Traumatic Brain Injury and Tinnitus in Military Veterans and Active-Duty Service Members

By James A. Henry, PhD, Kelly Reavis, MPH, and Tara Zaugg, AuD

A traumatic brain injury (TBI) is a structural injury to the brain or the physiological disruption of brain function that results from an external force to the head. It is usually categorized as mild, moderate, or severe, with mild being synonymous with concussion. It can be caused by contact sports, motor vehicle accidents, assaults, falls, and explosions (blasts). With an estimated incidence of 2.8 million persons per year in the United States, TBI is a leading cause of death and disability.

TBI is a major concern for the U.S. Departments of Defense (DoD) and Veterans Affairs (VA). Since 2000, nearly 380,000 service members have been diagnosed with TBI. Similar to the general population, an estimated 80 to 85 percent of TBI events experienced by military service members and veterans can be classified as “mild.” Even a mild TBI, however, can be associated with long-term physical, cognitive, and emotional problems. These long-term effects may be more prevalent in service members and veterans than in the general population as a result of factors such as multiple TBI events, including military-related blasts, and comorbid post-traumatic stress disorder (PTSD).

Studies have demonstrated an association between TBI and hearing loss and tinnitus. One study found that 76 percent of a veteran sample with a history of mild TBI reported tinnitus. Tinnitus may be perceived as the lesser of many problems immediately following a TBI event. As recovery takes place, however, persistent tinnitus can become increasingly problematic. Tinnitus can be further complicated by co-occurring mental health problems.

Noise Outcomes in Servicemembers Epidemiology (NOISE) Study

Numerous studies documented associations between exposure to high-intensity noise and hearing loss and tinnitus. These studies spurred the United States Congress to direct the VA to contract with the Institute of Medicine (IOM) to clarify the associations. The IOM completed and published its study, outlining areas in which additional research was needed. One recommendation was for research to document the types and amount of noise veterans are exposed to during and following discharge from service and to study the short- and long-term effects of military noise exposure. Our research group responded to that recommendation by initiating the Noise Outcomes in Servicemembers Epidemiology (NOISE) Study in 2013.

The NOISE Study focuses on hazardous levels of sound and other military exposures, including blasts and TBI that might be associated with auditory injury. One of the main research questions being addressed is: What are risk factors for hearing loss and tinnitus in the military population? NOISE Study participants include veterans recently separated from the military (within about 2.5 years) and active-duty service members. The study has two data collection sites: the National Center for Rehabilitative Auditory Research (NCRAR), located at the VA Portland Health Care System in Portland, Oregon; and the DoD Hearing Center of Excellence (HCE), located at Joint Base San Antonio in...
San Antonio, Texas. Data collection includes a comprehensive audiolingual evaluation and 15 questionnaires. For participants with tinnitus, three additional questionnaires are administered as well as a tinnitus psychoacoustic evaluation. Participants agree to complete questionnaires every year and to return for full testing every five years.

To date, over 630 participants have enrolled in the NOISE Study. Data analyses are conducted at different times, so different numbers of participants are included in each analysis. Of the first 589 participants, 234 were active service members (69% male; mean age 35.1 years) and 355 were recently discharged veterans (88% male; mean age 34.3 years). Tinnitus was experienced by 43 percent of the service members and 66 percent of the veterans. Eighty-four percent of these participants had average hearing thresholds within normal limits (that is, 20 decibels hearing level [dB HL] or better) on a conventional audiogram (250–8,000 Hz). Average hearing thresholds were, however, 8 dB poorer at the higher frequencies (3,000–8,000 Hz) for participants with tinnitus than for those without tinnitus.

**Associations Between TBI and Auditory Injuries**

Analyses were conducted to examine the associations between self-reported TBI and hearing and tinnitus among our veteran sample. We found that veterans with two or more TBIs were nearly six times more likely to report tinnitus. The combined effects of TBI and self-reported PTSD on tinnitus were also analyzed. Veterans with both TBI and PTSD were almost seven times more likely to report tinnitus compared to veterans with neither TBI nor PTSD.

We found that TBI was also associated with more severe tinnitus effects on a range of activities assessed using the Tinnitus Functional Index. For example, compared to veterans with no TBI, veterans with blast-related TBI were 4.0 times more likely to report severe tinnitus problems. Chronic tinnitus can lead to anxiety, depression, sleep disorders, and other troubling comorbidities related to a decreased quality of life. Chronic tinnitus is usually a permanent condition, and affected individuals must learn how to manage its functional effects for a lifetime.

**Providing Tinnitus Services for Individuals with TBI**

Research at the NCRAR has focused on developing effective methods of tinnitus management for veterans with bothersome tinnitus. These efforts led to the development of Progressive Tinnitus Management (PTM), a program that involves educational counseling to assist patients in learning effective coping strategies for tinnitus. The NOISE Study revealed that 82 percent of veterans with a history of TBI reported tinnitus when they were enrolled in the study (58% of those without TBI also reported tinnitus). Because of this high prevalence of tinnitus in veterans who had experienced TBI, we explored the feasibility of providing PTM via telehealth to veterans with TBI to improve access to care for this vulnerable population.

Home-based telehealth refers to the provision of healthcare services remotely to patients in their home environment and is an appropriate option for chronic conditions when in-person appointments may not be necessary. The evidence base supporting its use continues to grow. Bell et al conducted a trial to measure the effectiveness of telephone counseling for people with...
The telephone counseling resulted in improved overall outcomes when compared with usual outpatient care; the trial’s findings supported the idea of conducting home-based tinnitus management for veterans and military personnel with TBI.

We completed a pilot study to develop and test the feasibility and potential efficacy of a telephone-based tinnitus-management approach for veterans and military personnel with TBI who also reported bothersome tinnitus. The telephone intervention used the PTM counseling, which includes cognitive behavioral therapy (CBT). The counseling was administered to veterans and nonveterans who were grouped with respect to TBI: mild TBI, moderate to severe TBI, and no TBI. All three groups showed similar improvement in mean outcome scores, resulting in moderate to large effect sizes.

The telephone PTM (Tele-PTM) used in the pilot study was modified slightly, and a randomized controlled trial (RCT) to evaluate its efficacy was completed with 205 individuals (both veterans and nonveterans) with bothersome tinnitus located anywhere in the United States. Enrollment of individuals with a history of TBI was prioritized. Participants were randomized to either Tele-PTM intervention or 6-month wait-list control (WLC). The Tele-PTM intervention involved five telephone appointments—two led by an audiologist (teaching how to use sound to improve comfort with tinnitus) and three by a psychologist (teaching CBT-based coping skills). The lack of face-to-face contact with Tele-PTM did not preclude positive outcomes, with overall results showing convincingly that the Tele-PTM group had significantly better outcomes than the WLC group. Most notably, the Tele-PTM group had a mean reduction in TFI score (indicating improvement) of 21 points, compared to a 1-point reduction for the WLC group. Results were consistent across all outcome measures, indicating not only a reduction of tinnitus functional distress but also increased self-efficacy in managing reactions to tinnitus. Improvements in measures of anxiety and depression were also observed. Participants in all TBI categories showed significant improvement. The telephone counselors were able to establish good rapport with the participants, who often commented that the intervention was positive and beneficial.

Conclusions
TBI has become a particularly prevalent problem for military service members and veterans over the past two decades. However, these injuries are common in all populations, and tinnitus is often a side effect of TBI. We are conducting studies both to determine the extent of the problem of having both TBI and bothersome tinnitus and to provide effective care. The association between TBI and tinnitus is clear, although it is unknown exactly how TBI causes tinnitus. Many labs are conducting research to discover the mechanisms of tinnitus, including tinnitus associated with TBI. Over time, we will gain an understanding of these mechanisms, which should lead to treatments directed toward curing the underlying cause. In the meantime, results of our Tele-PTM studies provide strong support for use of that methodology nationwide to improve quality of life for persons with bothersome tinnitus, regardless of whether the person also has TBI symptoms.

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effectively helping individuals who are afflicted with bothersome tinnitus, and to increase accessibility to evidence-based tinnitus care.

Kelly Reavis, MPH, MS, CCC-A, is a licensed audiologist with over 15 years of auditory research experience at the Department of Veterans Affairs, Rehabilitation Research & Development, National Center for Rehabilitative Auditory Research (NCRAR) located at the VA Portland Health Care System. She is also a fourth-year PhD student in epidemiology at Oregon Health & Science University. Her research interests include reducing the prevalence and impact of hearing loss and tinnitus, particularly among aging and veteran populations.

Tara Zaugg is a certified, licensed, and clinically privileged research audiologist employed at the National Center for Rehabilitative Auditory Research (NCRAR) located at the Department of Veterans Affairs Portland Health Care System. Through involvement in tinnitus clinical trials over the last 18 years, she has acquired extensive experience with tinnitus assessment and management methods. She also teaches audiologists to implement tinnitus management methods. She co-developed Progressive Tinnitus Management (PTM), which is endorsed by the Department of Veterans Affairs Central Office as the standard method of tinnitus management for VA hospitals. Dr. Zaugg strives to understand the perspective of clinicians and patients using PTM, and to incorporate their needs and insights into PTM as it evolves.


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