
</tr>
<tr>
<td>dBA</td>
<td>A-Weighted; A-weighting</td>
<td>Sound level that has been filtered with the A-weighting network of the sound level meter, commonly used in describing environmental and occupational noise; A pitch/frequency response filter adjustment which makes its reading conform to the human ear response at a loudness level of 40 phons.</td>
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<tr>
<td>dBp</td>
<td>Peak</td>
<td></td>
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<tr>
<td>HCP</td>
<td>Hearing Conservation Program</td>
<td>Required by the Hearing Conservation Amendment (1983) which requires that a hearing conservation program be administered when employee noise exposures are 85 dBA TWA.</td>
</tr>
<tr>
<td>Hz</td>
<td>Hertz</td>
<td>A unit of measure of frequency, numerically equivalent to cycles per second.</td>
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<tr>
<td>HPD</td>
<td>Hearing Protection Device</td>
<td>A hearing protection device is a personal safety product (such as an earplug or earmuff) that is worn to reduce the harmful auditory and/or annoying effects of sound.</td>
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<tr>
<td>MHL</td>
<td>Mixed Hearing Loss</td>
<td>A hearing loss comprised of both a conductive and sensorineural component in the same ear.</td>
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<td>NIHL</td>
<td>Noise Induced Hearing Loss</td>
<td>A pattern of hearing loss possessing certain audiometric well-defined, research documented characteristics consistent with unprotected exposure to high levels of noise.</td>
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<td>NIOSH</td>
<td>National Institute for</td>
<td>NIOSH was established by the Occupational Safety and Health Act of 1970. NIOSH is part of the Centers for Disease Control and Prevention (CDC) and is the only federal institute responsible for conducting research and making recommendations for the prevention of work-related illnesses and injuries.</td>
</tr>
<tr>
<td></td>
<td>Occupational Safety and Health</td>
<td></td>
</tr>
<tr>
<td>NRR</td>
<td>Noise Reduction Rating</td>
<td>A single number rating required by law to be shown on every hearing protective device sold in the United States. This number is determined by applying a specified procedure in a controlled environment.</td>
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<tr>
<td>Acronym/Abbreviation</td>
<td>Description</td>
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<td>OSHA</td>
<td>Occupational Safety and Health Administration</td>
<td>A US government agency that was set up in 1971 to ensure safe and healthful conditions on the job for workers. It issues regulations, called standards, that protect workers from various hazards on the job. It is part of the US Department of Labor.</td>
</tr>
<tr>
<td>PEL</td>
<td>Permissible Exposure Limit</td>
<td>An exposure limit that is published and enforced by OSHA as a legal standard. The PEL refers to levels of exposure and conditions under which it is believed that nearly all healthy workers may be repeatedly exposed day after day without adverse effects. Currently, the OSHA PEL for noise is 90 dBA as an 8-hour Time-Weighted Average (TWA). Exposures at and above this level are considered hazardous.</td>
</tr>
<tr>
<td>PT</td>
<td>Pure-tone</td>
<td></td>
</tr>
<tr>
<td>PTA</td>
<td>Pure-tone average</td>
<td></td>
</tr>
<tr>
<td>SNHL</td>
<td>Sensorineural Hearing Loss</td>
<td>A hearing loss originating in the cochlea or the fibers of the auditory nerve.</td>
</tr>
<tr>
<td>STS</td>
<td>Standard Threshold Shift</td>
<td>As defined by OSHA, a change in hearing threshold relative to the baseline audiogram of an average of 10 dB or more at 2, 3, and 4kHz in either ear. Used by OSHA to trigger additional audiometric testing and related follow-up.</td>
</tr>
<tr>
<td>TWA</td>
<td>Time Weighted Average</td>
<td>An average of different exposure levels during an exposure period. A value, expressed in dBA, which is computed so that the resulting average would be equivalent to an exposure resulting from a constant noise level over an 8-hour period. OSHA PEL and action levels are based on this metric.</td>
</tr>
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I. INTRODUCTION

Noise-induced hearing loss (NIHL) is a major problem in the world today, but it is a preventable injury. Research has shown that NIHL occurs when there are damaging effects to the hearing mechanism from overstimulation of high sound levels, usually over a long period of time (Gelfand, 2009). However, NIHL may also occur suddenly as a result of exposure to impulsive sound-pressure levels greater than 140 dB(P). Research indicates that there are more than 30 million Americans occupationally exposed to noise levels greater than 85 dBA (Berger, 2000). The National Institute on Deafness and Other Communication Disorders (NIDCD) reports that as of 2011-2012, as many as 40 million adults have hearing loss either unilaterally or bilaterally as a result of exposure to hazardous noise (NIDCD, 2018). Yet, in the Army, hearing loss and tinnitus, a sensation of ringing in the ear – often as a result of NIHL, rank as two of the most prevalent consequences of service-to-date. In fact, the prevalence of hearing loss and tinnitus in the military is greater than that of the general public (Yong, 2015), as almost every soldier, airman, sailor, and marine will be exposed to hazardous noise at some point in his or her military career (Yankaskas, 2013; Pfannestiel, 2014; Collee et al., 2011), which is an indication of the need for preventative measures for NIHL.

The Army Hearing Program (AHP), which aims to prevent NIHL in soldiers and ensure their combat-effectiveness as stated by McIlwain, Gates, and Ciliax (2008), has become an important factor in the prevention of NIHL over the past few years. The Army, as well as the other branches of the armed forces (i.e., Air Force, Marines, Navy, Coast Guard), has seen an increase in the number of cases of hearing loss since World War I. McIlwain et al. (2008) reported that even before World War I, military veterans were receiving compensation for
hearing loss. Consequently, two major legislative movements – the General Law of 1862 and the Disability Act of 1890, would be the first of many influential events that would pave the way for the program now known as the Army Hearing Program (McIlwain et al, 2008).

Hazardous noise exists in many military environments; however, assessing its effects and impact on the hearing acuity of military and Department of Defense (DoD) personnel is not always straightforward (Committee on Noise-Induced Hearing Loss and Tinnitus, 2006).

This retrospective policy analysis focusing on the efficacy of the Army Hearing Program was conducted to develop a better understanding of public health in the military, the AHP, health outcomes associated with hearing loss intervention, and the need for hearing loss prevention.

**Background**

According to the hearing health foundation (2018), the number of Americans living with hearing loss increased from 24 million to 48 million between 2000 to 2015. Globally, the number of people suffering from hearing loss is up to 360 million, suggesting that it is a significant public health concern (2018). Hearing loss can be defined as a decrease in hearing ability, greater than 25 dB in severity, caused by illness, disease, or by exposure to excessively high noise levels. Hearing loss may be classified as conductive, sensorineural, or mixed in nature and is categorized by its etiology and the section of the auditory system, shown in Figure 1, where the injury or illness occurred. For example, a conductive hearing loss (CHL) may be caused by cerumen impaction in the ear canal, perforated tympanic membrane or eardrum, otitis media such as an ear infection, or other causes that affect the outer or middle-ear system. A CHL is usually temporary in nature and can typically be treated with medicine or surgery. A sensorineural hearing loss (SNHL) may be caused by an illness or injury to the inner ear mechanism (i.e., cochlea or auditory nerve) and is permanent.
Common causes of SNHL are NIHL, head trauma especially near the temporal lobe, infections such as meningitis, or exposure to ototoxic chemicals (carbon monoxide, lead, etc.) and medicine (gentamicin, aspirin, furosemide, cisplatin and other chemotherapeutic agents, etc.). A SNHL typically cannot be treated by medicine or surgery but is often managed with the use of a hearing aid or other assistive listening device.

**Figure 1. Basic Diagram of the Outer, Middle, and Inner Ear**

![Anatomy of the Ear](image)

Source: Gelfand, Essentials of Audiology

Regarding severity, degree of hearing loss ranges from mild to profound, with moderate and severe categories in-between (i.e., mild, moderate, severe, profound) (see Appendix A for audiogram). The effect of hearing loss on an individual is also determined by the frequencies that are affected, which typically range from a low of 250 hertz (Hz) to a high of 8000 Hz. Noise-induced hearing loss, as seen in Figure 2, initially occurs at or around 4000 Hz and then spreads to the adjacent frequencies of 3000 and 6000 Hz, significantly impacting and diminishing the ability to understand speech. NIHL is the most common cause of hearing loss in the military, affecting countless soldiers in the U.S. Army each day.
Figure 2. Audiogram reflecting progression of NIHL

Source: Council for Accreditation in Occupational Hearing Conservation
II. METHODS

Using the Beaufort Longest Framework (Health Policy Making in the US, 2015), current Army Hearing Program (AHP) policy was examined using secondary data from existing literature in journal articles, accessed through PUBMED and the Army Medical Department (AMEDD) Center and School website, from 2000 to 2015. Data were also gathered on Army Hearing Program metrics as reported by the Army Public Health Center (APHC) from 2000 to 2014 to determine the impact of the AHP on the prevention of noise-induced hearing loss. The Beaufort Longest Framework, displayed in Figure 3, is a model that was designed to aid in the understanding of health policymaking, specifically formulation, implementation, and modification at the federal, state, and local levels. One ideal method for utilizing the Longest Framework for research and policy analysis is to introduce a public health problem, discuss the scope of that problem, and recommend or analyze the solution(s) for the stated problem, including a discussion of politics.

Figure 3. Beaufort Longest Framework

III. SCOPE OF THE PROBLEM

Audiology and War

Whether in peacetime or wartime, hazardous noise is one of the primary occupational hazards in the United States Army, and the risk of soldiers incurring noise-induced hearing loss is greater than it has been in over 30 years (ST 4-02.501, 2008). Sensorineural hearing loss and tinnitus have been the top two combat-related injuries during mostly every period of war conflict (U.S. Department of Veterans Affairs, 2007). Seven out of the ten injuries in theater (i.e., deployed environment) are due to blast exposures, of which fifty percent result in permanent hearing loss (ST 4-02.501). Furthermore, evidence suggests that one in three soldiers who deploy will experience acoustic trauma (DA PAM 40-501, 2015). Therefore, the Department of the Army (DA) Pamphlet 40-501 mandates the requirement to wear protective equipment, use of administrative actions for not wearing protective equipment, possible disqualification from duties if hearing loss occurs, and use of hearing protection during off-duty, noise-hazardous activities. In conjunction with DA PAM 40-501, Executive Order 12196 requires the Department of Defense (DoD) to comply with the Occupational and Safety Health Act and all the standards and regulations put into effect by the Act. Lastly, Title 29, Code of Federal Regulations (CFR) 1910.95, Occupational Noise Exposure and Hearing Conservation Amendment, provides additional guidance and requires the implementation of a hearing conservation program when personnel is exposed to noise levels greater than 85 decibels (Noise Consultancy, 2018).

On the home-front, exceptional hearing acuity is essential to effective communication and an improved quality of life. A normal sense of hearing allows a father to hear his daughter’s whisper, a mother to hear her baby’s cry, a friend to hear his companion in a noisy
restaurant, a business partner to hear his colleagues during a meeting, a hunter to hear deer in the forest, a student to hear her teacher as he lectures, and a child playing alone in the yard to hear a snake hissing in the grass. On the battlefield, a soldier’s ability to hear is necessary for survivability and lethality. Often during battle, a soldier with normal hearing sensitivity is able to detect the enemy’s presence prior to direct contact. Detection distance decreases rapidly and significantly as hearing loss increases. For example, a soldier with normal hearing acuity can detect his adversary at a distance of 1000 meters; however, a soldier with decreased hearing sensitivity may be able to detect the same enemy at a distance of only 100 meters, thereby reducing the warfighter’s survivability and lethality.

On the home-front, hearing loss has been linked to depression, marital discord, lower income, and less opportunity in the workplace (ST 4-02.501). In addition, outcomes such as difficulty hearing speech in background noise, problems with sound localization, and poor situational awareness become truly evident when hearing sensitivity is diminished. Reducing these negative outcomes become even more important to a service member on the battlefield. Hearing acuity is a unique sense in that it never shuts off, has a 360 degree-directionality, and is unaffected by weather or lighting. A soldier’s hearing plays a huge role in situational awareness with over fifty percent of the soldier’s incoming information resulting from his sense of hearing. That same soldier’s situational awareness is heightened to 80%-90% when his visual field is limited.

A soldier’s capability to localize sound during combat, and determine the enemy’s presence and position, depends upon his ability to correctly identify and process sound. If he cannot do so, he becomes increasingly at risk for injury and death. Friendly-fire, or incurring injury from a battle-buddy, is another potential negative outcome of hearing loss in a training
or deployed environment. For instance, a soldier who is given the command to “get back” instead of hearing “attack” puts his team members at greater risk for combat-related injuries. Therefore, it is imperative that soldiers abide within the confines of the regulations set forth to protect their hearing sensitivity, especially during times of war.

**Noise Reduction Rating (NRR)**

One of the most common approaches or methods to controlling hazardous noise exposure is through the use of personal protective equipment (PPE) such as hearing protection devices (HPDs). One significant concern when evaluating the efficacy of HPDs is that of the noise reduction rating (NRR). Noise reduction rating indicates the attenuation level of the hearing protection device in a “controlled” environment such as a laboratory setting (Council for Accreditation in Occupational Hearing Conservation, 2014); therefore, the NRR is not a one-hundred percent reliable measure of protection of which to determine accuracy or in this case, the dampening or reduction of sound or noise since military exercises do not take place in a laboratory. In other words, because the NRR is derived in a laboratory setting, it does not accurately reflect how a worker performs with a particular HPD. Consequently, soldiers and other workers alike should not rely solely on the NRR alone but should consider using half of the NRR as a unit of measurement.
Figure 4. NRR required by Environmental Protection Agency (EPA) to be listed on packaging of all HPDs.

Source: Defense Imagery Digest

The Noise Reduction Rating is required by EPA regulation to be provided on all HPD point of sale packaging, illustrated in Figure 4. The Army recommends using the NRR as a screening tool when selecting and narrowing its choices for HPDs. Pictured in Figure 5, these devices may be in the form of foam earplugs, triple-flange or quad-flange earplugs, battle-plugs, combat-arms earplugs, or earmuffs. Because the NRR is a metric obtained in a laboratory setting instead of a “real-world environment,” the Occupational Safety and Health Administration (OSHA, 2018) reduces the NRR of HPDs by half. The National Institute for Occupational Safety and Health (NIOSH) derates the NRR by 25% for earmuffs, 50% for foam earplugs, and 70% for all other hearing protectors (Centers for Disease Control, 2018).
Figure 5. Military-approved hearing protection devices

Source: Defense Imagery Digest

Workload Requirements of the Military Audiologist

According to McIlwain et al (2008), the first six military audiologists were recruited by the Army sometime between 1965 and 1967. These audiologists were utilized in army medical centers performing clinical duties rather than out in the field implementing and enforcing hearing conservation standards. It was not until 1970 that an additional 25 audiologists were authorized and slotted for military service, all of whom spent half their time in clinical settings and the other half in hearing conservation (2008). Hospital Commanders, and/or clinic directors, did not initially understand the role of the Army Audiologist. In fact, even today Commanders are still briefed on the workload requirements and roles of military audiologists upon the beginning of their work at a new duty station or location. Often Commanders would rather the audiologist remain in the hospital or clinic full-time so that he or she could produce more revenue for the military treatment facility (MTF). Although the impact of military audiologists engaging in hearing conservation was astounding from the onset, there remained serious obstacles in implementing hearing
conservation programs, including bureaucratic red tape, lack of formal hearing conservation education during schooling, and a lack of standardization of HCPs at individual installations (McIlwain, 2008). Due to the backlash from Commanders and other politics, Department of the Army Pamphlet (DA PAM) 40-11 (2009) authorized military audiologists to spend 50% of their time in clinical hearing services and 50% in other preventive medicine activities. This authorization contributed to a significant decrease in hearing loss in the US Army and is directly attributable to hearing conservation efforts (DA PAM 40-501, 2015).
IV. RESULTS

Burden of Hearing Loss

As with any illness or injury, there are usually associated costs that accompany the burden of disease. According to McIlwain, Sisk, and Hill (2009), there was an average of one medical evacuation (MEDEVAC) per day for hearing loss alone during the first year of Operation Iraqi Freedom. A medical evacuation is generally warranted when an illness or injury occurs to an individual in a deployed environment requiring the affected person to be completely removed, often times airlifted, from the deployed and austere environment to a more sustainable and safe location and treatment facility. These evacuations, as with most injuries occurring in theater of operations (i.e., Iraq, Afghanistan, etc.), were sent to the audiology clinic at Landstuhl Regional Medical Center (LRMC) in Germany. Of the 564 patients seen at LRMC as a result of these MEDEVACs, 65%, or 366 patients, were a result of blast exposures (McIlwain et al, 2009). More disturbingly, 25% of the injuries, which resulted in SNHL, were caused by friendly-fire (McIlwain et al, 2009). Medical evacuations limit workforce production, result in lost wages, and trigger needs for other personnel to be trained to perform the same jobs of the service members being evacuated. MEDEVACs out of theater not only result in reduction of manpower, causing U.S. forces to become less effective, but also lead to additional costs, financially and otherwise.

There is a significant financial cost for evacuating service members out of deployed environments prior to the completion of their overseas tours. There are also other considerable financial expenditures sustained by the Army and the government due to injuries of soldiers while in theater. Consider the findings by the Veterans Administration Rehabilitative Research and Development Department. In 2006, total compensation to
Veterans exceeded $1.2 billion for hearing loss and tinnitus disabilities and accounted for 17% of total disability claims (U.S. Department of Veterans Affairs, 2007). In 2010, that number increased to $1.35 billion. There was an increase of 18% from 2005 to 2006 and 56% from 2002 to 2007 in total disability claims as a result of hearing loss and tinnitus. As reported by the Department of Veterans Affairs (Annual Benefits Report, 2012), the two most prevalent service-connected disabilities for veterans in the United States at the end of the fiscal year 2012 remained tinnitus and hearing loss, with tinnitus affecting 971,990 veterans and hearing loss affecting 774,384 veterans.

**Major Legislation**

According to Bruce, Hart, and Arellano (CAOHC, 2014), in 1949 the Air Force published the first governmental noise standard but it was not until 1955 that specified maximum noise levels were issued. In 1969 the first civilian noise standard was issued by the U.S. Department of Labor under the authority of the Walsh-Healy Act. The Walsh-Healy Act was a law that gave authority to the U.S. Department of Labor to regulate any company that had contracts with the federal government. In 1970 Congress enacted the Occupational Safety and Health Act to ensure safe and healthful working conditions for all working men and women. This Act led to the creation of the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH), requiring federal agencies to establish and maintain effective occupational health programs. Several years later in 1980, Executive Order 12196 was signed into law requiring the Department of Defense (DoD) to comply with the Occupational and Safety Health Act and all standards and regulations promulgated by the Act. Lastly, in 1983, Title 29 Code of Federal Regulations (CFR) 1910.95, also known as the Occupational Noise Exposure and
Hearing Conservation Amendment, became law. The Hearing Conservation Amendment stated that personnel must be entered into a HCP when noise levels reach 90dB(A), which is the OSHA action level. The Army action level is 85 dB(A) since DoD instruction must meet or exceed OSHA standards, and it applies to active-duty army personnel as well as national guard, reserves, military cadets, and DoD civilians. CFR 1910.95 also provided detailed instructions for developing a hearing conservation program. Eventually, a more complete and robust program would be formed, now known as the Army Hearing Program.

The Army Hearing Program (AHP)

The Army Hearing Program (AHP) was created to maximize soldier and civilian hearing and communication abilities (ST 4-02.501, 2008). The AHP is comprised of four elements: hearing readiness, clinical hearing services, operational hearing services, and hearing conservation. These four elements represent the leadership policies, strategies, and processes to prevent noise-induced hearing loss (NIHL) among military and civilian personnel and each element has its own specific purpose or goal. The specific components underlying the Army Hearing Program are as follows:

1. Hearing Readiness
   a. Health Education
   b. Hearing Readiness Monitoring

2. Clinical Hearing Services
   a. Hearing Injury Evaluation and Treatment

3. Operational Hearing Services
   a. Communication Enhancement and Hearing Protection Devices
   b. Noise Monitoring and Control
4. Hearing Conservation

   a. Garrison-based Occupational and Industrial Hearing Conservation Services

   Hearing readiness allows for audiometric monitoring and the tracking of individual and unit hearing readiness status to determine a soldier’s or civilian’s ability to deploy. Hearing readiness is a set of processes to ensure that personnel have the required hearing capability to perform their job-specific duties and the correct personal protective equipment (PPE) for their situation (ST 4-02.501, 2008). Hearing readiness also allows for health education, which includes medical threat briefs (prior to training exercises and deployments); unit education briefs (required annually); hearing program officer courses (as requested); and hearing technician certification courses (at least once per quarter). According to the Army’s Special Text 4-02.501 (2008), the purpose of hearing readiness is to identify early changes in hearing, and provide education, individual counseling, and hearing protection to prevent further damage to hearing sensitivity. The hearing readiness pillar, or element, of the AHP accomplishes its mission through the following: 1) monitoring audiometry, 2) hearing readiness classification, and 3) physical profile serial system. However, the two major focus areas of the hearing readiness element of the AHP are monitoring audiometry and health education.

   Monitoring audiometry is primarily accomplished using the Defense Occupational and Environmental Health Readiness System (DOEHRS) Hearing Conservation (DOEHRS-HC) software to screen hearing. All hearing screenings are saved to a database on the DOEHRS-HC computer and then sent to the DOEHRS Data Repository (DOEHRS-DR) for storing and reference. All soldiers must receive a DOEHRS-HC screening 1) prior to basic training and exposure to any work-related hazardous noise, 2) annually, 3) when filling a Professional
Filler System (PROFIS) position (i.e., deployment slot), and 4) immediately prior to separation from the Army (ST 4-02.501, 2008). Hearing screenings aid in early identification of hearing loss or susceptibility, determination of work-related hearing loss and disability, fitness-for-duty determinations for current service members, and deployability through hearing readiness classifications, usually found in the Medical Protection System (MEDPROS) database.

Prevention and education are key in understanding the hazard of noise-induced hearing loss and learning how to use strategies to mitigate this hazard. Health education training may be conducted anywhere and anytime. Education may be presented in the form of medical threat briefs given prior to deployment. Education is also provided through counseling immediately following hearing screenings and diagnostic audiological evaluations. Per Army Regulation 40-501 (2011), education regarding hazardous noise exposure is required annually for each military unit, whether noise-exposed or not. Lastly, education is provided during training and certification workshops such as the Council for Accreditation in Occupational Hearing Conservation (CAOHC) course or the Hearing Program Officer (HPO) course.

Clinical hearing services allow for quantifying a soldier’s hearing readiness classification as well as determining the extent of an injury from noise exposure. Whereas hearing readiness is comprised of hearing screenings carried out primarily by a hearing technician, clinical services are comprised of diagnostic audiological evaluations performed by a licensed, board-certified audiologist. During this process, the audiologist may also include a treatment and/or management plan such as the prescription of hearing aids or assistive listening devices, aural rehabilitation, or monitoring the medical condition (i.e., hearing loss,
balance dysfunction, ruptured eardrum, etc.) for changes. Training and counseling on the prevention of hearing loss may also be performed at this time. A service-member or noise-exposed civilian may be referred to an audiologist by the hearing technician if and when the results of his or her hearing screening is outside the normal range for hearing sensitivity or there has been a significant shift or decrease in hearing acuity since the previous screening. As eluded to earlier, the ultimate purpose of clinical hearing services is to quantify and qualify hearing in terms of the degree and cause of hearing loss (ST 4.02-501, 2008).

On the other hand, operational hearing services involve identifying noise levels and sources; reducing noise levels through engineering controls, administrative controls, and personal protective equipment (PPE); and providing communication enhancement through tactical communication and protective systems (TCAPS), displayed below in Figure 6.

![Figure 6. Tactical Communication and Protective Systems – TCAPS](image)

Source: Defense Imagery Digest

Operational hearing services ensure that soldiers remain combat-effective and deployable. The purpose of operational hearing services focuses on noise assessment, surveillance, and reduction, and hearing protection to reduce the impact of noise and NIHL on military operations (ST 4-02.501, 2008).

Noise assessment generally involves the identification, monitoring, and reduction of hazardous noise levels (i.e., impulse noise > 140 dBp or steady-state noise > 85dBA). These assessments may be performed by an audiologist, industrial hygienist, or certain safety
personnel, using either a sound-level meter (SLM) to measure noise within a certain area or a noise-dosimeter to measure the level of noise directly near the ear over a certain period of time. Engineering controls may be defined as any modification or replacement of equipment or other physical change at the noise source or along the transmission path that reduces the intensity of noise at an individual’s ear(s) (ST 4-02.501, 2008). Examples of engineering controls may include reducing noise at the source, interrupting the noise path, reducing reverberation, increasing the distance between the noise source and the operation, installing sound-absorbing material, and/or erecting acoustical enclosures and barriers, such as sandbags around a generator (ST 4-02.501, 2008). According to Schaible and Swisher (CAOHC, 2014), removing the source of hazardous noise through engineering controls is the most effective long-term solution to occupational noise hazards. On the other hand, administrative controls can be defined as changes in work schedule or operations which reduce noise exposure (ST 4-02.501, 2008). When the elimination or reduction of noise at its source is not feasible, the noise must be reduced at or by the receiver. One method for achieving this is through the use of administrative controls by rotating workers to quiet areas for a certain period of time to limit their overall exposure to the hazardous noise (CAOHC, 2014). Obviously, the best and most effective administrative control is noise prevention, which may be accomplished through hazardous noise policies. Lastly, tactical communication and protective systems (TCAPS) can be said to be a specialized type of hearing protection device. TCAPS are over-the-ear or in-the-ear devices that contain talk-through capabilities and can connect to at a minimum one radio and/or intercom (ST 4-02.501, 2008). These devices are especially useful to soldiers in Armor units, or Infantry and Field Artillery soldiers, since TCAPS are able to connect to radios and vehicle intercoms and
have a dual function which allows the soldier to effectively protect his or her hearing while at the same time still allowing for communication with other team members.

Finally, hearing conservation serves as the flagship for the prevention of noise-induced hearing loss (ST 4-02.501, 2008). The hearing conservation program (HCP) somewhat summarizes the four pillars or elements of the Army Hearing Program by providing an in-depth overview of the essential elements of the AHP with the addition of enforcement and program evaluation. Elements of the HCP include noise hazard evaluation; engineering controls; hearing protectors; monitoring audiometry; health education; enforcement; and program evaluation. As most of these have already been discussed, enforcement and program evaluation will be briefly defined here. The hearing conservation program primarily focuses on the prevention of NIHL in industrial settings, and although some soldiers work in industrial-based settings, this element of the AHP is primarily directed to the Department of the Army (DA) and Department of Defense (DoD) civilian workforce. It is Department of Defense (DoD) policy to protect all DoD personnel from hearing loss resulting from operational and occupational noise exposure through a continuing, effective, and comprehensive HCP (DODI 6055.12, 2010). From a public health and evidence-based perspective, enforcement and program evaluation are probably the two most important components of the HCP. Enforcement details the requirement to achieve program performance standards and compliance measures, or otherwise disciplinary actions in the event of noncompliance. Program evaluation describes the requirement for ongoing HCP internal and external evaluation (ST 4-02.501).
Analysis of Hearing Readiness Policy

The Army Hearing Program Status Report (AHPSR) is a component of the Public Health Management System that provides an avenue for Hearing Program Managers (HPMs), usually military audiologists, to monitor, assess, and report aspects of their programs as required by Department of Defense Instruction (DODI) 6055.12, Department of the Army Pamphlet (DA PAM) 40-501, and the Chief of Staff of the Army’s Safety and Occupational Health objectives (AHPSR, 2017; DODI 6055.12, 2010; DA PAM 40-501, 2015). DA PAM 40-501 directs HPMs to collect and report certain metrics for the purpose of program evaluation (AHPSR, 2017). Figure 7 reveals data for periodic, or annual, hearing tests from 2000 to 2014 while Figure 8 shows hearing injury rates from 2000-2014.

Figure 7. Number of Annual Hearing Tests in the U.S. Army from 2000 to 2014

Number of Periodic Tests - Army

Source: Army Public Health Status Report

Figure 7 shows the number of hearing tests (y-axis) provided to U.S. Army soldiers during each calendar year (x-axis) from 2000 to 2014. During the year 2000, only 130,000 tests (i.e., hearing screenings) were performed, which correlated to approximately 10% of the
Army’s total strength at that time (AHPSR, 2017). Although hearing screenings were required for every service member exposed to hazardous noise during this time, adherence to guidelines was not complete. In 2006, an All Army Activities (ALARACT) document was published requiring hearing readiness testing for all deploying soldiers. The Medical Protection System (MEDPROS), a monitoring tool used to track hearing readiness requirements, was used for reporting outcomes which eventually got the attention of the commanders and leaders of those military units that were not meeting the standards. Consequently, the number of hearing tests being performed on soldiers increased in 2006 and continued to rise to over one-million screenings in 2011 at which point the screenings began to level off at approximately 900,000 per year from 2012 through 2014. This increase revealed that over 90% of all soldiers were meeting their hearing readiness testing requirements.

Figure 8. Incidence of Significant Threshold Shifts (STS) in the U.S. Army, as a percentage, from 2000-2014.

Source: Army Public Health Status Report
As shown in Figure 8 above, the incidence of significant threshold shifts, an average of a 10 dB-decrease in hearing in one or both ears from 2k to 4k Hz on the audiogram, was reported as a percentage (y-axis) from 2000 to 2014 (x-axis). In 2003, there was an increase in STS, meaning a decrease in hearing sensitivity, consistent with the invasion of Iraq. The significant threshold shifts plateaued from 2006-2007 with the initiation of tracking and reporting of hearing readiness through MEDPROS. Furthermore, another meaningful event occurred in 2007 which could be attributable to the plateau and later decrease in STS rates. In 2007, non-linear earplugs in the form of combat arms earplugs (CAEs) were included in the Rapid Fielding Initiative (RFI) which provided active hearing protection to all deploying soldiers. Immediately following in 2008, a Special Text was published as directed by the Army Medical Command due to hearing issues identified in Operation Iraqi Freedom (OIF). The Special Text document (ST 4-02.501) indicated that hearing program managers (HPMs) were to focus more on operational hearing needs in order to mitigate the effects of acoustic injuries sustained by soldiers. This text, titled the Army Hearing Program, forced HPMs to think more about prevention and less about treatment. While there cannot be a one-hundred percent guarantee that these improvements are directly a result of the AHP only, data shows that as these policies went into effect, there was a corresponding drop in STS rate.
V. DISCUSSION and CONCLUSION

Despite being a common cause of functional and cognitive problems – and a major global health challenge – hearing loss is often preventable and avoidable. The Army has made great strides in identifying, assessing, monitoring, and reducing hearing loss since World War II. While data revealed that the Army is trending in the right direction regarding hearing loss prevention, one cannot declare absolute causation between the hearing readiness policy, the Army Hearing Program, and improved metrics. However, since data showed an increase in hearing loss rates prior to the implementation of the hearing readiness policy in 2006 and then a decrease following policy implementation, it is reasonable to conclude that this policy at least contributed to the decline in hearing loss rates.

Interpretation of Results

The implementation of the hearing readiness policy had a significant impact on the Army Hearing Program (AHP) and its mission to prevent and reduce noise-induced hearing loss (NIHL). Results indicate that the rates of significant threshold shifts (STS) and hearing loss decreased tremendously during the timeframe following implementation of the hearing readiness policy and the Army Hearing Program. Through the efforts of the Army Hearing Program, data showed that the hearing health of the Army improved (AHPSR, 2017). Data also suggested that the most critical policy occurred when hearing readiness became reportable through the Medical Protection System (MEDPROS), as both hearing loss and STS rates began dropping year after year from 2006 until the present time. Monitoring is a key element of public health and it illustrates the adage of “what gets measured, improves.”
Recommendations

Recommendations concerning the Army Hearing Program could be grouped into two separate, but conjoined, categories: 1) operational needs, and 2) research needs. Operational needs are those steps that if implemented can minimize the adverse effects of hazardous noise exposure in military personnel and allow for better documentation of noise-induced hearing loss (NIHL) and other ear-related symptoms as they occur during military service. The suggested operational needs are as follows:

1. Focused attention should be given to education and prevention, which would increase the understanding of NIHL in hopes of changing attitudes regarding the misconception that hearing loss in the military is inevitable;
2. Efforts to achieve greater compliance of hearing protection use;
3. Enhancement of the Defense Occupational and Environmental Health Readiness System (DOEHRS) – Hearing Conservation (HC) and Data Repository (DR) systems to improve reporting capabilities;
4. Development of a safety climate/culture which would promote behavior change; and
5. Stricter hearing readiness monitoring and tracking for Table of Distribution and Allowances (TDA) units, which are already being enforced for Table of Organization and Equipment (TO&E) units (i.e., those units that are regularly tasked to deploy to areas of conflict).

Research is needed to address areas where further research would be valuable in relation to answering broad scientific questions concerning the relationship between noise exposure, hearing loss, and other military-related symptoms. These include:
1. Future research on the relationship between significant threshold shift (STS) appointment follow-up and reduced STS rates;

2. Randomized trials of interventions within the different military occupational specialties (MOS) of the ARMY, as well as across service branches, to determine which approach or method leads to lower incidence and prevalence of NIHL; and

3. Perform real-world studies in military settings, including field and deployed environments, to accurately assess noise attenuation of hearing protection devices and actual utilization rates.

**Limitations & Barriers**

The ability to monitor and accurately track noise-induced hearing loss (NIHL) for reporting purposes has its challenges which must be addressed. NIHL may be caused by occupational as well as non-occupational noise exposure. The efficient tracking of NIHL as a result of occupational or work-related hazardous noise exposure is extremely important in relation to determining disability, OSHA-reportable and recordable hearing loss, and work-relatedness. To effectively do so, one must be able to rule out non-occupational noise exposure as a contributing factor to the NIHL. Non-occupational and/or recreational noise exposure may result from concerts and other high-level musical gatherings, fireworks, motorcycles and other loud-engine vehicles, lawnmowers, power tools, firearms, and sporting events. It can be quite difficult to separate occupational and non-occupational noise exposure, especially if an individual is heavily involved with both exposures. Therefore, hearing readiness through baseline audiograms (i.e., prior to noise exposure) as well as annual audiograms should be considered as a proven method for identification and mitigation of NIHL in addition to being looked at as an opportunity to educate on prevention.
In addition, it is quite possible to underestimate the true incidence rate of significant threshold shifts (STS), which is highly dependent upon a soldier’s compliance of returning for follow-up examinations. For example, if an STS is identified during an annual hearing screening, the soldier is required to return for follow-up testing within 30 days of the notification. If the soldier does not return for the follow-up screening within the required timeframe, the baseline audiogram is not reset and the opportunity to capture another STS is voided because the baseline was not updated when the STS was first identified.

Non-compliance with regard to hearing protection devices is another barrier to reducing or preventing NIHL. Employees and soldiers alike must be willing to be proactive rather than reactive when it comes to noise prevention. Soldiers engaged in battle during a deployment will often complain that they cannot hear the enemy when using hearing protection. While this may have been a valid complaint 20 years ago, it is no longer an accurate statement due to the advances in technology with TCAPS. Yet, other service members may make the claim that there are various sources of noise beyond their control. Lastly, others will exclaim that they already have hearing loss and therefore it cannot get worse. All of the above counterarguments to preventing NIHL lead to flawed thinking which is in part the reason why the Army Hearing Program exists.

Finally, presbycusis is another element of hearing loss that should be considered when discussing the progression of NIHL. Presbycusis is simply hearing loss, occurring primarily in the higher frequencies (i.e., 4000 to 8000 Hz), due to the aging process. According to Gelfand (2009), there is a general consensus that presbycusis is a result of various kinds of physiological degeneration to the auditory pathway due to the normal aging process plus the accumulated effects of noise exposure, ototoxicity, and medical disorders and their
associated treatments. While NIHL is primarily caused by exposure to hazardous noise, occupational and non-occupational, presbycusis is the cumulative result of the aging process on the ears. In comparison, NIHL can compound and exacerbate the effects of presbycusis, causing the onset of hearing loss to occur much earlier in life than anticipated. In spite of these limitations, there is still strong evidence which suggests that hearing readiness has improved within the Army since the implementation of the hearing readiness policy and the Army Hearing Program.

**Implications of Hearing Loss**

Hearing loss implications may be estimated in terms of 1) effect on the individual as well as others, 2) treatment needs, and 3) societal burden (NIDCD, 2018). When estimating the impact of hearing loss on a person, a pure-tone average (PTA) of more than 25 dB is used. A pure-tone average can be explained as the mean of the air-conduction thresholds at 500, 1000, and 2000 Hertz (Hz) as a summary of the degree of the hearing loss. Typically, when the PTA is greater than 40 dB bilaterally, hearing aids are warranted to assist with the diminished sense of hearing and the individual may need to utilize adaptive listening strategies such as sitting closer to the source of sound - usually another person or use a frequency-modulated (FM) system to channel the sound directly to the person’s ear via the assistive listening device. Hearing loss affects each person differently so it is important to remember that extraneous factors such as ototoxins, medications, and other environmental or lifestyle choices may contribute to outcome.
Implication on Public Health (Hearing Loss and the Public Health Cycle)

Hearing health in the Army has exponentially improved over time, largely due to military audiology and the Army Hearing Program. However, noise-induced hearing loss (NIHL) and other ear-and-hearing related symptoms have not been completely eliminated. Excessive exposure to noise may result in a myriad of symptoms or side effects that include but are not limited to increased stress levels, increased risk of accidents, tinnitus or ringing in the ears, fatigue, a feeling of fullness in the ears, permanent hearing loss, depression, and social isolation to name a few. Although mortality is not a direct result of hearing loss, hearing loss can lead to early morbidity due to associated health risks that burden affected individuals, their friends and families, and their community. The impact of hearing loss on an individual’s quality of life is enormous since it may also lead to accelerated cognitive decline, increased risk of dementia, headaches, and balance disorders (Hearing Health Foundation, 2018).

Therefore, it is important to note that the effectiveness and efficacy of the Army Hearing Program as with any other program is not only a matter of process, or the implementation of a program, but rather a result of whether the program has produced or is producing the desired outcomes.

Activities and operations within the area of hearing loss convey a bona fide model of the public health cycle in action which align seamlessly with the public health core functions and 10 essential services. The core functions of public health are 1) assessment, 2) policy development, and 3) assurance. There is an essential service within each of these areas that is directly related to the medical and public health concern of hearing loss. According to the Centers for Disease Control and Prevention (CDC), hearing loss is carried out within a three-stage public health cycle of 1) tracking, 2) research, and 3) intervention and prevention.
Tracking, also referred to as surveillance, is consistent with the first essential function, under assessment, which is to monitor health status to identify community health problems. The Army Hearing Program uses surveillance, through various approaches, as a public health measure to identify those personnel who are at risk for hearing loss and to determine the number of soldiers that are personally affected. Tracking, as a method of surveillance, in the Army is achieved via baseline, annual, and termination audiograms. The collection and analysis of this information then leads to the second core function of public health which is policy development. Policy development serves as a function to ensure that the interests and needs of the public are met. Essential service #3, which is to inform, educate, and empower people about health issues is realized through the Army Hearing Program’s mission to educate soldiers regarding the prevention of NIHL – part of its hearing readiness goals. Lastly, the third core function of assurance allows for the promotion and protection of public interests, accomplished through numerous avenues to include programs, events, campaigns, and regulations and other strategies. Essential service #6 which communicates the message to enforce laws and regulations that protect health and ensure safety is how and why the Army Hearing Program came into existence. As stated earlier in the paper, Executive Order 12196 was signed into law requiring the Department of Defense (DoD) to comply with the Occupational and Safety Health Act and all standards and regulations enacted by the Act. The Occupational and Safety Health Act required all companies to ensure a safe and healthful environment for all working individuals. The Army continues its practice of quality assurance today through enforcement and program evaluation, which is accomplished by program performance standards, compliance measures, disciplinary actions in the event of noncompliance, and internal and external evaluation.
In conclusion, hearing loss is a public health issue due to its prevalence being far more common than anticipated. Though hearing loss has been acknowledged as a public health problem in the U.S. military for many years, it was not until 2006 that the military mandated tracking and reporting of hearing loss through its hearing readiness policy as required by the Office of the Surgeon General. Given the sudden and delayed impact of NIHL on soldiers and their families, it is necessary that the Army sustains a vigorous monitoring system whereby hearing loss rates and hearing injuries are regularly tracked and analyzed in order to ensure progress is being made regarding the overall hearing health of its service members.

Disclaimer

The opinions expressed in this paper are those of the author. They do not necessarily reflect the official position of the Department of Defense, the Military Services or the U.S. Public Health Service.
VI. REFERENCES


VII. APPENDIX

Audiogram of Hearing Categories

Source: Gelfand, Essentials of Audiology
VIII. BIOGRAPHICAL SKETCH

This capstone was completed by Ahmad B. Alexander. He has earned a Bachelor of Science in Communicative Disorders from Nicholls State University in Thibodaux, Louisiana and a Doctorate of Audiology from Louisiana Tech University in Ruston, Louisiana. Ahmad is a member of the Military Audiology Association (MAA) and the American Speech-Language-Hearing Association (ASHA). Ahmad is a Captain(P), recently selected for promotion to the rank of Major, on active duty in the United States Army. Prior to enrolling in the MPH program at the University of Kentucky, Ahmad served under Public Health Command Region – Europe (PHC-E) as the Army Hearing Program Manager for Bavaria, Germany, Camp Bondsteel, Kosovo, and Camps Arifjan and Buehring, Kuwait. Upon completion of his MPH degree, he will report for duty at the Army Public Health Center at Aberdeen Proving Ground, Maryland where he will serve as the Officer-in-Charge (OIC) of the Field Support Branch within the Directorate of Clinical Public Health and Epidemiology in the Hearing Division.

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