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Frequency, Demographics, Comorbidities, and Health Care Utilization by Veterans With Migraine: A VA Nationwide Cohort Study

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Abstract

Objective: To describe the relative frequency, demographics, comorbidities, and healthcare utilization of veterans who receive migraine care at the Veteran's Health Administration (VHA) and to evaluate differences by gender.

Methods: This study extracted data from VHA administrative sources. Veterans diagnosed with migraine by a healthcare provider between fiscal year 2008-2019 were included. Demographics and military exposures were extracted at cohort entry. Comorbidities were extracted within 18 months of the first migraine diagnosis. Health care utilization and headache comorbidities were extracted across the study period. Differences between men and women were evaluated using chi-square tests and student t-tests.

Results: More than half a million (n = 567,121) veterans were diagnosed with migraine during the 12-year study period, accounting for 5.3% of the 10.8 million veterans served in the VHA; in the most recent year of the study period (2019), the annual incidence and one-year period prevalence of medically diagnosed migraine was 2.7% and 13.0% for women, and 0.7% and 2.5% for men. In the total cohort diagnosed with migraine, 27.8% were women and 72.2% men. Among those with diagnosed migraine, a higher proportion of men vs. women also had a TBI diagnosis (3.9% vs. 1.1%; *p < 0.001*). A higher proportion of women vs. men reported military sexual trauma (35.5% vs. 3.5%; *p < 0.001*). Participants with diagnosed migraine had an average of 1.44 (SD 1.73) annual encounters for headache. Primary care was the most common headache care setting (88.1%); almost one-fifth of veterans with diagnosed migraine sought care in the ED at least once during the study period. Common comorbidities were overweight/obesity (80.3%), non-headache pain disorders (61.7%), and mental health disorders (48.8%).

Conclusions: Migraine is commonly treated in the VHA setting, but likely under ascertained. Most people treated for migraine in the VHA are men. Pain comorbidities and psychiatric disorders are common. Future research should identify methods to improve diagnosis and treatment and to reduce use of the emergency department.

Introduction

Migraine is common in adults, with a one-year period prevalence of 6-10% in men and 18-21% in women in the United States (US).[1-3] Migraine is particularly burdensome with a greater prevalence during mid-life years when productivity is highest.[1, 4] Migraine is associated with higher healthcare utilization and direct medical costs compared to age, gender, and comorbidity-matched controls.[5-6] Improving migraine care quality could improve quality of life for a large number of people with migraine.[7-9]

The Veteran's Health Administration (VHA) is the largest integrated health care system in the US.[10] The VHA serves roughly 9 million veterans annually across 171 medical centers and 1,112 outpatient clinics throughout the US. Understanding the characteristics of veterans with migraine presenting to the VHA is the first step towards identifying gaps and improving quality of care.[6,11] The majority of patients by the VHA are men (90.4% in 2017)[10] providing a unique opportunity to better understand migraine in men.[12] Further, the VHA gives us an opportunity to evaluate service-related exposures (e.g., traumatic brain injury [TBI], the "signature injury" of the recent conflicts in Iraq and Afghanistan (Operation Enduring Freedom/Operation Iraqi Freedom/Operation New Dawn; OEF/OIF/OND),[13] and military sexual trauma[14]) that could contribute to the development and course of migraine.[15-19]

The current cohort study describes the annual incidence and one-year prevalence of medically diagnosed migraine in the VHA, as well as the demographics, comorbidities and healthcare utilization of veterans with medically diagnosed migraine by gender.

Methods

Study Design

This cohort study evaluated differences in demographics, comorbidities and healthcare utilization among men and women who presented to any VHA facility with migraine diagnosed by a healthcare provider during fiscal year (FY) 2008-2019 (corresponding to October 1, 2007—September 30, 2019).

Participants and Procedures

This study used the VHA Headache Centers of Excellence (HCoE) Administrative Data Headache Cohort, which at the time of the data pull included all veterans with at least one outpatient visit in the VHA for a headache diagnosis from FY 2008-2019. We selected FY 2008 to coincide with establishment of national TBI screening in VHA. A

validated algorithm which was previously used to identify veterans with specific conditions was adapted to identified veterans with headache disorders diagnosed with an *International Classification of Diseases Clinical Modification* (*ICD-CM*) code by a VHA healthcare provider from electronic VHA clinical and administrative data sources.[20] The prior algorithm required two outpatient visits or one inpatient visit within 18 months with identical ICD codes for inclusion in the cohort. In our preliminary data, we found that many patients with at least one migraine code received a variety of headache codes, including multiple types of migraine codes as well as headache not otherwise specified (NOS). For this reason, we adapted the algorithm by reducing the requirement to only a single outpatient encounter with a migraine diagnosis for inclusion into the cohort. We also removed inpatient headache diagnoses from the algorithm as chart review for veterans with only inpatient visits for headache revealed they were time-limited headaches associated with a medical condition, rather than a primary headache disorder such as migraine. Entry into the cohort occurred on the date of the first encounter with a coded headache disorder within the study period (FY 2008-2019).

As the sampling timeframe included both *ICD-CM*-9 and *ICD-CM*-109 and 10, a group of four neurologists board-certified in headache medicine independently reviewed a Centers for Medicare and Medicaid Services (CMS) General Equivalence Mapping crosswalk linking ICD-9-CM headache codes to the ICD-10-CM codes and then reached consensus on all headache diagnoses (Table 1; eTable 1). For the current study, we included only patients with a healthcare provider's diagnosis of migraine. In a preliminary chart review study designed to validate migraine diagnostic codes in the VHA electronic health record, 343 charts of veterans with *ICD*-CM migraine codes in FY 2017 were abstracted by an independent external peer review process team including registered nurses, registered health information administrators, and registered health information technicians.[21] In comparing their independent clinical impression to the *ICD-CM* diagnostic code, the overwhelming majority (330/343, 96.2%) had a definite clinical impression of migraine, and less than 1% (3/343) of the charts with coded migraine had a definite clinical impression of a diagnosis other than migraine, providing evidence for the validity of the use of *ICD-CM* codes (Table 1) for identifying migraine in the VHA.

To permit calculation of annual incidence and one-year period prevalence, age and gender were obtained from administrative data for the entire VHA population during the study period (FY 2008-2019).

Standard Protocol Approvals, Registrations and Patient Consents

The VHA HCoE Administrative Data Headache Cohort protocol has been approved by the VA Connecticut Healthcare System Institutional Review Board, which approved a waiver of informed consent.

Measures

Demographics. Age (evaluated both continuously and as an ordinal variable in 5-year increments), gender (assessed as a dichotomous social construct, men/women) race (American Indian or Alaska Native, Asia, Black or African American, Native Hawaiian or Other Pacific Islander, White, or Unknown) and ethnicity (Spanish, Hispanic, Latino) assessed via self-report upon enrollment or update in the healthcare system, smoking status (never smoker, former smoker, current smoker, unknown), first military campaign (World War II, Korean conflict, Vietnam War era, Gulf War, Operation Enduring Freedom/Operation Iraqi Freedom/Operation New Dawn [OEF/OIF/OND]), marital status (single/never married, married, separated/divorced, widowed), and geographic region (highly rural: < 7 residents per square mile; rural: any other non-urban location; urban: ≥ 50,000 people in the urban nucleus and an urban core with ≥ 1,000 residents per square mile)[22] were extracted at the date of entry into the cohort. Military exposure factors (traumatic brain injury [TBI] and military sexual trauma [MST]) were extracted from routinely administered patient reported measures using validated algorithms.[15-19] TBI includes TBIs incurred before and after active-duty service. The VHA definition of military sexual trauma includes both sexual harassment as well as sexual assault.

Comorbid Diagnoses. Body Mass Index (BMI) was derived from weight extracted from the measurement taken closest to entry in the cohort (range: -12 months to +6 months from date of cohort entry) and height from the median of all readings from the central VHA database. Other headache diagnoses were extracted from the entire study period (FY 2008-2019). Select medical and psychiatric comorbidities were also extracted from VHA administrative data sources using previously validated algorithms, [20, 23-26] including vascular and cardiovascular diseases, pain disorders, mental health disorders, substance-related/addictive disorders, sleep-wake disorders, neurologic diseases, pulmonary diseases, infection, rheumatologic diseases and for women only, gynecological diagnoses. Comorbidities required at least one inpatient or two outpatient codes within 18 months (12-months prior, 6-months post) of date of entry into the cohort. Only comorbidities that represented at least 1.0% of the total population of veterans with diagnosed migraine were displayed in table.

Healthcare Utilization. VHA healthcare utilization was captured for all outpatient headache visits. Commonly utilized clinics were described alone, and in the most common combinations. In the VHA, women commonly received

primary care services in women's clinic, therefore the primary care and women's clinic care settings were collapsed for these analyses.

Analysis

Annual incidence and one-year period prevalence were calculated in the total sample, and in men and women across 5-year age increments. For these analyses, annual incidence is defined as the first migraine diagnosis coded in a clinic during the cohort period. One-year period prevalence is defined as the number of veterans coded with a migraine diagnosis with at least one clinic visit for migraine within the specific FY divided by the total VHA population, to be consistent with the one-year period prevalence definition commonly reported in the migraine literature.[1-2] All other study variables were described in all veterans with diagnosed migraine, and in men and women with diagnosed migraine. Categorical variables are displayed using frequency and percentage, while continuous variables are displayed using means (standard deviation [SD]). Differences between women and men were evaluated using chi-square (χ2) test for categorical variables, and student's t-test or Wilcoxon rank-sum test for continuous variables. All analyses were two-tailed with alpha set at 0.05 and were performed using SAS, version 9.4 (Cary, NC). Consistent with previous cohort studies,[24] we consider results clinically relevant reflect at least 2% absolute difference or a 2-fold difference in overall proportions for proportions, or follow Cohen's conventions of $d \geq .20$.

Data Availability

Due to VA regulations and our ethics agreements, the analytic data sets used for this study are not permitted to leave the VA firewall without a Data Use Agreement. However, VA data are made freely available to researchers with an approved VA study protocol. For more information, please visit https://www.virec.research.va.gov or contact the VA Information Resources Center at VIReC@va.gov.

Results

From FY 2008-2019, the VHA served 11.5 million unique veterans, of which 92.6% were men. The annual incidence of medically diagnosed migraine ranged from 2.7% — 4.1% in women and 0.6% – 0.7% in men (Table 2). The one-year period prevalence of medically diagnosed migraine, taking each FY as a distinct period (e.g., not summing prevalence across years), ranged from 8.5% — 13.0% for women and 1.1% — 2.5% for men. Across the study period, the 12-year period prevalence of medically diagnosed migraine was 5.3%, including 19.6% of women, and 4.1% of men served in the VHA.

The remainder of the results will focus on the sample with medically diagnosed migraine during the study period.

More than half (56.1%) of veterans with diagnosed migraine received more than one coded headache diagnosis within

the study period (Table 3). After "migraine, unspecified," (73.2%) the next most frequently assigned headache diagnosis among veterans with diagnosed migraine was Headache NOS (52.4%; Table 3). Almost three-quarters of veterans with diagnosed migraine were coded as "migraine, unspecified" at least once during the study period; a higher proportion of women with diagnosed migraine received "migraine, unspecified" compared to men (77.7% vs. 71.4%, *p < 0.001*; Table 3). Among those with any migraine diagnosis, higher proportions of women (vs. men) were coded as migraine without aura (30.3% vs. 23.3%, *p < 0.001*), migraine with aura (19.5% vs. 16.5%, *p < 0.001*), and chronic migraine without aura (17.0% vs. 13.2%, *p < 0.001*; Table 3). Compared to men, smaller proportions of women with diagnosed migraine had a coded diagnosis of post-traumatic headache during the study period (1.8% vs. 4.4%, *p < 0.001*; Table 3).

Demographics

Both women and men have a steady increase in coded migraine between the ages of 20 and 34, and a steady decline through the 60s (Figure 1). The incline is steeper for women, rising from 12.6% in the 20-24 age bracket and peaking at 29.8% in the 30-34 age bracket, whereas men rise from a prevalence of 5.4% in the 20-24 age bracket to 12.7% in the 30-34 age bracket. Among all veterans diagnosed with migraine, women were younger than men (Table 4). For both women and men with diagnosed migraine, more than half did not identify as Hispanic ethnicity; however, a larger proportion of women (vs men) with diagnosed migraine identified as Black (31.8% vs 18.3%, *p < .001*), whereas a smaller proportion of women (vs. men) with diagnosed migraine identified as White (57.0% vs 71.5%, *p < 0.001*; Table 4). Among veterans with diagnosed migraine, a lower proportion of women were married relative to men (40.4% vs 58.0% *p < 0.001*; Table 4).

A smaller proportion of women (vs. men) with diagnosed migraine were current smokers (27.4% vs. 39.1%; *p < 0.001*) or former smokers (15.2% vs. 24.1%; *p < 0.001*; Table 4). A larger proportion of women (vs. men) with diagnosed migraine had served during the Gulf War era (55.5% vs. 30.6%; *p < 0.001*), whereas a smaller proportion of women (vs. men) had served during OEF/OIF/OND (24.8% vs. 30.8%; *p < 0.001;* Table 4). A larger proportion of men (vs. women) with diagnosed migraine had TBI (3.9% vs. 1.1%, *p < 0.001*; Table 4). More than a third of women with diagnosed migraine reported military sexual trauma (35.5%) compared to 3.5% of men (*p < 0.001;* Table 4). Most veterans with diagnosed migraine live in urban regions; a greater proportion of women than men live in urban regions (73.8% vs. 66.6%, *p < 0.001*; Table 4).

Patterns of Health Care Use for Migraine

On average, veterans with diagnosed migraine had 1.44 encounters for headache annually (standard deviation [SD] = 1.73; Table 5). Veterans with diagnosed migraine were seen in specialty care clinics (neurology, physical medicine and rehabilitation [PMR], pain clinic, physiatry) for headache infrequently, and primary care more frequently (Table 5). Roughly 60% of veterans with medically diagnosed migraine were seen in only one care setting for headache, whereas a substantial minority (19.8%) were seen in two or more care settings. By far, primary care was the most common headache care setting for veterans with migraine; 93.3% of women and 86.1% of men veterans with migraine were treated for headache in primary care at least once (Table 5). Neurology was the next most common headache care setting (37.4%). Primary care + neurology was the most common care combination among both men (32.6%) and women (35.7%; $p < .001$) with diagnosed migraine, followed by primary care + PMR (12.6% of men and 7.8% of women, $p < .001$; Table 5). One-fifth of veterans with diagnosed migraine sought headache care in the ED at least once during the study period, with a higher proportion of women (23.4%) compared to men (17.4%, $p < 0.001$; Table 5).

Concomitant disorders

Most veterans with diagnosed migraine were either overweight or obese based on BMI (80.3%); on average, women had lower BMI than men ($p < 0.001$, Table 6).

Most veterans with diagnosed migraine were also diagnosed with another, non-headache pain disorder (61.7%; Table 6). Limb (38.1%) and back pain (30.9%) were the most common pain comorbidities and were more common in men than women (Table 6). Neuropathy was also more commonly diagnosed in men with migraine 4.6% than women (2.4%, $p < .001$; Table 6). Among women with diagnosed migraine, fibromyalgia (5.8% vs. 1.8%), pelvic pain (4.6% vs. 1.0%), and abdominal pain (9.8% vs. 7.7%) were more common than among men (Table 6).

Approximately half of veterans with diagnosed migraine were also diagnosed with a mental health disorder (48.8%, Table 6). More than a quarter of veterans with diagnosed migraine were also diagnosed with post-traumatic stress disorder (with a higher proportion of men [28.3%] vs. women [22.5%], $p < .001$; Table 6). More than a fifth were diagnosed with a depressive disorder (with a higher proportion of women than men across depressive disorder diagnoses; Table 6). Bipolar disorder was diagnosed in 5.5% of women with diagnosed migraine, and 3.5% of men ($p < 0.001$, Table 6).

One-fifth of men veterans with diagnosed migraine also had a sleep-wake disorder diagnosis, a rate almost double that of women (20.5% vs. 11.3%, $p < 0.001$; Table 6). Sleep-related breathing disorder, sleep apnea, and obstructive sleep apnea accounted for the majority of these diagnoses in men (Table 6). Men with diagnosed migraine also had double

the rate of substance-related/addictive disorders compared to women (11.4% vs. 5.7%, $p < 0.001$; Table 6). Alcohol disorders accounted for the majority of these diagnoses. A small proportion of both men and women veterans with migraine had a diagnosis of opioid use disorder (1.6% vs. 0.8%, $p < 0.001$; Table 6).

Among the additional comorbidities commonly diagnosed in veterans with diagnosed migraine, the most common were spondylosis (35.1%) and connective tissue disease (16.8%; Table 6). Other neurological conditions (epilepsy, ischemic stroke and tremor) were co-diagnosed in a larger proportion of men than women veterans with migraine (Table 6). Among the 157,837 women veterans (vs. the 409,284 men) with diagnosed migraine, the most common gynecological diagnoses during the study period were menstrual disorder (n = 1,783, 6.1%), menopausal disorder (n = 4.845, 3.1%), fibroids (n = 2,564, 1.6%), endometriosis (n = 1,827, 1.2%), ovarian cyst (n = 1,783, 1.1%), and polycystic ovarian syndrome (n = 1,426, 0.9%); among the 409,284 men, less than 0.1% were also diagnosed with gynecological disorders (menstrual disorder n = 24; menopausal disorder n = 25; fibroids n = 7; endometriosis n = 4; ovarian cyst = 12; polycystic ovarian syndrome n = 7).

Discussion

This paper describes the prevalence, characteristics, healthcare utilization patterns, and concomitant conditions in the 567,121 veterans diagnosed with migraine in the VHA from FY 2008-2019, which represents 5.3% of veterans served by the VHA during that period. Veterans receiving care for migraine in the VHA have high levels of concomitant conditions, particularly non-headache pain disorders, mental health disorders, and sleep disorders, all of which have been previously associated with migraine.[27,28] This system-wide approach identified important patterns in diagnosis and treatment that can guide the VHA in improving care quality.

Diagnostic Rates and Specificity

Although more than half a million people in the VHA had medically diagnosed migraine, under-ascertainment of migraine is almost certainly an issue. In 2019, only 13.0% of women and 2.5% of men received a medical diagnosis of migraine in the VHA, which is lower than the rates we would expect simply based on one-year period prevalence of migraine in the general United States population (17.1% in women and 5.6% in men).[1] This is consistent with under-ascertainment of migraine in other systems;[29] for example, in the Henry Ford Health System in 2001, only half of patients who reported current migraine on a validated computer assisted telephone diagnostic interview had a diagnosis of migraine in their chart.[30] In the current study, annual incidence of medically-diagnosed migraine was stable across years evaluated, suggesting that migraine under-ascertainment is a persistent systems-level challenge.

One-year period prevalence slightly improved over time, which may indicate increased access to care corresponding to the roll-out of the congressionally-mandated VHA Headache Centers of Excellence initiative.

A specific diagnosis is the first step to effective care. A striking 73.2% of veterans with diagnosed migraine received a code of "migraine, unspecified", and more than half received a code of headache not otherwise specified, at least once during the study period. Lack of diagnostic specificity extended beyond headache disorders: we also observed higher rates non-specific vs. specific psychiatric diagnoses (i.e., "other depressive disorder" vs. "major depressive disorder"). Electronic health record systems create subtle disincentives to high specificity coding by inadvertently requiring greater time, effort, and knowledge to assign a specific diagnosis compared to unspecified diagnoses.[31] Healthcare provider time is a limited resource. VHA clinicians, who carry the majority of burden in coding visits, are generally not reimbursed on the basis of relative value units, and their compensation is not affected by diagnostic complexity, so expediency in ICD coding likely takes precedence over providing the most accurate ICD code. Among veterans with migraine, women received specific diagnoses (e.g., migraine with aura, migraine without aura, chronic migraine) more commonly than men. Higher diagnostic rates may reflect a gender difference in pain processing or communication about headache features, or a higher propensity to diagnose headache in women than men among providers.[32]

Gender Differences in Veterans with Migraine

Women veterans with diagnosed migraine sought/received more headache-related care than men with migraine, presenting more frequently than men in every clinic type except physical medicine and rehabilitation (which handles the majority of TBI screening in the VHA, potentially explaining this finding). Overall, ED utilization was high among veterans with diagnosed migraine, with more than one-fifth of veterans presenting for migraine care in the ED at least once during the study period, compared to estimates outside the VHA where approximately 6% of people with migraine use the ED for headache.[33]

We observed a rate of TBI among veterans with migraine greater than the overall rates seen in the VHA. Between 2000 and 2019, approximating 1.6% of Veterans using VHA services had a TBI.[34] The relative risk of TBI for men:women is approximately 2:1 in Veterans screened for TBI,[35] which is less than the >3:1 ratio depicted in our study. Among the one million service members screened for TBI after deployment to OIF/OEF from 2007 to 2015, the rate of TBI was 8.4%, reflecting a higher risk overall in this combat-exposed population than the overall VA population.[36] The TBI rates in each of these studies is highly dependent on the population of interest. In a population inclusive of all Veterans in VHA regardless of combat exposure, the rate of TBI would be expected to be lower than in a cohort of persons exposed to combat with a high risk of trauma. That our rates are higher than predicted if migraine

and TBI sorted independently suggests that migraine and TBI are at least associated conditions, possibly more so in males with greater exposure to combat conditions.

More than one-third of women veterans with diagnosed migraine had a history of military sexual trauma (including both harassment and assault), which is comparable with the VHA population.[37] Although this number is ten times higher than men veterans with diagnosed migraine, it is notable that over fourteen thousand men also reported experiencing military sexual trauma. In fact, this is almost twice the rate of military sexual trauma reported by men veterans seeking care in the VHA in other studies.[37] Given the stigmatized nature of military sexual trauma, these figures are likely underestimates; self-report and interview methodology consistently find higher rates of military sexual trauma than administrative data sources.[37] Previous research has shown that childhood adverse events, including sexual abuse, are common in migraine and associated with higher migraine symptoms.[18,19] VHA providers should be aware of the likelihood many of their migraine patients experienced military sexual trauma and develop pro-active strategies to cultivate a safe environment to optimize migraine care for both women and men with a history of military sexual trauma.

Concomitant Diagnoses

The profiles of concomitant diagnoses in veterans with diagnosed migraine in the VHA provided ample opportunities for improving migraine disease severity and quality of life through co-treatment. Eighty percent of veterans with diagnosed migraine were overweight or obese, which is slightly higher than the rates reported in the VHA primary care population.[38] Overweight and obesity are associated with higher migraine symptom severity, disability and risk of progression.[39] Over 60% of veterans with diagnosed migraine also had at least one non-headache pain disorder diagnosis, consistent with the high rates of musculoskeletal pain disorders in the VHA,[24] and the known migraine comorbidities of low back pain and fibromyalgia.[40] Co-occurring pain disorders (particularly multiple pain disorders) and their treatments (especially opioids) may exacerbate and make migraine symptoms more treatment refractory.[41] Almost half of veterans with diagnosed migraine also had at least one diagnosed mental health disorder, which is higher than rates observed in VHA primary care.[42] Differences between genders were small in magnitude, indicating that a large proportion of both men and women veterans are managing migraine while at the same time managing at least one mental health disorder. Sleep disorders, most commonly sleep-related breathing disorders and apnea, were diagnosed in almost one-fifth of veterans with diagnosed migraine, and more commonly in men. The association between migraine and sleep disorders outside the VHA has been well-documented.[43] Interestingly, sleep disorders are

somewhat higher in the VHA than in the general United States population, and rates observed in among veterans with migraine were consistent with overall trends in the VHA.[44]

Limitations

These results are limited to veterans presenting for care in the United States VHA and may not generalize to other health systems, particularly as men are over-represented in the VHA. However, this also provides us with a unique opportunity to evaluate gender differences in migraine and to characterize migraine diagnosis and treatment patterns in men, who are typically underrepresented in migraine research.

The current study utilized administrative data therefore questions were limited to those that can be answered by using structured data routinely gathered in the treatment of people with migraine in the VHA. Administrative data have greater risk of errors and lack of specificity compared to data collected specifically for research. For example, we described rates of comorbidities in veterans with diagnosed migraine; however, these rates are likely higher than those we would observe in the entire population of veterans with both diagnosed and undiagnosed migraine, as they reflect care-seeking in addition to a migraine diagnosis. Similarly, gender is coded with two categories, rather than the broader array of categories that more accurately capture the social construct of gender. Additionally, incidence is defined as the first diagnosis of migraine within the study period, rather than the first occurrence of the disease in each veteran. Prior research has demonstrated that a diagnosis of migraine is frequently delayed by more than 5 years.[45] Furthermore, the VHA only cares for veterans after they have concluded their military service, limiting our ability to capture migraine onset that occurred earlier in life. However, administrative data is ideal to evaluate patterns that indicate problems such as under-ascertainment or lack of specificity in diagnosis are results that are crucial to understand to help health systems improve care quality, and to help future researchers understand the limitations of these administrative data.

Future Directions

These data demonstrate promise of the VHA Headache Cohort and other VHA data sources to evaluate migraine in men, a traditionally under-represented group in migraine research.

Future research should attempt to quantify under-ascertainment of migraine in the VHA and identify patient characteristics (such as gender and comorbidities) and systems-level characteristics (such as care setting and provider type) associated with non-diagnosis of migraine to inform system-level interventions to improve diagnosis, particularly for those in need of medical care.[6,11] Rurality in particular should be evaluated as a potential determinant of under-ascertainment of migraine, as challenges with accessing care in rural geographic settings may limit the

opportunity for a patient to bring up migraine symptoms and receive a diagnosis. Natural language processing and machine learning techniques could further mine the electronic health record for clinical information included in unstructured data including diagnostic codes, migraine symptom severity, and migraine-related disability. Provider education and informatics solutions should be developed to encourage specificity of migraine diagnosis in the VHA. Future research should utilize a control group of veterans receiving care in the VHA without a headache disorder diagnosis matched on age, gender, race, and treatment location, specifically to evaluate migraine risk factors this study suggests the VHA is well-positioned to answer, such as diagnoses that occur commonly in men (e.g., obstructive sleep apnea) and among individuals who serve in the armed forces (e.g., TBI). A matched control could also permit evaluation of questions related to the burden of migraine, such as by evaluating differences in overall healthcare utilization between people with and without migraine.

Deep phenotyping among veterans with TBI who present with and without headache and migraine symptoms, particularly from the OEF/OIF/OND era, should be used to understand how TBI-related headache presents over the long term, and to untangle diagnostic issues related to post-traumatic headache and migraine. Future research should identify characteristics associated with ED utilization for migraine in the VHA and develop strategies to streamline effective care in other primary and tertiary care ambulatory clinics within the VHA.

Future studies should capitalize on the large integrated care setting of the VHA to evaluate stepped care and co-treatment strategies to manage migraine and its comorbidities. Effective weight loss interventions and physical activity interventions may reduce migraine symptom severity and disability.[46] Because migraine and chronic non-migraine pain conditions may have shared mechanisms of pain sensitization and altered psychological processing of pain,[47] combined treatment of migraine and concurrent pain conditions is advisable. Effective migraine treatment can improve psychiatric symptoms,[48] but likely the most effective approach is to address symptoms concomitantly. Sleep in particular may have an important relationship with migraine,[42,43,49] interventions to improve both sleep and migraine show promise,[50] and the VHA demonstrated a commitment to system-wide implementation of evidence-based sleep interventions.[44]

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Table 1. International Classification of Diseases Clinical Modification (ICD-CM) Versions 9 and 10 Included in the Cohort[a]

ICD-9-CM		ICD-10-CM	
Migraine Diagnosis	ICD-9-CM Code	Migraine Diagnosis	ICD-10-CM Code
Migraine with aura	346.0	Migraine with aura, not intractable, without status migrainosus	G43.109A
Migraine without aura	346.1	Migraine without aura, intractable, without status migrainosus	G43.019
Variants of migraine, not elsewhere classified	346.2	Ophthalmoplegic migraine, not intractable	G43.B0
Hemiplegic migraine	346.3	Hemiplegic migraine, intractable, without status migrainosus	G43.419
Menstrual migraine	346.4	Menstrual migraine, intractable, without status migrainosus	G43.839
Persistent migraine aura without cerebral infarction	346.5	Persistent migraine aura without cerebral infarction, intractable, without status migrainosus	G43.519
Persistent migraine aura with cerebral infarction	346.6	Persistent migraine aura with cerebral infarction, intractable, without status migrainosus	G43.619
Chronic migraine without aura	346.7	Chronic migraine without aura, intractable, without status migrainosus	G43.719
Other forms of migraine	346.8	Other migraine, intractable, without status migrainosus	G43.819

		Migraine, unspecified, intractable,	
Migraine unspecified	346.9	without status migrainosus	G43.919

[a]The current table provides the cross-walk for only the first decimal in ICD-9-CM; for the complete table, please see eTable 1.

Table 2. Annual Incidence and One-Year Period Prevalence of Veterans with a Coded Migraine Diagnosis in the VHA for each Annual Period From FY 2008- 2019 by Gender

Gender	Fiscal Year											
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Women												
Annual Incidence[a]		4.1%	3.3%	2.8%	2.7%	2.8%	2.8%	2.8%	2.9%	2.7%	2.8%	2.7%
One-Year Period Prevalence[b]	8.5%	9.1%	9.2%	9.5%	9.8%	10.2%	10.7%	11.1%	10.3%	11.1%	12.1%	13.0%
Men												
Annual Incidence[a]		0.6%	0.6%	0.5%	0.5%	0.6%	0.5%	0.6%	0.7%	0.6%	0.7%	0.7%
One-Year Period Prevalence[b]	1.1%	1.2%	1.3%	1.4%	1.5%	1.6%	1.8%	1.9%	1.8%	2.0%	2.2%	2.5%

Note:

[a]Annual incidence is defined as the first migraine diagnosis coded in a clinic during the cohort period. Incidence is not calculated for the first year of the cohort, as this would conflate prior diagnoses with diagnoses first identified in the initial year of the cohort.

[b]*One-year period prevalence* is defined as the number of veterans coded with a migraine diagnosis with at least one clinic visit for migraine within the specific FY divided by the total VHA population.

Table 3. Coded Migraine Subtypes and Other Headache Diagnoses Among People with at least one Migraine Diagnosis in the VHA from FY 2008 – 2019 by Gender

	Gender			
Diagnosis	**Women** (N = 157,837)	**Men** (N = 409,284)	**Total** (N = 567,121)	**Significance[a]**
Migraine Diagnoses[b]				
Migraine without aura	47,876 (30.3%)	95,210 (23.3%)	143,086 (25.2%)	<0.001*
Migraine with aura	30,815 (19.5%)	67,383 (16.5%)	98,198 (17.3%)	<0.001*
Hemiplegic Migraine	886 (0.6%)	1,700 (0.4%)	2,586 (0.5%)	<0.001
Persistent migraine aura with cerebral infarction	67 (<0.1%)	167 (<0.1%)	234 (<0.1%)	0.78
Persistent migraine aura without cerebral infarction	389 (0.2%)	1,079 (0.3%)	1,468 (0.3%)	0.25
Chronic migraine without aura	26,853 (17.0%)	54,190 (13.2%)	81,043 (14.3%)	<0.001*
Menstrual migraine[c]	2,503 (1.6%)	989 (0.2%)	3,492 (0.6%)	<0.001*
Ophthalmoplegic migraine	4,206 (2.7%)	19,378 (4.7%)	23,584 (4.2%)	<0.001*
Other migraine	29,992 (19.0%)	63,935 (15.6%)	93,927 (16.6%)	<0.001*
Migraine unspecified	122,696 (77.7%)	292,429 (71.4%)	415,125 (73.2%)	<0.001*
Other Headache Diagnoses (Yes vs. No)				
Headache, NOS[d]	83,312 (52.8%)	213,959 (52.3%)	297,271 (52.4%)	<0.001
Primary Headache Disorders				
Tension-Type Headache	12,988 (8.2%)	30,368 (7.4%)	43,356 (7.6%)	<0.001
Trigeminal Autonomic Cephalalgia	1,942 (1.2%)	10,890 (2.7%)	12,832 (2.3%)	<0.001*
Other Primary Headache[e]	5,253 (3.3%)	13,131 (3.2%)	18,384 (3.2%)	0.022
Secondary Headache Disorders				
Post-Traumatic Headache	2,919 (1.8%)	17,827 (4.4%)	20,746 (3.7%)	<0.001*

Diagnosis	Gender		Total	Significance[a]
	Women	Men		
	(N = 157,837)	(N = 409,284)	(N = 567,121)	
Post-Whiplash Headache	5,484 (3.5%)	9,227 (2.3%)	14,711 (2.6%)	<0.001
Other Secondary Headache[f]	2,606 (1.7%)	6,970 (1.7%)	9,576 (1.7%)	0.17
Number of Unique Headache Diagnoses FY 2008-2019				
Mean (SD)[g]	1.73 (0.77)	1.74 (0.79)	1.74 (0.78)	<0.001
Median (IQR)	2 (1 - 2)	2 (1 - 2)	2 (1 - 2)	0.009
1[g]	68,884 (43.6%)	179,962 (44.0%)	248,846 (43.9%)	<0.001
2	67,854 (43.0%)	169,739 (41.5%)	237,593 (41.9%)	
≥ 3	21,099 (13.4%)	59,583 (14.6%)	80,682 (14.2%)	

Note:

[a] P-values are presented in the significance column; if the p-value has an asterisk, that indicates the p-value is also "clinically relevant," defined as at least 2% absolute difference or a 2-fold difference in overall proportions, or a Cohen's d of at least .20.

[b] Every participant had at least one migraine diagnosis; migraine subtypes sum to greater than 100% as many people have more than one migraine diagnostic code

[c] Menstrual migraine may occur in individuals who menstruate and identify as men, or may indicate provider miscoding;

[d] NOS = Not otherwise specified;

[e] Other Primary Headache included codes for any primary headache other than a migraine, tension-type headache, and the trigeminal automomic cephalalgias;

[f] Other Secondary Headache included codes for any secondary headache other than post-traumatic headache and post-whiplash headache;

[g] Non-equal variances, Satterthwaite method is applied to calculate adjusted DF

[h] 1 unique headache diagnosis indicates that the migraine diagnosis which lead to cohort inclusion is the only headache diagnosis provided during the study period.

Table 4. Demographics of Veterans with a Coded Migraine Diagnosis in the VHA from FY 2008- 2019 by Gender

Characteristic	Gender			Significance[a]
	Women (N =157837)	Men (N = 409284)	Total (N = 567121)	
Age at first VHA[b] Diagnosis				
Mean (SD)[c]	39.7 (11.4)	46.2 (15.2)	44.4 (14.5)	<0.001*
Race				
White	89,980 (57.0%)	292,450 (71.5%)	382,430 (67.4%)	<0.001*
Black	50,175 (31.8%)	74,819 (18.3%)	124,994 (22.0%)	
Asian	2,213 (1.4%)	5,966 (1.5%)	8,181 (1.4%)	
Pacific Islander	1,758 (1.1%)	4,201 (5.7%)	5,959 (1.1%)	
American Indian	1,719 (1.1%)	3,879 (1.0%)	5,598 (1.0%)	
Mixed Race	2,711 (1.7%)	4,625 (1.1%)	7,336 (1.3%)	
Unknown	9,279 (5.9%)	23,344 (5.7%)	32,632 (5.8%)	
Ethicity				
Hispanic	13,069 (8.3%)	34,153 (8.3%)	47,222 (8.3%)	0.430
Non-Hispanic	144,768 (91.7%)	375,131 (91.7%)	519,899 (91.7%)	
Smoking Status				
Never Smoke	89,245 (56.5%)	147,062 (35.9%)	236,307 (41.7%)	<0.001*
Former Smoker	24,049 (15.2%)	98,518 (24.1%)	122,567 (21.6%)	
Current Smoker	43,210 (27.4%)	160,101 (39.1%)	203,311 (35.8%)	
Unknown	1,333 (0.8%)	3,603 (0.9%)	4,936 (0.9%)	
Marital Status				
Single/Never Married	33,854 (21.4%)	58,989 (14.4%)	92,843 (16.4%)	<0.001*
Married	63,691 (40.4%)	237,527 (58.0%)	301,218 (53.1%)	

| Characteristic | Gender | | | Significance[a] |
	Women (N =157837)	Men (N = 409284)	Total (N = 567121)	
Separated/Divorced	54,794 (34.7%)	99,714 (24.4%)	154,508 (27.2%)	
Widowed	3,294 (2.1%)	8,540 (2.1%)	11,834 (2.1%)	
Missing/Unknown	2,204 (1.4%)	4,514 (1.1%)	6,718 (1.2%)	
Military Campaigns				
World War II	215 (0.1%)	3,188 (0.8%)	3,403 (0.6%)	<0.001*
Korean conflict	681 (0.4%)	12,506 (3.1%)	13,187 (2.3%)	
Vietnam War era	29,489 (18.7%)	141,180 (34.5%)	170,669 (30.1%)	
Gulf War	87,583 (55.5%)	125,261 (30.6%)	212,844 (37.5%)	
OEF/OIF/OND[d]	39,072 (24.8%)	125,976 (30.8%)	165,048 (29.1%)	
Others/Unknown	797 (0.5%)	1,173 (0.3%)	1,970 (0.3%)	
Military Exposure Related				
TBI[e] (includes post-discharge)	1,780 (1.1%)	16,077 (3.9%)	17,857 (3.1%)	<0.001*
Military Sexual Trauma	55,692 (35.3%)	14,345 (3.5%)	70,037 (12.3%)	<0.001*
Rurality Status				
Urban	116,240 (73.8%)	271,507 (66.6%)	387,747 (68.6%)	<0.001*
Rural	40,128 (25.5%)	131,884 (32.3%)	172,012 (30.4%)	
Highly Rural	1,164 (0.7%)	4,403 (1.1%)	5,567 (1.0%)	
Unknown	305 (0.2%)	1,490 (0.4%)	1,795 (0.3%)	

Note:

[a] P-values are presented in the significance column; if the p-values has an asterisk, that indicates the p-value is also "clinically relevant," defined as at least 2% absolute difference or a 2-fold difference in overall proportions, or a Cohen's d of at least .20.

[b] VHA = Veterans Health Administration;

[c] Non-equal variances, Satterthwaite method is applied to calculate adjusted DF;

Table 5. Outpatient Visit with Coded Headache Diagnosis Among Veterans with Diagnosed Migraine in the VHA from Fiscal Years (FY) 2008 - 2019 by Gender

Healthcare Utilization For Headache	Gender			Significance[a]
	Women (N = 157837)	Men (N = 409284)	Total (N = 567121)	
Number of Encounters/FY				
Overall[b] Mean (SD)[c]	1.62 (1.84)	1.37 (1.68)	1.44 (1.73)	<0.001
PC+	0.80 (0.70)	0.65 (0.66)	0.69 (0.68)	<0.001*
ED	0.08 (0.33)	0.06 (0.25)	0.06 (0.27)	<0.001
Urgent Care[c]	0.01 (0.08)	0.008 (0.08)	0.009 (0.08)	<0.001
Neurology	0.30 (0.69)	0.26 (0.61)	0.27 (0.63)	<0.001
PMR	0.05 (0.31)	0.08 (0.42)	0.07 (0.39)	<0.001
Pain Clinic	0.04 (0.28)	0.03 (0.24)	0.03 (0.25)	<0.001
Psychiatry	0.02 (0.19)	0.02 (0.20)	0.02 (0.20)	0.14
Others[d]	0.32 (0.72)	0.27 (0.70)	0.28 (0.70)	<0.001
Number of Care Settings (PC+, ED, Urgent Care, Neurology, PMR, Pain Clinic, Psychiatry)				
Mean (SD)[c]	1.30 (1.41)	1.10 (1.29)	1.16 (1.33)	<0.001
≤ 1	91,212 (59.8%)	249,230 (60.9%)	340,442 (60.0%)	<0.001*
≤ 2	37,156 (23.5%)	82,883 (20.3%)	120,039 (21.2%)	
> 2	26,187 (16.6%)	53,482 (13.1%)	79,669 (14.0%)	
Other settings[d]	3,282 (02.1%)	23,689 (05.8%)	26,971 (04.8%)	

Healthcare Utilization	Gender		Total	Significance[a]
For Headache	Women (N = 157837)	Men (N = 409284)	(N = 567121)	
Care Settings				
PC+	147,207 (93.3%)	352,280 (86.1%)	499,487 (88.1%)	<0.001*
ED	36,862 (23.4%)	71,248 (17.4%)	108,110 (19.1%)	<0.001*
Urgent Care[e]	6,797 (4.3%)	13,674 (3.3%)	20,471(3.6%)	<0.001
Neurology	60,155 (38.1%)	152,206 (37.2%)	21,2361 (37.4%)	<0.001
PMR	13,040 (8.3%)	58,425 (14.3%)	71,465 (12.6%)	<0.001*
Pain Clinic	10,187 (6.5%)	20,546 (05.0%)	30,733 (05.4%)	<0.001
Psychiatry	9,442 (6.0%)	22,915 (05.6%)	32,357 (05.7%)	<0.001
Others[d]	84,677 (53.6%)	205,703 (50.3%)	290,380 (51.2%)	<0.001*
Combinations of Care Settings				
PC+ & Neurology	56,287 (35.7%)	133,583 (32.6%)	189,870 (33.5%)	<0.001*
PC+ & PMR	12,280 (7.8%)	51,576 (12.6%)	63,856 (11.3%)	<0.001*
PC+ & Pain Clinic	9,855 (6.2%)	19,368 (4.7%)	29,223 (5.2%)	<0.001
PC+ & Psychiatry	9,074 (5.7%)	21,333 (5.2%)	30,407 (5.4%)	<0.001
Neurology & PMR	8,300 (5.3%)	30,593 (7.5%)	38,893 (6.9%)	<0.001
Neurology & Pain Clinic	7,324 (4.6%)	14,685 (3.6%)	22,009 (3.9%)	<0.001
Neurology & Psychiatry	5,804 (3.7%)	13,991 (3.4%)	19,795 (3.5%)	<0.001
PMR & Pain Clinic	2,370 (1.5%)	6,474 (1.6%)	8,844 (1.6%)	0.029
PMR & Psychiatry	1,598 (1.0%)	6,503 (1.6%)	8,101 (1.4%)	<0.001
Pain Clinic & Psychiatry	1,759 (1.1%)	3,578 (0.9%)	5,337 (0.9%)	<0.001

Note:

[a] P-values are presented in the significance column; if the p-values has an asterisk, that indicates the p-value is also

"clinically relevant," defined as at least 2% absolute difference or a 2-fold difference in overall proportions, or a Cohen's

d of at least .20.

Table 6. Comorbidities for Veterans with a Coded Migraine Diagnosis in the VHA from FY 2008 - 2019 by Gender

	Gender			
	Women (N = 157837)	Men (N = 409284)	Total (N = 567121)	Significance[a]
BMI[b]				
Mean (SD)[c]	29.3 (6.1)	29.9 (5.5)	29.7 (5.7)	<0.001
Underweight (<18.5)	1,501 (1.0%)	1,965 (0.5%)	3,466 (00.6%)	<0.001*
Normal (18.5-24.9)	36,909 (24.8%)	64,483 (16.7%)	101,392 (19.0%)	
Overweight (25-29.9)	48,380 (32.5%)	145,424 (37.7%)	193,804 (36.2%)	
Obese (≥30)	62,300 (41.8%)	173,781 (45.1%)	236,081 (44.1%)	
Any Pain Disorder	**95,541 (60.5%)**	**254,197 (062.1%)**	**349,738 (61.7%)**	**<0.001**
Limb Pain	57,782 (36.6%)	158,555 (38.7%)	216,337 (38.1%)	<0.001*
Back Pain	44,116 (28.0%)	131,211 (32.1%)	175,327 (30.9%)	<0.001*
Neck Pain	17,122 (10.8%)	45,969 (11.2%)	63,091 (11.1%)	<0.001
Abdominal Pain	15,524 (9.8%)	31,387 (7.7%)	46,911 (8.3%)	<0.001*
Fractures, Sprains, Strains	8,277 (5.2%)	23,969 (5.9%)	32,246 (5.7%)	<0.001

Musculoskeletal Chest Pain	7,355 (4.7%)	24,842 (6.1%)	32,197 (5.7%)	<0.001
Neuropathy	3,722 (2.4%)	18,727 (4.6%)	22,449 (4.0%)	<0.001*
Fibromyalgia	9,227 (5.8%)	7,329 (1.8%)	16,556 (2.9%)	<0.001*
Pelvic Pain	7,339 (4.6%)	3,966 (1.0%)	11,305 (2.0%)	<0.001*
Systemic Pain	4,458 (2.8%)	4,807 (1.2%)	9,265 (1.6%)	<0.001
Any Mental Health Disorder	**78,903 (50.0%)**	**197,624 (48.3%)**	**276,527 (48.8%)**	**<0.001**
Post-Traumatic Stress Disorder	35,493 (22.5%)	115,869 (28.3%)	151,362 (26.7%)	<0.001*
Other Depressive Disorder	37,591 (23.8%)	85,688 (20.9%)	123,279 (21.7%)	<0.001*
Major Depressive Disorder	30,905 (19.6%)	56,975 (13.9%)	87,880 (15.5%)	<0.001*
Anxiety Status, unspecified	22,557 (14.3%)	47,036 (11.5%)	69,593 (12.3%)	<0.001*
Manic Episode or Bipolar Disorder	8,677 (5.5%)	14,344 (3.5%)	23,021 (4.1%)	<0.001
Anxiety, General	6,276 (4.0%)	11,678 (2.9%)	17,954 (3.2%)	<0.001
Schizophrenia	1,320 (0.8%)	4,733 (1.2%)	6,053 (1.1%)	<0.001
Any Sleep-Wake Disorder	**17,786 (11.3%)**	**83,890 (20.5%)**	**101,676 (17.9%)**	**<0.001***
Sleep Related Breathing Disorder	9,262 (5.9%)	60,448 (14.8%)	69,710 (12.3%)	<0.001*
Sleep Apnea	5,307 (3.4%)	36,652 (9.0%)	41,959 (7.4%)	<0.001*
Insomnia	8,908 (5.6%)	27,820 (6.8%)	36,728 (6.5%)	<0.001
Obstructive Sleep Apnea	4,247 (2.7%)	30,400 (7.4%)	34,647 (6.1%)	<0.001*
Any Substance-Related/Addictive Disorder	**9,037 (5.7%)**	**46,689 (11.4%)**	**55,726 (9.8%)**	**<0.001***
Alcohol Use Disorder	5,554 (3.5%)	33,266 (8.1%)	38,820 (6.8%)	<0.001*
Alcohol Abuse/Dependence/Psychosis	4,633 (2.9%)	27,726 (6.8%)	32,359 (5.7%)	<0.001*
Drug Abuse/Dependence/Psychosis	4,863 (3.1%)	25,060 (6.1%)	29,923 (5.3%)	<0.001*
Alcohol Related Disorder	1,269 (0.8%)	6,423 (1.6%)	7,692 (1.4%)	<0.001
Opioid Use Disorder	1,226 (0.8%)	6,637 (1.6%)	7,863 (1.4%)	<0.001*
Additional Comorbidities				
Spondylosis	50,883 (32.2%)	148,148 (36.2%)	199,031 (35.1%)	<0.001*
Connective Tissue Disease	30,699 (19.4%)	64,296 (15.7%)	94,995 (16.8%)	<0.001*
Diabetes	8,085 (5.1%)	44,947 (11.0%)	53,032 (9.4%)	<0.001*

Asthma	10,051 (6.4%)	13,235 (3.2%)	23,286 (4.1%)	<0.001*
Chronic Obstructive Pulmonary Disease	2,700 (1.7%)	17,827 (4.4%)	20,527 (3.6%)	<0.001*
Epilepsy	3,303 (2.1%)	11,710 (2.9%)	15,013 (2.6%)	<0.001
Hepatitis C Virus	900 (0.6%)	8,041 (2.0%)	8,941 (1.6%)	<0.001*
Gout	226 (0.1%)	6,573 (1.6%)	6,799 (1.2%)	<0.001*
Stroke, Ischemic	827 (0.5%)	5,620 (1.4%)	6,447 (1.1%)	<0.001*
Tremor	925 (0.6%)	4,586 (1.1%)	5,511 (1.0%)	<0.001

Note:

[a] P-values are presented in the significance column; if the p-values has an asterisk, that indicates the p-value is also "clinically relevant," defined as at least 2% absolute difference or a 2-fold difference in overall proportions, or a Cohen's d of at least .20.

[b] n = 534,743 as we were unable to assess BMI for a total of 32,378 veterans (8,747 women and 23,631 men); Weight was limited within 50-700 pounds, and height was limited within 58-80 inches, based on US Army recruitment physical exam requirement;

[c] Non-equal variances, Satterthwaite method is applied to calculate adjusted degrees of freedom.

Figure Titles

Figure 1. Percentage of veterans with migraine out of the total VHA population stratified by gender and 5-year age intervals.
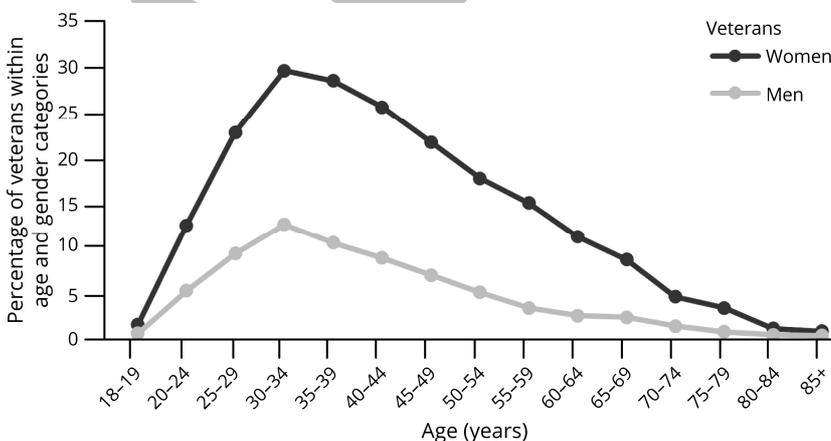
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Frequency, Demographics, Comorbidities, and Health Care Utilization by Veterans With Migraine: A VA Nationwide Cohort Study

Elizabeth K Seng, Brenda T Fenton, Kaicheng Wang, et al.

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Characteristics and Gender Differences of Headache in the Veterans Health Administration: A National Cohort Study, Fiscal Year 2008–2019

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assisted in the review of ICD-CM headache codes for the creation of the VHA HCoE Administrative Data Cohort. The views expressed in this article are those of the authors and do not necessarily represent the view of the Department of Veterans Affairs.

Abstract

Background and Objectives – To determine gender differences in headache types diagnosed, sociodemographic characteristics, military campaign and exposures, and healthcare utilization among United States (U.S.) Veterans in the Veterans Health Administration (VHA).

Methods – This study employed a retrospective cohort design to examine VHA Electronic Health Record (EHR) data. This cohort includes Veterans who had at least one visit for any headache between fiscal years 2008 and 2019. Headache diagnoses were classified into eight categories using *International Classification of Disease, Clinical Modification* codes. Demographics, military-related exposures, comorbidities, and type of provider(s) consulted were extracted from the EHR, and compared by gender. Age-adjusted incidence and prevalence rates of medically diagnosed headache disorders were calculated separately for each type of headache.

Results – Of the 1,524,960 Veterans with headache diagnoses included in the cohort, 82.8% were men. Compared with women, men were more often white (70.4% vs 56.7%), older (52.0±16.8 vs 41.9±13.0 years), with higher rates of traumatic brain injury (2.9% vs 1.1%) and post-traumatic stress disorder (23.7% vs 21.7%), and lower rates of military sexual trauma (3.2% vs 33.7%; $p<0.001$ for all). Age adjusted incidence rate of headache of any type was higher among women. Migraine and trigeminal autonomic cephalalgias rates were most stable over time. Men were more likely than women to be diagnosed with headache not-otherwise-specified (77.4% vs 67.7%) and have higher incidence rates of headaches related to trauma (3.4% vs 1.9% [post-traumatic]; 5.5% vs 5.1% [post-whiplash]; $p <0.001$ for all). Men also had fewer headache types diagnosed (mean ± standard deviation; 1.3 ± 0.6 vs 1.5 ± 0.7), had fewer encounters for headache/year (0.8 ± 1.2 vs 1.2 ± 1.6) and fewer visits to headache specialists (20.8% vs 27.4% $p <0.001$ for all), compared to women. Emergency Department utilization for headache care was high for both genders and higher for women compared to men (20.3% vs 22.9%; $p<0.001$).

Discussion – Among Veterans with headache diagnoses, important gender differences exist for men and women Veterans receiving headache care within VHA regarding sociodemographic characteristics, headache diagnoses, military exposure, and headache healthcare utilization. The findings have potential implications for providers and the healthcare system caring for Veterans living with headache.

Introduction

Headache is one of the most common and debilitating neurological conditions encountered by neurologists and other healthcare providers.[1] The worldwide lifetime prevalence of any headache disorder is 66%, with half of all people with a diagnosed headache disorder experiencing headache attacks annually.[1, 2] Prevalence estimates vary by headache type, age, gender, race, and ethnicity.[3] Gender differences have also been reported for headache healthcare utilization, with women seeking medical care and seeing specialists for headache management more than men.[4] Estimates of headache diagnoses and receipt of headache care are built on studies of community-based samples which have consistently demonstrated disparities in care and areas in need of improvement,[1, 5-8] including diagnosis, coding, treatment, and referral processes related to headache.

Headache disorders are problematic in Veterans beyond the high rates of primary headache disorders. Traumatic brain injury (TBI) or other injuries sustained during deployment (e.g., whiplash) can lead to headache. Other military-related exposures (e.g., combat or military sexual trauma [MST]-related post-traumatic stress disorder [PTSD], airborne hazards and burn pit) may increase headache risk.[9-12] However, relatively few studies have examined headache disorders in United States (U.S.) Veterans. Most studies to date generally focused on Veterans of the recent military campaigns in Iraq and Afghanistan.[13-15]

Veterans served by the VHA are predominantly men, however the number of women has been growing. Attributed in part due to changes in legislation, women have been enlisting into the military at higher rates during more recent military campaigns. Among Veterans, women are younger and more likely to be from a minority background compared with men.[16] Conducting epidemiological investigations within the VHA examining gender differences across sociodemographic characteristics, military campaign and exposures, headache diagnoses, and healthcare utilization is imperative. Such studies would forward our understanding of the population-level burden within the largest integrated healthcare system in the U.S. They would also guide explorations related to patient-level burden of headache, identify patient and healthcare system factors associated with care quality, and inform policy change should meaningful healthcare differences and disparities be identified. We report on gender differences in headache diagnoses, sociodemographic characteristics, military campaign and exposures, and healthcare utilization among Veterans receiving care within the VHA.

Methods

Cohort Design and Study Population

The VHA serves more than 9 million Veterans annually across 1,293 health care facilities[17]; all VHA medical centers (VAMCs) and clinics utilize the same electronic health record (EHR) platform. 9.1 million inpatient records and 2.4 billion outpatient visits from October 1st, 2007 (Fiscal Year [FY] 2008) to September 30th, 2019 (FY2019) were searched to gather Veterans medically diagnosed with headache disorders. As part of the Congressionally mandated VHA Headache Centers of Excellence (HCoE) program, the VHA HCoE Administrative Data Cohort was created to improve our understanding of the epidemiology of headache and headache care within the VHA. In the spirit of the VHA Learning Healthcare System, these data are also intended to be used to improve headache care quality and delivery for Veterans living with headache disorders.[18]

First, *International Classification of Diseases* 9th version (*ICD-9-CM*) and 10th version (*ICD-10-CM*) codes for headache disorders were identified with guidance from the American Academy of Neurology (AAN)[19] and the International Headache Society.[20] Next, we accessed the Centers for Medicare and Medicaid Services General Equivalence Mapping crosswalk to link the *ICD-9-CM* headache codes to the *ICD-10-CM* codes.[21] Four United Council for Neurological Subspecialties [UCNS] Headache Medicine Certified neurologists independently reviewed the crosswalk of headache diagnoses. Using both *ICD-9-CM* and *ICD-10-CM* codes, headache diagnoses were then classified into eight categories: headache, not-otherwise-specified (NOS), migraine, tension-type headache (TTH), trigeminal autonomic cephalalgias (TACs), other primary headache disorders (e.g., New daily persistent headache), post-traumatic headache (PTHA), post-whiplash headache

(PWHA), and other secondary headache disorders (e.g., Headache attributed to infection). Given the importance of headache related to head trauma, separate categories for PTHA and PWHA were created (eTable 1).

We adapted a validated algorithm to identify Veterans with specific (non-headache) conditions using VHA electronic clinical and administrative data sources.[22] We included 1,562,036 Veterans who had at least one outpatient or inpatient visit with an *ICD-CM*-coded headache diagnosis between FY 2008 and FY 2019. One single visit was sufficient for cohort entry, given concerns informed by clinical experience and the literature about the underestimation of headache diagnoses within and outside of the VHA.[23] However, those Veterans who only had inpatient visits and without any outpatient visits during the cohort period, were determined to be singular time-limited headaches associated with an acute or exacerbated medical condition leading to hospitalization and hence, were excluded from the current analysis (n=37,058). Veterans may have multiple specific headache types over the 12-year period. The index date for entry into the cohort was the date of the Veteran's first headache diagnosis coded in the EHR during the cohort period FY 2008-2019. We also excluded Veterans less than 18 years old at the time of cohort entry (n=18; likely data entry errors in year of birth).

Measures and Variables

For included Veterans, we obtained demographics from VHA Corporate Data Warehouse (CDW) at initial headache diagnosis including gender (assessed as a dichotomous social construct, men/women), age, race (American Indian or Alaska Native, Asia, Black or African American, Native Hawaiian or Other Pacific Islander, White, or Unknown) and ethnicity (Spanish, Hispanic, Latino) assessed via self-report upon enrollment or update in the healthcare system, , marital status, military campaign, and military exposures. Military campaign refers to era of service rather than combat deployment, and was categorized into World War II, Korean Conflict, Vietnam War, first Persian Gulf War, Operation Enduring Freedom/Operation Iraqi Freedom/Operation New Dawn (OEF/OIF/OND), or Others/unknown (e.g., current active duty, World War I, and missing). Anthropometric measurements were extracted from the closest measurement within the window of one year prior and up to six months after to-headache index date. Height was recorded as the median height from all available measurements. Weights <75 or >700 lbs., or heights <48 or >84 inches were considered biologically implausible[24], and therefore excluded. Body Mass Index (BMI) was calculated as weight in pounds by height in inches squared and multiplying by a conversion factor of 703.

Military exposure factors, physical and mental health comorbidities, and non-headache painful condition data were obtained from CDW. Clinical features of particularly high interest, including TBI, PTSD, and MST. MST was defined by 38 U.S. Code § 1720D as "physical assault of a sexual nature, battery of a sexual nature, or sexual harassment which occurred while the Veteran was serving on active duty or active-duty training." MST was coded positive if at least one of the MST screens administered to the Veteran starting in 2008 was positive. Baseline comorbidity was defined as starting within the year before and up to six months following the first diagnosis of headache. We used diagnostic algorithms from other large VHA and non-VHA cohorts: Northeast Program Evaluation Center (NEPEC) for mental health conditions, Kaiser for musculoskeletal and pain conditions, the VHA Musculoskeletal Disorders Cohort, Veterans Aging Cohort Study, and Women Veterans Cohort. [22, 25, 26] The coding of baseline comorbid conditions required at least one inpatient visit with a selected *ICD-CM* diagnostic code, or two outpatient visits with selected *ICD-CM* diagnostic codes within 18 months of each other.

To assess clinical provider types and healthcare unitization, we defined clinics as Primary Care, Women's Health, Emergency Department (ED), Neurology, Physical Medicine and Rehabilitation (PM&R), Pain Management, and Mental Health. Within VHA, clinics and specialties are identified by unique stop codes, making it possible to determine where Veterans attended when receiving headache care (eTable 2). To compare differences in visits with specialty types between men and women Veterans, we further combined Primary Care and Women's Health as 'Primary Care Plus.' All provider types were displayed as dichotomous variables. We also investigated the utilization of interdisciplinary care using a combination of different specialty types. For example, whether and when patients were seen or managed by Primary Care Providers and Neurologists.

Additional data gathered to construct the cohort included: outpatient prescriptions of headache abortive and conventional preventive medications, Calcitonin gene-related peptide antagonists and opioids; headache procedures such as occipital nerve blocks and neurotoxin injections identified by common procedural terminology (CPT); nonpharmacologic headache interventions such as physical therapy referral and biofeedback, and headache services under the purview of VHA prosthetics (e.g., neuromodulator devices, oxygen). Geographic location of Veterans across the U.S. was also determined from administrative data, by mapping Veterans to the VAMC assigned by the VHA as their primary location of receiving care. VAMCs are nested within geographic regions known as Veterans Integrated Service Networks (VISNs; eTable 3).

Statistical Analysis

Categorical variables were reported as frequencies and percentages, and continuous variables as means and standard deviations. Differences between men and women Veterans were compared using the Chi-square test for categorical variables, and independent samples t-test for continuous variables. A p value < 0.05 was considered statistically significant. We also indicated categorical results that reflected at least 2% absolute difference or a two-fold difference in overall proportions or followed Cohen's conventions of $d \geq 0.20$ as clinically significant. All analyses were performed using SAS version 9.4 (Cary, NC).

The crude incidence rates equal the total number of new headaches diagnosed in a specific fiscal year, divided by the at-risk population. Period prevalence was defined as the number of Veterans with at least one outpatient encounter in a specific fiscal year, divided by the total VHA population. Incidence and prevalence rates were reported as number of cases per 100,000 people per year. After visualizing the age distributions of men and women Veterans, age-adjusted rates were calculated to the 2010 U.S. standard population. The proportions of the 2010 U.S. standard population in each age group serve as weights for calculating age-adjusted rate. Additionally, incidence rates at FY 2008 were not reported, as Veterans could previously be diagnosed with headache disorders prior to cohort initiation. Then age-adjusted incidence rate for each specific headache type was calculated separately.

Standard Protocol Approvals, Registrations, and Patient Consents

The VHA HCoE Administrative Data Cohort was approved by the Institutional Review Board of the VHA Connecticut Healthcare System and granted a Health Insurance Portability and Accountability Act waiver and waiver of informed consent.

Data Availability

Anonymized data not published within this article will be made available by request from any qualified investigator. As per VA policy, analytic data sets used for this study are not permitted to leave the VA firewall without a Data Use Agreement. Drs. Sico, Fenton, Wang, and Seng affirm that the manuscript is an honest, accurate, and transparent account of the resource and analyses being described; no important aspects have been omitted.

Results

Description of Veterans with Headache by Gender

A total of 11.5 million Veterans were served by the VHA in the 12 years of observation covered by the headache cohort; 7.4% of them were women. The VHA HCoE Administrative Data Cohort includes 1,524,960 distinct Veterans who were medically diagnosed with any type of headache in at least one outpatient visit (total of 8.2 million visits for headache) between FY 2008-2019 (Table 1). Women made up 17.2% of the cohort and were significantly younger (41.9 versus 52.0 years old), more often non-White (43.3% versus 29.6%) and unmarried (62.7% versus 43.4%) compared to men. Women are an increasing proportion of Veterans serving in more recent military campaign eras; three-quarters of women Veterans served after Vietnam as compared to 45.6% of men Veterans. A bimodal age distribution for first headache diagnosis was noted in men whereas a single peak for women ages 25-29 was noted (Figure 1). With respect to events/conditions of high interest in the VHA, men with headache had clinically significant higher rates of overweight/obesity (81.0% vs 74.3%), TBI (2.9% vs. 1.1%), and PTSD (23.7% vs. 21.7%), and lower rate of MST (3.2% vs. 33.7%).

Description of Headache Types and Incidence

Table 2 displays the gender-specific incidence and one-year period prevalence rates of 'any headache' diagnosis per 100,000 Veterans per fiscal year. Age-adjusted incidence rates of medically diagnosed headache disorders were higher among women Veterans in all years observed, with a range of 4,283 to 7,155 per 100,000 compared to a range of 2,897 to 4,386 per 100,000 for men. While age-adjusted incidence rates decreased over time for both genders, we saw an increase in the one-year period prevalence rates over the same period for men and women. The age-adjusted prevalence rates of headache in women Veterans were always higher than men.

Table 3 contains number of Veterans who were given each headache diagnosis stratified by gender; individual patients may be listed more than one time in this table. More than three quarters of Veterans within the VHA HCoE Administrative Data Cohort dataset received a diagnosis of headache NOS, with migraine being the next most common headache diagnosis. There were significant differences between men and women in the cohort on headache NOS, migraine and migraine subtypes, and statistically significant differences on all other headache types, except for hemicrania continua (p=0.33). A higher proportion of men in the VHA HCoE Administrative Data Cohort had diagnoses of headache NOS (77.4% vs. 67.7%), post-traumatic headache (3.4% vs. 1.9%), post-whiplash headache (5.5% vs 5.1%), and cluster headache (1.7% vs. 0.9%) than women. A higher proportion of women were diagnosed with migraine (60.1% vs. 32.4%, including all migraine

subtypes), tension-type headache (8.2% vs 7.0%), other primary (3.2% vs 2.9%), and other secondary headaches (1.3% vs 1.0%). More men than women had only a single headache type documented (75.0% vs. 61.6%).

Figure 2 shows the age-adjusted gender-specific incidence rates for each distinct headache type per 100,000 Veterans per fiscal year. Of note, the VHA transitioned from *ICD-9-CM* to ICD-*10-CM* at the beginning of FY 2016 (on October 1, 2015). We observed that the incidence curves for the specific headache types were quite different over time. Whereas incidence rate of migraine remained stable from FY2009 onward; TAC, tension-type headache, other primary headache, PTHA, and other secondary headache show sharp increases following the establishment of the *ICD-10-CM*. The incidence rate for PWHA had a surge in FY2014 and FY2015, and then dropped back to their baseline rates after the transition to *ICD-10-CM*. Men and women had incidence profiles that were similar in shape, with women Veterans having higher rates for all headaches but PTHA and TACs.

Headache-Related Care Utilization

Women Veterans with at least on headache diagnosis had a significant larger average number of annual encounters for headaches (1.2 vs. 0.8) and were evaluated by more provider types (1.5 vs. 1.3) for their headaches than men (Table 4). 74% of Veterans receive their headache care from Primary Care providers, with less than a quarter of all Veterans with headache seeing a Neurologist. A significant greater proportion of women had Primary Care Plus visits (84.1% vs 71.9%), ED visits (22.9% vs 20.3%), Neurology visits (27.4% vs 20.8%) and other specialty visits (45.7% vs 38.4%). Meanwhile significantly more men had PM&R visits (9.9% vs 6.7%) and were less likely to be evaluated by Pain Clinic Specialists (2.8% vs. 4.6%) and Psychiatrists (2.9% vs. 4.2%). For interdisciplinary headache care, significantly more women received their headache-related care from Primary Care Provider and Neurologist (24.5% vs. 16.4%), Primary Care Provider and Pain Clinic Specialist (4.3% vs. 2.3%). Geographically, Veterans with headache are served by VAMCs distributed across the country. However, distribution of headache cases overall, as well as by gender, varied across the VISNs (eTable 3).

Discussion

The VHA HCoE Administrative Data Cohort is the world's largest administrative dataset of patients with headache and was created to increase the understanding of headache among Veterans. We report data for more than 1.5 million Veterans with headache across more than 8.2 million headache-related visits over a 12-year period in the largest integrated healthcare system in the U.S., examining gender differences in headache types diagnosed, sociodemographic characteristics, military campaign and exposures, and healthcare utilization gender differences in age, race, ethnicity, military campaign era and military exposures, geography,

diagnoses, and healthcare utilization. We found important gender differences in Veterans with headache which have potential implications for Veterans, healthcare providers, and policy makers.

Men comprise both the majority of U.S. Veterans (90.6%)[27] and of the VHA HCoE Administrative Data Cohort (82.8%). When diagnosed with a headache disorder, men are more often classified as headache NOS, have a lower number of headache-related visits, and generally see providers other than their Primary Care providers (e.g., headache specialists) less frequently than women for headache care. Among all U.S. Veterans, men are significantly older than women.[27] Similarly, within the VHA HCoE Administrative Data Cohort, men were on average a decade older than women and had a bimodal distribution of age of first headache diagnosis; both men and women experienced peaks in headache diagnoses between 25 and 29 years of age whereas men experienced a second peak between 60 and 64 years of age. The relatively low numbers of women Veterans from conflicts prior to the Gulf War may, at least partially explain both the gender difference in average age and the lack of bimodality in women. In addition, we found the incidence and prevalence rates of medically diagnosed headache disorders almost doubled when adjusted with 2010 U.S. Standardized population among men. The age distribution shifts between Veterans and the U.S. population highlights the unique composition in headaches diagnosed and treated in the VHA. The earlier peak for rates of headache among younger Veterans is not surprising, as headache commonly affects people during their most productive years and preferentially so among women. [3, 28] Reports on the one-year period prevalence of medically diagnosed migraine show an increase for both men and women up until ages 30-39, with prevalence higher for women than men (24.4% vs. 7.4%). Among patients 60 years and older, the prevalence of migraine for women and men decreases substantially (5.0% vs. 1.6%).[29] VHA-based studies examining headache among Veterans serving in the most recent military campaigns in Iraq and Afghanistan find comparable mean ages between men and women with migraine and that the majority with headache occur in persons under 50 years of age.[14, 23]

The overall proportion of Black Veterans with headache (22.2%) is elevated in comparison with their representation in the VHA (Overall 12%; Men: 10.0%, Women 18.9%).[27] This trend may be partially explained by the fact that Black Veterans are more likely to be women and younger, groups at higher risk for headache disorders. Data from the 2014 National Health Interview Survey reported that 15.0% of Black persons or persons of African American ancestry experienced migraine and severe headache.[3]

In considering conditions associated with military service, TBI is a signature injury of modern military conflicts.[33] Headache is the most common, persistent symptom after TBI, with an incidence reaching 90%; approximately 15 to 53% of these patients going on to develop persistent PTHA.[34] The literature on Veterans suggests that women are less likely to sustain a TBI, but more likely to report headache after TBI than men.[35]

In our study, men had higher rates of PTHA, which may be accounted for by the higher rate of TBI among men. PTSD and TBI are more common among Veterans with headache compared to those without headache, and PTSD itself may also exacerbate headache.[13, 36] Among Veterans, military sexual trauma occurs in 8.4% overall, in 33 to 41% of women and in 1 to 4% of men; headache is one of the many physical symptoms associated with this form of trauma.[37, 38]

Our current work confirms gender differences in headache diagnoses; women are more frequently diagnosed with migraine and tension type headache than men. Men are more frequently diagnosed with cluster headache, other TACs, and headaches associated with trauma, specifically post-trauma headache and post-whiplash headache.[39, 40] A large percentage of Veterans with headache were diagnosed with headache NOS, an *ICD-CM* symptom code that typically represents a failure to accurately diagnose an *ICHD defined* primary or secondary headache disorder or disorders. Two studies reported the proportions of headache NOS diagnosed in the Emergency Department were 26% and 42%, respectively.[41, 42] Reasons why men may have had higher rates of being diagnosed with headache NOS in VHA administrative data likely are less related to the underlying biology of headache. Rather, this phenomenon may reflect a combination of men seeing fewer headache specialists invested in making specific diagnoses, possible underreporting of or experiencing headache and headache-associated symptoms which would support a more specific diagnosis, lower number of follow-up visits, and hence opportunities to make a more specific diagnosis, for men compared to women, deficiencies in diagnosis and coding by healthcare providers, or implicit bias providers may have towards headache in men.

We also observed dramatic increase in the incidence rates of TAC, TTH, Other Primary Headache, PTHA and Other Secondary Headache after the transition from *ICD-9-CM* to *ICD-10-CM* coding. One VHA study revealed a 75% consistency of headache *ICD-CM* codes assigned to the same patients before and after the transition.[43] Although *ICD-9-CM* and *ICD-10-CM* share similar hierarchy on disease classification, *ICD-10-CM* is more granular and contains seven-fold more diagnostic codes, which allows for greater diagnostic specificity. A good example is the coding of Other Secondary Headache attributed to cranial or cervical vascular disorder. In *ICD-10-CM*, vascular headache was coded as G44.1, and was included with 784.0, a non-specific symptom code in *ICD-9-CM*. This cross-sectional difference due to coding transition was also observed in subarachnoid hemorrhage, intracerebral hemorrhage, ischemic stroke, and Parkinson's disease.[44] Without sudden changes in rate of exposure or healthcare access, incidence of a chronic disease should remain constant over time. The incidence of headaches in recent fiscal years returns to similar rates before the *ICD-9/10-CM* transition, thus the distinct headache incidences examined in this national Veteran

cohort are relatively accurate. While it remains unclear why there was a surge in PWHA incidence in FYs 2014 and 2015, we hypothesize that this phenomenon is linked to the Polytrauma Blast-Related Injury Quality Enhancement Research Initiative on OEF/OIF/OND Veterans with TBI sequelae in 2013.[45] Exactly how the coding of discrete headache diagnoses may have been impacted by the coding transition needs to be addressed in future work.

Women on average had more visits for headache than did men, were more likely to see a healthcare professional other than a primary care provider for their headache, and to see multiple specialists, with the exception that men were more likely to see physiatrists as part of their headache management. In VHA, physiatrists are more often responsible for polytrauma centers than neurologists and there was more medically diagnosed TBI in men than women with headache. Women with migraine were more likely than men with migraine to report having consulted any doctor for headache management. In a study of a single VHA Polytrauma Center, men Veterans with a positive mTBI screen and persistent headaches refused Neurology clinic referrals more often than women. Still, for those who accepted a Neurology Clinic referral, nearly 70% appeared for the initial Neurology Clinic appointment and 29.2% appeared for at least one follow-up appointment.[34]

Gender differences in healthcare use may reflect differences in rates of various headache disorders, severity, and patterns of consultation for those disorders among Veterans. For example, in both the American Migraine Study and VHA Polytrauma Center study, patients were more likely to accept a referral outside of primary care if they were having more severe headache pain.[34, 46] In our cohort, headache care was delivered to 20.7% of Veterans with headache in the VHA ED, more frequently for women than men. Headache is one of the most common reasons for patients to go to EDs for patients ages 15-64, being the 6th and 19th most common diagnosis seen in women and men, respectively.[3] The lifetime prevalence of ED use for headache management differs between women and men with migraine (19.5% versus 13.4%).[47] Among the limitations, our cohort is comprised of U.S. military Veterans served by the VHA, a predominantly male population. While these results may be less generalizable to other populations, the VHA HCoE Administrative Data Cohort allows for an unparalleled opportunity to study headache among men as well as examine rarer headache diagnoses in men and women (e.g., Hemicrania continua). With respect to gender, the VHA recorded self-reported binary gender in the EHR during the study period. As EHR data capture extends beyond these binary categories, future headache studies should include transgender and non-binary gender identities While we examined military campaign and exposures, VHA data does not routinely have the branch of the military Veterans served in. Noting that military exposures may vary by service branch suggest that headache may differ across service branches. Our administrative data cohort relies on *ICD-CM* codes entered by providers working within a non-fee for service healthcare system. Patients reported here have been medically diagnosed with headache

by various VHA providers; as such, universal use of validated instruments to diagnoses specific headache diagnoses did not occur, nor would be feasible. Also, while this cohort has a sizable number of cases, under-coding of specific headache diagnoses likely occurs. Similar to claims data, VHA administrative data does not routinely capture pain severity, frequency, disability, or other measures of the burden headache imposes on patients. Furthermore, while men are less likely to see Neurologists and other headache specialists in our cohort, we cannot determine if this is due to unobserved patient and/or provider factors such as differences in real and reported headache severity and frequency between men and women, whether men are less apt to seek medical assistance in the form of a referral[48] or be given a referral, or other reasons which may determine referral patterns. Finally, we do not currently report headache treatment or a comprehensive list of chronic pain and mental health comorbidities. The decision was made to not include that data here, given the heterogeneity of headaches and noting that some treatments are more applicable to specific headache types.

Our current findings have important headache management implications for providers and healthcare systems. Recognizing the large number of older Veterans with headache, providers should consider tailoring treatment regimens to this age group and undertake evaluation for secondary causes of headache as appropriate.[30, 31] Understanding the racial and ethnic composition is imperative to delivering high-quality guideline concordant care. Migraine attacks have been found to be more severe and frequent among Black patients compared to White patients with migraine, perhaps due to stresses related to minority status and observed underutilization of headache services.[32] Evaluation and treatment strategies should be sensitive to these racial/ethnic differences. Clinicians providing headache care for Veterans with TBI, PTSD, and MST should be aware of potential treatment implications, both holistically and for headache management, in the presence of these conditions. From a healthcare systems perspective, specific areas which warrant attention include the high rates of both ED utilization for headache care and headache NOS diagnoses. Veterans with headache are going to the ED at roughly the same proportion as going to a Neurologist or a higher rate than to other headache specialists. One likely predictor of higher ED use for headache may be limited access to providers with expertise in headache care. Reduced access is likely contributing to the observed rates of headache NOS. It would be impossible for the more than one million Veterans living with a headache NOS diagnosis to see a headache specialist. Large scale educational interventions focusing on accurate and specific headache diagnoses and coding, alone or in combination with EHR/informatics-based approached, could begin addressing this important and previously underappreciated issue among Veterans.

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Table 1. Demographic and Key Clinical Features of Veterans with a Medically Diagnosed Headache Disorder in the VHA from Fiscal Year 2008-2019 by Gender [a]

	Gender			
	Women (n = 262,505)	Men (n = 1,262,455)	Total (N = 1,524,960)	P Value
Age				
Mean (SD)	41.9 (13.0)	52.0 (16.8)	50.3 (16.6)	<0.001 [b]
Race				
American Indian/Alaska Native	2,890 (1.1%)	10,983 (0.9%)	13,873 (0.9%)	
Asian	3,637 (1.4%)	14,924 (1.2%)	18,561 (1.2%)	
Black	84,682 (32.3%)	253,358 (20.1%)	338,040 (22.2%)	
Native Hawaiian/Pacific Islander	2,847 (1.1%)	11,992 (0.9%)	14,839 (1.0%)	
White	148,819 (56.7%)	888,218 (70.4%)	1,037,037 (68.0%)	<0.001 [b]
Mixed Race	4,330 (1.6%)	12,906 (1.0%)	17,236 (1.1%)	
Unknown	15,300 (5.8%)	70,074 (5.6%)	85,374 (5.6%)	
Ethnicity				
Hispanic	21,316 (8.1%)	100,966 (8.0%)	122,282 (8.0%)	0.035
Military Campaigns				
World War II	1,336 (0.5%)	31,140 (2.5%)	32,476 (2.1%)	<0.001 [b]
Korean conflict	2,805 (1.1%)	82,142 (6.5%)	84,947 (5.6%)	
Vietnam War era	61,842 (23.6%)	573,277 (45.4%)	635,119 (41.6%)	
Gulf War	134,935 (51.4%)	291,744 (23.1%)	426,679 (28.0%)	
OEF/OIF/OND	60,247 (23.0%)	281,468 (22.3%)	341,715 (22.4%)	
Others/Unknown	1,340 (0.5%)	2,684 (0.2%)	4,024 (0.3%)	
Marital Status				
Single/Never Married	59,333 (22.6%)	185,783 (14.7%)	245,116 (16.1%)	<0.001 [b]
Married	97,902 (37.3%)	676,520 (53.6%)	774,422 (50.8%)	
Separated/Divorced	94,047 (35.8%)	340,550 (27.0%)	434,597 (28.5%)	
Widowed	7,845 (3.0%)	49,435 (3.9%)	57,280 (3.8%)	
Others/Unknown	3,378 (1.3%)	10,167 (0.8%)	13,545 (0.9%)	
Body Mass Index				
Mean (SD)	29.5 (6.3)	29.8 (5.7)	29.8 (5.8)	<0.001
Underweight	2,519 (1.1%)	7,390 (0.7%)	9909 (0.7%)	<0.001 [b]
Normal	57,988 (24.8%)	199,485 (18.2%)	257473 (19.4%)	
Overweight	74,457 (31.9%)	408,640 (37.3%)	483097 (36.3%)	
Obese	98,544 (42.2%)	481,346 (43.9%)	579890 (43.6%)	
Unable to Assess	28,997	165,594	194,591	

Military Exposure Related

	Gender		Total (N = 1,524,960)	P Value
	Women (n = 262,505)	Men (n = 1,262,455)		
TBI	2,832 (1.1%)	36,321 (2.9%)	39,153 (2.6%)	<0.001 [b]
PTSD	56,977 (21.7%)	299,483 (23.7%)	356,460 (23.4%)	<0.001 [b]
MST	88,450 (33.7%)	40,359 (3.2%)	128,809 (8.4%)	<0.001 [b]

[a] Abbreviations: Veterans Health Administration (VHA); Operation Enduring Freedom/Operation Iraqi Freedom/Operation New Dawn (OEF/OIF/OND); Traumatic Brain Injury (TBI); Post-Traumatic Stress Disorder (PTSD); Military Sexual Trauma (MST); Standard deviation (SD)

[b] Clinically significant: Clinical significance for categorical results reflects at least 2% absolute difference or a two-fold difference in overall proportions, or follows Cohen's $d \geq 0.20$

Table 2. Gender-Specific Incidence and Period Prevalence Rates per 100,000 Veterans with any Medically Diagnosed Headache by Year

	Fiscal Year											
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Crude Period Incidence [a]												
Women	--	7,442.6	6,012.3	5,125.1	4,829.6	4,834.4	4,831.8	4,824.1	4,369.1	4,063.3	4,164.3	4,012.6
Men	--	2,390.4	2,112.6	1,923.2	1,829.6	1,801.5	1,906.6	1,980.8	1,733.0	1,664.3	1,684.6	1,692.8
Age-Adjusted Incidence [a]												
Women	--	7,155.2	5,836.4	5,016.2	4,721.2	4,763.5	4,766.2	4,818.5	4,445.9	4,282.9	4,540.0	4,370.7
Men	--	4,386.3	3,768.1	3,372.9	3,174.3	3,190.1	3,257.3	3,298.8	2,954.6	2,897.2	2,950.5	2,983.4
Crude Period Prevalence												
Women	13,952.5	14,932.5	15,197.9	15,305.9	15,589.7	16,059.3	16,790.3	17,581.5	16,063.4	16,748.1	17,986.9	18,917.2
Men	3,534.7	3,892.7	4,057.5	4,140.4	4,273.1	4,450.7	4,812.9	5,186.7	4,489.2	4,729.9	5,099.7	5,450.6
Age-Adjusted Prevalence												
Women	13,105.8	13,956.5	14,165.4	14,204.1	14,398.3	14,811.3	15,443.7	16,177.6	14,885.0	15,668.2	16,970.0	17,875.5
Men	6,318.0	6,977.6	7,107.0	7,126.6	7,185.7	7,445.0	7,844.5	8,273.7	7,340.6	7,746.6	8,315.5	8,839.4

[a] Incidence rate is not reported in FY2008 veterans could previously be diagnosed with headache disorders period to cohort initiation.

Table 3. Breakdown among Medically Diagnosed Headache Disorders from Fiscal Year 2008 – 2019 by Gender [a]

	Gender		Total (N = 1,524,960)	P Value
	Women (n = 262,505)	Men (n = 1,262,455)		
Headache Conditions [b]				
Headache, NOS	177,586 (67.7%)	977,169 (77.4%)	1,154,755 (75.7%)	<0.001 [c]
Migraine	157,837 (60.1%)	409,284 (32.4%)	567,121 (37.2%)	<0.001 [c]
without aura	47,876 (18.2%)	95,210 (7.5%)	143,086 (9.4%)	<0.001 [c]
with aura	30,815 (11.7%)	67,383 (5.3%)	98,198 (6.4%)	<0.001 [c]
Chronic	26,853 (10.2%)	54,190 (4.3%)	81,043 (5.3%)	<0.001 [c]
TAC	2,804 (1.1%)	24,125 (1.9%)	26,929 (1.8%)	<0.001
Cluster Headache	2,368 (0.9%)	21,772 (1.7%)	24,140 (1.6%)	<0.001
Hemicrania Continua	360 (0.1%)	1,831 (0.1%)	2,191 (0.1%)	0.33
Tension-Type Headache	21,639 (8.2%)	88,699 (7.0%)	110,338 (7.2%)	<0.001
Other Primary Headache	8,421 (3.2%)	36,097 (2.9%)	44,518 (2.9%)	<0.001
Post-Traumatic Headache	4,874 (1.9%)	42,475 (3.4%)	47,349 (3.1%)	<0.001
Post-Whiplash Headache	13,439 (5.1%)	69,622 (5.5%)	83,061 (5.4%)	<0.001
Secondary Headache	3,286 (1.3%)	12,619 (1.0%)	15,905 (1.0%)	<0.001
Drug-induced Headache	1,965 (0.7%)	7,014 (0.6%)	8,979 (0.6%)	<0.001
Vascular Headache	1,355 (0.5%)	5,694 (0.5%)	7,049 (0.5%)	<0.001
Number of Headache Diagnoses				
Mean (SD)	1.5 (0.7)	1.3 (0.6)	1.3 (0.6)	<0.001 [c]
1	161,794 (61.6%)	946,500 (75.0%)	1,108,294 (72.7%)	<0.001 [c]
2	078,582 (29.9%)	248,465 (19.7%)	0327,047 (21.4%)	
≥ 3	022,129 (8.4%)	067,490 (5.3%)	0089,619 (5.9%)	

[a] Abbreviations: Not-otherwise-specified (NOS); Trigeminal Autonomic Cephalalgia (TAC); Standard deviation (SD);

[b] Headache diagnoses are not mutually exclusive

[c] Clinically significant: Clinical significance for categorical results reflects at least 2% absolute difference or a two-fold difference in overall proportions, or follows Cohen's $d \geq 0.20$

Table 4. Outpatient Visits with Medically Diagnosed Headache Disorders from Fiscal Year 2008 - 2019 by Gender [a]

	Gender		Total (N = 1,524,960)	P Value
	Women (N = 262,505)	Men (N = 1,262,455)		
Number of Encounters per Fiscal Year				
Mean (SD)	1.2 (1.6)	0.8 (1.2)	0.9 (1.3)	<0.001 [c]
Specialty Types				
Primary Care Plus [b]	220,785 (84.1%)	907,969 (71.9%)	1,128,754 (74.0%)	<0.001 [c]
Primary Care	182,347 (69.5%)	0907,567 (71.9%)	1,089,914 (71.5%)	<0.001 [c]
Women's Health	89,811 (34.2%)	1,560 (0.1%)	91,371 (6.0%)	<0.001 [c]
ED	60,237 (22.9%)	255,843 (20.3%)	316,080 (20.7%)	<0.001 [c]
Neurology	71,918 (27.4%)	262,907 (20.8%)	334,825 (22.0%)	<0.001 [c]
PM&R	17,505 (6.7%)	125,482 (9.9%)	142,987 (9.4%)	<0.001 [c]
Pain Clinic	12,128 (4.6%)	34,822 (2.8%)	46,950 (3.1%)	<0.001
Psychiatry	11,001 (4.2%)	36,205 (2.9%)	47,206 (3.1%)	<0.001
Others	119,898 (45.7%)	048,5224 (38.4%)	605,122 (39.7%)	<0.001 [c]
Number of Specialty Types per Person				
Mean (SD)	1.5 (1.0)	1.3 (0.8)	1.4 (0.9)	<0.001 [c]
0	13,219 (5.0%)	113,995 (9.0%)	127,214 (8.3%)	<0.001 [c]
1	148,979 (56.8%)	786,039 (62.3%)	935,018 (61.3%)	
2	61,835 (23.6%)	246,984 (19.6%)	308,819 (20.3%)	
≥ 3	38,472 (14.7%)	115,437 (9.1%)	153,909 (10.1%)	
Combinations				
Primary Care Plus & Neurology	64,231 (24.5%)	206,437 (16.4%)	270,668 (17.7%)	<0.001 [c]
Primary Care Plus & PM&R	14,652 (5.6%)	83,053 (6.6%)	97,705 (6.4%)	<0.001
Primary Care Plus & Pain Clinic	11,184 (4.3%)	28,904 (2.3%)	40,088 (2.6%)	<0.001 [c]
Primary Care Plus & Psychiatry	10,108 (3.9%)	30,129 (2.4%)	40,237 (2.6%)	<0.001
Neurology & PM&R	9,098 (3.5%)	41,297 (3.3%)	50,395 (3.3%)	<0.001
Neurology & Pain Clinic	7,916 (3.0%)	19,617 (1.6%)	27,533 (1.8%)	<0.001
Neurology & Psychiatry	6,164 (2.3%)	17,593 (1.4%)	23,757 (1.6%)	<0.001
PM&R & Pain Clinic	2,584 (1.0%)	8,670 (0.7%)	11,254 (0.7%)	<0.001
PM&R & Psychiatry	1,739 (0.7%)	8,794 (0.7%)	10,533 (0.7%)	0.05
Pain Clinic & Psychiatry	1,884 (0.7%)	4,446 (0.4%)	6,407 (0.4%)	<0.001

[a] Abbreviations: Emergency Department (ED); Physical Medicine and Rehabilitation (PM&R); Standard deviation (SD);
[b] Primary Care Plus is a combination of Primary Care and Women's Health.

^{c} Clinically significant: Clinical significance for categorical results reflects at least 2% absolute difference or a two-fold difference in overall proportions, or follows Cohen's $d \geq 0.20$

**Figure 1. Baseline Age Distribution of Veterans in the VHA HCoE Administrate Data Cohort by Gender**
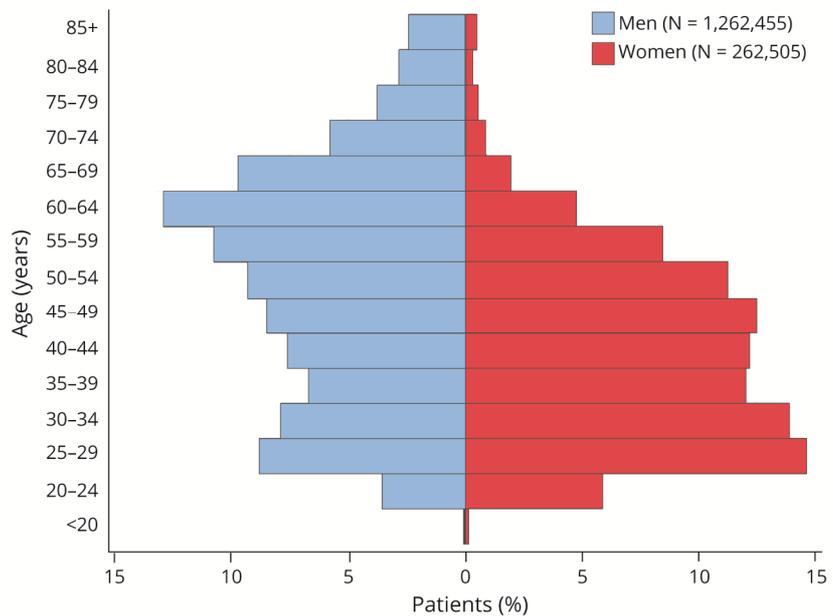
Figure 2. Age-Adjusted Headache Incidence of Distinct Headache Types Encountered within the Veterans Health Administration, Stratified by Gender and Standardized to the United States Population (2010), Fiscal Year 2009-2019
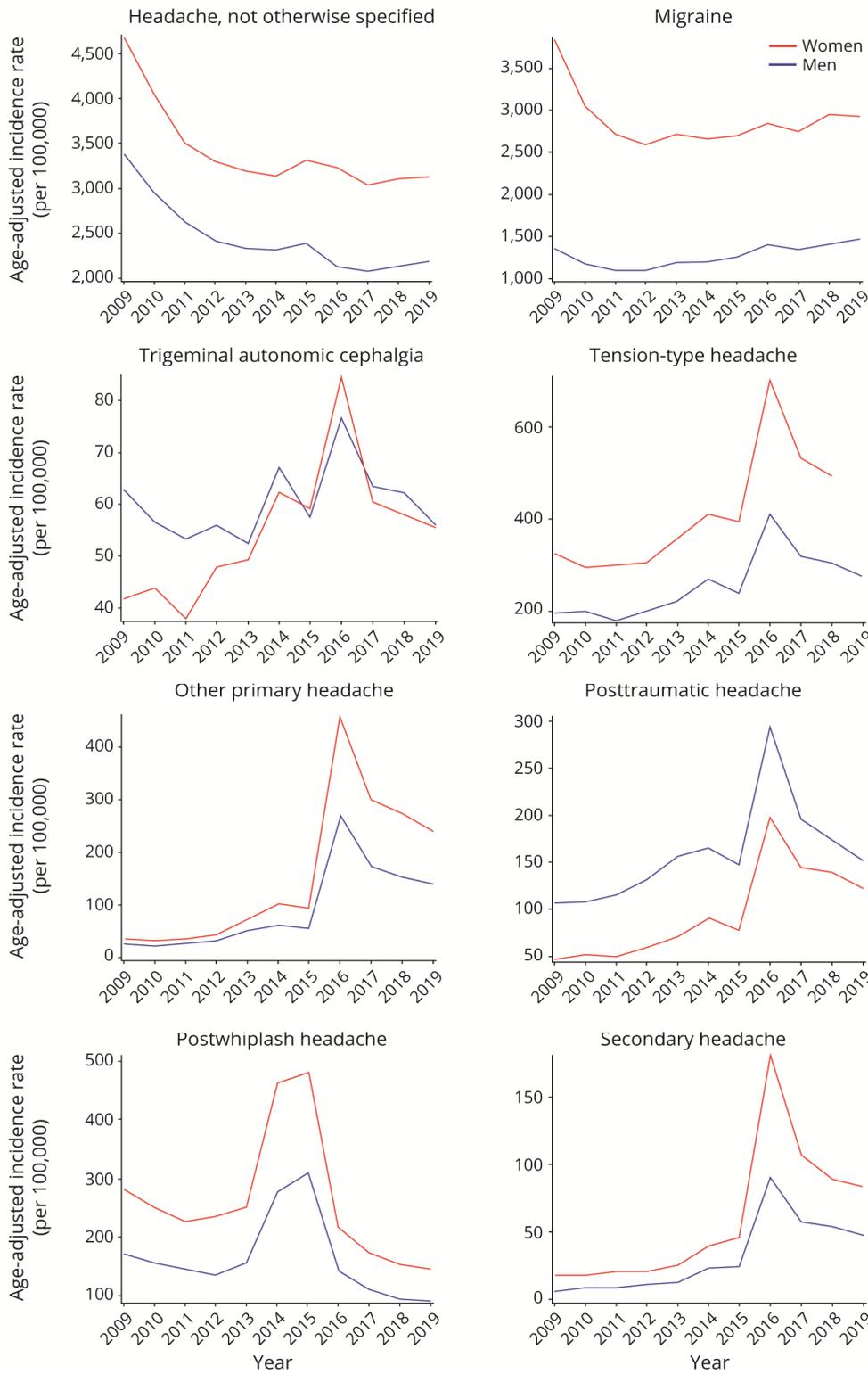
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Characteristics and Gender Differences of Headache in the Veterans Health Administration: A National Cohort Study, Fiscal Year 2008–2019

Jason Jonathon Sico, Elizabeth Seng, Kaicheng Wang, et al.

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