Noise-Induced Hearing Loss in Military Personnel - A Comparative Review

Kayleen Lavan

State University of New York at New Paltz

Senior Thesis

04/30/21
Keywords: Communication Disorders, Audiology, Military, Noise Exposure, Noise-Induced Hearing Loss

Table of Contents:

Abstract 3

Introduction 3

Personal Background 3

Objectives 4

Historical Perspective 5

Noise Dosimetry 9

Hearing Protection Devices 11

Literature Review 13

Prevalence of Hearing Loss by Severity in the United States 13

Vital Signs: Noise-Induced Hearing Loss Among Adults – United States 13

Hearing Testing in the U.S. Department of Defense 15

NOISE Study 20

Survey 23

Sample/Method 23

Questions 24

Data and Results 24

Comparison of Findings of Literature Review and Survey 27

Conclusion 28

Summary of Data 28

Future Recommendations Per Findings 29

Appendix 31

References 36
Abstract:

Military servicemembers are often exposed to damaging occupational noise levels. The focus of this research is to investigate why noise induced hearing loss is still so prevalent in the military today, despite modern day regulations, protection, and programs. I will be working on this research under the guidance of Dr. Arnao and Professor Beers, as my senior thesis advisors. Primarily using peer reviewed journals and government statistics, as well as surveys, I will be investigating and documenting the correlation between combat and noise-induced hearing loss. I will be discussing the different sources of noise exposure in the military. I will also discuss how the different branches of the military compare in their noise exposure, as well as comparing hearing conservation and hearing protection of soldiers/sailors/airmen during the Vietnam War to those of more recent wars. I will be delving into the history of audiology within the military as well as the science of audiology itself, and attempting to explain why hearing loss is still the number one disability among veterans. In conclusion, I will summarize and discuss the commonalities and/or differences found between the published literature and the survey results.

Introduction

Personal Background

I began studying American Sign Language during high school and became very interested in Deaf culture. I had known since then that I wanted to work with individuals with hearing loss. At first, I thought I wanted to be a teacher (either a teacher of sign language or a teacher of deaf children). The summer after graduating high school I interned at Cleary School for the Deaf. I interned there for two summers, working with many children ranging from 3 years old to middle school. I loved working with those children, especially the younger ones. They were energetic and spirited with such a desire to absorb all of the information they were being given, and I decided I wanted to be a teacher of young children with hearing aids or cochlear implants, assisting them in learning how to speak and function in a verbal classroom.
I had begun to pursue a degree in elementary education, however, during my second year of interning I began to ponder other fields that were out there. Speech Language Pathology entered my scope of consideration. I asked permission at the Deaf school to shadow one of the speech pathologists. I subsequently declared a major in communication disorders. However, while I found the subject matter intriguing to learn about in a classroom setting, speech-language pathology involved many different kinds of communication disorders in practice, and the process of diagnosis and treatment seemed much more therapy-based, while audiology is more focused on diagnostics and technology. Much of speech language pathology diagnosis and treatment is trial and error; there are many disorders that present similarly. Also, speech language pathologists can work with the deaf/hard of hearing at times, but they mainly work with all different categories of disorders, from stuttering to swallowing, and I already knew I wanted to work exclusively with afflictions of the ears. This led me to audiology, something I had never thought of or considered up until that point. It seemed perfect because it was much more technology based, and much more concrete.

After finally settling comfortably in audiology I decided fairly quickly that my goal was to work primarily with Veterans, or active duty military, in some capacity. My father is a firearms instructor for the New York State Courts, and he often discusses with me the audiologic exams he must receive annually, the hearing protection he uses and how loud the firearms are in the event he has to remove his protection for some reason. These conversations left me thinking about how audiologic practices and hearing protection work in a military setting.

**Objectives**

In this paper I will be addressing five key points. I will discuss different sources of noise exposure in the military and examine the four main branches of the military. I will also look at some of the different kinds of regulation hearing protection being used and compare hearing protection efforts of recent wars to that of use during the Vietnam War. Lastly, I will explore
possible reasons for today’s high prevalence of noise-induced hearing loss in the military despite modern regulations.

**Historical Perspective**

Audiology within the military has had a long history. The professional discipline of audiology itself actually began with the military in the 1940s. Prior to that time period we had the “tolerance theory.” This dated back to the early 1900s, but presumptively even before that. The premise of this theory was that hearing protection is a weakness. They believed that eventually, through repeated exposure, the ears would adjust to the noise, thus preventing any damage or hearing loss (McIlwain et al., 2008). Today, we know that is far from true. Noise induced hearing loss is a type of sensorineural hearing loss caused by damage to the ear’s hair cells, thus making it permanent. The body has certain limits that no amount of exposure will make us immune to. It’s not until the 1940s, after thousands of young servicemen returned home after World War II with noise-induced hearing loss that people started taking the idea of protecting their ears seriously. It is to be surmised that the reasoning was because people were horrifically dying in the wars every day; soldiers had much more important problems to think about than the silly notion of protecting their ears against loud noises. However, in 1941, the U.S. Army opened the Armored Medical Research Lab. A study conducted here led to a recommendation that hearing protection be used around gunfire, however, it was not a requirement (McIlwain et al., 2008).

In 1944, Franklin Roosevelt passed the Servicemen’s Readjustment Act, commonly referred to as the GI Bill. This provided several benefits to returning veterans from World War II. One of these benefits was making aural rehabilitation more accessible to soldiers, with help from many university clinics, which began providing government sponsored aural rehabilitation. Around this same time, use of jet engines began. This would be the first time that a sound of this volume and duration (approximately 140 dB) would ever be experienced. It was noted that even
brief exposure to the decibel level that a jet engine was capable of producing was a detriment to the hearing mechanism, and could cause permanent hearing loss. This new development led to AFR 160-3 “Precautionary Measures Against Noise Hazards,” the first ever military regulation on hearing conservation, published by the U.S. Air Force in 1948. Included in these regulations were limiting noise exposure, as well as wearing ear plugs. However, these ear plugs are not of the caliber that we see today. “Regulation” hearing protection at this point in time would be cotton wads soaked in paraffin (McIlwain et al., 2008).

In 1952, the armed services Committee on Hearing And Bio-Acoustics (CHABA) was created in response to a naval investigation into noise hazards, the report of which concluded that the effect that the sound jet engines had on the sailors was much more serious than they were previously aware, due to their close proximity to these engines. The creation of CHABA was an important step towards hearing loss prevention. A year later, CHABA released the results of the Biological Effects of Noise Exploratory Study (BENOX Report). “The report covered aural pain, hearing loss and protection, limiting factors for protecting the ear from noise, communication, orientation in space, and the psychological, neuropsychological, and central nervous system effects of noise.” This report was the first time it was ever recommended to monitor for prevention of noise-induced hearing loss and establish a database to track it. In 1956, AFR 160-3 was renamed “Hazardous Noise Exposure,” and became the basis of the first hearing conservation program, inside and outside of the military. While noise-induced hearing loss is still extremely prevalent in the military today, the introduction of the first audiologists to the military between 1965 and 1967 directly contributed to a significant decrease in hearing loss. And in 1968, the Military Audiology and Speech Pathology Society was formed, now called the Military Audiology Association, to “provide a foundation for the standardization of military hearing conservation programs and a way to mentor and educate audiologists with little or no hearing conservation experience” (McIlwain et al., 2008).
In 1970, the Occupational Health and Safety Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) were created to develop safety criteria for the workplace and enforce it. During this time the VA estimated that 20% of Army veterans were entering hearing loss claims (McIlwain et al., 2008). While hearing loss is quite prevalent among civilians as well (22.7% at least unilaterally), those numbers would include citizens of all ages, and hearing loss becomes more prevalent with age. Prevalence is higher among men above the age of 40 years. It’s also estimated that about 2.5% of the Americans have severe to profound hearing loss in at least one ear, but 75% of these people are above the age of 60 (Goman, 2016).

Bear in mind that most of the men being discharged from the Army are still fairly young to have developed permanent hearing loss. Therefore, with relative age in mind, 20% is quite a high percentage in comparison to the civilian population. NIOSH published “Criteria for a Recommended Standard: Occupational Exposure to Noise” in 1972, which would quantify hazardous noise exposure, recommending no more than 85 dB over an 8-hour average. Towards the end of the 1970s, Department of Defense Instruction (DODI) 6055.12 to standardize military conservation was published. It has been updated since then to reflect new standards in audiology. But this regulation paved the way for the “Hearing Conservation Program,” which would allow for regulated, enforceable hearing conservation (McIlwain et al., 2008).

Advancing to 1990, the Military Occupational Health Vehicle (MOHV) is brought to fruition. The purpose of these vehicles was mobile hearing monitoring, taking the services to the soldiers (only the army used them). The MOHVs were tested out in Kuwait at the conclusion of the first Gulf War, after the armistice was signed and as troops began to be sent home. Thousands of hearing screening and audiologic evaluations were conducted while soldiers waited to fly home. Bringing the service to them saved an estimated 3280 hours worth of work that would have otherwise happened back at home. It also benefitted the soldiers, many of whom would not have had easy access these services back home as civilians. However, as great as this
all sounds, funding was cut after following the military drawdown of the early ‘90s and use of MOHVs was no longer sustainable (McIlwain et al., 2008).

At the start of Operation Enduring Freedom (2001) the combat arms earplug was introduced. Theoretically these were supposed to allow for communication and situational awareness while blocking out loud impulse sounds. While these were at first shunned by the military for operational use and deemed too expensive ($6.00 per pair), commanders soon began to recognize the importance of hearing readiness due to the ever decreasing strength of their military units, mostly attributed to hearing loss. Therefore in 2004, all soldiers being deployed were issued these earplugs. This is around the time that a necessary shift in the hearing conservation strategy begins, and the Army Conservation Program becomes the embodiment of this shift in the overall goals and way of thinking. While before the main objective was just to protect the ears and focus solely on hearing conservation, people were now beginning to consider the overall safety of soldiers on the battlefield. Therefore, a second focus emerges. First, to prevent noise-induced hearing loss, and second, to ensure maximum combat effectiveness of the soldier. They established four pillars of service to accomplish this: operational hearing services, hearing conservation, clinical services, and hearing readiness. The U.S. Army Human Engineering Laboratory conducted a study that “found that a tank crewman's ability to understand verbal orders influenced their response times as well as their performance of specific tasks; poor understanding led to slower response times, which can mean the difference between life and death on the battlefield.” To try to solve this problem, new equipment has been developed called Tactical Communication and Protective Systems (TCAPS), introduced to the Army in 2007 (McIlwain et al., 2008).

TCAPS has the same basic premise as combat arms earplugs, aiming to protect hearing while allowing for effective communication. However, this would be the first electronic hearing protection, using active noise reduction technology to enhance speech discrimination while
reducing loud impulses noise by up to 40 dB. These devices allow soldiers to monitor environmental sounds, communicate, gauge auditory distance, and localize sounds (McIlwain et al., 2008). Electronic hearing protection devices are still being studied and technologically improved, but this kind of product shows that they are still innovating and it’s a step in the right direction.

Today it’s estimated that 51.8% of combat soldiers have moderately severe to profound hearing loss, mostly attributable to hazardous noise levels (McIlwain et al., 2008). One would expect the number to be lower since there have been decades of advancements and research, and audiologic knowledge is ever expanding. Why, if we’ve supposedly come so far with hearing protection and hearing conservation, is noise-induced hearing loss still so prevalent in the military today?

**Noise Dosimetry**

A noise dosimeter is a small sound level meter worn by someone over typically a full workday. It has a microphone attached to it and measures that person’s noise exposure over a period of time (Selwyn, 2010). Noise dosimetry is common in the military; ideally, the results are helpful for research purposes since it allows us to know the exact decibel level experienced by the wearer throughout the day. A noise dosimeter can be used a few different ways. Free field noise surveys, which are used to gather noise information about an environment rather than for an individual. Additionally, there are on-body devices and in-ear devices. Although the top of the shoulder would be considered an optimal dosimeter position, the ideal position for the microphone would be in the ear. This makes the most sense because the microphone would be located in the most natural position to receive sounds accurately to how the ear would be receiving them. However, this method is not practical for long term wear, because it interferes with hearing protection, situational awareness, and comfort. Therefore, near-ear position is a compromise between the two. On-body devices can warn soldiers, sailors, airmen and medics
when noise is exceeding dangerous threshold. This kind of immediate feedback could improve the chances of delivering therapy when it would be most effective. “When administered within one hour of the exposure, pharmacological interventions may provide as much as 30 dB of protection against a permanent threshold shift” (Smalt et al., 2017). This would involve the use of oral drugs.

Doses are supposed to account for all exposure within a 24-hour period, but it is typical to assume that off-duty noise is negligible and therefore they do not collect data from those off-duty hours (Smalt et al., 2017). However, depending on the individual and what they are doing during those hours, this time could definitely contribute to the sound levels of the dosimeter and the absence of this information could interfere with the noise estimates they collect. If dosimetry is being used to forward research for hearing protection/conservation technology, having inaccurate data could lead to subpar results in the long run.

Given this information, dosimetry studies can have a real impact on the effect of noise exposure. Several studies are trying to model auditory damage from complex noise exposure that is more realistic to a military setting, using the doses they collect with these dosimeters. This way they can predict the risks and come up with strategies and metrics to reduce noise-induced hearing loss. As of 2017, MIT Lincoln Laboratory has been developing an on-body dosimeter that can provide acoustic information about both continuous and impulsive sounds (dosimeters tend to have a lot of trouble computing both at the same time due to the different durations), as well as filter out “false noise events from objects hitting the microphone” (Smalt et al., 2017). They tend to wrongfully register this as a very loud impulse sound, similar to when you tap a microphone lightly, but it comes over the speaker as a loud boom. Information from studies like this can help to improve noise exposure standards and inform individual susceptibility for noise-induced hearing loss. It’s believed that certain people may be more susceptible due to certain physiological and genetic factors (Smalt et al., 2017).
Hearing Protection Devices

There are four main types of hearing protection that are currently approved by the Department of Defense. Earplugs are probably the most commonly used because they can be used on their own but are also often used in conjunction with something else, as double protection. There are two categories of earplugs: pre-formed and handformed. Pre-formed ear plugs are made of silicone or rubber, and there are 4 different designs for them. Single-flange, triple-flange, quad-flange, and combat arms (which was discussed earlier). These all work slightly different but accomplish basically the same thing. They all provide a noise reduction of approximately 25 dB. There are certain pros and cons to pre-formed earplugs. Some of the advantages that these types of earplugs have is that they are effective, comfortable, and they are reusable/durable so that are cost effective in the long run. However, they can cause irritation with frequent insertion, and they require a medical fitting. They are much less effective without a proper fit and even just minimal jaw movement (talking, eating) can loosen their position in the ears since they are not molded to the ears (Navy and Marine Corps Public Health Center, n.d.).

Handformed ear plugs are made of foam, sometimes called foamies. These provide noise reduction of around 31 dB. These are effective if inserted correctly; they do not require a medical fit, but it is important that personnel learn the proper way to use them. As previously mentioned, they can be worn and are often worn with helmets or noise muffs. They are also supposedly more comfortable than pre-formed earplugs, and these, unlike the pre-formed, are a universal fit, because as the name suggests, they are formed by hand for that individual’s ear. They are a one-time use item, so in that way they are hygienic, and since they are foam, they are fairly inexpensive. However, they can become expensive if one is using multiple per day. They also should not be used when handling corrosive or ototoxic chemicals; if these chemicals are introduced into the ear canal, they can cause skin damage, hearing loss and dizziness (Navy and Marine Corps Public Health Center, n.d.). Since they are made of a porous material, they easily
absorb dirt and oil that can be transferred into the ear canal, which can make the hygiene portion questionable if not being inserted with clean hands, although servicemen most likely are not particularly concerned about the hygiene of their hands when they are in dangerous situations.

The second type of hearing protection are noise muffs, or a circumaural headset. These provide noise reduction of approximately 30 dB, and they are often used in conjunction with ear plugs for double protection. This would exceed the average 30 dB of protection. Noise muffs are more expensive than earplugs, but they are cost effective over time since they can be used over and over again. The headband is usually adjustable which gives it a universal fit, with a good seal around the entire pinna. They “can incorporate communication equipment and/or Active Noise Reduction (ANR) features.” However, these are bulky, heavy, and difficult to carry, as well as very uncomfortable in a hot or humid environment, and things like hair and glasses can get in the way (Navy and Marine Corps Public Health Center, n.d.).

The next main hearing protection device is ear canal caps. The noise reduction rating for these varies due to inconsistent sealing of the ear canal, but it’s typically around 18 dB. This device is lightweight, can be inserted quickly and easily, and fits universally. And it is somewhat effective for “intermittent or modest noise (95 dB or less).” However, the effectiveness is limited, and they are more expensive and uncomfortable than earplugs. “Generally half of employees prefer foamies as HPD” (Navy and Marine Corps Public Health Center, n.d.).

The last main kind of hearing protection approved for current use is the helmet, which is not used as often as devices such as ear plugs and noise muffs. The sound attenuating helmet is generally reserved for specific operational uses. They tend to incorporate communication capabilities, and they are only really used by certain personnel members. Among this crew are aviators/aviation crew, flight and well deck personnel, tank crews and amphibious assault vehicle crew members (Navy and Marine Corps Public Health Center, n.d.).
Literature Review

Prevalence of Hearing Loss by Severity in the United States

In 2016, the American Public Health Association analyzed data from 2001 to 2010, from the National Health and Nutrition Examination Survey on 9,648 individuals to estimate the prevalence of different severities of hearing loss in the United States, for varying age and race demographics. The parameters for hearing thresholds in this specific study were as follows: mild hearing loss = >25-40 dB, moderate hearing loss = 41-60 dB, severe hearing loss = 61-80 dB, profound hearing loss = >80 dB (Goman, 2016).

As previously mentioned, results showed that prevalence and severity increases with age. While 22.7% of the total U.S. population above the age of 12 has hearing loss in at least one ear, the majority of these cases are mild. Only the oldest age bracket studied (80+) showed the prevalence of moderate hearing loss exceeds that of mild hearing loss (Goman, 2016).

Also, the statistics in this study are accounting for all types of hearing loss, not exclusively noise-induced hearing loss. It can be inferred that the percentage of those in this study with hearing loss due to noise exposure is smaller than the total 22.7% proposed, other common causes being ototoxic drugs, presbycusis (hearing loss due to aging), traumatic brain injuries and other afflictions such as meningitis, chronic otitis media, viral infections, and acoustic neuromas.

Vital Signs: Noise-Induced Hearing Loss Among Adults - United States

Another report published by the CDC in 2016 focused solely on noise induced hearing loss, specifically in participants aged 20-69 years, in order to estimate the prevalence of audiometric notches and exposure to noise among adults. This age range is more pertinent to hearing loss within the military, since those afflicted would be adults. The data in this report is based on 2011-2012 statistics (Carroll, 2017).
According to this study, 21% of people older than 18 years of age had difficulty following a conversation with background noise, 11.2% had tinnitus and 5.9% had hyperacusis (a disorder in loudness perception). Researchers conducted audiometric testing and distributed hearing related questions to a sample of 3583 participants age 20-69 years. Their audiograms were analyzed using an algorithm to identify high frequency audiometric notches, which suggest noise induced hearing loss. An audiometric notch is defined in this study as a deterioration in the threshold at 3, 4 or 6kHz that exceeded the average threshold at 500 or 1kHz by greater than 15 dB HL, and the threshold at 8kHz was at least 5 dB lower than the maximum threshold at 3, 4 or 6kHz (Carroll, 2017).

Weighted prevalence of this audiometric notch was 24.4% (6.2% bilaterally, 18.2% unilaterally). The age range of the sample in this study began at age 20, yet the previous study included ages as young as 12. It is assumed that when the sample is older as a whole, the prevalence of noise induced hearing loss is bound to increase. In this study they found that the presence of the audiometric notch increased with age. The prevalence for adults age 20-29 was 19.2%, and the prevalence for adults age 50-59 was 27.3%. The percentage was also higher among males in all categories (exposure at work, no exposure at work, unilateral and bilateral) (Carroll, 2017).

They also found self-reporting to not always be telling of test results. 19.9% of people who reported no exposure to loud noise at work had a notch, and those who did report exposure at work were about twice as likely to have a notch. This study defined “loud noise” as a circumstance in which “you had to speak in a raised voice to be heard” and “very loud” as when “you have to shout in order to be understood by someone standing 3 feet away from you.” Also, 23.5% of participants who self-reported having excellent/good hearing had a notch as well (31% of which reported exposure at work and 20.1% of which reported no exposure) (Carroll, 2017).
Therefore, self-assessment is not always reliable, and audiometric testing and noise measurement with a sound meter are important metrics when researching hearing loss in a population.

It was also discovered that 70% of the participants who reported having exposure to loud noise in the last 12 months never or seldom wore hearing protection. Only 46% of the adults who had trouble hearing had seen a professional regarding this issue in the last 5 years (Carroll, 2017). This is problematic, especially if individuals are choosing not to be proactive in protecting and conserving their hearing. It is recommended that a professional be seen if hearing difficulties are suspected. The recommended exposure limit is 70 dB over a period of 24 hours, 75 dB over a period of 8 hours, and 85 dB over a period of 1 hour. In 2002, the national total cost of first year hearing loss treatment was about $8.2 billion, which already presents a large problem in this country. However, this cost is expected to increase to $51.4 billion by the year 2030 (Carroll, 2017). That is over 500% increase in 28 years, a rate that far outpaces inflation, so it must be due to either an increase in cases, an increase in people consulting a doctor, or possibly both. However, not only is this a problem, but a problem that is growing exponentially.

**Hearing Testing in the U.S. Department of Defense**

A study was published in 2017 regarding hearing testing in the U.S. Department of Defense (DoD) and disability awards received through the U.S. Veterans Affairs (VA), to determine if having a record of testing in the Defense Occupational and Environmental Health Readiness System - Hearing Conservation (DOEHRSHC) led to any changes in VA hearing loss disability award rates. They also aimed to examine the different factors that are associated with disability claims that were awarded to Veterans who filed within one year of separation. According to this study, hearing loss is the second most common disability award granted by the VA (Nelson, 2017).

DoD hearing conservation programs provide [at least] air conduction testing for personnel deemed “noise-exposed.” These audiograms are recorded in the DOEHRSHC with
baseline, periodic and follow-up testing. There have been some changes to the criteria involved in the programs as of 2006, such as increasing enrollment to almost all service members, all operational forces are required to have annual audiometric monitoring, hearing protection fitting and hearing health education. As of 2009, the army began requiring all deploying soldiers to obtain audiograms following deployment. In 2012, the marine corps mandated all personnel to receive annual audiograms (Nelson, 2017).

The U.S. Government Accountability Office (GAO) hearing loss prevention report in 2011 recommended several improvements for the weaknesses they observed in hearing related policies, such as improving hearing protection training and making it more frequent and comprehensible, and implementing performance indicators to assess how much the services are actually reducing hearing loss. According to the GAO, the military has since made efforts to accomplish these recommendations. Also, one of the recommendations that was followed through on was using the DoD Hearing Conservation Work Group, which meets once a quarter and provides technical evaluations and make recommendations to improve the hearing conservation program. As a result of this group’s efforts, the HC program has been improved in a variety of ways: “an overall decrease in significant threshold shift rates over the past 5 years”, the emphasis of hearing loss as a readiness issue, improving policies and guidance documents, developing better HC training products, and “and collaboration and awareness of Military Service research laboratory activities to evaluate new hearing protection devices and equipment noise reduction engineering” (U.S. Government Accountability Office, 2011).

In the 2017 DoD study, the outcome measure being used was hearing loss disability award granted, and hearing loss disability award denied. Certain variables that were taken into account were the presence or absence of a record (documented hearing test) in the DOEHRS-HC, fiscal year, sex, and age at the time of application for the claim. Researchers also took note of the presence of any International Classification of Diseases, 9th Revision, Clinical
Modification (ICD-9-CM) diagnoses, or diagnoses of other miscellaneous ear-related conditions, as well as the presence of a threshold shift. This information is only available for those with records in the DOEHRS-HC (Nelson, 2017).

Unlike many other studies, this “sample” included everyone in the population of interest, which would be all individuals with hearing loss claims submitted to the VA at this time. This amounts to 276,288 individuals, 92% male, averaging at an age of 35.92 years. It was found that roughly half of those filing for hearing loss disability claims were from the U.S. Army; the other half was made up of the other three main military branches (U.S. Navy, U.S. Marine Corps, U.S. Air Force) all split in relatively even proportions (See Fig. 1 for incidence rates) (Nelson, 2017).

![Hearing Loss Diagnoses Incidence per 1,000 people](image)

**Fig. 1** According to the Military Health System Management and Reporting Tool, the U.S. Army is shown to have the highest incidence of hearing loss diagnoses per 1,000 people of any military branch between the fiscal years 2003-2013.

The data results show that only 32.3% of these disability claims were granted, meaning that 67.7% were denied. Individuals most likely to be granted their award were male, over the age of 26 years, with at least one hearing loss diagnosis. Also, individuals that served in the U.S.
Army are more likely to receive this award than those that served in one of the other branches. It is noted that 90% of the individuals presented here had at least one record in the DOEHRS-HC, however those with a record were less likely to have their hearing loss disability claim granted. Although originally thought to be due to a more complicated disability adjudication, meaning the award grants were taking longer to be decided for those with records in the DOEHRS-HC, this does not appear to be the case. It is believed a possible explanation could be that the dramatic increase in the amount of servicemembers enrolled in hearing conservation programs over the years has skewed the observed success rate of their claims, however, it’s not conclusive at this time (See Fig. 2) (Nelson, 2017).
Fig. 2 These plots show differences in the rate of disability claims granted to those with a record in the DOEHRS-HC versus those with no record in the DOEHRS-HC between the fiscal years 2003 and 2013 for each branch of service.

The individuals in the DOEHRS-HC were shown to be two or three times more likely to have their claim granted (relative to others in DOEHRS-HC) if they have at least one documented threshold shift or hearing loss diagnosis while on active duty. However, the main takeaway is that those in hearing conservation and hearing readiness programs are consistently less likely to receive a hearing loss disability award than someone who was not in this program (Nelson, 2017).

Overall, “the odds of having a hearing loss disability claim granted has continuously diminished over time throughout the observation period.” This could be due to the increasing number of claims each year. Since hearing conservation programs and required hearing tests are expanding throughout the military, there are greater rates of hearing loss diagnosis than there were previously (Nelson, 2017). This is one possible answer to the question of why we have so many veterans with hearing loss in the U.S. in the modern day. It is possible that the numbers were much higher in the 20th century, however, rate of testing has increased. With more testing comes more diagnoses. Nevertheless, with hearing conservation and hearing readiness programs expanding as they are, one would still expect the numbers to be lower than they are currently. Even with increased testing, one would hope that advancements such as better hearing protection and technology would balance out the inevitable increase in diagnoses. Comparable to the way that increased testing for a disease will lead to more positive cases for the disease, but typically medical advancements, such as vaccines, will still lead to an overall downward trend over time, or plateau in cases annually.

Why hasn’t the increase in education, training, protection, and medical technology done anything to combat the recent spike in disability claims for hearing loss? Why are the numbers
still going up, and will the curve ever flatten? Perhaps there is just no way to realistically account for all the noise that servicemembers encounter in the field, but with the research being conducted every year using data from dosimetry, attempting to innovate new kinds of hearing protection, there is hope that technology may eventually catch up and equalize the numbers to some extent.

**NOISE Study**

Another study in 2017, conducted by the VA and the DoD was published detailing “audiologic characteristics in a sample of recently separated military Veterans.” It was called The Noise Outcomes In Servicemembers Epidemiology Study (or NOISE Study). The premise of this study was to examine military related and self-perceived hearing problems of veterans over time, and attempting to get a better understanding of a variety of causes (noise, head trauma, ototoxic exposure, etc.). It is an ongoing 20-year longitudinal study, so the data reported here is only a baseline assessment. There were 100 participants, mostly male, all living in Oregon and Southern Washington. They ranged from 21-58 years old with an average age of 33.5 years. They could have been from any military branch, but must have been able to provide an active duty discharge form or National Guard discharge form dated within the last 2.5 years (Gordon et al., 2017).

All participants were given a complete audiologic evaluation, which included both pure tone air conduction and bone conduction testing, immittance testing and speech audiometry. They were also required to complete a number of self-report questionnaires (18 if they had tinnitus, 15 if they did not). Of these questionnaires were the LENS-Q questions, covering exposure of non-military occupational, military occupational, and non-occupational/recreational noise (See Fig. 3 for examples). The results identified 15% of participants as having low to mid frequency hearing loss, 25% with high frequency hearing loss and 29% total in either or both
frequency ranges, as well as 42% having hearing loss in the extended high frequency range (Gordon et al., 2017).

<table>
<thead>
<tr>
<th>Occupational Noise</th>
<th>Year Started (YYYY)</th>
<th>Year Ended (YYYY)</th>
<th>Length of time at job (yr/mon)</th>
<th>How often were you around loud noise?</th>
<th>How often did you use hearing protection while in loud noise?</th>
</tr>
</thead>
<tbody>
<tr>
<td>NON-Military</td>
<td></td>
<td></td>
<td></td>
<td>Never</td>
<td>Others</td>
</tr>
<tr>
<td>1a. Did you work in any of these types of jobs?</td>
<td></td>
<td></td>
<td></td>
<td>Several times a year</td>
<td>Some of the time</td>
</tr>
<tr>
<td>A. Automotive......No Yes</td>
<td></td>
<td></td>
<td></td>
<td>Several times a month</td>
<td>Some of the time</td>
</tr>
<tr>
<td>B. Construction...No Yes</td>
<td></td>
<td></td>
<td></td>
<td>Several times a week</td>
<td>Some of the time</td>
</tr>
<tr>
<td>C. Industrial......No Yes</td>
<td></td>
<td></td>
<td></td>
<td>Several times a day</td>
<td>Some of the time</td>
</tr>
<tr>
<td>D. Manufacturing. No Yes</td>
<td></td>
<td></td>
<td></td>
<td>Always</td>
<td>Some of the time</td>
</tr>
<tr>
<td>E. Carpentry.......No Yes</td>
<td></td>
<td></td>
<td></td>
<td>Always</td>
<td>No</td>
</tr>
<tr>
<td>F. Airport Staff....No Yes</td>
<td></td>
<td></td>
<td></td>
<td>Always</td>
<td>No</td>
</tr>
<tr>
<td>G. Agricultural/ Farming...... No Yes</td>
<td></td>
<td></td>
<td></td>
<td>Always</td>
<td>No</td>
</tr>
<tr>
<td>H. Logging/Lumber Industry....... No Yes</td>
<td></td>
<td></td>
<td></td>
<td>Always</td>
<td>No</td>
</tr>
<tr>
<td>I. Mining.............No Yes</td>
<td></td>
<td></td>
<td></td>
<td>Always</td>
<td>No</td>
</tr>
<tr>
<td>J. Printing ...........No Yes</td>
<td></td>
<td></td>
<td></td>
<td>Always</td>
<td>No</td>
</tr>
</tbody>
</table>

**Military Occupational**

Please answer each question by circling or marking the answer as indicated. If you are unsure about how to answer a question, please give the best answer you can.

<table>
<thead>
<tr>
<th>Occupational Noise during Military Service</th>
<th>Year Started (YYYY)</th>
<th>Year Ended (YYYY)</th>
<th>Length of time at job (#yrs/mon)</th>
<th>How often were you around loud noise?</th>
<th>How often did you use hearing protection?</th>
</tr>
</thead>
<tbody>
<tr>
<td>JOB TITLE 1:</td>
<td></td>
<td></td>
<td></td>
<td>Others</td>
<td>Others</td>
</tr>
<tr>
<td>Occupational Specialty Code (MOS, Ranking):</td>
<td></td>
<td></td>
<td></td>
<td>Several times a week</td>
<td>Some of the time</td>
</tr>
<tr>
<td>Were you exposed to any of the following during your time in this job?</td>
<td></td>
<td></td>
<td></td>
<td>Some of the time</td>
<td>Some of the time</td>
</tr>
<tr>
<td>A. Artillery....... No Yes</td>
<td></td>
<td></td>
<td></td>
<td>Always</td>
<td>No</td>
</tr>
<tr>
<td>B. Explosion....... No Yes</td>
<td></td>
<td></td>
<td></td>
<td>Always</td>
<td>No</td>
</tr>
<tr>
<td>C. Planes Helicopters. No Yes</td>
<td></td>
<td></td>
<td></td>
<td>Always</td>
<td>No</td>
</tr>
<tr>
<td>D. Small arms... No Yes</td>
<td></td>
<td></td>
<td></td>
<td>Always</td>
<td>No</td>
</tr>
<tr>
<td>E. Tanks, other heavy equipment... No Yes</td>
<td></td>
<td></td>
<td></td>
<td>Always</td>
<td>No</td>
</tr>
<tr>
<td>F. Aircraft carriers, ships submarines... No Yes</td>
<td></td>
<td></td>
<td></td>
<td>Always</td>
<td>No</td>
</tr>
<tr>
<td>G. Other types of noise:</td>
<td></td>
<td></td>
<td></td>
<td>Always</td>
<td>No</td>
</tr>
</tbody>
</table>
Noise induced hearing loss has the propensity to decrease sensitivity in the higher frequency range, which is consistent with these results showing that the majority of participants who had hearing loss presented it in the high or extended high frequencies. This suggests that most of those who develop hearing loss through their military service acquire it by means of noise exposure. 76% of the participants stated difficulties hearing speech or other sounds. Of those participants, 45% of them cited loud noise as the cause, and the other 55% stated that they did not know the cause, therefore it is possible that noise accounts for more than 45% of these Veterans. Also, of those participants who reported difficulties hearing, 92% of them considered it to be a mild, moderate, or very significant problem in their life; only 8% did not feel it posed a problem. Since this is a longitudinal study, in the future they can possibly determine if there is a
“delay in the onset of noise induced hearing loss related to military service” and any other effects that hearing loss may have on the Veterans over time (Gordon et al., 2017).

This study also showed a discrepancy between self-reports and testing results. The majority of participants showed hearing within normal limits, however, “27% reported a self-perceived mild/moderate hearing handicap and 14% reported a significant handicap.” Although participants in the CDC study reported their hearing as better than it actually was, people in the NOISE study appear to assume that their hearing was worse than it is in actuality. Therefore, people’s own judgement is often skewed. However, having hearing checked by a professional is always better than assuming one outcome or another. Even though the average thresholds for participants were within normal range and word recognition scores averaged better than 95% bilaterally, researchers still identified a significant number of people with some form of hearing loss in either the conventional range or the extended high frequency range, but particularly in the higher frequencies, which is characteristic of noise induced hearing loss. While the sample size of 100 participants is small and more research in this area is needed, the findings still appear notable (Gordon et al., 2017).

Survey

Sample/Method

To better understand the inner workings of the military’s handling of noise exposure, a survey was collected from several veterans of various military backgrounds, regarding their experiences. This student researcher conducted a survey in Fall 2020, to evaluate the disparity in hearing conservation/hearing readiness education between men who served in the Vietnam War, and men who have served in more recent wars. There were 15 participants, none of whom were still serving active duty. The individuals served in all branches of the military, serving in various wars/military conflicts. Many responses of willing participants were yielded through occupational and personal connections. Responses were received both through email and
traditional mail. For the purposes of privacy, the identities of all participants will remain confidential.

**Questions**

Each participant was given a set of identical questions. There were 19 open-ended questions and 10 close-ended questions (see Appendix for the questionnaire used).

**Data and Results**

Every participant in this survey reported having significantly worse hearing after leaving the service. Twelve out of fifteen participants self-reported their baseline hearing (prior to service) as either “great” or “excellent,” with the exception of three individuals who responded “good.” Two out of the fifteen participants self-reported their hearing following their military service as “great” or “excellent.”

Following their military service, ten out of the fifteen participants self-reported their hearing as either “bad” or “very bad.” Three of the participants responded “okay,” though this still shows a decline from their baseline answers of “great” and “excellent.” It should be mentioned that one of the participants who reported his hearing following the military as “okay” also reported currently requiring hearing aids. As previously established, self-reports are not always reliable, however, in this case, they are not claiming to have diagnosable hearing loss. They are simply comparing their current hearing (following military service) to their baseline hearing (before service). Anecdotally, every participant reported personally knowing multiple servicemembers who acquired hearing loss from their time in the military. In general, these cases were reported as occurring gradually as opposed to a single traumatic acoustic event.

The results of this survey did not yield enough definitive information to determine whether the amount of time in combat had any bearing on their hearing difficulties. The length of time served ranges from six months to several years, even to several decades for some. However, since all of the participants spent a minimum of six months serving, this researcher is inferring
that this is enough time to give someone hearing loss. It is also difficult to determine based on this data, whether the participants branch of service had any effect on their experience with hearing difficulties. In addition, it is very difficult to determine the percentage of hearing loss that was exacerbated or caused by recreational noise exposure. For example, eleven out of the fifteen participants did report exposure to occupational and/or recreational noise exposure since serving in the military, although they all admittedly always wore hearing protection when exposed to this noise.

In examining the differences between men who served in the Vietnam War and more recent wars/conflicts (Gulf War, Iraq, Afghanistan, Bosnia, etc.), the most notable difference was the emphasis placed on hearing protection. Men who served in Vietnam reported no requirement/enforcement of hearing protection and therefore no use of it. Men who served within the last three decades reported a completely different account. They were required in many instances to wear hearing protection: while flying or outside of an aircraft, at firing ranges, in combat conditions, although some reported that while required, it was not enforced.

Most of these men self-reported that they did wear their hearing protection when they were supposed to “always” or “most of the time,” with the exception of one individual who replied, “some of the time.” This is in sharp contrast to the men who served in Vietnam, all of which responded “never” to how often they wore hearing protection. One out of the ten men who served within the last three decades currently requires hearing aids. He felt that this was almost definitely due solely to noise exposure in the military. This participant began wearing hearing aids at the young age of 23 years, right after his deployment. Three out of the five men who served in Vietnam currently wears hearing aids. This disparity could be due to several reasons. It’s certainly possible that presbycusis has played a part in those who served in the 1960s. It’s also equally possible that the lack of hearing protection and lack of emphasis on hearing conservation within the military at that time led to higher likelihood of needing hearing aids in
the future. Whatever the reason, it can be concluded that regulated hearing protection has improved considerably since the Vietnam War.

Only one of the participants had been a part of the military Hearing Conservation Program (many were not even aware that such a program existed), however, at least four other participants reported that they were required to have their hearing tested annually although they were not a part of the program. These same five participants were also the only ones who reported being required to receive education on hearing protection and hearing conservation. Another point worth noting is that although only four participants currently use hearing amplification, eight of the participants said that a hearing professional has diagnosed them with a degree of hearing loss. This shows that the number of servicemembers with diagnosable hearing loss is potentially much larger than those who have chosen to wear hearing amplification. This doesn’t even take into account the amount of people with hearing loss who go undiagnosed because they do not receive audiologic evaluations.

Five of the participants reported filing a claim with the VA for hearing loss disability; only one of them wears hearing aids. Two of these claims were denied, two were granted, and one is still currently being reviewed. One of the claims that was denied was the participant who requires hearing aids. One possible reason for this claim being denied is the age of the participant. Since he served so long ago and age is often a contributor to hearing loss, it would have been more difficult to prove that the military was a significant factor in the hearing loss and the claim was therefore more likely to be denied. As expected, most participants who filed a claim were also those who reported having a diagnosed hearing loss. Interestingly, one of the men who filed a claim and had the claim granted, said that when he had seen a hearing professional, they never mentioned any degree of hearing loss to him. It is surprising that his claim was granted, since he is also of the age at which presbycusis could play a factor in his hearing difficulty, and he supposedly has no diagnosed hearing loss.
Comparison of Findings of Literature Review and Survey

In the survey, men from Vietnam said they were sometimes given cotton to stick in their ears as hearing protection. In the historical background it is stated that cotton soaked in paraffin was an acceptable form of protection for the time. Some men even recalled in more recent years using cigarette butts as hearing protection when nothing else was available. Some stated that, although protection was technically required under certain circumstances, it was not ever checked; sometimes it was not even provided to them in training. They admitted that many men would take off their hearing protection devices and accept the extra risk of dangerous noise exposure in order to reduce the physical threat to their lives that comes with being in combat. It is a risk-benefit analysis, and life is prioritized over hearing. Being in the field, a keen sense of hearing is crucial to be able to hear their radios and surroundings, to tell where their enemy is, or what their fellow servicemembers are trying to tell them. This could mean the difference between life and death. Heavy duty hearing protection, such as helmets and noise muffs, can be uncomfortable and interfere with their ability to do their job effectively. So even though there are requirements in place, and far more people utilize protection now than in the past, it is not a foolproof way to prevent hearing loss because it cannot be regulated and appropriately enforced. Not all people will choose to wear HPDs in the field until they are able to do so safely, without putting any extra risk on themselves or their team.

Even for those veterans who do not currently wear hearing aids, they may still need them as they age. Admittedly, although they do not use hearing aids at this time, their present hearing is poor from military service, and expect that it will only worsen with age. This becomes even more true when it is taken into account any dangerous noise levels that they will most likely be exposed to throughout the rest of their lives (i.e., loud music, power tools, target shooting, etc.); these contributors will simply exacerbate any hearing difficulties they already have.
One participant from the survey reported having been a part of the hearing conservation program. He stated that while he was never required to wear a noise dosimeter, he knew people who did. According to this participant, “We have an OSHA rep come through each workspace to create a Health Safety report that dictates who needs to be on what program (hearing conservation included); they have different members wear one [noise dosimeter] for the entire work day to measure sound levels.” Since only one of the participants was in the HC program, this researcher is unable to determine if having a record in the DOEHRS-HC had any bearing on their ability to receive a hearing loss disability award.

According to the previous study conducted by Goman, 22.7% of Americans above the age of twelve have a diagnosed hearing loss. According to the NOISE Study, whose participants also completed a questionnaire, 25% of those participants had hearing loss in the high frequency range and 42% had hearing loss in the extended high frequency range. According to this survey, approximately 50% of the participants have diagnosed hearing loss. In comparison, this number seems high. Of course, it’s important to reiterate that as with the literature review studies, self-reporting is not always accurate, and due to the small sample size of this survey, these results do not provide conclusive evidence for or against anything.

Conclusion

Summary of Data

After looking at the data and the findings of several studies, it is clear that noise-induced hearing loss is still a very real problem within the military. Though hearing protection and audiological practices have improved, the VA still spends billions of dollars each year on hearing loss claims. This is a sign that technology still has a considerable way to go, not necessarily because the hearing protection itself is not effective, but because it is only effective if worn properly. Due to the negative safety impact that wearing it could have, many servicemembers are not wearing this protection in the field.
Future Recommendations Per Findings

In theory, hearing protection should not prevent the soldiers, sailors, and airmen from hearing their surroundings, but it should protect against impulse noise and other loud decibel levels such as firearms or aircraft carriers. This is what a device such as TCAPS is designed to do. This is what they are supposed to do, but it doesn’t always work as intended. Researchers should continue spending more time developing safer hearing protection devices that are possibly more comfortable and therefore more likely to be used. It’s possible that a foolproof version of this technology does not or will never exist, but it’s worth looking into. One area of research that has been studied for decades now is use of otoprotective agents. These are pharmacological agents that can be taken prior to noise exposure, in order to reduce the damage that can be done to the ears by making the cochlea less susceptible to injury and aiming to prevent cell deaths. Among the agents being studied are magnesium supplements, certain antioxidants, glucocorticoids and anti-apoptotics. There have been clinical trials using animals as subjects, however, there are currently no FDA approved agents for hearing loss prevention (Bielefeld, 2019).

Servicemembers should not have to choose between their life and their hearing, and hearing loss should not just be “part of the territory,” or it shouldn’t have to be. Further effort in this area of study would effectively save the hearing of millions of people in the future as well as save the government billions of dollars to put towards something else.

I wouldn’t necessarily recommend for hearing protection to be checked and mandated more heavily in the field, or for any restrictions to be added. As an audiology student, I can’t in good conscience say soldiers/sailors/airmen should be neglecting their hearing protection, however, for the time being I believe they need to do whatever keeps them safe and alive, because of course life takes priority. This is why it’s so crucial that the technology continue to be studied. We seem to have come such a long way from the days of using cotton balls, paraffin,
and cigarettes, but it wasn’t really that long ago. In speaking to a family member who served more recently, he said when they didn’t readily have hearing protection their sergeant would say “quick, everyone smoke two cigarettes.”

Why is noise-induced hearing loss still so prevalent in the military today? This question is important to the community because technology will only advance so long as we continue to look at where we are and think about where we could be. We need to study the military noise experience in order to understand the problems we have and where we need to go from here.
Appendix

The following is a copy of the questionnaire used for the military noise exposure survey.

Military Noise Exposure Survey: *answer all questions to the best of your recollection; if you do not remember, please write that. Thanks for your help!!*

What branch of the military did you serve?

What was your job title/what jobs did you have?

How many years did you serve in combat?

What year did you begin and end your service?

How would you self-rate your hearing prior to being in the military?

- [ ] Very bad
- [ ] Bad
- [ ] Okay
- [ ] Good
- [ ] Great
- [ ] Excellent

What, if any, conflict(s) were you involved in?

Were you exposed to any of the following during your time in the service:

A. Artillery

- [ ] Never
Several times a year
Several times a month
Several times a week
Daily

B. Explosion
Never
Several times a year
Several times a month
Several times a week
Daily

C. Planes/Helicopters
Never
Several times a year
Several times a month
Several times a week
Daily

D. Small arms
Never
Several times a year
Several times a month
Several times a week
Daily

E. Long arms
Never
Were you part of the military’s Hearing Conservation Program?

Were you required to receive education on hearing protection use and hearing conservation?

Were you ever told to wear a noise dosimeter while in the military? (This would have been small device with a microphone, worn on the body, most likely near the ear, to measure the noise levels in your environment)

While serving, were you required to have your hearing evaluated annually?
Were you at all required to wear hearing protection? If so, under what circumstances was it required?

How often did you wear hearing protection?

- Never
- Some of the time
- Most of the time
- Always

What kind of hearing protection did you use (if you remember)? (i.e., foam earplugs, silicone/rubber ear plugs, noise muffns, Tactical Communication and Protective System (TCAPS), ear canal caps, sound attenuating helmet, other)

How would you self-rate your hearing after being in the military?

- Very bad
- Bad
- Okay
- Good
- Very good
- Excellent

Have you ever seen a hearing professional regarding hearing difficulty? Did the doctor mention you having any hearing loss?
Does you or anyone you know personally from the service currently have hearing loss? If yes, around how many people? To your knowledge, was this the result of a single traumatic event or was it a gradual change that occurred during your/their years served (leave blank if the first answer was no)? (If they served under a different branch than you, please specify which branch)

Have you ever filed a claim with the VA for hearing loss disability? If so, was it granted or denied?

Do you wear any sort of hearing amplification device? (i.e., hearing aid, cochlear implant,...) If so, at what age did you begin wearing it/them?

Are you currently or have you been regularly exposed to occupational or recreational loud noise outside of the military service? Such as?

If so, were you wearing hearing protection?
References


Selwyn, B. (2010, September 01). The use of NOISE dosimeters in the workplace. Retrieved