RESEARCH ARTICLE

Burden of Insomnia Disorder Among US Active-Duty Military Personnel

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Abstract

Background and Objectives

Insomnia is highly prevalent among military personnel, with many gaps in knowledge. The purpose of this study was to quantify the medical, psychiatric, and utilization burden of insomnia among active-duty military personnel. We hypothesized that insomnia is associated with worsened health and economic outcomes.

Methods

This was a retrospective case-control study. Data were derived from the Military Data Repository (2016–2021). Active-duty service members (ADSMs) younger than 65 years, with 12 months of continuous enrollment before and after first insomnia diagnosis and no evidence of previous insomnia or insomnia treatment, were matched 1:1 on demographic, clinical, and military characteristics to ADSMs without insomnia. Insomnia and psychiatric and medical comorbidities were defined using International Classification of Diseases, 10th Revision diagnostic codes. The impact of newly diagnosed insomnia on psychiatric and medical outcomes within 12 months was examined using time-to-event models. The impact of newly diagnosed insomnia on 12-month health care resource utilization (HCRU) was examined using generalized linear models.

Results

A total of 40,978 ADSMs met insomnia criteria and were matched to 40,978 ADSMs without insomnia. Participants were 78.6% male and 61.8% identified as White, with most younger than 44 years (90.3%). Insomnia was associated with increased risk of almost every studied physical and psychological health outcomes; relative to those without insomnia, ADSMs with insomnia demonstrated a 6-fold increased risk of post-traumatic stress disorder (hazard ratio [HR] 6.51, 95% CI 5.95–7.12, $p < 0.001$), as well as elevated risk of traumatic brain injury (HR 5.32, 95% CI 4.53–6.24, $p < 0.001$). ADSMs with insomnia demonstrated greater all-cause HCRU across all points of service (all p's < 0.001).

Discussion

Among active-duty personnel, new-onset insomnia was associated with substantially increased risk of adverse medical and psychiatric burden, as well as increased utilization, over 12 months. Key limitations include our observational study design.

Introduction

Insomnia, defined as difficulty initiating and/or maintaining sleep with associated daytime consequence, is the most common sleep disorder among adults and highly prevalent in the US military. Military personnel experience an unrelenting work tempo, nontraditional work

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Glossary

ADSM = active-duty service member; **CBTI** = cognitive-behavioral treatment for insomnia; **ED** = emergency department; **HCRU** = health care resource utilization; **HR** = hazard ratio; **ICD-10** = International Classification of Diseases, 10th Revision; **MDR** = Military Data Repository; **MHS** = Military Health System; **MSKI** = musculoskeletal injury; **OSA** = obstructive sleep apnea; **PTSD** = post-traumatic stress disorder; **RtR** = rate ratio; **SMD** = standardized mean difference; **TBI** = traumatic brain injury.

schedules, and global operations that all increase risk of poor sleep. Indeed, within the past decade, multiple studies have documented high prevalence rates of insomnia among the active-duty population. Prevalence estimates of moderate-to-severe insomnia have ranged from 11.2% to 19.9%,[1,2] and the recognition of insomnia has increased multiple-fold.[3-5]

Generally speaking, insomnia is associated with a very broad range of adverse medical (e.g., cardiovascular,[6] metabolic,[7] and neurodegenerative[8]) and psychiatric (e.g., depression,[9,10] anxiety,[10] chronic pain,[11] and substance misuse[10,12]) consequences, with diminished health-related quality of life.[13,14] Furthermore, in nonmilitary samples, insomnia is associated with increased economic burden borne by patients, payers, employers, and society.[15] Based on these consequences and increased awareness of insomnia within the military, it is notable that few empirical studies have examined the health or economic burden of insomnia among active-duty service members (ADSMs). A longitudinal analysis (2001–2008) among military personnel found that self-reported trouble falling asleep and/or staying asleep was associated with reduced self-reported health, greater absenteeism, lower odds of deployment, higher odds of discharge, and greater self-reported health care resource utilization (HCRU).[16]

Clearly, insomnia is a major concern within the US military, with many gaps in knowledge. To advance understanding, the objective of this study was to quantify the health and economic burden of insomnia among the key subgroup of ADSMs. Our primary hypothesis was that relative to ADSMs without insomnia, ADSMs with insomnia demonstrate increased risk of adverse physical and psychological health outcomes and increased economic burden.

Methods

Standard Protocol Approvals

This study used fully deidentified data and received an exempt determination from the Institutional Review Board at the Walter Reed Army Institute of Research (protocol #2985).

Data Source

The Military Data Repository (MDR) for years 2016–2021 was the data source for this study. The MDR includes encounter, procedure, pharmacy, and durable medical equipment information for active-duty military personnel, military dependents, National Guard, and Reservists treated within the Military Health System (MHS), including both direct on-base care within military treatment facilities and the private sector TRICARE network, which offers medical care to eligible beneficiaries through contracts with private sector providers.

Participants

We conducted a retrospective cohort study using 2 cohorts (i.e., insomnia and no insomnia) of United States–based ADSMs aged 17–64 years. Eligibility required 24 months of continuous enrollment, including at least 12 months in TRICARE Prime both before and after the date of first insomnia diagnosis, which was considered the index date. We excluded any individuals with use of any insomnia medication during the previous 12 months, as well as any individuals with a history of insomnia-related care. Individuals with history of obstructive sleep apnea (OSA) or OSA treatment during the preindex period were also excluded. This comparison cohort of ADSMs was created by selecting a random set of 237,000 patients with at least 24 months of enrollment and no diagnosis of insomnia or OSA; for these, a random index date was selected such that there were ≥12 months of continuous enrollment both before and after the index date. For this matched comparison cohort of ADSMs, we also applied the same exclusions for insomnia medications or insomnia-related care during the 12 months before the index date. Our approach to matching is described further.

Insomnia

Insomnia was defined as receipt of 1 or more provider-assigned International Classification of Diseases, 10th Revision (ICD-10) codes F51.01, F51.02, F51.03, F51.04, F51.05, F51.09, G47.00, G47.01, or G47.09 in any position on an inpatient or outpatient claim after a twelve-month clean period without evidence of insomnia diagnosis or medications used to treat insomnia.

Outcomes

Outcomes were selected based on discussions with military stakeholders and included new diagnoses of physical and psychological health conditions (Table 1) and HCRU assessed over the year after the index date. Physical health and psychological health conditions were defined using ICD-10 codes. In addition, we created a variable representing any musculoskeletal injury.[17] All-cause HCRU was measured as total counts of visits by point of service (inpatient, outpatient, emergency department [ED]). In addition to all-cause visits,

Table 1 Participant Demographic, Military, and Clinical Characteristics at Index Date, Stratified by Insomnia Status (N = 81,956)

	Non-insomnia, n (%)	Insomnia, n (%)	Total, n (%)	SMD
	40,978 (100.0)	40,978 (100.0)	81,956 (100.0)	
Demographics				
Age (cat)				0.095
18–24	7,009 (17.1)	7,895 (19.3)	14,904 (18.2)	
25–34	13,684 (33.4)	14,703 (35.9)	28,387 (34.6)	
35–44	16,062 (39.2)	14,668 (35.8)	30,730 (37.5)	
45–54	3,990 (9.7)	3,495 (8.5)	7,485 (9.1)	
55–64	233 (0.6)	217 (0.5)	450 (0.5)	
Female	9,043 (22.1)	8,483 (20.7)	17,526 (21.4)	0.033
CCI category				0.022
0	38,943 (95.0)	38,890 (94.9)	77,833 (95.0)	
1	1,594 (3.9)	1,734 (4.2)	3,328 (4.1)	
2+	276 (0.7)	324 (0.8)	600 (0.7)	
Missing	165 (0.4)	30 (0.1)	195 (0.2)	
Race				0.040
American Indian/Alaska Native	451 (1.1)	436 (1.1)	887 (1.1)	
Asian/Pacific Islander	2,790 (6.8)	2,939 (7.2)	5,729 (7.0)	
Black	10,123 (24.7)	10,599 (25.9)	20,722 (25.3)	
White	25,520 (62.3)	25,110 (61.3)	50,630 (61.8)	
Other	1,821 (4.4)	1,608 (3.9)	3,429 (4.2)	
Unknown	271 (0.7)	285 (0.7)	556 (0.7)	
Missing	2 (0.0)	1 (0.0)	3 (0.0)	
Ethnicity				0.021
Hispanic	5,559 (13.6)	5,848 (14.3)	11,407 (13.9)	
None	10,555 (25.8)	10,480 (25.6)	21,035 (25.7)	
Other	24,116 (58.9)	23,936 (58.4)	48,052 (58.6)	
Unknown	748 (1.8)	714 (1.7)	1,462 (1.8)	
Service branch				0.126
Army	19,947 (48.7)	22,228 (54.2)	42,175 (51.5)	
Air Force	10,088 (24.6)	8,557 (20.9)	18,645 (22.8)	
Coast Guard	824 (2.0)	611 (1.5)	1,435 (1.8)	
Marine Corps	3,088 (7.5)	3,212 (7.8)	6,300 (7.7)	
NOAA	8 (0.0)	3 (0.0)	11 (0.0)	
Navy	6,806 (16.6)	6,214 (15.2)	13,020 (15.9)	
PHS	217 (0.5)	153 (0.4)	370 (0.5)	
Enlisted	34,263 (83.6)	34,877 (85.1)	69,140 (84.4)	0.041
Region				0.217

Continued

Table 1 Participant Demographic, Military, and Clinical Characteristics at Index Date, Stratified by Insomnia Status (N = 81,956) *(continued)*

	Non-insomnia, n (%)	Insomnia, n (%)	Total, n (%)	SMD
East North Central	188 (0.5)	271 (0.7)	459 (0.6)	
East South Central	1,072 (2.6)	1,626 (4.0)	2,698 (3.3)	
Mountain	1,241 (3.0)	1,036 (2.5)	2,277 (2.8)	
Pacific	5,148 (12.6)	4,641 (11.3)	9,789 (11.9)	
South Atlantic	9,743 (23.8)	9,840 (24.0)	19,583 (23.9)	
West South Central	3,595 (8.8)	5,560 (13.6)	9,155 (11.2)	
Missing	19,991 (48.8)	18,004 (43.9)	37,995 (46.4)	
Medical history				
Fracture	110 (0.3)	120 (0.3)	230 (0.3)	0.005
TBI	609 (1.5)	1,102 (2.7)	1,711 (2.1)	0.084
Asthma	1,028 (2.5)	1,065 (2.6)	2,093 (2.6)	0.006
COPD	310 (0.8)	324 (0.8)	634 (0.8)	0.004
Diabetes	268 (0.7)	271 (0.7)	539 (0.7)	0.001
Fibromyalgia	6,848 (16.7)	7,476 (18.2)	14,324 (17.5)	0.040
Hyperlipidemia	2,905 (7.1)	2,754 (6.7)	5,659 (6.9)	0.015
Hypertension	50 (0.1)	51 (0.1)	101 (0.1)	0.001
Cardiovascular disease	257 (0.6)	248 (0.6)	505 (0.6)	0.003
Psychiatric history				
Anxiety	6,678 (16.3)	7,293 (17.8)	13,971 (17.0)	0.040
Depression	3,383 (8.3)	3,759 (9.2)	7,142 (8.7)	0.033
PTSD	1,531 (3.7)	1,209 (3.0)	2,740 (3.3)	0.044
Adjustment disorder	6,150 (15.0)	5,930 (14.5)	12,080 (14.7)	0.015
Alcohol/SUD	3,882 (9.5)	2,612 (6.4)	6,494 (7.9)	0.115
Other mood disorders	8,435 (20.6)	8,597 (21.0)	17,032 (20.8)	0.010
Number of psychiatric diagnoses				0.081
0	25,457 (62.1)	25,457 (62.1)	50,914 (62.1)	
1	6,713 (16.4)	6,713 (16.4)	13,426 (16.4)	
2	4,748 (11.6)	5,246 (12.8)	9,994 (12.2)	
3+	4,060 (9.9)	3,562 (8.7)	7,622 (9.3)	

Abbreviations: CCI = Charlson Comorbidity Index; COPD = chronic obstructive pulmonary disease; MSKI = musculoskeletal injury; NOAA = National Oceanic and Atmospheric Administration; PHS = Public Health Service; PTSD = post-traumatic stress disorder; SUD = substance use disorder; TBI = traumatic brain injury.

we removed insomnia-related HCRU from this count and compared non–insomnia-related HCRU between groups.

Covariates

Age, sex, race, ethnicity, service branch (Army, Navy, Air Force, Marines, Space Force, Coast Guard, Public Health Service), military rank (enlisted vs officer), and region were available in the MDR. Age was measured in categories (18–24, 25–34, 35–44, 45–54, 55–64). Baseline Charlson Comorbidity Index scores were calculated using the 12-month baseline period (categorized into 0, 1, 2+). All physical health and psychological health comorbidities (Table 1) diagnosed during the 12 months before the index date were considered present at baseline. After exploratory analysis of

baseline variables, we observed high prevalence of psychological health comorbidities in the insomnia cohort. For matching purposes, we created a count of these conditions by summing the total number of psychological comorbidities (range 0–6).

Statistical Analysis

We matched ADSMs with insomnia 1:1 to ADSMs without insomnia who met all other inclusion criteria using nearest neighbor matching on a propensity score. To obtain the propensity score (likelihood of having insomnia) for each individual, we first estimated a logistic regression model using the entire pool of individuals, with insomnia as the dependent variable and predictors including sex, age, race, ethnicity, service branch, military rank, Charlson Comorbidity Index, and 12-month history of all comorbidities listed in Table 1. We used this model to predict the probability of insomnia in each individual and used this propensity score to identify the nearest neighbor individual (noninsomnia) for each ADSM with insomnia, breaking ties randomly and matching without replacement. Standardized mean differences (SMDs) representing the postmatching difference in the distribution of each characteristic between individuals with and without insomnia were used to assess covariate balance. After this procedure, psychological comorbidities remained unbalanced (SMDs >0.2) between the cohorts and showed no meaningful improvement when the count of psychological comorbidities was added to the model. Therefore, to improve our matching process, we stratified the cohorts by the count of psychological comorbidities and repeated the matching process within each stratum. This final matched study cohort is reported here.

Then, to test the hypothesis that insomnia worsens health outcomes, we estimated a series of Cox proportional hazard models, 1 for each psychiatric and medical outcome. We calculated time to event as days from the index date. Individuals were censored at occurrence of the outcome of interest or at 365 days, whichever occurred first. For each model, individuals with previous diagnosis of that outcome were excluded, along with their corresponding match. We tested the proportional hazard assumption using Schoenfeld residuals. If the proportional hazard assumption was not met, we used the Akaike information criterion to assess nonparametric time-to-event model specifications (exponential, loglog, and log normal) and reanalyzed the outcome using the best alternative specification. All models included any covariates that were not balanced (SMD >0.2) after matching. For Cox models, hazard ratios (HRs) and 95% CIs are reported. For nonparametric models, time ratios with 95% CIs are reported.

To test the hypothesis that insomnia increases economic burden, we modeled counts of all-cause and non–insomnia-related HCRU across points of service (i.e., inpatient, ED, or outpatient) using Poisson models. As mentioned above, these models included covariates with SMD >0.2 after matching. In addition, these models adjusted for the number of (all-cause) visits of the same type during the 12 months before the index date. Finally, the approach of Sidak[18] was used to adjust critical values for outcomes (n = 17) and utilization (n = 6), using $\alpha = 0.003$ for physical and psychological health outcomes and $\alpha = 0.009$ for HCRU.

Data Availability

Data are not available from the authors because of restrictions in the data sharing agreement. Consistent with the policies of the Department of Defense, any request to the government for raw data will require a data sharing agreement (and protocol modification, if applicable) to limit the use of data and to protect participant confidentiality.

Results

Participants

The final sample included 40,978 ADSMs with insomnia meeting study criteria. These individuals were matched as described to 40,978 ADSMs without insomnia. This study cohort was 78.6% male and 61.8% White (Table 1). The most common physical comorbidities were fibromyalgia (17.5%) and hyperlipidemia (6.9%). Common psychological comorbidities included anxiety (17.0%) and adjustment disorder (14.7%). Almost 10% of participants experienced 3 or more psychological comorbidities. All SMDs were less than 0.2, so no characteristics were included as covariates in the models.

Health Burden of Insomnia

Insomnia was associated with significantly increased risk of all physical and psychological outcomes (Table 2). Among physical health outcomes, greatest increases in risk were observed for traumatic brain injury (TBI; HR 5.32, 95% CI 4.53–6.24, $p < 0.001$) and fibromyalgia (HR 2.49, 95% CI 2.37–2.62, $p < 0.001$). Risk of any musculoskeletal injury (HR 1.76, 95% CI 1.67–1.85, $p < 0.001$) was also elevated. Greatest increases in risk among psychological health outcomes were observed for post-traumatic stress disorder (HR 6.51, 95% CI 5.95–7.12, $p < 0.001$), anxiety (HR 5.23, 95% CI 4.94–5.55, $p < 0.001$), and other mood disorders including bipolar disorder (HR 5.64, 95% CI 5.35–5.94, $p < 0.001$). The proportional hazard assumption was violated for approximately half of the outcomes studied. Thus, we reran these models using alternate specifications as described above. Results were consistent with those from the Cox models (eTable 1). Figure 1 displays the HRs of physical and psychological health outcomes.

Economic Burden of Insomnia

Table 3 presents the total number of all-cause and non–insomnia-related HCRU visits based on point of service (outpatient, inpatient, ED). Relative to individuals without insomnia, ADSMs with newly diagnosed insomnia experienced significantly higher rates of all-cause encounters in inpatient (rate ratio [RtR] 2.26, 95% CI 2.13–2.39, $p < 0.001$), ED (RtR 1.61, 95% CI 1.57–1.64, $p < 0.001$), and outpatient (RtR 2.38, 95% CI 2.37–2.38, $p < 0.001$) settings. A similar pattern of results was observed for non–insomnia-related

Table 2 Summary of Time-to-Event Models to Determine the Association of Insomnia With Psychological and Physical Health Outcomes, Including Time to Event, Adjusted HRs, and 95% CIs

		Noninsomnia		Insomnia		
Outcome	**N[a]**	**n events (%)**	**TTE**	**n events (%)**	**TTE**	**HR (95% CI)**
Psychiatric outcomes						
Anxiety	30,557	1,369 (4.5)	164	6,474 (21.2)	101	5.23 (4.94–5.55)
Depression	35,009	930 (2.7)	168	4,049 (11.6)	119	4.58 (4.26–4.92)
PTSD	38,678	552 (1.4)	168.5	3,448 (8.9)	110	6.51 (5.95–7.12)
Adjustment disorder	33,060	1,363 (4.1)	165	6,023 (18.2)	90	4.82 (4.54–5.11)
Alcohol/SUD	35,362	775 (2.2)	165	1,988 (5.6)	121	2.62 (2.41–2.84)
Other mood disorders	31,111	1,692 (5.4)	165	8,328 (26.8)	84	5.64 (5.35–5.94)
Medical outcomes						
Fracture	40,763	59 (0.1)	145.5	96 (0.2)	141	1.66 (1.20–2.29)
TBI	39,350	180 (0.5)	162.5	947 (2.4)	120	5.32 (4.53–6.24)
Asthma	39,065	360 (0.9)	137	672 (1.7)	154.5	1.87 (1.65–2.13)
COPD	40,380	212 (0.5)	190	323 (0.8)	173	1.53 (1.28–1.81)
Diabetes	40,455	125 (0.3)	158	158 (0.4)	172.5	1.26 (1.00–1.60)
Fibromyalgia	30,131	2,196 (7.3)	159	5,161 (17.1)	134	2.49 (2.37–2.62)
Hyperlipidemia	36,368	1,202 (3.3)	161	1,858 (5.1)	132	1.56 (1.45–1.68)
Hypertension	40,877	26 (0.1)	172	53 (0.1)	163	2.04 (1.28–3.26)
Cardiovascular disease	40,499	116 (0.3)	192	212 (0.5)	151	1.83 (1.46–2.29)
MSKI: any	7,455	2,378 (31.9)	132	3,618 (48.5)	105	1.76 (1.67–1.85)

Abbreviations: COPD = chronic obstructive pulmonary disease; HR = hazard ratio; MSKI = musculoskeletal injury; PTSD = post-traumatic stress disorder; SUD = substance use disorder; TBI = traumatic brain injury; TTE = time to event (in days, median).
[a] Number of matched pairs after excluding those with baseline diagnosis of outcome of interest.

HCRU. Figure 2 displays the average number of HCRU visits by point of service.

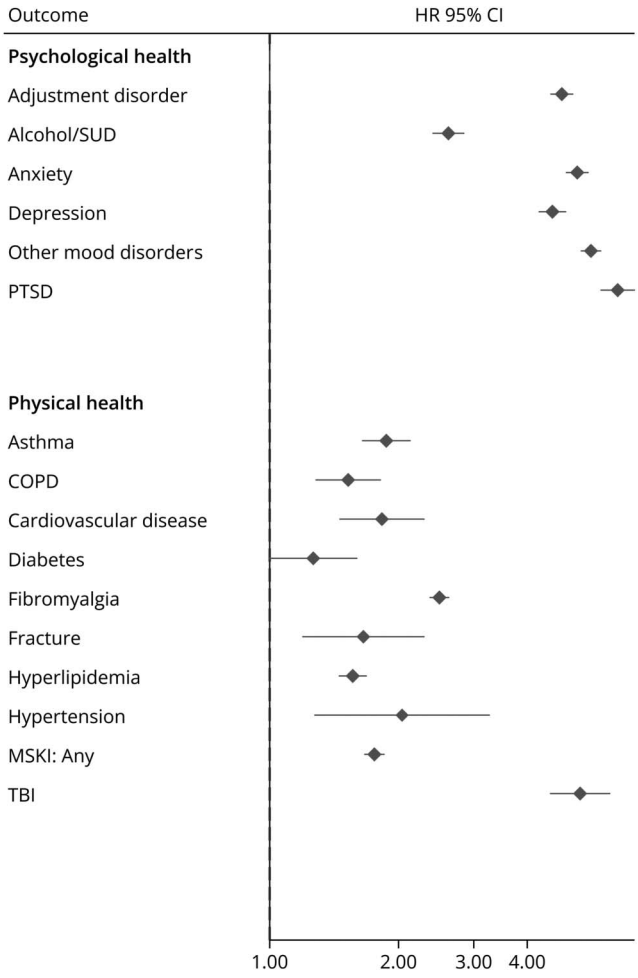
Discussion

In this national analysis of ADSMs, newly diagnosed insomnia was associated with dramatically increased risk of adverse health and economic outcomes over 12 months. Relative to matched individuals without insomnia, ADSMs with newly diagnosed insomnia demonstrated 6.5-fold risk of post-traumatic stress disorder (PTSD), 5.3-fold risk of TBI, and 1.8-fold risk of musculoskeletal injury (MSKI). Furthermore, insomnia was associated with substantially increased all-cause HCRU across all points of service, including an additional 239,531 outpatient encounters, 533 inpatient stays, and 2,472 ED visits over 12 months. These results highlight the need for sleep-focused care within the MHS and suggest several directions for both clinical and health systems research.

Our findings pertaining to insomnia and trauma are among the first in the literature to demonstrate that insomnia is a risk factor of subsequent TBI and MSKI, key outcomes from the military perspective. Insomnia is common and associated with worsened psychiatric, quality-of-life, and cognitive outcomes after TBI.[19-23] Furthermore, it is often speculated that insufficient and disturbed sleep demonstrate bidirectional relationships with TBI.[20,21] Similarly, sleep is recognized as an important component of MSKI prevention and management among ADSMs.[24] Yet, owing in part to the need for large samples of longitudinal data such as those examined here, very few empirical studies have actually examined insomnia as a risk factor of subsequent TBI or MSKI. One possible explanation for our findings is that among military personnel (many of whom obtain insufficient sleep), insomnia degrades cognitive and neurobehavioral performance and increases risk of accidents and errors that result in TBI and MSKI.[25,26]

Beyond TBI and MSKI, newly diagnosed insomnia was also associated with 6.5-fold increased risk of incident PTSD over 12 months. Disturbed sleep is a diagnostic criterion for PTSD, and insomnia and PTSD frequently co-occur.[27] Furthermore, these results are consistent with findings from a study of longitudinal survey data (2001–2008)[28] which determined

Figure 1 Adjusted HRs Based on Time-to-Event Models, Reflecting Risk of Psychiatric and Medical Outcomes, Stratified by Insomnia Status (n = 40,978 Without Insomnia, n = 40,978 With Insomnia)



COPD = chronic obstructive pulmonary disease; HR = hazard ratio; MSKI = musculoskeletal injury; OSA = obstructive sleep apnea; PTSD = posttraumatic stress disorder; SUD = substance use disorder; TBI = traumatic brain injury.

that combat-related trauma and predeployment insomnia were both associated with increased risk of PTSD, depression, and anxiety after deployment. It is worth considering whether insomnia could be an early, unrecognized symptom or reflect a shared underlying vulnerability for these conditions.

In addition to advancing understanding of insomnia and health outcomes, this study quantifies the economic burden of insomnia within the US military. In the modern health economic climate of increasing costs on the one hand and limited resources on the other, understanding the economic burden of physical and psychological health problems and potential cost-benefit of treatment has never been more important. In our study, insomnia was associated with significantly elevated HCRU over 12 months. These results build on and expand previous findings that insomnia is associated with increased HCRU at the population level and within specific disease subgroups.[29-33] We anticipate that these data will be of interest not only to military health policymakers seeking to allocate scarce resources but also insomnia clinicians and scientists seeking to understand this common condition within a large health system.

From a clinical perspective, results highlight the importance of insomnia as a critical risk factor of a broad range of especially adverse psychiatric outcomes, as well as increased economic burden. These data thus support ongoing efforts to increase access to evidence-based insomnia care, including screening, triage, assessment, and treatment. Such efforts are underway within the Department of Defense and Veteran Affairs as well as within the broader sleep health universe.[34,35] Both cognitive-behavioral treatment of insomnia (CBTI) and evidence-based insomnia medication therapy, particularly newer evidence-based insomnia medications, are emphasized. One challenge is that within the MHS, as in the civilian sector, there is a gross shortage of trained sleep specialists, limiting access to care and requiring careful allocation of health care resources to meet the demand for insomnia care. In this vein, telehealth approaches and digital therapeutics both show promise in improving outcomes for a proportion of patients with insomnia.

Our most important direction for future research is to determine whether insomnia treatment can mitigate risk and improve health and economic outcomes among MHS beneficiaries. Previous reviews in nonmilitary samples have found that both CBTI and insomnia medications provide positive economic benefit.[15] At the same time, recent research highlights the importance of measurement sensitivity for detecting insomnia treatment-related change.[36] For example, studies among general nonmilitary samples and using administrative claims methodologies have reported worsened 12-month outcomes among individuals with insomnia treated with medications including z-drugs, trazodone, and benzodiazepines.[29-33] A related research need is to disentangle the effects of insomnia from insomnia treatment, a methodological challenge. Regardless, to advance personalized insomnia care, military sleep researchers have begun development of predictive algorithms to identify individuals likely to benefit from insomnia medication treatment or CBTI, with promising early results.[37,38] Identification of insomnia subgroups such as those at risk of adverse outcomes and those likely to benefit from treatment represents opportunities to advance understanding and improve outcomes at the clinical and health system level. In this vein, leveraging linked data sets including clinical (e.g., electronic health record and/or validated outcome assessments) and administrative data is likely to be a useful strategy.

Our study possesses numerous strengths. It is important to note that this is the first national analysis to quantify the health and economic burden of insomnia in the US military health system, thus providing not only novel insight to inform

Table 3 Total and Excess Number of All-Cause and Non–Insomnia-Related Health Care Encounters During the 12 Months After Insomnia Diagnosis or Matched Index Date and Adjusted RtRs and 95% CIs of Associations Between Insomnia and Health Care Resource Utilization by Point of Service (n = 40,978 With Insomnia; n = 40,978 Without Insomnia)

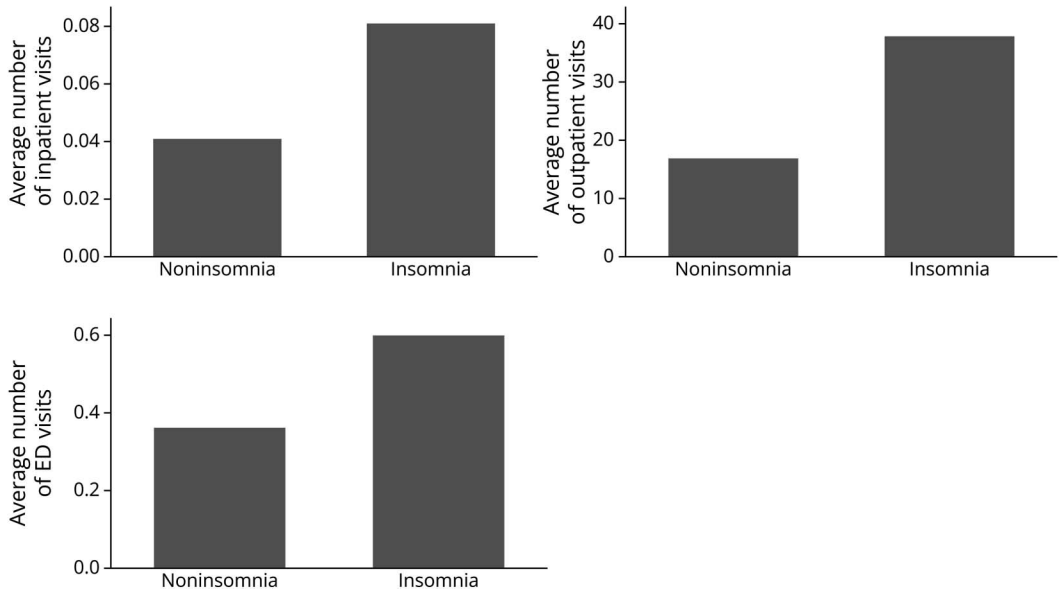
	Noninsomnia	Insomnia	Effect	
Encounter type	n encounters	n encounters	RtR (95% CI)	Excess
All-cause				
Outpatient	690,998	1,649,121	2.38 (2.37–2.38)	239,531
Inpatient	1,684	3,816	2.26 (2.13–2.39)	533
ED	14,803	24,689	1.61 (1.57–1.64)	2,472
Noninsomnia				
Outpatient	690,114	1,549,424	2.24 (2.23–2.24)	214,828
Inpatient	1,674	3,315	1.96 (1.85–2.08)	410
ED	14,799	24,538	1.60 (1.57–1.63)	2,435

Abbreviations: ED = emergency department; RtR = rate ratio.
RtRs were estimated using Poisson models, which adjusted for previous year utilization. All p values <0.001.

evidence-based military policy but also advancing understanding of the burden of insomnia within a large health system. Second, our sample was large and included nearly all ADSMs, thus ensuring adequate statistical power and high generalizability. Third, by leveraging the MDR, we were able to assess a broad range of medical and psychiatric outcomes, as well as HCRU from the military perspective. Fourth, our analytic plan was both robust and conservative, lending credibility to our findings.

Our study also has several limitations. First, our administrative data source lacks detailed clinical assessments such as insomnia severity, objective sleep quality, daytime symptoms, and other clinical variables of interest. Similarly, we were unable to assess lifestyle factors such as shift work, smoking, alcohol consumption, caffeine use, exercise, previous trauma exposure, occupational or environmental exposures, social support, and baseline health care–seeking behavior that could influence both insomnia and health outcomes. Second, our

Figure 2 Mean Number of Outpatient, Inpatient, and ED Encounters Over 12 Months, Stratified by Insomnia Status (n = 40,978 Without Insomnia, n = 40,978 With Insomnia)



ED = emergency department.

operational definition of insomnia (i.e., receipt of ≥1 physician-assigned ICD-10 diagnostic code for insomnia) has not been validated against clinical assessment or validated insomnia measures; future work should seek to validate claims-based definitions against other data sources, such as sleep diaries, questionnaires, and clinical notes. Furthermore, related to our administrative claims methodology, miscoding errors are possible. In addition, although we performed a robust analysis of HCRU across multiple points of service from the payer perspective, we were unable to assess the impact of insomnia on key military-relevant outcomes from the employer perspective, such as military readiness to deploy, disability, or separation. To overcome the aforementioned limitations, future research should leverage linked data sets, including survey, administrative, and employer metrics. Third, although our sample was large and representative of the ADSM population, it was not randomly selected. While our requirement for 24 months of continuous coverage was necessary to support analytic approach, it could have resulted in selection bias and thus underestimated the true burden of insomnia. In addition, it is unknown how well findings will generalize to Retirees, Veterans, or civilians unconnected to the military. These are all important directions for future research, including military-academic collaboration. Finally, despite our robust matching design, there are inherent limitations to any observational study, including the potential for residual confounding. This lack of randomization precludes determination of causality.

In summary, in this national analysis of active-duty military personnel, insomnia was associated with increased risk for adverse psychiatric and medical outcomes and substantially increased health care resource utilization across multiple points of service. Future research should examine the potential beneficial effects of insomnia treatments within this vulnerable population.

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Author Contributions

E.M. Wickwire: drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data; study concept or design; analysis or interpretation of data. V.F. Capaldi: drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data; study concept or design; analysis or interpretation of data. J. Herrin: drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data; study concept or design; analysis or interpretation of data. B. Stryckman: drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data; study concept or design; analysis or interpretation of data. C. Thomas: drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data. S.G. Williams: drafting/revision of the manuscript for content, including medical writing for content. J.K. Werner: drafting/revision of the manuscript for content, including medical writing for content. W. Funk: drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data. T.H. Nassif: analysis or interpretation of data; study concept or design; drafting/revision of the manuscript for content, including medical writing for content. J. Albrecht: drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data; study concept or design; analysis or interpretation of data.

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