

The relationship between post-traumatic stress disorder and gastrointestinal disease in United States Military Veterans

SAGE Open Medicine

Volume 12: 1–12

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DOI: 10.1177/20503121241260000

journals.sagepub.com/home/smoKelsey G Kent 

Abstract

Background: This study examined the relationship between gastrointestinal disease and post-traumatic stress disorder in U.S. military Veterans. Based on literature and clinical practice data sources from the U.S. Veterans Administration, gastrointestinal disease and post-traumatic stress disorder were hypothesized to be positively correlated in Veterans.

Objectives: This study aimed to determine the frequency with which gastrointestinal disease and post-traumatic stress disorder are diagnosed comorbidities, a diagnosis of gastrointestinal disease accompanies a diagnosis of post-traumatic stress disorder, and a diagnosis of post-traumatic stress disorder accompanies a diagnosis of a gastrointestinal disease.

Methods: The methodology was a retrospective, correlational design using data collected from the U.S. Department of Veterans Affairs patient database.

Results: The results were that post-traumatic stress disorder is bi-directionally correlated with the gastrointestinal diseases of gastroesophageal reflux disease, peptic ulcer disease, functional dyspepsia, Crohn's disease, diverticular disease, irritable bowel syndrome, and the symptoms of constipation and nausea/vomiting within Veterans who served during wartime periods. The study also found that post-traumatic stress disorder is not correlated with ulcerative colitis in Veterans.

Conclusions: The conclusions are that clinicians who see a presentation of post-traumatic stress disorder should be screening for gastrointestinal disease, while primary care and gastroenterology providers treating gastrointestinal disease should be screening for a history of trauma, as improved diagnosis rates may lead to improved treatment.

Keywords

Post-traumatic stress disorder, gastrointestinal disease, Veterans

Date received: 4 December 2023; accepted: 21 May 2024

Twenty percent of Veterans returning from Iraq and Afghanistan have been diagnosed with a gastrointestinal (GI) disease. Additionally, those Veterans with a mental health diagnosis were twice as likely to be diagnosed with a GI disease.¹ Post-traumatic stress disorder (PTSD) is a mental illness that commonly affects Veterans and can be considered a form of chronic stress, as those with PTSD relive the traumatic experience in the form of nightmares, flashbacks, and intrusive memories. Stress has a well-established impact on the GI system and may be a contributor to the development of GI symptoms in Veterans with PTSD.

Researchers have made significant progress in linking PTSD with GI disorders. Iorio et al.² studied a group of 21,264 African Americans and selected all the individuals with irritable bowel syndrome (IBS) from this population (8.2%). They found those with IBS were significantly more likely to be diagnosed with PTSD.² In a study of 313 adults

with Inflammatory Bowel Disease (IBD), including either ulcerative colitis (UC) or Crohn's disease, 32.8% met criteria for PTSD.³ However, another study of 797 patients with IBD found a much lower PTSD prevalence rate of 9.6% who met full criteria for PTSD.⁴ While these studies show that PTSD is common within patients with GI disease, they do not examine the reverse, in that they do not reflect the prevalence of GI disease within patients with PTSD. One study that does potentially link trauma to the development of GI symptoms was completed with World Trade Center responders. Those responders with high psychological distress were

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more likely to report new-onset GI symptoms at both 3 and 6 years post-9/11.⁵

In the Danish population, researchers found that among those with PTSD, risk of any GI disease was 25%, with PTSD having the strongest association with peptic ulcer.⁶ This study is a good start at describing the relationship between GI disease and PTSD, but generalizability is limited to the Danish population. Another study of 597 adults in Switzerland found PTSD to exacerbate symptoms of Crohn's disease.⁷ While important research, these studies do not review PTSD in the context of the U.S. Veteran population.

In studies among U.S. Veterans, PTSD has been correlated to IBS in several studies and meta-analysis.^{8–10} A study of Gulf War Veterans found that those with PTSD had higher odds of also being diagnosed with IBS, gastroesophageal reflux disease (GERD), and colonic polyps.¹¹ A national study of over 60,000 Veterans with IBD found the rate of co-occurring IBD and PTSD to be rising in this population, whereas incidence of co-occurring IBD and depression was declining.¹² Finally, in one systematic review that included both civilian and Veteran studies, the overall prevalence of PTSD in patients with GI disease was 36%, but when the Veteran studies were removed this prevalence rate dropped to 18%.¹³ This finding is indicative that the Veteran population has unique factors that must be considered when researching the prevalence of co-occurring PTSD and GI disease, so there is a need for more research on this population.

Rationale for study

The current research begins to explore but does not fully examine whether GI disease and PTSD accompany each other in Veterans. It is known that disorders of gut-brain interaction (formerly known as functional GI diseases) occur more frequently in Veterans than in the average population.¹⁴ The current state of the science has begun to establish that PTSD is common in those with GI disease, but the reverse has not been studied. The research does not fully examine whether GI disease is commonly prevalent in Veterans with PTSD, so it is unclear whether the relationship is bi-directional. Research is needed to describe the relationship between PTSD and GI disease before there can be progress in treatment.

Objectives

The objective of this study is to determine the relationship between GI disease and PTSD in U.S. military Veterans. This study was designed to use national data from the Department of Veterans Affairs to identify populations of Veterans who have PTSD or GI disease. Completion of this objective is expected to enhance current knowledge which will aid in the formulation of future research regarding relationships between GI disease and PTSD.

Methods

This study was part of a larger study that also obtained rates of GI disease in the entire U.S. Veteran population from January 1999 to March 2019.¹⁵ The retrospective, correlational study retrieved data from the Department of Veterans Affairs patient record database, managed by the VA Information Resource Center. This population includes all Veterans who are enrolled in the Veterans Health Administration (VHA) system in the United States. Participants were age 18 or older and could include potentially all ethnicities, and males and females.

Data was created when a healthcare provider entered records as a patient care visit into the Department of Veterans Affairs patient charting system at an inpatient or outpatient encounter within a Department of Veterans Affairs facility anywhere in the US. This study utilized data from outpatient encounters only. Any licensed clinician can enter a diagnosis with their patient encounter, including physicians, nurse practitioners, physician's assistants, licensed clinical social workers, and psychologists. Diagnostic information was determined using ICD-9 and ICD-10 codes entered by the provider at each encounter, shown in Table 1.¹⁶ In the VHA system, providers made the transition from ICD-9 to ICD-10 gradually during the 2015 calendar year. Codes were not necessarily in the currently used coding format (ICD-10), since patients have died or otherwise stopped seeking care before coding was updated.

Participant inclusion and exclusion criteria

Participants in the study were Veterans with either or both diagnosis of PTSD and GI disease. Specific GI diseases were those that accounted for more than 500,000 ambulatory care visits annually in the United States, which included peptic ulcer disease, GERD, diverticular disease, UC, Crohn's disease, IBS, and functional dyspepsia, as well as the symptoms of constipation and nausea/vomiting. There is a potential that a single patient could be diagnosed with more than one GI disease or with multiple symptoms.

Participants/subjects were excluded from the study who were not diagnosed with GI Disease or PTSD. Due to the numerous ICD-9 and ICD-10 codes that fall under the term "GI disease," specific diseases were only included if they had accumulated more than 500,000 ambulatory care visits annually in the United States, so that rare diseases were excluded. Diseases with a non-GI cause were excluded, such as cancer, infection, and acute injury or hernia. Medical diseases that could lead to GI symptoms of nausea, vomiting, and constipation were excluded. Diseases of the liver, gallbladder, and pancreas were also excluded.¹⁷

Human subjects: IRB approval

The study was deemed exempt from review by the Institutional Review Boards at the Tennessee Valley Healthcare System (TVHS) as a division of the Department

Table 1. ICD 9 and ICD10 codes utilized in the study.

Disease	ICD9 codes	ICD10 codes
Post-traumatic stress disorder	309.81	F43.1, F43.10, F423.11, F43.12
Gastroesophageal reflux disease	530.81	K.21.0, K21.9
Peptic ulcer disease	533	K.27 (all subcodes)
Functional dyspepsia	536.8	K30 (all subcodes)
Crohn's disease	555 (all subcodes)	K50 (all subcodes)
Ulcerative colitis	556 (all subcodes)	K51 (all subcodes)
Diverticular disease	562 (all subcodes)	K57 (all subcodes)
Irritable bowel syndrome	564.1	K58 (all subcodes)
Constipation	564.00, 564.01, 564.02, 564.09	K59.04
Nausea/vomiting	787 (all subcodes)	R11 (all subcodes)
Secondary mental illness	290–319, except 309.81 (all subcodes)	F01–F48, except F43.1-.11 (all subcodes)

Table shows the ICD9 and ICD10 codes that were used for data collection.

of Veterans Affairs, and at the University of Texas Medical Branch, exemption number 19-0039. The risks to participants in this study were minimal. HIPAA-identifying information was not included in the data set. The consent process was waived by both IRBs due to minimal risk. The study was also approved by the Research and Development Committee at TVHS, which is not affiliated with the IRB.

Data collection

Once exempt by the IRB, the VA Information Resource Center created a cohort of patients as requested by the researcher from the Corporate Data Warehouse database, which contains patient diagnostic and demographic information on all patients treated by VHA from 1999 to present. The cohort was accessed by the researcher using Microsoft SQL Server, which is only accessible via a remote workspace with VHA identification card and password. VHA security measures prevented data from being removed from this remote workspace. Variables collected included ICD-9 or ICD-10 diagnostic codes for PTSD, GI disease, and secondary mental illness, as well as gender, period of service, ethnicity, and age. The prevalence of secondary mental illness in participants with PTSD and GI disease were observed to assess as potential confounding variables, as noted in similar studies of physical comorbidities with PTSD.¹⁸

The year 1999 was the creation of the computerized record database and therefore was a transition year in which not all records were computerized until the end of that calendar year. For this reason, National Data Systems (NDS) was not able to give the researcher a total number of patients treated within the VHA system in 1999. The year 2019 had to be collected as a partial year because of the start date of project listed on the TVHS IRB application, which was 1 April 2019. Data collected for 2019 pertained only to visits dated 1 January 2019 to 31 March 2019. For this reason, numbers of participants from 2019 cannot be accurately compared to total VHA patient counts for 2019 but are valuable to include in total disease counts for the population over time.¹⁹

ICD-9 or 10 codes were pulled from a visit located anywhere outpatient at VHA. Veteran records would only show in a table if they were treated for the illness in that year. The same individual Veteran will be included in every individual year that s/he was treated. For example, if a Veteran was treated for GERD in 2000, but was not treated in 2001, then this Veteran would not be recorded in the 2001-year table. If the Veteran was seen in both 2000 and 2001, then that Veteran's data will show in both 2000 and 2001 year tables. When combining all years, that individual Veteran would be recorded only once as positive for a diagnosis of GERD in the "All Years" table.

Age was recorded at the age of the last visit, and when all years were combined into one table, age was recorded as the most recent age. For example, if a Veteran was aged 40 at last related visit in 2000 and then deceased before 2001, that Veteran would not be recorded in the 2001 table. However, in the "All Years" table that Veteran record would be included, and age would show as 40.

Secondary mental illnesses were collected by ICD-9 and ICD-10 diagnostic codes and compiled into categories based on the DSM-5. Categories included "depressive disorders," of "anxiety disorders."

Data analysis

Since the study aimed to identify the exact prevalence of PTSD and co-occurring GI disease, the researcher chose to collect data on all available outpatient records at VHA nationally instead of calculating a sample size prior to data collection. SAS 9.4 software, of SAS Institute, was utilized to statistically analyze and interpret the frequency data. Descriptive statistics, including means, percentages, Chi-Square, and contingency tables were used to examine the relationship between GI disease and PTSD.¹⁵

Over the course of 2000–2019, VHA-treated 13,669,058 Veterans and 15,842,376 total patients. VHA does treat some individuals who are not Veterans, such as foreign dignitaries and allied beneficiaries. A total of 6,352,586

Table 2. Total observed counts of disease after removing outliers.

Diagnosis	Total observed counts	Percent of the population (13,669,058) (%)
Post-traumatic stress disorder	2,001,180	14.64
Gastroesophageal reflux disease	3,488,344	25.52
Peptic ulcer disease	248,132	1.82
Functional dyspepsia	415,307	3.04
Chron's disease	55,758	0.41
Ulcerative colitis	103,076	0.75
Diverticular disease	1,396,359	1.02
Irritable bowel syndrome	288,368	2.11
Constipation	871,109	6.37
Nausea/vomiting	2,159,137	15.80

Table shows the total observed counts of each condition within the population studied.

Table 3. Prevalence of diagnosis by gender of Veterans.

Disorder	Female (7.89%), n (%)	Male (92.11%), n (%)
PTSD only	213125 (10.65%)	1787994 (89.35%)
PTSD and GERD	80340 (10.19%)	708096 (89.81%)
PTSD and peptic ulcer disease	3817 (7.08)	50085 (92.92)
PTSD and functional dyspepsia	n = 13,563, 12.34%	n = 96,320, 87.66%
PTSD and Crohn's disease	n = 1482, 12.65%	n = 10,233, 87.35%
PTSD and ulcerative colitis	n = 2468, 11.10%	n = 19,757, 88.90%
PTSD and diverticular disease	n = 16,369, 5.77%	n = 267,276, 94.23%
PTSD and constipation	n = 31,421, 15.53%	n = 170,963, 84.47%
PTSD and IBS	n = 27,959, 25.51%	n = 81,641, 74.49%
PTSD and nausea/vomiting	n = 69,667, 12.93%	n = 469,232, 87.07%

Table shows the prevalence of PTSD and then PTSD combined with each GI condition within the studied population. In the general population of 13,669,058 Veterans, the expected rate of PTSD by gender is that 9% of cases will be female, and 91% of cases will be male. This table shows that the proportion of PTSD cases is much higher in females when combined with certain GI conditions.

participants were identified as having a diagnosis of PTSD and/or GI disease. The total number of Veterans and patients treated by VHA was unavailable for 1999 as it was the year of transition from paper charts to computerized records. In this study the 2019 data was pulled for the first quarter only, January 1 through March 31, due to April 1, 2019, data authorization request on IRB application. Therefore 1999 and 2019 data cannot be analyzed by year as full data is not available. When comparing participants with PTSD or GI disease to those Veterans without either diagnosis, the total number of Veterans treated at VHA was used—13,669,058—hereafter referred to as the “general population” of Veterans at VHA.

The participants numbered 500,997 females and 5,851,856 males, with three participants missing gender information. Outliers were removed from analysis. For example, the participants with missing gender were removed from analysis. Participants aged 110 or above were removed from analysis, as it is assumed that their death was not reported. Patients who were not Veterans were removed from analysis, such as foreign dignitaries who had utilized VHA healthcare.

The prevalence of PTSD and GI disease was tracked over time and reported every 3 years from 2000 to 2018 and reported in Tables 2 and 3. The prevalence of each GI disease among Veterans with PTSD was compared to the prevalence of GI disease in all Veterans treated at VHA. Conversely, the prevalence of PTSD among Veterans with each GI disease was compared to the prevalence of PTSD in all Veterans treated at VHA. Descriptive statistics including frequency counts and percentages are used to describe the data. Chi squares were calculated for each year shown and reported in the table. Chi-square tests can be affected by the large sample size, so goodness-of-fit tests were performed to validate the Chi squares. The probability of Veterans with PTSD being also diagnosed with co-occurring GI disease was calculated by comparing the rate of the GI disease in Veterans with PTSD to the rate of GI disease in the entire sample of Veterans treated at VHA as a ratio and is shown in Table 6. Likewise, the probability of Veterans with a specific GI disease also being diagnosed with co-occurring PTSD was calculated by comparing the rate of PTSD in Veterans with the specific GI disease to the rate of PTSD in all Veterans treated at VHA as a ratio and is shown in Table 7.

Table 4. Rates of PTSD in Veterans with GI diseases compared to rates of GI diseases in Veterans with PTSD.

Rate of PTSD in Veterans with GERD	Total cases of both PTSD and GERD: 788436	All cases of GERD: 3488344	22.60%	Rate of GERD in Veterans with PTSD	Total cases of both PTSD and GERD: 788436	All cases of PTSD: 2001180	39.40%
Rate of PTSD in Veterans with IBS	Total cases of both PTSD and IBS: 190600	All cases of IBS: 288367	38.01%	Rate of IBS in Veterans with PTSD	Total cases of both PTSD and IBS: 190600	All cases of PTSD: 2001180	9.52%
Rate of PTSD in Veterans with peptic ulcer disease	Total cases of both PTSD and PUD: 53902	All cases of PUD: 284132	18.97%	Rate of peptic ulcer disease in Veterans with PTSD	Total cases of both PTSD and PUD: 53902	All cases of PTSD: 2001180	2.69%
Rate of PTSD in Veterans with functional dyspepsia	Total cases of both PTSD and FD: 109883	All cases of FD: 415307	26.46%	Rate of functional dyspepsia in Veterans with PTSD	Total cases of both PTSD and FD: 109883	All cases of PTSD: 2001180	5.49%
Rate of PTSD in Veterans with Crohn's	Total cases of both PTSD and Crohn's: 11715	All cases of Crohn's: 55758	21.01%	Rate of Crohn's in Veterans with PTSD	Total cases of both PTSD and Crohn's: 11715	All cases of PTSD: 2001180	0.59%
Rate of PTSD in Veterans with ulcerative colitis	Total cases of both PTSD and UC: 22225	All cases of UC: 103076	21.56%	Rate of ulcerative colitis in Veterans with PTSD	Total cases of both PTSD and UC: 22225	All cases of PTSD: 2001180	1.11%
Rate of PTSD in Veterans with diverticular disease	Total cases of both PTSD and DD: 283646	All cases of DD: 1396359	20.31%	Rate of diverticular disease in Veterans with PTSD	Total cases of both PTSD and DD: 283646	All cases of PTSD: 2001180	14.17%
Rate of PTSD in Veterans with constipation	Total cases of both PTSD and constipation: 202385	All cases of constipation: 871109	23.23%	Rate of constipation in Veterans with PTSD	Total cases of both PTSD and constipation: 202385	All cases of PTSD: 2001180	10.11%
Rate of PTSD in Veterans with nausea/vomiting	Total cases of both PTSD and N/V: 538900	All cases of N/V: 2159137	24.96%	Rate of nausea/vomiting in Veterans with PTSD	Total cases of both PTSD and N/V: 538900	All cases of PTSD: 2001180	26.93%

Table compares the calculated rates of PTSD within Veterans with each group of GI disease. It then compares the calculated rate of GI disease within Veterans with PTSD.

Results

Frequency counts of Veterans diagnosed with each condition by gender are reported in Table 2. It was expected that the prevalence of PTSD would be 9% females and 91% males.²⁰ The final observed frequency counts of each condition are reported in Table 3.

Total counts of each disease across all years are shown in Table 4. Rates are calculated for the rate of PTSD in Veterans with each GI disease and rates of each GI disease in Veterans with PTSD. Results of each condition over time are shown in Table 5. The probability of Veterans diagnosed with PTSD also being diagnosed with a GI disease is shown in Table 6, and the probability of a Veteran diagnosed with a GI disease also being diagnosed with PTSD is shown in Table 7. These results are discussed below by specific GI diseases.

Gastroesophageal reflux disease, peptic ulcer disease, and functional Dyspepsia

Based on these results, a diagnosis of gastroesophageal reflux disease (GERD), peptic ulcer disease (PUD), and

functional dyspepsia (FD) were all positively correlated with a diagnosis of PTSD in Veterans. Prevalence of both GERD and PTSD is increasing in the general population of Veterans treated at VHA. The prevalence of GERD among Veterans with PTSD is increasing over time, continuously surpassing the prevalence of GERD in the general population. On average Veterans with PTSD were 1.5 times more likely to have GERD than other Veterans.

The prevalence of PUD is falling both in the general population of Veterans and in Veterans with PTSD, while the prevalence of PTSD is climbing, both in the general population of Veterans and in Veterans with PUD. The prevalence of PUD in Veterans with PTSD surpasses the prevalence of PUD in the general population of Veterans in all years except 2018, although the prevalence continues to increase over time. On average, Veterans with PTSD are 1.36 times more likely to have PUD than the general population of Veterans.

The prevalence of FD is falling over time, but in Veterans with PTSD, the prevalence of FD continuously surpasses those in the general population of Veterans. The prevalence of PTSD is climbing over time in both groups. On average, Veterans with PTSD are 1.8 times more likely to have FD

Table 5. Prevalence of conditions over time.

Year	Prevalence of GERD among Veterans with PTSD	Prevalence of GERD among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84	Prevalence of PTSD among Veterans with GERD	Prevalence of PTSD among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84
2000	13.33%	7.61%	1.75	<.0001	8486.39	7.71%	4.40%	1.75	<.0001	8219.42
2003	17.89%	11.69%	1.53	<.0001	9185.64	7.42%	4.85%	1.53	<.0001	8532.47
2006	19.61%	13.34%	1.47	<.0001	12009.15	9.50%	6.46%	1.47	<.0001	11110.81
2009	20.00%	13.78%	1.45	<.0001	16510.45	12.58%	8.66%	1.45	<.0001	15621.97
2012	23.26%	13.84%	1.68	<.0001	41804.24	15.14%	10.29%	1.47	<.0001	21999.18
2015	20.15%	14.26%	1.41	<.0001	22658.22	17.47%	12.36%	1.41	<.0001	22249.86
2018	19.71%	14.41%	1.37	<.0001	20518.95	18.87%	18.39%	1.02	<.0001	146.37
Year	Prevalence of PUD among Veterans with PTSD	Prevalence of PUD among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84	Prevalence of PTSD among Veterans with PUD	Prevalence of PTSD among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84
2000	1.89%	1.26%	1.5	<.0001	639.89	6.60%	4.40%	1.5	<.0001	600.48
2003	1.31%	0.94%	1.39	<.0001	367.44	6.76%	4.85%	1.39	<.0001	377.72
2006	1.04%	0.76%	1.37	<.0001	374.76	8.87%	6.46%	1.37	<.0001	397.56
2009	0.77%	0.60%	1.28	<.0001	257.32	11.18%	8.66%	1.29	<.0001	280.58
2012	0.69%	0.46%	1.5	<.0001	655.42	13.49%	10.29%	1.31	<.0001	319.11
2015	0.40%	0.32%	1.25	<.0001	147.39	15.49%	12.36%	1.25	<.0001	185.31
2018	0.12%	0.10%	1.2	<.0001	35.56	16.34%	18.39%	0.89	<.0001	18.53
Year	Prevalence of Functional Dyspepsia among Veterans with PTSD	Prevalence of Functional Dyspepsia among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84	Prevalence of PTSD among Veterans with Functional Dyspepsia	Prevalence of PTSD among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84
2000	1.94%	1.01%	1.92	<.0001	1567.17	8.42%	4.40%	1.91	<.0001	1612.55
2003	1.66%	0.88%	1.87	<.0001	1724.83	9.14%	4.85%	1.88	<.0001	1719.2
2006	1.33%	0.77%	1.73	<.0001	1431.38	11.06%	6.46%	1.71	<.0001	1482.7
2009	1.17%	0.66%	1.73	<.0001	2028.28	15.31%	8.66%	1.77	<.0001	2168.84
2012	1.13%	0.57%	1.98	<.0001	3086.51	17.81%	10.29%	1.73	<.0001	2179.8
2015	0.76%	0.45%	1.69	<.0001	1696.18	20.62%	12.36%	1.67	<.0001	1852.31
2018	0.44%	0.26%	1.69	<.0001	1086.29	23.28%	18.39%	1.27	<.0001	269.27
Year	Prevalence of Crohn's among Veterans with PTSD	Prevalence of Crohn's among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84	Prevalence of PTSD among Veterans with Crohn's	Prevalence of PTSD among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84
2000	0.22%	0.17%	1.29	<.0001	21.94	5.65%	4.40%	1.28	<.0001	25.83
2003	0.22%	0.20%	1.1	0.006379	7.44	5.49%	4.85%	1.13	0.001653	9.09
2006	0.23%	0.21%	1.1	0.002867	8.89	7.04%	6.46%	1.09	0.010371	6.57
2009	0.25%	0.23%	1.09	0.000625	11.7	9.62%	8.66%	1.11	<.0001	28.54
2012	0.32%	0.24%	1.33	<.0001	136.23	11.74%	10.29%	1.14	<.0001	34.35
2015	0.28%	0.26%	1.08	0.001032	10.77	13.32%	12.36%	1.08	0.000153	14.34
2018	0.29%	0.27%	1.07	0.000441	12.35	15.03%	18.39%	0.82	<.0001	130.68
Year	Prevalence of Ulcerative Colitis among Veterans with PTSD	Prevalence of Ulcerative Colitis among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84	Prevalence of PTSD among Veterans with ulcerative colitis	Prevalence of PTSD among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84
2000	0.27%	0.24%	1.13	0.024912	5.03	4.84%	4.40%	1.1	0.032919	4.55
2003	0.28%	0.28%	1	0.75183	0.1	4.97%	4.85%	1.02	<.0001	94.19
2006	0.28%	0.28%	1	0.977719	0.00078	6.42%	6.46%	0.99	0.841481	0.04
2009	0.29%	0.35%	0.83	<.0001	55.1	8.52%	8.66%	0.98	0.52197	0.41
2012	0.35%	0.31%	1.13	<.0001	25.81	10.22%	10.29%	0.99	0.75183	0.1
2015	0.38%	0.37%	1.03	0.1117	2.53	12.81%	12.36%	1.04	0.037009	4.35
2018	0.51%	0.46%	1.11	<.0001	55.77	15.43%	18.39%	0.84	<.0001	175.25

(continued)

Table 5. (Continued)

	Prevalence of diverticular disease among Veterans with PTSD	Prevalence of diverticular disease among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84	Prevalence of PTSD among Veterans with diverticular disease	Prevalence of PTSD among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84
2000	2.30%	1.79%	1.28	<.0001	268.16	5.67%	4.40%	1.29	<.0001	282.41
2003	2.94%	2.19%	1.34	<.0001	641.81	6.48%	4.85%	1.34	<.0001	644.21
2006	3.18%	2.38%	1.34	<.0001	977.77	9.96%	6.46%	1.54	<.0001	2280
2009	3.20%	2.46%	1.3	<.0001	1151.47	11.28%	8.66%	1.3	<.0001	1246.05
2012	3.13%	2.39%	1.31	<.0001	1315.94	11.78%	10.29%	1.45	<.0001	360.17
2015	2.84%	2.37%	1.2	<.0001	753.94	14.83%	12.36%	1.2	<.0001	855.55
2018	2.41%	1.79%	1.35	<.0001	1973.2	15.98%	18.39%	0.89	<.0001	524.41
	Prevalence of IBS among Veterans with PTSD	Prevalence of IBS among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84	Prevalence of PTSD among Veterans with IBS	Prevalence of PTSD among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84
2000	1.39%	0.46%	3.02	<.0001	3473.95	13.61%	4.40%	3.09	<.0001	3762.94
2003	1.36%	0.48%	2.83	<.0001	4027.52	13.82%	4.85%	2.85	<.0001	4242.55
2006	1.42%	0.54%	2.63	<.0001	5083.98	17.10%	6.46%	2.65	<.0001	5485.6
2009	1.49%	0.58%	2.57	<.0001	7244.25	22.31%	8.66%	2.58	<.0001	7952.93
2012	1.93%	0.64%	3.02	<.0001	14768.56	27.14%	10.29%	2.64	<.0001	12313.76
2015	1.98%	0.77%	2.57	<.0001	15211.03	31.72%	12.36%	2.57	<.0001	17226.02
2018	2.38%	0.96%	2.48	<.0001	19093.1	34.39%	18.39%	1.87	<.0001	10631.85
	Prevalence of constipation among Veterans with PTSD	Prevalence of constipation among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84	Prevalence of PTSD among Veterans with constipation	Prevalence of PTSD among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84
2000	0.00%	0.00%	1	N/A	N/A	5.48%	4.40%	1.25	0.527089	0.4
2003	2.29%	1.44%	1.59	<.0001	1260.79	7.72%	4.85%	1.59	<.0001	1309.52
2006	2.58%	1.71%	1.51	<.0001	1573.78	9.71%	6.46%	1.5	<.0001	1635.86
2009	2.85%	1.90%	1.5	<.0001	2429.53	12.96%	8.66%	1.5	<.0001	2595.37
2012	3.49%	2.02%	1.73	<.0001	6099.88	15.56%	10.29%	1.51	<.0001	3787.93
2015	2.44%	1.68%	1.45	<.0001	2796.38	17.93%	12.36%	1.45	<.0001	9537.52
2018	0.27%	0.16%	1.69	<.0001	641.97	23.59%	18.39%	1.28	<.0001	183.61
	Prevalence of N/V among Veterans with PTSD	Prevalence of N/V among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84	Prevalence of PTSD among Veterans with N/V	Prevalence of PTSD among all Veterans	Ratio	p-Value of Chi square	Goodness-of-fit tests: critical value 3.84
2000	8.38%	3.03%	2.77	<.0001	17737.76	12.19%	4.40%	2.77	<.0001	18058.88
2003	9.37%	3.24%	2.89	<.0001	29552.79	14.01%	4.85%	2.89	<.0001	30013.28
2006	9.92%	3.63%	2.73	<.0001	39916.48	17.63%	6.46%	2.73	<.0001	40997.65
2009	10.75%	4.02%	2.67	<.0001	59488.29	23.20%	8.66%	2.68	<.0001	57238.51
2012	12.47%	4.26%	2.93	<.0001	92859.36	26.39%	10.29%	2.56	<.0001	74555.6
2015	9.92%	4.14%	2.4	<.0001	67380.93	29.67%	12.36%	2.4	<.0001	73964.59
2018	2.90%	1.19%	2.44	<.0001	22506.6	36.36%	18.39%	1.98	<.0001	15486.7

Table shows how the prevalence of each condition is changing over time and compares the prevalence of the single condition to the condition combined with PTSD. For example, the prevalence of IBS in patients with PTSD is always significantly higher than the prevalence of IBS alone. And vice versa, the prevalence of PTSD in patients with IBS is always significantly higher than the prevalence of PTSD alone. Chi-square and goodness-of-fit tests show this significance. This leads to the conclusion that IBS and PTSD are risk factors for each other.

Table 6. Probability of Veterans with PTSD diagnosed with co-occurring GI disease.

Disorder	In Veterans with PTSD, likelihood that they will also have the indicated GI disease
GERD	1.50
Peptic ulcer disease	1.36
Functional dyspepsia	1.80
Crohn's disease	1.15
Ulcerative colitis	1.03
Diverticular disease	1.30
IBS	2.73
Constipation	1.50
Nausea/vomiting	2.69

Table shows the probability that Veterans who have been diagnosed with PTSD will also be diagnosed with the listed GI conditions.

than Veterans without PTSD, and although the prevalence has fluctuated over time, there is a downward trend.

Additionally, a diagnosis of PTSD is positively correlated with a diagnosis of GERD, PUD, and FD in Veterans. The prevalence of PTSD among Veterans with GERD is increasing over time, continuously surpassing the prevalence of PTSD in the general population except in the year 2018, when this seems to have leveled off with the prevalence of PTSD similar in those with GERD and the general population. In Veterans with PUD or FD, the prevalence of PTSD continuously surpasses the prevalence of PTSD in the general population of Veterans. On average Veterans with GERD were 1.44 times more likely to have PTSD than other Veterans. On average, Veterans with PUD are 1.29 times more likely to have PTSD than the general population of Veterans, however, this prevalence appears to be decreasing over time. On average, Veterans with FD are 1.71 times more likely to have PTSD than Veterans without FD. This prevalence has also fluctuated over time but has a downward trend.

Crohn's disease and ulcerative colitis

It was observed that a diagnosis of Crohn's disease is positively correlated with a diagnosis of PTSD, although not as considerably as other GI diseases and ulcerative colitis (UC) was not correlated with a diagnosis of PTSD. The prevalence of both Crohn's disease and UC is climbing in the general population of Veterans and in Veterans with PTSD. The prevalence of Crohn's disease in Veterans with PTSD continuously surpasses the prevalence of Crohn's disease in the general population of Veterans. On average, a Veteran with PTSD is 1.15 times more likely to have Crohn's disease as a Veteran in the general population. This prevalence has fluctuated over time with no general trend. The prevalence of UC in Veterans with PTSD surpasses the prevalence of UC in the general population only some of the time. On average,

Table 7. Probability of Veterans with GI disease diagnosed with co-occurring PTSD.

	In Veterans with GI disease, likelihood that they will also have PTSD
GERD	1.44
Peptic ulcer disease	1.29
Functional dyspepsia	1.71
Crohn's disease	1.09
Ulcerative colitis	.99
Diverticular disease	1.29
IBS	2.61
Constipation	1.44
Nausea/vomiting	2.57

Table shows the probability that when Veterans are diagnosed with each of the listed GI conditions, they will also be diagnosed with PTSD.

Veterans with PTSD are 1.03 times more likely to have UC than the general population of Veterans. Although Chi-square and *p*-value show a correlation, goodness-of-fit tests do not in most years. Chi-square results are likely due to large sample size.

Additionally, a diagnosis of PTSD is positively correlated with a diagnosis of Crohn's disease in Veterans, although not as strongly as in other GI diseases, and was not associated with a diagnosis of ulcerative colitis. The prevalence of PTSD in Veterans with Crohn's disease surpasses the prevalence of PTSD in the general population of Veterans in all years except 2018. On average a Veteran with Crohn's disease is 1.09 times more likely to have PTSD than the general population. Although the prevalence has fluctuated over time, it appears to be trending downward. The prevalence of PTSD in Veterans with UC is roughly the same as the prevalence of PTSD in the general population of Veterans. On average, Veterans with UC are 0.99 times as likely to have PTSD as the general population of Veterans. Although Chi-square and *p* values show a correlation, goodness-of-fit tests do not in most years. Chi-square results are likely due to large sample size.

Diverticular disease

The study found that a diagnosis of diverticular disease is positively correlated with a diagnosis of PTSD in Veterans. Prevalence of diverticular disease in the general population climbed until 2009 when they peaked and then began to fall. Prevalence of diverticular disease in Veterans with PTSD followed the same pattern, but each year continuously surpassed the prevalence of diverticular disease in the general population of Veterans. On average, Veterans with PTSD are 1.30 times more likely to have diverticular disease than the general population of Veterans. This prevalence has fluctuated over time.

Additionally, a diagnosis of PTSD is positively correlated with a diagnosis of diverticular disease in Veterans. The

Table 8. Prevalence of depression and anxiety in Veterans with PTSD or GI disease.

Condition	Prevalence of depression	Prevalence of anxiety
PTSD	69.25% (n = 1,397,219)	52.18% (n = 1,052,879)
GERD	37.07% (n = 1,309,326)	28.56% (n = 1,009,428)
Peptic ulcer disease	41.18% (n = 103,170)	31.39% (n = 78,713)
Functional dyspepsia	43.97% (n = 185,426)	35.64% (n = 150,494)
Crohn's disease	39.60% (n = 22,361)	30.86% (n = 17,455)
Ulcerative colitis	37.50% (n = 39,024)	29.29% (n = 30,527)
Diverticular disease	33.14% (n = 467,593)	24.75% (n = 349,566)
IBS	53.83% (n = 158,076)	47.77% (n = 140,353)
Constipation	42.55% (n = 375,566)	32.31% (n = 285,660)
Nausea/vomiting	41.46% (n = 906,882)	31.28% (n = 685,105)

Table introduces the diagnoses of depression and anxiety. The table shows the prevalence of depression and anxiety in each condition (PTSD or GI disease) alone.

prevalence of PTSD has continuously climbed in both the general population of Veterans and in Veterans with diverticular disease. The prevalence of PTSD in Veterans with diverticular disease continuously surpassed the prevalence of PTSD in the general population of Veterans except for the year 2018. On average, Veterans with diverticular disease are 1.29 times more likely to have PTSD as Veterans in the general population. This prevalence has also fluctuated over time.

Irritable bowel syndrome

It was observed that a diagnosis of IBS is positively correlated with a diagnosis of PTSD in Veterans, more so than any other GI disease in this study. The prevalence of IBS has increased over time in both the general population of Veterans and in Veterans with PTSD. The prevalence of IBS in Veterans with PTSD continuously surpasses the prevalence of IBS in the general population of Veterans. On average, Veterans with PTSD are 2.73 times more likely to have IBS than the general population of Veterans. This prevalence has fluctuated over time with no defined trend.

Additionally, a diagnosis of PTSD is positively correlated with a diagnosis of IBS in Veterans. The prevalence of PTSD has increased over time in both the general population of Veterans and in Veterans with IBS. The prevalence of PTSD in Veterans with IBS continuously surpasses the prevalence of PTSD in the general population of Veterans. Veterans with IBS are 2.61 times more likely to have PTSD than the general population of Veterans. This prevalence has fallen over time.

Symptoms of constipation and nausea/vomiting

Based on these observations, the symptoms of constipation and nausea/vomiting are all positively correlated with a diagnosis of PTSD in Veterans. The prevalence of constipation in the general population of Veterans increased over time until peaking in 2012, then began to fall. The prevalence of constipation in Veterans with PTSD followed the same pattern but continuously surpassed the prevalence of constipation in

the general population of Veterans. On average, Veterans with PTSD are 1.50 times as likely to have constipation as the general population of Veterans. This prevalence has fluctuated over time with a general increasing trend. The prevalence of nausea/vomiting increased over time in both the general population of Veterans and Veterans with PTSD, until it decreased dramatically in 2018. The prevalence of nausea/vomiting in Veterans with PTSD continuously surpassed the prevalence of nausea/vomiting in the general population of Veterans, even in 2018. On average, Veterans with PTSD are 2.69 times more likely to experience nausea/vomiting than the general population of Veterans.

Additionally, a diagnosis of PTSD is positively correlated with the symptoms of constipation and nausea/vomiting in Veterans. The prevalence of PTSD has continuously increased over time in both the general population of Veterans and in Veterans with constipation and nausea/vomiting. The prevalence of PTSD in Veterans with constipation and nausea/vomiting has continuously surpassed the prevalence of PTSD in the general population of Veterans. On average, Veterans with constipation are 1.44 times more likely to have PTSD than Veterans in the general population. This prevalence has fluctuated over time with no consistent trend. On average, Veterans who experience nausea/vomiting are 2.57 times more likely to have PTSD than the general population of Veterans. This prevalence has a general downward trend over time.

Secondary mental illness

This study observed prevalence of depression in Veterans with either PTSD or GI disease, as reported in Table 8. It was observed that the prevalence of depression and anxiety is even higher in those Veterans who have been diagnosed with both PTSD and any GI disease, as reported in Table 9.

Conclusions

In summary, findings were that PTSD is bi-directionally correlated with the GI diseases of GERD, PUD, FD, Crohn's

Table 9. Prevalence of depression and anxiety in those with both PTSD and GI disease.

Co-occurring conditions	Prevalence of depression	Prevalence of anxiety
PTSD and GERD	78.54% (n = 619,269)	61.94% (n = 488,387)
PTSD and Peptic ulcer disease	79.81% (n = 34,017)	63.69% (n = 34,328)
PTSD and functional dyspepsia	92.78% (n = 90,958)	67.76% (n = 74,459)
PTSD and Crohn's disease	81.43% (n = 9540)	65.69% (n = 7696)
PTSD and ulcerative colitis	79.71% (n = 17,715)	65.69% (n = 14,211)
PTSD and diverticular disease	77.92% (n = 221,010)	59.38% (n = 168,422)
PTSD and IBS	82.68% (n = 90,616)	71.64% (n = 78,515)
PTSD and constipation	83.20% (n = 168,394)	66.83% (n = 135,252)
PTSD and nausea/vomiting	81.56% (n = 439,539)	65.00% (n = 350,263)

Table shows the prevalence of depression and anxiety in Veterans who have been diagnosed with both PTSD and a GI disease. The rates of depression and anxiety are significantly higher here than in this Table, showing that the combination of PTSD and a GI disease increases the risk for depression and anxiety.

disease, diverticular disease, and IBS, and the symptoms of constipation and nausea/vomiting among Veterans who served during wartime periods. This study found that PTSD is not correlated with UC. Additionally, PTSD was most strongly associated with IBS, FD, and the symptoms of nausea/vomiting.

Discussion

In the Danish population, researchers found that among those with PTSD, risk of any GI disease was 25%, with PTSD having the strongest association with peptic ulcer.²¹ This study's results were consistent in that a strong association between PTSD and PUD was identified. The rate of PTSD in Veterans with PUD was 18.97%, while the rate of PUD in Veterans with PTSD was 2.69%. Interestingly, while Veterans with PTSD were more likely to have PUD than Veterans without PTSD, this rate is still lower than the 5%–10% lifetime prevalence that is expected in the general population.²²

However, the results were inconsistent with the Danish study in that IBS was the most strongly correlated GI disease with PTSD, rather than PUD. The rate of PTSD in Veterans with IBS was 38.01%, while the rate of IBS in Veterans with PTSD was 9.52%. This supports research that found those with IBS were significantly more likely to be diagnosed with PTSD in African Americans.²³ The American College of Gastroenterology reports that 5%–7% of American adults have been diagnosed with IBS but estimates that 10%–15% of Americans suffer from the disorder.²⁴ Therefore, these results show that Veterans are being diagnosed with IBS at a higher rate than the general American population.

The existing research reported differing rates of PTSD in people with IBD. Fuss et al.²³ reported 32.8%, while Taft et al. reported 9.6%.²⁴ Findings from this study fall within this range of results. The study identified a total of 55,758 Veterans with Crohn's disease, and 21.01% of those patients were also diagnosed with PTSD. The study identified a total of 103,076 Veterans with UC, and 21.56% of those patients

were also diagnosed with PTSD. The findings from this study are consistent with the report from Thakur et al.²⁵ that the incidence of co-occurring IBD and PTSD is rising over time.

The current study supports findings related to those of Savas et al.,²⁶ who found that female Veteran participants with IBS and dyspepsia reported significantly higher levels of anxiety and depression when compared to women without GI diseases. The findings in this study supported higher prevalence of depression and anxiety in both men and women with IBS and FD than the general population of Veterans.

The study reveals the complexity of Veteran health. Gould et al. found in their study that Veterans do not have increased prevalence of depression and anxiety over non-Veterans. The researchers identified the prevalence of prevalence of depression in Veterans as 11% and the prevalence of anxiety in Veterans as 9.9%.²⁷ However, this study found prevalence of depression and anxiety to be higher, at least in Veterans with GI disease and/or PTSD, summarized in Tables 7 and 8. These results highlight the difference in prevalence of depression and anxiety among Veterans with co-occurring conditions compared to the general population of Veterans.

Study implications

The implication of findings is that psychiatric providers can expect to frequently see Veterans with a triad of PTSD, GI disease, and depression or anxiety. Nurses working in primary care settings are optimally situated to screen for all conditions and refer to specialist care as appropriate. Mental health nurses should routinely screen for GI symptoms in Veterans who have been diagnosed with these mental health conditions. When positive, providers should consult with primary care or gastroenterology for coordination of care. Since several antidepressants have evidence to support use in GI diseases, mental health prescribers should consider these medications when applicable to treat two conditions.

Additionally, this study points toward the need for improved understanding of disorders of gut-brain interaction, such as IBS and FD. Improved treatments are needed to address both symptomology and quality of life issues associated with these disorders.

Study strengths and limitations

A strength of the study was that the researcher was able to observe prevalence of secondary mental illness among Veterans with PTSD and those with GI disease. Prevalence of depression and anxiety in GI disease were compared to the national averages for Veterans and found to be higher than expected. In the future nurses will be able to improve screening processes for depression and anxiety within patients experiencing GI disease and/or PTSD.

This study does not account for Veterans with a GI or PTSD diagnosis who are not being treated by the Department of Veterans Affairs, such as those treated in private or community care, who are not being treated at all, with a misdiagnosis, or with an inaccurate recording of information at the provider level. Additionally, the study included only patients treated in the outpatient setting and may not include those Veterans who were treated inpatient and never followed up in the outpatient setting. Since any licensed provider can enter a diagnosis by adding an ICD-9 or ICD-10 code to their encounter and it is unknown whether the provider was a mental health specialist, gastroenterologist, or general practitioner, there is potential for lack of accuracy in the diagnosis.

The study was limited by lack of access to population data for all VHA-treated Veterans. The study did not have access to exact prevalence of age, ethnicity, and period of service for the entire population treated by VHA. The literature showed estimated prevalence of depression and anxiety for Veterans,²⁷ as well as estimated prevalence of gender,²⁸ but the specific data was not accessible through VHA. The study could not control for all possible confounding variables together without this data.

A sample size was not calculated for this study. While a larger sample size leads to more accurate reflection of the population, it is also a potential limitation as it was a burden for data collection via Microsoft SQL Server. Data had to be collected 1 year at a time rather than as a whole and limited some methods of data analysis.

Additionally, data gathered included both ICD-9 codes and ICD-10 codes. The United States, including VHA, made the switch from ICD-9 to ICD-10 codes in the year 2015. In years 2016 and forward, this study found prevalence of disease to be unexpectedly dissimilar from the trend from the previous years. It is likely that the change in ICD coding procedures has influenced the results of the study. To confirm this effect, future studies should be repeated with data gathered by month rather than by year to follow the change more precisely as coding changes.¹⁵

Recommendations for further research

Future research studies should attempt to control for confounding variables by gathering population data from the Department of Veterans Affairs. Data on the entire VHA population should be collected for both demographics and secondary mental illness. A similar study should be done with a smaller sample size where a multilevel correlation between PTSD, depression, anxiety, and GI disease can be performed with access to population-level data, to control for potential confounding variables in mental health diagnosis. Previous research identifying depression and anxiety as correlating with GI disease should be reviewed and potentially repeated to account for PTSD as a possible confounding variable.

Conclusions

This study identified the prevalence of PTSD and co-occurring GI disease and found that PTSD is bi-directionally correlated with the GI diseases of GERD, PUD, FD, Crohn's disease, diverticular disease, IBS, and the GI symptoms of constipation and nausea/vomiting. The study also identified a high level of depression and anxiety in those Veterans with both PTSD and GI disease.

Previous research has reported a correlation between depression, anxiety, and GI disease. The researcher recommends that this research be reviewed to account for PTSD as a potential confounding variable. However, whether PTSD or depression/anxiety is the confounding variable, clinically the presentation will often look the same as a triad of PTSD, depression/anxiety, and GI disease diagnosis. The researcher recommends improved screening in both directions. Clinicians in mental health clinics who see a presentation of PTSD should be screening for GI disease, while primary care and gastroenterology providers treating GI diseases should be screening for trauma and PTSD. Improved diagnosis rates may lead to improved treatment.

Acknowledgements

Not applicable.

Author contributions

Kelsey G Kent conceived the study and determined the methodology, collected, and analyzed the data, and wrote and organized the manuscript.

Declaration of conflicting interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author received no financial support for the research, authorship, and/or publication of this article.

Ethics approval

Ethical approval for this study was waived by the IRBs at the University of Texas Medical Branch and the Department of Veterans Affairs Tennessee Valley Healthcare System because there was minimal risk to participants. No HIPAA-identifying information was collected. University of Texas Medical Branch IRB exemption number 19-0039.

Informed consent

Informed consent was waived by the IRBs.

Trial registration

n/a.

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