Research Article

Incidence Rates of Tinnitus in Active Duty Military Service Members Between 2001 and 2015

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Purpose: Due to hazards in the contemporary operating environment, U.S. military service members are at increased risk for tinnitus. Previous research has characterized tinnitus prevalence in military veterans, but no population-based study of tinnitus has been conducted in active duty military service members. This study evaluated the incidence of tinnitus diagnoses in military electronic health records based on International Classification of Diseases, 9th Revision (ICD-9) codes for active duty service members between 2001 and 2015.

Method: Data on 85,438 active duty military service members who served between 2001 and 2015 were drawn from the Defense Medical Epidemiological Database and stratified by race, age, sex, marital status, service branch, and military pay grade.

Results: The incidence rate of tinnitus in U.S. military service members (per 1,000) rose consistently from 1.84 in 2001 to

6.33 in 2015. Service members most often diagnosed with tinnitus were White (72%), married (72%), males (88%), in the enlisted pay grade of E-5 to E-9 (55%), in the Army (37%), and were 35 years of age or older (50%). Statistically significant differences ($p < .001$) were found between observed and expected counts across all 6 demographic variables.

Conclusions: This is the first study to assess the incidence rates of tinnitus in active duty service members. Although there are many risk factors for auditory damage in the contemporary military operating environment, the extant literature on tinnitus in active duty military service members is limited. Future studies should consider the relationship between tinnitus-related psychological comorbidity and objective health-related quality of life, as it impacts operational readiness in active duty military service members.

Tinnitus is defined as a “phantom auditory perception,” perceived in one or both ears, that occurs without any objective noise source (Hazell & Jastreboff, 1990).

Types of sounds experienced by those with chronic tinnitus include ringing, buzzing, hissing, rushing sounds, or a combination of sounds (Moring, Bowen, Thomas, & Bira, 2016) and varies across individuals in terms of intensity, frequency, and duration (Unterrainer, Greimel, Leibetseder, & Koller, 2003). Chronic tinnitus occurs in 3%–14% of the civilian population (Shargorodsky, Curhan, & Farwell, 2010) and is defined as tinnitus that persists for at least 3 months (Hoffman & Reed, 2004). Recent findings indicate chronic

tinnitus may impact cognitive functioning and emotional well-being (Tegg-Quinn, Bennett, Eikelboom, & Baguley, 2016; Trevis, McLachlan, & Wilson, 2018).

Despite the relative prevalence of tinnitus in the civilian population, the risk for developing tinnitus is significantly greater for individuals who have served in the military (Groenewold, Tak, & Masterson, 2011). Many military occupational specialties may involve proximity to extremely loud noise (Ahroon, Hill, & Goodes, 2011) that can cause acoustic trauma and promote the genesis of tinnitus. Acoustic trauma is a subcategory of noise-induced hearing loss that often occurs following the exposure to impulse noises (e.g., discharging weapons; Rezaee, Mojtahed, Ghasemi, & Saedi, 2012). Impulse noise, and thereby acoustic trauma, is especially prevalent in the military (Grantham, 2012) and may result from training experiences (e.g., discharging weapons; Beach, Gilliver, & Williams, 2013; Grantham, 2012; Rezaee et al., 2012), working near loud engines (e.g., jet engines or aircraft carriers; Smalt, Lacirignola, Davis, Calamia, & Collins, 2017), playing musical instruments (Smith, Beamer, Hall, Helfer, & Kluchinsky, 2015), or combat operations (e.g., improvised explosive devices, mortar

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attacks, or rocket-propelled grenades; Moring, Peterson, & Kanzler, 2018). The scenarios discussed above present examples of noise exposure that service members may experience, but it is certainly not an exhaustive list of occurrences that may result in acoustic trauma.

We posit that acoustic trauma should be considered in conjunction with extant safety guidelines (e.g., Occupational Safety and Health Administration, 2011) and consistent with recommendations by Ward (1988) that acoustic trauma should also be considered based on the extent to which it may potentially result in auditory or extra-auditory damage (e.g., issue with speech discrimination, inflammation, earache, or dizziness; Rezaee et al., 2012). It should be noted that not every service member who is exposed to acoustic trauma or noise hazards will develop tinnitus. For example, Cave, Cornish, and Chandler (2007) found only 49% of Army personnel who reported deployment-related blast exposure also reported tinnitus. Similarly, not all service members with tinnitus will present with a history of acoustic trauma. For example, tinnitus is known to occur in the absence of noise exposure (e.g., due to migraine; Chen, Hsu, Chen, & Yin, 2019).

The contemporary operating environment in which active duty service members live and work is inundated with noise hazards that may result in exposure to acoustic trauma. Consequently, this has contributed to an environment wherein tinnitus has become significantly more problematic, intrusive, and debilitating. Debilitating tinnitus may be conceptualized as tinnitus that is strong enough to cause a reaction in individuals, to the point of impacting ordinary functioning (e.g., experiencing poor sleep, an inability to concentrate, or chronic depression and anxiety; Colucci, 2014). Debilitating tinnitus is likely uncommon as only a minority of the population with tinnitus experience cognitive, psychological, and behavioral problems that result in functional impairment (Andersson, Eriksson, Lundh, & Lyttkens, 2000; Briner, 1995; Hesse, Laubert, Schaaf, & Almeling, 2006; Kaldo et al., 2008; Sood & Coles, 1998) and reduced quality of life (Eggermont & Roberts, 2004). For those with debilitating tinnitus, however, it may present with very serious comorbidities (e.g., depression, anxiety, or insomnia; McCormack, Edmondson-Jones, Somerset, & Hall, 2016) that impact the individual service member's ability to perform specific duties (Grantham, 2012).

At the present time, little research has focused on the prevalence and incidence of tinnitus among active duty military. One such study found that over 30% of Army active duty, Reserve, and National Guard members who visited a military audiology clinic from April 2003 to March 2004 had a postdeployment-related diagnosis of tinnitus (Helfer, Jordan, & Lee, 2005). However, this study is limited as the sample was restricted to treatment-seeking U.S. Army personnel, within a single year. A more recent study conducted by Cave et al. (2007) identified a 49% prevalence rate of tinnitus. Similarly, their study was limited, namely, in sample size, but also in that it only examined Army personnel who reported blast exposure. Finally, in the extant literature, many studies on tinnitus incidence and prevalence rates have

focused on the veteran population (e.g., Swan et al., 2017; Theodoroff et al., 2015), or have examined tinnitus within the context of an injury, such as a traumatic brain injury (e.g., Karch et al., 2016), or blast injuries (e.g., Dougherty et al., 2013).

At the present time, there is inconsistency across the broader literature with regard to defining and reporting tinnitus rates (McCormack et al., 2016). Due to the lack of a readily available, objective, diagnostic measure, considerable difficulty exists for clinicians when they are required to objectively quantify and capture the severity of individual tinnitus symptoms (Kostek & Poremski, 2013; McCormack et al., 2016; Yankaskas, 2013). When considered together, these shortcomings may contribute to unreliable estimates of tinnitus incidence, and thereby unintentional misallocation of resources that could be used to enhance tinnitus treatments or hearing conservation programs.

The available scientific literature is unclear as to whether tinnitus incidence has increased over time and whether the incidence rate varies across members of different branches or even by demographics within branches. Therefore, the primary objective of this study was to examine the incidence rates of tinnitus in active duty U.S. military service members between 2001 and 2015 and establish a comparative cohort from which future research involving incidence and prevalence of tinnitus diagnoses may be conducted. Additional objectives were to evaluate differences across service branches and to determine how various demographic factors relate to tinnitus diagnoses. We hypothesized that, due to predeployment training requirements (e.g., weapons qualifications and participation in live fire exercises) and the subsequent exposure to military and combat-related acoustic traumas, there would be an increase in first-time tinnitus diagnoses over the course of the study period.

Method

To determine tinnitus incidence rates within the U.S. military, we analyzed data stored in the Defense Medical Epidemiological Database (DMED). The DMED is a subset of the Defense Medical Surveillance System and records count data of medical conditions in active duty military service members. All data stored within the DMED is validated by Department of Defense medical records and is retrievable by International Classification of Diseases, 9th Revision (ICD-9) codes. The DMED documents medical events that are identified whenever a service member has had a medical concern noted by a physician or other provider in their electronic medical record (i.e., during a primary care visit, at a hearing clinic, when seen by a physician assistant at the unit level, or when seen in an emergency room). The DMED extracts and collates ICDs from the various service branches' electronic medical records and then de-identifies and stratifies diagnoses by service branch (i.e., Army, Navy, Air Force, Marine Corps), sex (i.e., male/female), age, military pay grade (i.e., enlisted/officer pay grades), marital status (i.e., married, single, or other), and race (i.e., White, Black, or other). Additionally, the DMED allows

researchers to examine data by two categories: (a) the first time a service member received a diagnosis of a disorder (true incidence) and (b) all visits in which an ICD was entered into the electronic medical record systems database.

Primary tinnitus diagnosis data were accessed on April 10, 2018, and was filtered for initial diagnoses of tinnitus (ICD-9-388.3). So as to avoid overestimation of incidence, we assessed tinnitus incidence by available demographics (i.e., sex, marital status, branch of service, age, military pay grade, and race) only when it was input into a service member's electronic medical record for the first time.

Data drawn from the DMED only pertain to active duty military service members and are available as group-level count data, which allows for comparisons only at the population level. Therefore, one-sample chi-square goodness of fit tests were conducted to assess which demographic subgroups were over- or underrepresented with tinnitus diagnoses relative to their respective representation across the various demographics available with the DMED. The one-sample chi-square test was used to determine whether the distribution of cases in a single categorical variable (e.g., new onset tinnitus cases by pay grade) follows a known or hypothesized distribution (e.g., pay grade distribution in the military). Significance of the one-sample chi-square goodness of fit test indicates that the observed proportions differ significantly from those in the known or hypothesized distributions.

The expected counts of diagnoses for each military composition variable were provided with the DMED data at the time of data extraction. Expected counts are based simply on the averaged percentage of service members represented in a given variable over the course of this study. For instance, when extracting data, we observed that service members less than 20 years of age account for only 6% of the total active population; therefore, we expected them to account for 6% of all tinnitus diagnoses over the course of this study. Based on DMED data, the mean population of service members each year was calculated to be 1,381,244 service members, with a low of 1,302,810 in 2015 and a high of 1,418,896 in 2010. All demographic variables in this article were reported and analyzed based on the cohort groupings by which they are stored in the DMED (i.e., race: White, Black, or other). The present project evaluated data from 2001 to 2015 as these data are the most representative of the current state of tinnitus incidence in the active force. The present project was reviewed by the institutional review board at the University of Texas Health Science Center at San Antonio and was deemed to be not human research (protocol number: HSC20190245N).

Results

Between 2001 and 2015, the incidence rates of tinnitus (per 1,000 service members) in the U.S. military ranged between 1.84 in 2001 and 6.33 in 2015 (see Figure 1). Analysis of these data with one-sample chi-square tests indicated that the observed and expected frequencies differed significantly for all six demographic variables. In the present sample, those most often diagnosed with tinnitus (see Table 1) were

White (72%), married (72%), males (88%), in the enlisted pay grade of E-5 to E-9 (noncommissioned officers; 55%), in the Army (37%), and age 35 years or older (50%). Figure 2 shows the initial diagnoses of tinnitus in active duty military males and females between 2001 and 2015. The observed distribution of sex (see Figure 2) in the new onset cases differed from that expected when considering the ratio of males to females in the military, $\chi^2(1, 85,438) = 721.09$, $p < .001$. Specifically, males comprise approximately 85% of the service members in the United States, but accounted for 88% of all diagnosed cases, presenting with approximately 4% (observed versus expected [O/E] = 1.04) more cases observed ($n = 75,425$) than expected ($n = 72,622$). Conversely, females comprise approximately 15% of the service members in the U.S. military but only account for 12% of all diagnosed cases, presenting with approximately 22% fewer (O/E = 0.78) observed cases ($n = 10,013$) than expected ($n = 12,815$).

A significant chi-square was also found for pay grade (see Figure 3), $\chi^2(3, 85,438) = 19,189.05$, $p < .001$. Figure 3 shows the initial diagnoses of tinnitus in active duty service members by pay grade between 2001 and 2015. Senior commissioned officers (O-4/CW4 to O-6/CW5) comprise only 6% of the service members in the U.S. military but accounted for 13% of the diagnoses, presenting with 110% (O/E = 2.10) more observed cases ($n = 10,787$) than expected ($n = 5,126$). Likewise, noncommissioned officers (E-5 to E-9) comprise 40% of the service members in the U.S. military but accounted for 55% of the total diagnoses, presenting with 39% (O/E = 1.39) more observed cases of tinnitus ($n = 47,364$) than expected ($n = 34,174$). Junior commissioned officers (O-1/WO1 to O-3/CW3) and junior enlisted service members (E-1 to E-4) comprise a combined 54% of U.S. military service members but only accounted for 32% of all diagnosed cases (O/E = 0.71 and 0.57, respectively). Junior commissioned officers and junior enlisted service members presented with fewer cases observed ($n = 6,058$ and $n = 21,227$, respectively) than expected ($n = 8,543$ and $n = 37,591$, respectively).

Figure 4 shows the initial diagnoses of tinnitus in active duty service members by service branch between 2001 and 2015. Similar significant differences in incidence were found between different military service branches for new cases of tinnitus using chi-square analyses, $\chi^2(3, 85,438) = 32,539.91$, $p < .001$. Service members in the Air Force comprise 25% of the overall U.S. military but accounted for 32% of the total diagnosed cases (O/E = 1.3), presenting with more observed cases of tinnitus ($n = 27,439$) than expected ($n = 21,148$). Service members in the Army comprise approximately 37% of the overall U.S. military and presented (O/E = 1.01) with nearly as many observed cases ($n = 31,684$) as would be expected ($n = 31,299$). Service members in the Marine Corps and Navy comprise approximately 38% of the U.S. military but only accounted for 31% of the total diagnosed cases (O/Es = 0.84 and 0.78, respectively). Both the Marine Corps and Navy were underrepresented in the observed instances of tinnitus ($n = 9,898$ and 16,417, respectively) relative to their expected values ($n = 11,843$ and 21,148,

Figure 1. Incidence rates of tinnitus diagnoses from 2001 to 2015 ($N = 85,438$) are represented by percentage of cases per 1,000 service members. The number of participants represented by each data point on the graph ranges from 2,517 to 8,610 new diagnoses per year. Callouts represent incidence of new diagnoses by year by percentage based on the overall representation in the active duty military.

respectively). Significant differences in incidence also existed for race (see Figure 5), $\chi^2(2, 85,438) = 1,296.69, p < .001$.

Figure 5 shows the initial diagnoses of tinnitus in active duty service members by race between 2001 and 2015. White service members comprise approximately 69% of the active force but accounted for 72% of all diagnosed cases, presenting with 6% ($O/E = 1.06$) more new cases of tinnitus ($n = 61,589$) than expected ($n = 58,369$). Black service members comprise 18% of the active force, but accounted for only 13% of all diagnoses, presenting with 26% ($O/E = 0.74$) fewer observed cases ($n = 11,201$) than expected ($n = 15,227$). Other minority service members comprise approximately 14% of the active force but accounted for 15% of all diagnosed cases, presenting with 7% more observed cases ($n = 12,648$) than expected ($n = 11,843$).

The distribution of new cases within each marital status grouping also significantly differed from expected values, $\chi^2(1, 85,438) = 4,947.83, p < .001$. Figure 6 depicts the initial diagnoses of tinnitus in active duty service members by marital status between 2001 and 2015. Married service members comprise 55% of service members but accounted for 72% of all diagnosed cases, presenting with 30% ($O/E = 1.30$) more diagnosed cases ($n = 61,204$) than expected ($n = 46,991$). Nonmarried service members comprise approximately 45% of service members, but accounted for only 28% of all diagnosed cases, presenting with 37% ($O/E = 0.63$) fewer observed cases ($n = 24,234$) than expected ($n = 38,447$).

Finally, the distribution of new cases by age was found to significantly differ from expected distributions,

$\chi^2(5, 85,438) = 52,808.22, p < .001$. Figure 7 shows the initial diagnoses of tinnitus in active duty service members by age group between 2001 and 2015. Service members under the age of 35 years comprise 78% of all service members but accounted for only 49% of all diagnosed cases. Service members under the age of 35 years presented with fewer observed cases than expected (ages < 20 $O/E = 0.20$; observed $n = 1,189$; expected $n = 5,921$; ages 20–24 $O/E = 0.54$; observed $n = 15,016$; expected $n = 27,914$; ages 25–29 $O/E = 0.79$; observed $n = 15,412$; expected $n = 19,455$, ages 30–34 $O/E = 0.84$; observed $n = 10,609$; expected $n = 12,688$). Conversely, service members between the ages of 35–39 years presented comprise only 12% of all service members but account for 17% of all diagnosed cases, presenting with 44% ($O/E = 1.44$) more observed cases ($n = 14,634$) than expected ($n = 10,151$). Service members aged 40 years or above comprise only 10% of all service members but accounted for 33% of all diagnosed cases, presenting with 207% ($O/E = 3.07$) more observed cases ($n = 28,574$) than expected ($n = 9,305$).

Discussion

This study provides a comprehensive characterization of incidence rates of tinnitus as it pertains to active duty U.S. military service members. Overall, we found similarities between the demographics of active duty service members newly diagnosed with tinnitus and veteran populations with tinnitus (see Theodoroff, Lewis, Folmer, Henry, & Carlson, 2015). The results from this study indicated that

Table 1. Demographics (*N* = 85,438).

Demographic	Military composition (%)	Tinnitus representation (%)	Tinnitus cases (<i>n</i>)	Observed versus expected counts	χ^2
Gender***					
Male ^a	85	88	75,425	4% (1.04)	χ^2 (1, 85,438) = 721.09, <i>p</i> < .001
Female ^b	15	12	10,013	−22% (0.78)	
Age, years***					
< 20 ^b	7	1	1,189	−80% (0.20)	χ^2 (5, 85,438) = 52,808.22, <i>p</i> < .001
20–24 ^b	33	18	15,016	−46% (0.54)	
25–29 ^b	23	18	15,412	−21% (0.79)	
30–34 ^b	15	12	10,609	−16% (0.84)	
35–39 ^a	12	17	14,634	44% (1.44)	
40+ ^a	10	33	28,574	207% (3.07)	
Marital status***					
Married ^a	55	72	61,204	30% (1.30)	χ^2 (1, 85,438) = 4,947.83, <i>p</i> < .001
Other ^b	45	28	24,234	−37% (0.63)	
Race/ethnicity***					
White ^a	69	72	61,589	6% (1.06)	χ^2 (2, 85,438) = 1,296.69, <i>p</i> < .001
Black ^b	18	13	11,201	−26% (0.74)	
Other ^b	14	15	12,648	7% (1.07)	
Service branch***					
Army	37	37	31,684	1% (1.01)	χ^2 (3, 85,438) = 32,539.91, <i>p</i> < .001
Air Force ^a	25	32	27,439	30% (1.30)	
Navy ^b	25	19	16,417	−22% (0.78)	
Marine Corps ^b	14	12	9,898	−16% (0.84)	
Military pay grade***					
E-1 to E-4 ^b	43	25	21,227	−43% (0.57)	χ^2 (3, 85,438) = 19,189.05, <i>p</i> < .001
E-5 to E-9 ^a	40	55	47,364	39% (1.39)	
O-1 (WO1) to O-3 (CW3) ^b	10	7	6,058	−29% (0.71)	
O-4 (CW4) to O-6 (CW5) ^a	7	13	10,787	110% (2.10)	

Note. Military composition percentages provided by the Defense Medical Epidemiological Database.

^aDenotes more cases than expected. ^bDenotes fewer cases than expected. Observed versus expected counts represent the percentage of representation of cases ($[(O/E \times 100) - 100]$ in relation to the expected percentage of cases, by demographic.

***Indicates demographic significance at *p* < .001.

Figure 2. Tinnitus diagnoses from 2001 to 2015 (*N* = 85,438). The number of participants represented by each data point on the graph ranges from 277 to 7,656 new diagnoses per year.

Figure 3. Tinnitus diagnoses from 2001 to 2015 ($N = 85,438$). The number of participants represented by each data point on the graph ranges from 183 to 4,597 new diagnoses per year.

Figure 4. Tinnitus diagnoses from 2001 to 2015 ($N = 85,438$). The number of participants represented by each data point on the graph ranges from 116 to 3,565 new diagnoses per year.

Figure 5. Tinnitus diagnoses from 2001 to 2015 ($N = 85,438$). The number of participants represented by each data point on the graph ranges from 298 to 6,229 new diagnoses per year.

Figure 6. Tinnitus diagnoses from 2001 to 2015 ($N = 85,438$). The number of participants represented by each data point on the graph ranges from 732 to 6,171 new diagnoses per year.

Figure 7. Tinnitus diagnoses from 2001 to 2015 ($N = 85,438$). The number of participants represented by each data point on the graph ranges from 56 to 2,662 new diagnoses per year.

the incidence rates of tinnitus (per 1,000) steadily increased among active duty military service members from 1.84 in 2001 to 6.33 in 2015. The incidence rates recorded in the final few years of this study (e.g., 2012 to 2015) are also very similar to the previously noted prevalence rates in veterans with only tinnitus (6.54%) and veterans with tinnitus and hearing loss (6.24%; Swan et al., 2017).

Tinnitus diagnoses by age provided a particularly interesting finding, as we noted a sharp increase in diagnoses starting at the age of 35 years, rather than exclusively in those 40 years of age or older. This study did, however, extend the validity of previous findings that showed service members aged 40 years or more were at twice the risk of those aged between 35 and 39 years (Helfer, Canham-Chervak, Canada, & Mitchener, 2010). This study found that though both age categories (i.e., 35–39, 40+) represent a combined 22% of the service members on active duty, they account for a combined total of 50% of all diagnoses. Namely, the service members who are 40 years of age or older accounted for 33% of the total diagnoses whereas service members aged 35–39 years accounted for 17% of all diagnoses.

Despite accounting for the majority of service members and tinnitus diagnoses overall, active duty service members in the Army had approximately as many tinnitus diagnoses as expected. As noted in Figure 4, there was an overall increase in the incidence of tinnitus in Army personnel over the course of this study. Swan et al. (2017) note that increases in diagnoses may be due to the expanded enrollment in

hearing programs across the Army and Marine Corps during this time, rather than due to the additive effects of increased combat and training exposure over the past 18 years of constant military operations. It is likely that there is validity in both possibilities. If we consider both possibilities, however, we would expect to have found similar incidence levels of tinnitus in service members in the Marine Corps. Instead, we found that service members in both the Marine Corps and Navy were each underrepresented by nearly 20%. Conversely, despite representing a small cross-section (25%) of the military, the Air Force presented with the most significant deviations from expected norms in that they represented 32% of all tinnitus diagnoses over the course of this study period.

The high rates of tinnitus in the Air Force is surprising as it has been estimated that only 20% of Air Force personnel are likely to encounter hazardous noise routinely (Soderlund, McKenna, Tastad, & Paul, 2016). It seems plausible that a significant number of individuals in the Air Force with a tinnitus diagnosis may be experiencing tinnitus due to secondary issues such as migraine (Moore et al., 2019) or traumatic brain injury (Moring et al., 2018). Conversely, it is also possible that Air Force physicians are simply more attuned to issues related to hearing. This hypothesis is not entirely ungrounded; as recent research has found, the Air Force reported the highest percentage of hearing injuries between 2009 and 2013 (Smith et al., 2015). Additional research is needed to help determine factors that may account

for these service branch differences. Considering the potential for comorbid tinnitus and behavioral health concerns, tinnitus among Air Force personnel, in particular, may warrant additional consideration, research, and strategies to reduce exposure to acoustic trauma and comorbid concerns.

When considering the interplay of sex and tinnitus diagnoses, we found that male service members presented with approximately 4% more cases diagnosed than expected, whereas female service members presented with approximately 22% fewer newly diagnosed cases. This finding supports the broader literature. For example, a recently published meta-analysis found that 80% ($k = 16$) of their examined studies reported a higher prevalence of tinnitus in males (McCormack et al., 2016). Interestingly, however, when McCormack et al. (2016) examined tinnitus severity, they did not find a difference between sexes. At the time the current data were collected, females were not authorized to serve in a combat-related military occupational specialty. With consideration to the recent policy shifts in the U.S. military, wherein females are now able to serve in combat arms roles, the future incidence and prevalence rates of tinnitus in female military service members may become similar to the rate observed in male service members. This highlights a potential inconsistency that would be beneficial for future studies to examine. Unfortunately, such a study is currently beyond the scope of the DMED database.

There are a number of limitations to the current study, and results should be interpreted with caution. As a retrospective study, the accuracy of these data is dependent on proper diagnoses being entered into a patient's medical record. Although all data in this study were drawn from military electronic medical records, previous research conducted in the Defense Occupational and Environmental Health Readiness System–Hearing Conservation (DOEHRS-HC) shows that many individual's Department of Defense–mandated annual hearing exam outcomes sometimes do not transfer into other systems (Nelson, Swan, Swiger, Packer, & Pugh, 2016). It is possible that a similar situation may exist for this study, wherein some cases of tinnitus were not effectively captured by the DMED. Additionally, the data were cross-sectional and did not allow us to explore the incidence of chronic or debilitating tinnitus nor were we able to include any information on the etiology of the tinnitus such as acoustic trauma or head trauma. The nature of the DMED database also did not allow for an evaluation of incidence rates of tinnitus by military occupational specialties. We were also unable to extrapolate the potential military operational readiness impact of the tinnitus. Furthermore, it should also be noted that statistically significant results may not have clinical significance. For instance, we found that married service members were more likely to have tinnitus relative to single service members. This finding is likely a function of age, as older service members are also more likely to be married.

Despite its limitations, this study also has a number of strengths. It has established a representative sample of tinnitus incidence in active duty U.S. military service members and provides a comparison sample for future research.

Additionally, each service member who received a diagnosis of tinnitus was seen by a medical professional while serving on active duty in the military. We have also identified the groups of active duty service members most at risk of receiving a diagnosis of tinnitus and those who are potentially at risk of developing chronic tinnitus. In 2011, Ahroon et al. recommended that current hearing conservation standards in the Army should not be relaxed, and we echo that recommendation and extend it to include the hearing conservation measures used across the total force. We also suggest that the data presented in this study be considered as the Department of Defense shapes their hearing conservation programs in the coming years. We contend this is especially important for service members in the Air Force as well as those 35 years of age and older. Though it is beyond the scope of this study, we recommend that researchers interested in a well-described overview of military hearing conservation programs and policies review the recent article by Grantham (2012).

Though we know there are many risk factors for auditory damage in the contemporary operating environment, the extant literature on tinnitus is limited in the active force. To the best of our knowledge, this is the first study to assess the incidence rates of tinnitus among active duty service members across all branches. Given the increasing tinnitus incidence rates in active duty military service members, there is concern about not only the limited treatment options but also impacts on operational readiness and service members' health-related quality of life (Yankaskas, 2013). Currently, there is no cure for tinnitus (Trevis et al., 2018) and existing therapeutic options only aim to alleviate the emotional distress associated with tinnitus (Hesser, Weise, Westin, & Anderson, 2011). Future studies should consider the relationship between tinnitus severity and the perceived impact of tinnitus on a service member's ability to hear and function in dynamic environments.

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