THE INTERACTION OF POST-TRAUMATIC STRESS DISORDER, CARDIOMETABOLIC RISK FACTORS, AND DEMOGRAPHICS ON CARDIOVASCULAR DISEASE OUTCOMES: A NATIONAL COHORT ANALYSIS

By

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Abstract

Background:

Post-traumatic stress disorder (PTSD) has been recognized as a condition associated with elevated cardiovascular risk. PTSD patients frequently present with multiple cardiovascular risk factors, such as hypertension, type 2 diabetes, hyperlipidemia, obesity, and nicotine dependence that may increase the likelihood of major adverse cardiovascular events (MACE). While the prevalence of PTSD and cardiovascular disease differs across race and sex, the relationship between PTSD and cardiovascular disease (CVD) and PTSD's impact on CVD across race and sex remains poorly defined.

Objective:

This study examines how the cumulative burden of cardiovascular risk factors affects the incidence of MACE among PTSD patients and evaluates whether these associations vary across race and sex.

Methods:

De-identified electronic health record data from the TriNetX Research Network was used to create cohorts examining PTSD patients without cardiovascular risk factors and with a varied number of risk factors, stratified by race and sex. Propensity score matching was applied within each comparison to balance cohorts for age, sex, and psychiatric comorbidities. Logistic and Cox proportional hazards models were used to estimate risk difference, risk ratio, odds ratio, and hazard ratio for MACE across increasing numbers of risk factors across race and sex. Additional generalized linear modeling tested for two way and three way interactions between number of cardiovascular risk factors, race, and sex to assess potential subgroup differences.

Results:

Across all PTSD patients, MACE incidence increased steadily with each additional cardiovascular risk factor. Compared to matched baseline cohorts (no risk factors), MACE risk increased by 0.6-1.0% with one risk factor, 4-5% with two risk factors, and more than 20% with four or more risk factors (all $p < 0.0001$). A separate subanalysis by sex identified greater increased MACE risk increase per factor for women, while race did not significantly alter the slope. The three way interaction between the number of risk factors, race, and sex was not significant, indicating that the risk accumulation trends were similar across all race and sex subgroups.

Conclusion:

Each additional cardiovascular risk factor significantly increases the absolute and relative risk of MACE in PTSD patients, independent of race or sex. The absence of significant racial difference suggests that when patients are propensity score matched, multimorbidity burden is the primary determinant of cardiovascular outcomes, instead of demographic identity. These findings show the importance of comprehensive cardiovascular screening and risk factor management in PTSD care.

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Introduction

Post-traumatic stress disorder is a chronic psychiatric condition that may develop following exposure to traumatic events. While PTSD is traditionally studied within the context of mental health, it has been increasingly recognized as a multisystem disorder with physical health implications. Previous studies have linked PTSD to increased risk of cardiovascular disease, including hypertension, hyperlipidemia, and major adverse cardiovascular events such as heart attack and stroke.[1-4] The biological mechanisms causing this association are complex and these physiological changes are also compounded by behavioral factors such as poor diet, physical inactivity, smoking, and improper medication adherence. As PTSD patients frequently develop clusters of cardiovascular risk factors, this may elevate risk and accelerate cardiovascular disease progression.

While racial and sex differences in cardiovascular disease are well documented in the general population, it is unclear whether these disparities persist within PTSD populations when patients are matched for clinical and demographic characteristics. Understanding the relationship between multimorbidity burden and major adverse cardiovascular event risk across race and sex is essential for identifying subgroups at higher risk and establishing equitable prevention strategies.

This study aims to address these gaps using a large, multi-institutional electronic health record database (TriNetX) to examine the association between the number of cardiovascular risk factors and the incidence of major adverse cardiovascular events among patients with PTSD across race and sex. With propensity score matching, this analysis results in a comprehensive, demographically stratified assessment of cardiovascular risk accumulation in PTSD patients.

Background

To understand the association between post-traumatic stress disorder (PTSD) and cardiovascular disease (CVD), this literature review is organized into four sections. First, we will examine existing research on PTSD, including its symptoms, diagnostic features, prevalence, and known disparities across race and sex. Second, we will review disparities in CVD and major adverse cardiovascular events (MACEs), examining the influence of race, ethnicity, and sex on cardiovascular risk and outcomes. Third, we will review current literature indicating that PTSD has effects on the development of CVD and MACEs and the prevalence of CVD among PTSD patients across race and sex. Finally, we will identify key gaps in the existing literature that prompted the need for the analysis in this study.

Post-Traumatic Stress Disorder (PTSD): Overview, Prevalence, and Risk Factors

Post-traumatic stress disorder is a psychiatric condition that may develop following exposure to a traumatic or life-threatening event and is characterized by symptoms of intrusion, avoidance, changes in cognition and mood, and changes in arousal and reactivity stemming from biological changes. Individuals with PTSD were observed with amygdala hyperactivity and medial prefrontal cortex hypoactivity, hippocampal abnormalities, and dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis, contributing to an increased fear response, intrusive traumatic memories, and irregular stress hormone levels.[5]

While PTSD affects approximately 5-10% of the U.S. population, the lifetime prevalence varies depending on demographic factors, trauma type, and trauma frequency. Women experience around twice the rate of PTSD as men [5] and its prevalence differs across race, impacting 8.7% of Black individuals, 7.4% of White individuals, 7.0% of Hispanic individuals, and 4.0% of Asian individuals within the U.S.[6]

In addition to trauma exposure, there are biological and psychological risk factors that may increase the risk of PTSD. Heritability estimates range from 30-40% for genes involved in stress regulation. Epigenetic modifications like the demethylation of the FKBP5 gene has been implicated in heightened stress reactivity. Early life adversity, high neuroticism and low resilience personality traits, and low social support after a trauma are also associated with increased vulnerability for PTSD.[5]

Cardiovascular Disease (CVD) and Major Adverse Cardiovascular Events (MACE): Overview, Prevalence, and Risk Factors

Cardiovascular disease encompasses a range of disorders involving the heart and vasculature, many times leading to major adverse cardiovascular events (MACE), such as myocardial infarction (heart attack), cerebral infarction (stroke), and heart failure. Since 1921, these conditions have collectively remained the leading cause of mortality within the U.S. [7] and in recent years, accounts for roughly 20-25% of all deaths in the U.S.[8]

Well-established risk factors for CVD include hypertension, dyslipidemia, type 2 diabetes mellitus, obesity, tobacco use, physical inactivity, and older age. Among these, elevated blood pressure and elevated low-density lipoprotein (LDL) cholesterol are the major causal agents for CVD, approximately doubling cardiovascular risk, whereas diabetes and smoking increase risk by two to three times.[9-11]

Like PTSD, cardiovascular disease risk and risk factors vary across demographics. Black Americans exhibit the highest prevalence of hypertension, heart failure, and stroke, while non-white Hispanics have elevated rates of obesity and diabetes.[12] Mexican Americans also have the highest prevalence of no leisure time physical activity, or physical inactivity.[13] Social

determinants, such as poverty, limited access to preventive care, community support, and more, further amplify these disparities.

PTSD and Cardiovascular Disease: Epidemiologic Evidence and Mechanisms

Growing evidence has demonstrated that PTSD has a significant, independent risk on cardiovascular morbidity and mortality. Edmonson et al.[2] found a 55% increase in risk of coronary heart disease among PTSD patients and 27% increase in risk among PTSD patients when adjusting for a depression diagnosis. This effect is comparable in magnitude to smoking or diabetes on CVD. Preexisting CVD conditions can be further exacerbated by this effect as well. As a consequence of cardiovascular disease events, some patients develop PTSD which may further worsen their prognosis.[1] Further meta-analyses have found consistent associations between PTSD and multiple CVD outcomes, including heart attack, stroke, and MACE overall, across both civilian and veteran populations.[3] This relationship was found to be mediated by stress-associated neural activity, heart rate variability, and high sensitivity C-reactive protein, pointing to the role of neuro-immune pathways in the association between PTSD and MACE.[4]

This association remains across demographics, however its relative prevalence varies. For individuals with PTSD, there is a higher likelihood of developing a cardiovascular event for non-Latino Blacks, Latinos, and non-Latino Whites from highest to lowest, but not for Asian individuals.[14] Among patients with depression, PTSD was associated with increased risk of coronary artery disease among Black patients, but decreased risk among White and Latino patients, and no significant association in Asian patients.[15] Further, a scoping review analyzing the intersectionality of sex and race reported that many past studies failed to report on race and/or ethnicity or investigate sex differences in the link between PTSD and CVD.[16]

Gaps in the Literature

Although the current body of knowledge firmly links PTSD with CVD, there are still several limitations to our understanding of their relationship. Many prior studies use White or veteran samples, while racial and ethnic minorities and women remain under-studied.[14, 16] Additionally, previous studies have limited modeling of psychiatric and sleep comorbidities such as depression, anxiety, substance use, and obstructive sleep apnea which are common in PTSD and related to CVD. The interaction effects of PTSD with sex and race on cardiovascular outcomes are also under-studied. While there are studies on the difference in prevalence of CVD among PTSD patients across race,[14-16] these rates of prevalence follow the same rates of CVD among non-PTSD patients across race. This difference in CVD prevalence across race is mainly attributed to social determinants of health such as income, social support, inadequate access to healthcare, and more. These disparities also transcend to PTSD populations and explain the different prevalence of CVD across race within this population, however, previous studies have not investigated whether PTSD impacts different races at different strengths.

Methodology

Research Question

Previous studies have established that racial and ethnic disparities in cardiovascular disease persist among individuals with and without post-traumatic stress disorder. Specifically, Black individuals consistently exhibit higher rates of CVD than White, Hispanic, or Asian populations. However, this pattern is largely attributed to social determinants of health, including access to healthcare, socioeconomic disadvantages, and structural inequities that disproportionately affect minority groups. While the general direction of these disparities is well characterized, few studies have investigated whether PTSD amplifies cardiovascular risk differently across race and sex. Thus, limited evidence suggests that PTSD may exert stronger physiological and behavior effects among women and racial minorities, but a definitive link is still unclear. To address these gaps, this capstone aims to answer the question: *How does post-traumatic stress disorder influence the risk of major cardiovascular disease outcomes, and are these effects modified by race and sex?*

Study Design and Data Source

This study uses a retrospective cohort design utilizing de-identified electronic health record (EHR) data from the TriNetX Research Network, a global federated health research platform that collects longitudinal clinical data. TriNetX includes demographics, diagnoses, procedures, laboratory values, and medications, enabling for larger scale observational analyses. Specifically, the US Collaborative Network was used for this study which includes EHR data from over 128 million patients across 70 healthcare organizations.

Study Population and Cohort Definitions

Patient cohorts were constructed to evaluate cardiovascular risk among patients diagnosed with post-traumatic stress disorder, stratified by race, gender, and the number of cardiovascular risk factors present after the PTSD diagnosis. Separate analyses were conducted for patients identifying as Black, White, Hispanic or Latino, and Asian. Each racial cohort was mutually exclusive, i.e. the Black cohort included only patients coded as Black and excluded those coded as White, Hispanic or Latino, or Asian. Post-traumatic stress disorder patients were defined by the presence of a PTSD diagnosis (ICD-10-CM F43.1). Patient cohorts were further categorized based on the number of cardiovascular risk factors recorded after their PTSD diagnosis. The cohorts are presented in a cohort diagram in Figure 1. These five cardiovascular risk factors included essential (primary) hypertension (ICD-10-CM I10), disorders of lipoprotein metabolism and other lipidemias (ICD-10-CM E78), type 2 diabetes mellitus (ICD-10-CM E11), overweight and obesity (ICD-10-CM E66), and nicotine dependence (ICD-10-CM F17). The "Baseline cohort" included PTSD patients without any of the five risk factors following their PTSD diagnosis. The "1-factor cohort" included patients who developed exactly one of the risk factors following their PTSD diagnosis. The "2-factor cohort" included patients who developed exactly two of the risk factors, the "3-factor cohort" included those with three risk factors, the "4-factor cohort" included those with four risk factors, and the "5-factor cohort" included those with all five of the risk factors after PTSD diagnosis. The index date was established as the date of first PTSD diagnosis and all comorbidities and set outcomes were evaluated relative to this index date.

The cohort diagram in Figure 1 shows the inclusion criteria, exclusion criteria, time frame, and propensity score matching process for the analysis of Black PTSD patients (combined

sex) baseline (no risk factors) vs. 1 cardiovascular risk factor cohorts. Additional cohorts follow the same format, increasing the number of cardiovascular risk factors (2, 3, 4, or 5 factors), and switching race in exclusion criteria. For sex-specific cohort analyses, the male or female characteristic was added to the inclusion criteria.

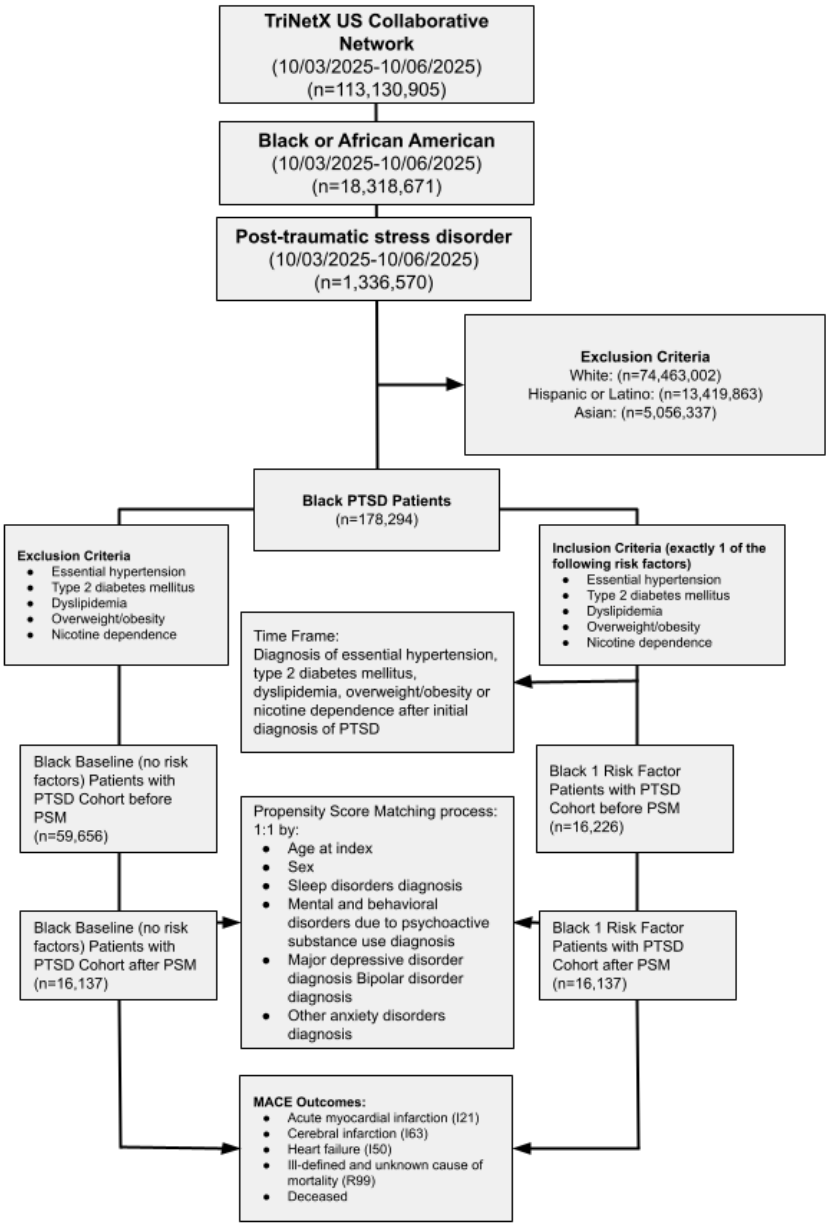

Figure 1. ***Baseline vs. 1 Risk Factor Cohort Design For Black PTSD Patients***

Outcome Events

The study's outcomes were incident cardiovascular events occurring after the PTSD diagnosis and onset of cardiovascular risk factors. These events included acute myocardial infarction (ICD-10-CM I21), cerebral infarction (ICD-10-CM I63), heart failure (ICD-10-CM I50), ill-defined and unknown cause of mortality (ICD-10-CM R99), and deceased. This temporal sequencing ensured cardiovascular outcomes reflect new disease events following diagnosis of PTSD and related comorbidities, rather than from preexisting conditions. For each patient, the time to event was measured from the index date to the first recorded occurrence of any cardiovascular outcomes included.

Covariates

Propensity score matching (PSM) was used to minimize baseline differences between cohort comparisons and to control for potential confounders that could influence cardiovascular risk. PSM variables were selected based on established relationships with both PTSD and cardiovascular disease and included demographic and additional characteristics available in the TriNetX database. For cohorts already stratified by sex, PSM variables included age at index (continuous variable), sleep disorders (ICD-10-CM G47), mental and behavioral disorders due to psychoactive substance use (ICD-10-CM F10-F19), major depressive disorder, recurrent (ICD-10-CM F33), bipolar disorder (ICD-10-CM F31), and other anxiety disorders (ICD-10-CM F41). For cohorts that combined both sexes, sex was additionally included as a covariate in the propensity score model to control for sex-based differences in both PTSD prevalence and cardiovascular outcomes.

Propensity score matching was conducted through TriNetX and each variable was assessed as present or absent up to one day before the index event, ensuring only preexisting conditions were included in the balancing process.

Statistical Analysis

All statistical analyses were performed within the TriNetX analytics platform using the "Compare Outcomes" function. This function computes measures of association between matched cohorts, resulting in the estimation of both absolute and relative measures of association. The statistical outputs of the measures of association analysis included risk difference with 95% confidence intervals (CIs), risk ratio (RR) with 95% CIs, and statistical significance of risk differences assessed using z-tests with p-values considered significant at $p < 0.05$. These measures quantify the relative risk and absolute risks of cardiovascular outcomes between PTSD patients within each race and sex specific group, and across factor based subgroups.

Results

The findings of the cohort comparison illustrates the relationship between post-traumatic stress disorder and major adverse cardiovascular events across racial and sex subgroups. The results are organized into four sub-analyses. First, we examine overall trends in cardiovascular risk across all PTSD cohorts. Second, we present an analysis of combined-sex cohorts to evaluate patterns of cardiovascular risk across race. Third, we isolated a male-only cohort analyses and female-only cohort analyses to assess sex-based differences in cardiovascular risk relationships in PTSD patients across race. Finally, a cross-cohort synthesis summarizes consistent trends in cardiovascular outcomes across all subgroups.

Analysis 1: All Demographics

The total population size included 1,166,830 PTSD patients, of which 63.19% were female and 63.17% were White, with smaller proportions identifying as Black or African American (16.60%), Hispanic or Latino (4.09%), and Asian (1.53%). The mean age was 45±18 years. As the number of post-PTSD cardiovascular risk factors increased, the mean age at index rose (28.6±14.9 years in the baseline cohort vs. 50.9±11.8 years in the 5-risk factor cohort). The prevalence of covariate psychiatric disorders including sleep disorders (18.74% at baseline vs. 75.24% at 5-risk factors), major depressive disorder (25.94% at baseline vs. 55.16% at 5-risk factors), bipolar disorder (13.62% at baseline vs. 48.09% at 5-risk factors), and anxiety disorders (54.68% at baseline vs. 84.89% at 5-risk factors) also increased as the number of cardiovascular risk factors increased.

Table 1. ***Demographic and Baseline Characteristics of PTSD Patients by Number of Cardiovascular Risk Factors***

		Demographic and Baseline Characteristics						
		PTSD Diagnosis	0 Risk Factors (Baseline)	1 Risk Factor	2 Risk Factors	3 Risk Factors	4 Risk Factors	5 Risk Factors
Total Patients (N)		1,166,830	367,288	97,134	39,063	17,616	7,961	2,092
Age at Index								
	Mean±SD	38.4±17.4	28.6±14.9	35±14.8	40.1±15.5	44±14.6	45.9±13.2	50.9±11.8
Gender, n (%)								
	Female	737,319 (63.19)	224,907 (66.68)	66,041 (67.99)	26,445 (67.70)	11,663 (66.21)	5,320 (66.83)	1,397 (66.82)
	Male	428,576 (36.73)	121,939 (33.20)	31,005 (31.92)	12,590 (32.23)	5,941 (33.73)	2,635 (33.11)	692 (33.12)
Race, n (%)								
	White	737,117 (63.17)	245,533 (66.85)	71,333 (73.44)	29,150 (74.62)	13,286 (75.42)	5,907 (74.20)	1,479 (70.70)
	Black or African American	196,638 (16.60)	59,656 (16.24)	16,226 (16.70)	6,882 (17.62)	3,179 (18.05)	1,533 (19.26)	438 (20.94)
	Hispanic or Latino	47,774 (4.09)	22,200 (6.04)	5,591 (5.76)	2,083 (5.33)	908 (5.15)	401 (5.04)	104 (4.97)
	Asian	17,818 (1.53)	7,732 (2.11)	1,561 (1.61)	563 (1.44)	249 (1.41)	107 (1.34)	17 (0.81)
Comorbidities, n (%)								
	Essential (primary) hypertension	178,733 (15.32)	0 (0.00)	13,377 (13.77)	18,620 (47.67)	13,696 (77.75)	7,478 (93.93)	2,092 (100.00)
	Type 2 diabetes mellitus	84,192 (7.22)	0 (0.00)	2,713 (2.79)	4,513 (11.55)	5,661 (32.14)	5,645 (70.91)	2,092 (100.00)
	Disorders of lipoprotein metabolism and other lipidemias	156,983 13.45)	0 (0.00)	15,304 (15.76)	17,317 (44.33)	12,738 (72.31)	7,314 (91.87)	2,092 (100.00)
	Overweight and obesity	155,992 (13.37)	0 (0.00)	26,283 (27.06)	20,381 (52.17)	11,787 (66.91)	6,823 (85.71)	2,092 (100.00)

	Nicotine dependence	161,889 (13.87)	0 (0.00)	39,457 (40.62)	17,295 (44.27)	8,966 (50.90)	4,584 (57.58)	2,092 (100.00)
PSM Covariates, n (%)								
	Sleep Disorders	190,291 (16.31)	68,817 (18.74)	33,441 (34.43)	18,052 (46.21)	10,013 (56.84)	5,426 (68.16)	1,574 (75.24)
	Mental and behavior disorders due to psychoactive substance use	241,429 (20.69)	77,429 (21.08)	53,047 (54.61)	22,719 (58.16)	11,238 (63.79)	5,529 (69.45)	2,092 (100.00)
	Major depressive disorder	166,915 (14.30)	95,288 (25.94)	62,215 (64.05)	16,088 (41.18)	8,320 (47.23)	4,180 (52.51)	1,154 (55.16)
	Bipolar disorder	110,124 (9.44)	50,032 (13.62)	35,300 (36.34)	11,393 (29.17)	5,651 (32.08)	2,866 (36.00)	1,006 (48.09)
	Other anxiety disorders	350,125 (30.00)	200,842 (54.68)	70,590 (72.67)	30,009 (76.82)	14,026 (79.62)	6,505 (81.71)	1,776 (84.89)

Table 1 presents the demographic characteristics, cardiovascular comorbidities, and psychiatric propensity score matched covariates of PTSD patients identified in the TriNetX U.S. Collaborative Network, stratified by the number of post-diagnosis cardiovascular risk factors.

Across all cohorts of patients diagnosed with post-traumatic stress disorder, the risk of experiencing a major adverse cardiovascular event increased sharply with the number of coexisting cardiovascular risk factors, including hypertension, type 2 diabetes mellitus, hyperlipidemia, obesity, and nicotine dependence. Because each comparison was propensity score matched to a new baseline cohort, event rates represent matched populations rather than a single global baseline. Accordingly, risk differences (RD) were used as the primary measure to quantify absolute increases in MACE across racial groups, supported by risk ratios (RRs) as relative measures.

Across all races and sexes combined, incidence of MACE rose by 0.6-1.0% with one factor, 4-5% with two factors, and over 20% with four or more factors relative to matched baseline groups ($p < 0.0001$). These absolute increases corresponded to risk ratios ranging from 2.3 to 6.7, odds ratios between 3.5 and 8.3, and hazard ratios between 2.2 and 3.3, indicating both acute and sustained cardiovascular vulnerability as comorbidity burden increased.

While event rates and effect sizes slightly varied across races and sex, the direction and magnitude of change were consistent. This pattern confirms that multimorbidity burden is the dominant determinant of cardiovascular risk among PTSD patients, not race or sex alone. Each additional cardiovascular risk factor produces a measure increase in both absolute and relative risk of MACE.

Sub-Analysis 1: Combined Sex Cohorts

When male and female patients were combined into a single model, the pattern of risk escalation with increasing cardiovascular comorbidities was consistent and significant ($p < 0.0001$). Across all racial groups, MACE risk increased exponentially as patients accumulated more cardiovascular risk factors. Compared to their matched baseline cohorts, patients with one cardiovascular risk factor had a +0.7-1.0% absolute increase in MACE risk (RD range: +0.59% to +1.86%; all $p < 0.05$). At two factors, the risk difference expanded to +4.5-5.0%, and by four factors, the absolute increase exceeded +20% across all groups ($p < 0.0001$).

Relative measures were also consistent with these trends. Among Black PTSD patients, MACE risk increased from 1.81% at baseline to 25.29% with four factors [RD +22.25%, 95% CI (19.722%, 24.768%)], corresponding to RR = 8.31, 95% CI [6.086, 11.359]. White patients demonstrated a similar pattern [RD +21.86%, 95% CI (20.544%, 23.173%), RR = 6.17, 95% CI (5.393, 7.063)], while Latino patients showed comparable increases [RD +17.11%, 95% CI

(12.575%, 21.641%), RR = 6.69, 95% CI (3.607, 12.416)]. The Asian PTSD cohorts with three, four, and five cardiovascular risk factors were too small to run analyses on through TriNetX. However, Asian PTSD cohorts with two factors compared to baseline showed comparable increases as well [RD +4.42%, 95% CI (2.044%, 6.789%), RR = 3.36, 95% CI (1.675, 6.753)].

These findings show that each additional cardiovascular factor contributes an absolute 4-5% increase in MACE risk and around a two to threefold relative increase, with consistent trends across racial groups. Hazard ratios confirmed the persistence of these effects over time.

Table 2. ***Combined-Sex Cohort Analysis Results***

Combined-Sex Cohort Analysis									
Cohort Statistics				Risk Difference				Risk Ratio	
Cohorts	# of Patients	Patients w/ Outcome	Risk	Risk Difference	95% CI	z	p	Risk Ratio	95% CI
Black or African American									
1 Risk Factor	13,518	384	2.84%	1.03%	(0.673%,1.389%)	5.654	< 0.0001	1.57	(1.341,1.838)
Baseline	13,759	249	1.81%						
2 Risk Factors	6,146	455	7.40%	4.98%	(4.227%,5.738%)	12.944	< 0.0001	3.058	(2.556,3.659)
Baseline	6,362	154	2.42%						
3 Risk Factors	2,837	419	14.77%	12.00%	(10.57%,13.435%)	16.268	< 0.0001	5.338	(4.237,6.726)
Baseline	2,964	82	2.77%						
4 Risk Factors	1,309	331	25.29%	22.25%	(19.722%,24.768%)	16.686	< 0.0001	8.314	(6.086,11.359)
Baseline	1,381	42	3.04%						
5 Risk Factors	238	48	20.17%	16.35%	(10.791%,21.906%)	5.914	< 0.0001	5.28	(2.806,9.937)
Baseline	288	11	3.82%						
White									
1 Risk Factor	61,181	2,101	3.43%	0.71%	(0.52%,0.906%)	7.241	< 0.0001	1.262	(1.185,1.344)
Baseline	61,951	1,686	2.72%						
2 Risk Factors	26,904	2,171	8.07%	4.53%	(4.141%,4.924%)	22.703	< 0.0001	2.282	(2.12,2.456)
Baseline	27,680	979	3.54%						

3 Risk Factors	12,001	1,972	16.43%	12.22%	(11.466%,12.967%)	31.588	< 0.0001	3.898	(3.553,4.277)
Baseline	12,502	527	4.22%						
4 Risk Factors	5,137	1,340	26.09%	21.86%	(20.544%,23.173%)	31.552	< 0.0001	6.172	(5.393,7.063)
Baseline	5,418	229	4.23%						
5 Risk Factors	928	211	22.74%	16.55%	(13.539%,19.567%)	11.207	< 0.0001	3.677	(2.869,4.712)
Baseline	1,229	76	6.18%						
Hispanic or Latino									
1 Risk Factor	4,890	120	2.45%	0.59%	(0.019%,1.168%)	2.026	0.0427	1.319	(1.008,1.726)
Baseline	4,945	92	1.86%						
2 Risk Factors	1,926	111	5.76%	3.73%	(2.51%,4.939%)	6.01	< 0.0001	2.827	(1.98,4.035)
Baseline	1,962	40	2.04%						
3 Risk Factors	840	89	10.60%	7.59%	(5.213%,9.959%)	6.241	< 0.0001	3.521	(2.298,5.394)
Baseline	864	26	3.01%						
4 Risk Factors	353	71	20.11%	17.11%	(12.575%,21.641%)	7.215	< 0.0001	6.692	(3.607,12.416)
Baseline	366	11	3.01%						
5 Risk Factors	Patient cohort sample size too small to run analysis with TriNetX								
Baseline									
Asian									
1 Risk Factor	1,409	43	3.05%	1.86%	(0.796%,2.918%)	3.431	0.0006	2.555	(1.464,4.457)
Baseline	1,423	17	1.20%						
2 Risk Factors	525	33	6.29%	4.42%	(2.044%,6.789%)	3.644	0.0003	3.363	(1.675,6.753)
Baseline	535	≤ 10*	1.87%						
3 Risk Factors	Patient cohort sample size too small to run analysis with TriNetX								
Baseline									
4 Risk Factors	Patient cohort sample size too small to run analysis with TriNetX								
Baseline									
5 Risk Factors	Patient cohort sample size too small to run analysis with TriNetX								
Baseline									

Table 2 summarizes the TriNetX outcome analyses evaluating the relationship between the number of cardiovascular risk factors (hypertension, type 2 diabetes, hyperlipidemia, obesity, and nicotine dependence) and major adverse cardiovascular event risk among PTSD patients. Cohorts are stratified by race (Black, White, Hispanic/Latino, and Asian) and represent combined male and female patients after propensity score matching for psychiatric covariates. The risk difference and risk ratio were estimated using TriNetX's "Compare Outcomes" function.

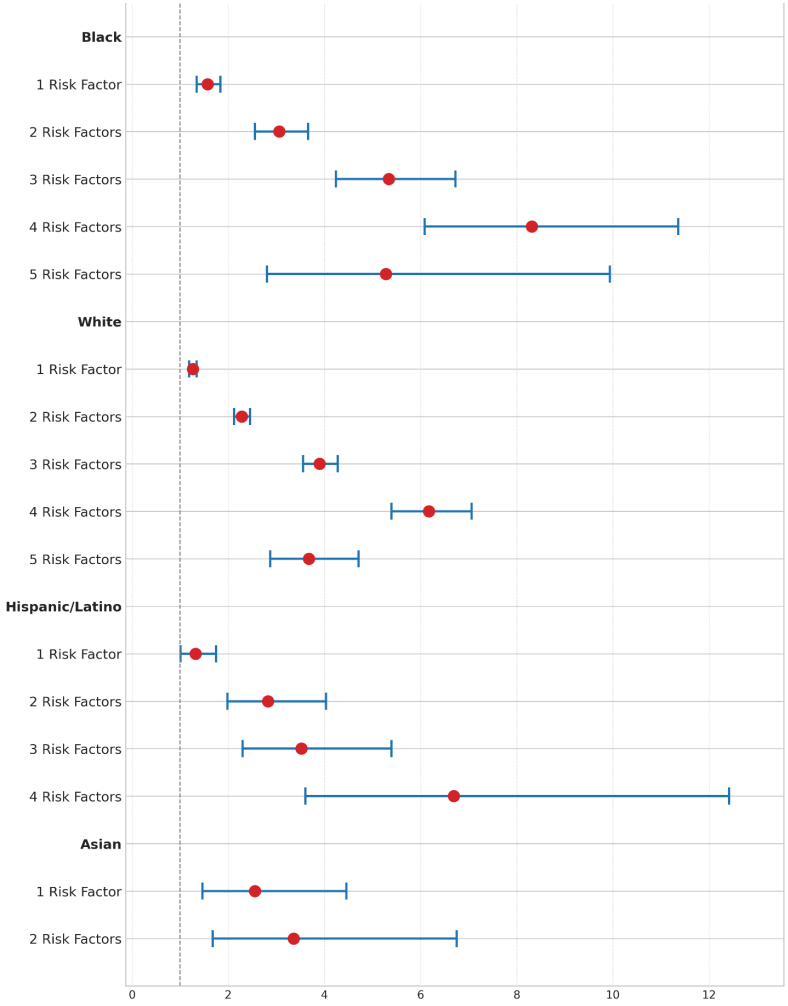

Figure 2. ***Forest Plot of Race-Stratified Risk Ratios for MACE Outcomes Among PTSD Patients***

Figure 2 displays the risk ratios (red circles) and corresponding 95% confidence intervals (horizontal blue lines) for MACE among PTSD patients stratified by race (Black, White, Hispanic/Latino, and Asian). Each row represents patients with a specified number of post-PTSD cardiovascular risk factors relative to a baseline PTSD cohort with no risk factors. Data represents combined male and female cohorts.

Sub-Analysis 2: Male Cohorts

Among male PTSD patients, MACE risk also increased exponentially as the number of cardiovascular risk factors increased. In White men, incidence of MACE rose from 6.35% at baseline to 28.67% at four factors [RD +22.33%, 95% CI (19.905%, 24.745%), RR = 4.52, 95% CI (3.728, 5.474)]. Black men demonstrated a similar trend [RD +22.88%, 95% CI (18.355%, 27.395%), RR = 6.13, 95% CI (3.931, 9.561)]. Latino men showed smaller absolute changes but had similar relative changes when comparing three factors and baseline cohorts [RD +11.52%, 95% CI (6.932%, 16.111%), RR = 4.17, 95% CI (2.202, 7.911)]. For Asian men, limited sample size prevented comparison of two, three, four, and five cardiovascular risk factor cohorts with baseline. However, risk directionality was consistent when comparing the one factor and baseline cohort [RD +1.22%, 95% CI (-1.759%, 4.19%), RR = 1.33, 95% CI (0.658, 2.705)].

Overall, male patients demonstrated a rise in MACE risk with increasing comorbidity burden. Hazard ratios in the range of 1.7 to 2.3 confirmed this risk accumulation persists over time, highlighting the compounding cardiovascular impact of multimorbidity among men with PTSD.

Table 3. *Male-Only Cohort Analysis Results*

Male-Only Cohort Analysis									
Cohort Statistics				Risk Difference				Risk Ratio	
Cohorts	# of Patients	Patients w/ Outcome	Risk	Risk Difference	95% CI	z	p	Risk Ratio	95% CI
Black or African American									
1 Risk Factor	5,004	189	3.78%	0.99%	(0.291%,1.682%)	2.783	0.0054	1.354	(1.093,1.677)
Baseline	5,089	142	2.79%						
2 Risk Factors	2,150	188	8.74%	4.59%	(3.138%,6.047%)	6.193	< 0.0001	2.106	(1.653,2.683)
Baseline	2,216	92	4.15%						
3 Risk Factors	991	165	16.65%	11.31%	(8.609%,14.001%)	8.153	< 0.0001	3.115	(2.325,4.173)
Baseline	1,029	55	5.35%						
4 Risk Factors	450	123	27.33%	22.88%	(18.355%,27.395%)	9.555	< 0.0001	6.13	(3.931,9.561)
Baseline	471	21	4.46%						
5 Risk Factors									
Baseline	Patient cohort sample size too small to run analysis with TriNetX								
White									
1 Risk Factor	18,592	838	4.51%	0.62%	(0.216%,1.028%)	3.002	0.0027	1.16	(1.053,1.278)
Baseline	18,865	733	3.89%						
2 Risk Factors	8,390	853	10.17%	5.07%	(4.272%,5.862%)	12.501	< 0.0001	1.994	(1.785,2.227)
Baseline	8,687	443	5.10%						
3 Risk Factors	3,917	719	18.36%	12.20%	(10.783%,13.616%)	16.792	< 0.0001	2.982	(2.602,3.416)
Baseline	4,142	255	6.16%						
4 Risk Factors	1,709	490	28.67%	22.33%	(19.905%,24.745%)	17.551	< 0.0001	4.518	(3.728,5.474)
Baseline	1,812	115	6.35%						
5 Risk Factors	270	70	25.93%	19.88%	(14.11%,25.654%)	7.028	< 0.0001	4.29	(2.728,6.744)
Baseline	364	22	6.04%						
Hispanic or Latino									
1 Risk Factor	1,589	60	3.78%	0.96%	(-0.284%,2.197%)	1.511	0.1307	1.339	(0.916,1.959)
Baseline	1,596	45	2.82%						

2 Risk Factors	617	42	6.81%	4.06%	(1.687%,6.425%)	3.342	0.0008	2.475	(1.424,4.299)
Baseline	618	17	2.75%						
3 Risk Factors	297	45	15.15%	11.52%	(6.932%,16.111%)	4.85	< 0.0001	4.174	(2.202,7.911)
Baseline	303	11	3.63%						
4 Risk Factors									
Baseline	Patient cohort sample size too small to run analysis with TriNetX								
5 Risk Factors									
Baseline	Patient cohort sample size too small to run analysis with TriNetX								
Asian									
1 Risk Factor	350	17	4.86%	1.22%	(-1.759%,4.19%)	0.802	0.4227	1.334	(0.658,2.705)
Baseline	357	13	3.64%						
2 Risk Factors									
Baseline	Patient cohort sample size too small to run analysis with TriNetX								
3 Risk Factors									
Baseline	Patient cohort sample size too small to run analysis with TriNetX								
4 Risk Factors									
Baseline	Patient cohort sample size too small to run analysis with TriNetX								
5 Risk Factors									
Baseline	Patient cohort sample size too small to run analysis with TriNetX								

Table 3 summarizes the TriNetX outcome analyses evaluating the relationship between the number of cardiovascular risk factors (hypertension, type 2 diabetes, hyperlipidemia, obesity, and nicotine dependence) and major adverse cardiovascular event risk among PTSD patients. Cohorts are stratified by race (Black, White, Hispanic/Latino, and Asian) and represent only male patients after propensity score matching for psychiatric covariates. The risk difference and risk ratio were estimated using TriNetX's "Compare Outcomes" function.

Sub-Analysis 3: Female Cohorts

Among female PTSD patients, the association cardiovascular comorbidity and MACE was slightly steeper than that in males, which suggests a greater marginal effect of each added cardiovascular risk factor. White women showed an increase in MACE incidence from 3.24% at baseline to 24.79% at four risk factors [RD +21.55%, 95% CI (19.987%, 23.104%), RR = 7.64, 95% CI (6.332, 9.227)]. Black women demonstrated a similar trend from 2.87% at baseline to 24.19% at four risk factors [RD +21.31%, 95% CI (18.251%, 24.375%), RR = 8.42, 95% CI (5.661, 12.52)]. The sample size for Latino women with PTSD was limited for the four and five risk factor cohorts; however, when comparing one, two, and three risk factor cohorts, Latino women showed a smaller absolute increase [RD +5.20% at three factors, 95% CI (2.642%, 7.759%), RR = 3.35, 95% CI (1.773, 6.324)]. For Asian women, limited sample size also prevented comparison of two, three, four, and five cardiovascular risk factor cohorts with baseline. However, risk directionality was consistent when comparing the one factor and baseline cohort [RD +1.70%, 95% CI (0.576%, 2.83%), RR = 2.81, 95% CI (1.372, 5.757)]. These results indicate that female PTSD patients experience both higher absolute and relative increases in MACE per additional comorbidity compared to males.

Table 4. *Female-Only Cohort Analysis Results*

Female-Only Cohort Analysis									
Cohort Statistics				Risk Difference				Risk Ratio	
Cohorts	# of Patients	Patients w/ Outcome	Risk	Risk Difference	95% CI	z	p	Risk Ratio	95% CI
Black or African American									
1 Risk Factor	8,497	191	2.25%	0.72%	(0.313%,1.128%)	3.47	0.0005	1.472	(1.182,1.834)
Baseline	8,644	132	1.53%						
2 Risk Factors	3,996	265	6.63%	4.59%	(3.708%,5.476%)	10.195	< 0.0001	3.252	(2.554,4.14)
Baseline	4,119	84	2.04%						
3 Risk Factors	1,830	252	13.77%	11.24%	(9.509%,12.969%)	12.605	< 0.0001	5.439	(4.022,7.356)
Baseline	1,896	48	2.53%						
4 Risk Factors	860	208	24.19%	21.31%	(18.251%,24.375%)	13.198	< 0.0001	8.419	(5.661,12.52)
Baseline	905	26	2.87%						
5 Risk Factors									
Baseline	Patient cohort sample size too small to run analysis with TriNetX								
White									
1 Risk Factor	42,478	1,237	2.91%	0.67%	(0.461%,0.886%)	6.214	< 0.0001	1.301	(1.197,1.414)
Baseline	42,968	962	2.24%						
2 Risk Factors	18,477	1,321	7.15%	4.40%	(3.96%,4.837%)	19.649	< 0.0001	2.599	(2.353,2.871)
Baseline	18,903	520	2.75%						
3 Risk Factors	8,071	1,247	15.45%	12.28%	(11.404%,13.151%)	27.208	< 0.0001	4.87	(4.281,5.541)
Baseline	8,353	265	3.17%						
4 Risk Factors	3,425	849	24.79%	21.55%	(19.987%,23.104%)	26.145	< 0.0001	7.644	(6.332,9.227)
Baseline	3,577	116	3.24%						
5 Risk Factors	652	139	21.32%	16.04%	(12.567%,19.52%)	9.489	< 0.0001	4.041	(2.942,5.552)
Baseline	872	46	5.28%						
Hispanic or Latino									
1 Risk Factor	3,293	63	1.91%	0.57%	(-0.045%,1.175%)	1.816	0.0694	1.419	(0.971,2.074)
Baseline	3,337	45	1.35%						

2 Risk Factors	1,299	65	5.00%	3.35%	(1.982%,4.72%)	4.804	< 0.0001	3.027	(1.878,4.88)
Baseline	1,331	22	1.65%						
3 Risk Factors	526	39	7.41%	5.20%	(2.642%,7.759%)	3.984	< 0.0001	3.349	(1.773,6.324)
Baseline	542	12	2.21%						
4 Risk Factors									
Baseline	Patient cohort sample size too small to run analysis with TriNetX								
5 Risk Factors									
Baseline	Patient cohort sample size too small to run analysis with TriNetX								
Asian									
1 Risk Factor	1,059	28	2.64%	1.70%	(0.576%,2.83%)	2.958	0.0031	2.811	(1.372,5.757)
Baseline	1,063	≤ 10*	0.94%						
2 Risk Factors									
Baseline	Patient cohort sample size too small to run analysis with TriNetX								
3 Risk Factors									
Baseline	Patient cohort sample size too small to run analysis with TriNetX								
4 Risk Factors									
Baseline	Patient cohort sample size too small to run analysis with TriNetX								
5 Risk Factors									
Baseline	Patient cohort sample size too small to run analysis with TriNetX								

Table 4 summarizes the TriNetX outcome analyses evaluating the relationship between the number of cardiovascular risk factors (hypertension, type 2 diabetes, hyperlipidemia, obesity, and nicotine dependence) and major adverse cardiovascular event risk among PTSD patients. Cohorts are stratified by race (Black, White, Hispanic/Latino, and Asian) and represent only female patients after propensity score matching for psychiatric covariates. The risk difference and risk ratio were estimated using TriNetX's "Compare Outcomes" function.

Sub-Analysis Four: Three-Way Interaction Analysis

A three-way interaction model investigating the interaction between the number of cardiovascular risk factors, race, and sex, was tested to explore whether race and sex jointly modified the association between multimorbidity and MACE in PTSD patients. The three-way interaction model did not significantly improve fit compared to the two-way interaction model investigating the interaction between the number of cardiovascular risk factors and race, number of cardiovascular risk factors and sex, or race and sex. A chi-square analysis of the odds ratios of the racial groups indicated no statistically significant intersectional effect of race and sex on risk of MACE ($p > 0.05$), indicating instead that multimorbidity had a greater impact than ethnic or racial classification.

Summary Across All Cohort Analyses

Across all cohort analyses, the risk difference revealed the clearest measure of absolute MACE increase, while the risk ratios explained these findings in relative terms. The three-way interaction model confirmed that even though women experienced a steeper increase in risk, race and sex together did not produce statistically distinct risk patterns. These findings demonstrate that multimorbidity burden is the most powerful driver of MACE risk among PTSD patients, even across demographics. The pattern of progressive risk accumulation, especially the steep increase after three cardiovascular comorbidities demonstrates the importance of comprehensive cardiovascular health management in PTSD patients.

Discussion

This study demonstrates an important relationship between multimorbidity burden and the risk of major adverse cardiovascular events among patients with post-traumatic stress disorder. Across all analyses examining combined male and female, male only, and female only cohorts, each additional cardiovascular risk factor (hypertension, type 2 diabetes, hyperlipidemia, obesity, or nicotine dependence) was associated with a significant increase in both absolute and relative risk of MACE. On average, each additional risk factor increased the absolute risk of MACE by 4-5% and doubled the odds of MACE, independent of race or sex. However, when analyzed separately by sex, women showed a steeper increase in MACE risk as the number of cardiovascular risk factors increased compared to men.

These findings are consistent with prior research linking PTSD to elevated cardiovascular morbidity and mortality.[3] Previous studies have demonstrated that PTSD patients have higher rates of hypertension and other cardiovascular disease, mediated by chronic sympathetic activation, hypothalamic-pituitary-adrenal axis dysregulation, and elevated levels of inflammatory cytokines.[1,3,5] This study's findings expand on this by quantifying how specific combinations of cardiovascular risk factors compound MACE incidence in PTSD patients. The absolute risk increase of over 20% for PTSD patients with four or more cardiovascular risk factors is comparable to those reported in patients without PTSD with similar comorbidity profiles.

The steeper increase in MACE risk among women is also consistent with recent literature, which suggests that female PTSD patients experience greater physiological effects of multimorbidity. The absence of significant racial differences after propensity score matching suggests that disparities in MACE risk among PTSD patients may be largely driven by

underlying comorbidity profiles and social determinants of health rather than any specific biological property of race itself.

These findings emphasize the importance of integrating risk factor based cardiovascular screening in care for PTSD patients. Routine monitoring for hypertension, diabetes, dyslipidemia, and obesity is especially important for patients who already have one or more risk factors and preventive interventions such as promotion of exercise, diet modification, and smoking cessation may be impactful in lowering absolute cardiovascular risk for patients with PTSD. A need for sex-specific cardiovascular management is also highlighted from these results. While both men and women with PTSD experience MACE risk, women showed a steeper risk trajectory with each additional cardiovascular risk factor. This trend supports expanding targeted screening and prevention in female PTSD populations who may be less likely to receive aggressive cardiovascular management in today's practices.

A major strength of this study is its use of the propensity score matching (PSM) function through TriNetX. With each cohort comparison, PSM minimizes confounding by age, sex, and psychiatric comorbidities, such as depression, anxiety, and substance use. This ensures that observed differences in MACE incidence reflect the incremental addition of cardiovascular risk factors, rather than baseline imbalances.

Limitations and Future Directions

While this study offers insights into how cardiovascular multimorbidity influences major adverse cardiovascular events among patients with post-traumatic stress disorder, several limitations should be acknowledged. Each cohort analysis compared patients with PTSD and varying numbers of cardiovascular risk factors using propensity score matching to minimize confounding variables. Because matching was performed separately for each comparison (e.g. baseline vs. one factor and baseline vs. four factors) the baseline groups were redefined in each analysis. As a result, baseline event rates differ slightly between comparisons, limiting direct cross-comparison across factor levels.

Additionally, PSM only controls for measured covariates, but it cannot account for unmeasured confounding variables. The TriNetX database does not report several clinically important variables that may influence cardiovascular outcomes, such as PTSD duration, PTSD severity, physical activity, dietary patterns, and specific substance use details. These missing variables could potentially mediate the observed associations between comorbidity burden and MACE. PTSD is also strongly influenced by social and environmental determinants, such as income, education, and access to mental healthcare, which are not reported in the TriNetX database. These unmeasured socioenvironmental and psychosocial factors could shape the development of both cardiovascular risk factors and access to preventive care that may influence the observed differences in risk between cohort groups.

Although overall, the TriNetX dataset contains a large amount of patient EHR data, there were relatively small numbers of Asian and Latino patients with PTSD and multiple cardiovascular risk factors. For the combined sex analyses, this prevented the cohort comparison analyses between Latino PTSD patients with all five risk factors and baseline and Asian PTSD

patients with three, four, and five risk factors and baseline. For male cohorts, the limited sample size prevented cohort comparison analyses between Black PTSD patients with five risk factors with baseline, Latino PTSD patients with four and five risk factors with baseline, and Asian PTSD patients with two, three, four, and five risk factors with baseline. For female cohorts, the limited sample size also prevented the analyses of these same cohorts. This limited statistical power of these subgroups results in wider confidence intervals and less precise effect estimates. Therefore, the findings of these smaller population samples should be interpreted cautiously and validated in larger cohorts.

Since data from the TriNetX research network encompasses patient electronic health records from multiple health systems, there may be differences in coding practices, documentation completeness, and care across healthcare organizations. These differences may introduce misclassification bias or limit generalizability to populations not included within the TriNetX network. Additionally, patients included in TriNetX may differ from community or uninsured PTSD populations in their level of healthcare engagement and baseline cardiovascular risk.

Due to the retrospective study design, it is also limited as it cannot establish causality, determine whether accumulation of cardiovascular risk factors directly causes MACE in PTSD patients, or the precise timing of risk onset. Future studies should employ longitudinal designs that track PTSD patients over time as cardiovascular risk factors develop, are treated, or progress. Also, using time-dependent Cox models would allow for the evaluation of the temporal sequence between PTSD onset, accumulation of cardiovascular risk factors, and MACE incidence. This approach would help determine whether multimorbidity mediates the

relationship between PTSD and cardiovascular outcomes or if both arise from shared biological mechanisms.

Future studies should incorporate behavioral and social determinants of health to best contextualize cardiovascular risk in PTSD patients. Variables such as physical activity, diet, medication adherence, trauma exposure severity and history, and socioeconomic status should be included in future analyses. Future research should also aim for larger, more diverse datasets that include underrepresented racial and ethnic groups, veterans and civilians, and patients across different healthcare systems to strengthen generalizability.

This study's findings support testing integrated cardiovascular prevention models within PTSD care settings. Future clinical trials could evaluate routine cardiovascular screening during mental health visits, lifestyle modification interventions around exercise, diet, and smoking cessation tailored for PTSD populations, and collaborative care programs linking psychiatric and primary care. These interventions may reduce long term MACE risk, especially for patients with multiple comorbidities. Integrating cardiovascular risk management into trauma-focused care could also have major public health implications. Future research could assess the effectiveness of multidisciplinary care pathways combining PTSD treatment with cardiovascular monitoring. Additional identification of high-risk subgroups through predictive models could guide targeted interventions that optimize resource allocation and reduce health disparities.

Conclusion

This study provides strong evidence that the accumulation of cardiovascular risk factors is a primary driver of major adverse cardiovascular events among patients with post-traumatic stress disorder. Across all analyses looking at combined sex cohorts, male only cohorts, and female only cohorts, each additional cardiovascular risk factor was associated with a consistent, stepwise increase in absolute and relative MACE risk. These findings were significant even after propensity score matching, showing that the relationship between cardiovascular multimorbidity and cardiovascular outcomes is independent of baseline differences. The analysis showed that there were no statistically significant differences in the rate of MACE increase across racial groups. Once patients were matched on relevant covariates, Black, White, Latino, and Asian PTSD patients demonstrated nearly identical cardiovascular risk trajectories. In comparable clinical contexts, this finding suggests that race does not alter the biological or behavioral relationship between cardiovascular multimorbidity and adverse cardiovascular events.

However, comparisons of male only and female only cohorts showed that sex is a modifier in the relationship between cardiovascular multimorbidity and MACE in PTSD patients. Women experienced a slightly steeper increase in MACE risk as cardiovascular risk factors increased compared to men. Though, the absence of a significant three-way (number of cardiovascular risk factors, race, and sex) interaction suggests that sex related differences are consistent across racial groups and that multimorbidity burden is the main consistent determinant of cardiovascular risk in PTSD patients.

These findings highlight the need for comprehensive cardiovascular risk management incorporated into PTSD care, regardless of racial background. Targeted interventions could focus on early detection and control of cardiovascular risk factors, especially for patients with

preexisting comorbidities. The integration of mental health treatment with cardiovascular screening may reduce long term incidence of MACE. With equivalent risk patterns across racial groups, the focus of these preventive strategies can be shifted to more universal approaches to multimorbidity prevention and management.

References

1. Edmondson D, Von Känel R. Post-traumatic stress disorder and cardiovascular disease. *The Lancet Psychiatry*. 2017;4(4):320-329. doi:10.1016/S2215-0366(16)30377-7
2. Edmondson D, Kronish IM, Shaffer JA, Falzon L, Burg MM. Posttraumatic stress disorder and risk for coronary heart disease: A meta-analytic review. *American Heart Journal*. 2013;166(5):806-814. doi:10.1016/j.ahj.2013.07.031
3. Padhi BK, Khatib MN, Serhan HA, et al. Cardiovascular impact of post-traumatic stress disorder: A systematic review and meta-analysis. *Current Problems in Cardiology*. 2024;49(8):102632. doi:10.1016/j.cpcardiol.2024.102632
4. Seligowski AV, Grewal SS, Abohashem S, et al. PTSD increases risk for major adverse cardiovascular events through neural and cardio-inflammatory pathways. *Brain, Behavior, and Immunity*. 2024;117:149-154. doi:10.1016/j.bbi.2024.01.006
5. Yehuda R, Hoge CW, McFarlane AC, et al. Post-traumatic stress disorder. *Nat Rev Dis Primers*. 2015;1(1):15057. doi:10.1038/nrdp.2015.57
6. Roberts AL, Gilman SE, Breslau J, Breslau N, Koenen KC. Race/ethnic differences in exposure to traumatic events, development of post-traumatic stress disorder, and treatment-seeking for post-traumatic stress disorder in the United States. *Psychol Med*. 2011;41(1):71-83. doi:10.1017/S0033291710000401
7. Achievements in Public Health, 1900-1999: Decline in Deaths from Heart Disease and Stroke -- United States, 1900-1999. CDC. *MMWR. Morbidity and mortality weekly report*. 2019;48(30), 649–656. https://www.cdc.gov/mmwr/preview/mmwrhtml/mm4830a1.htm

8. King SJ, Wangdak Yuthok TY, Bacong AM, et al. Heart Disease Mortality in the United States, 1970 to 2022. *JAHA*. 2025;14(13):e038644. doi:10.1161/JAHA.124.038644
9. Dahlöf B. Cardiovascular Disease Risk Factors: Epidemiology and Risk Assessment. *The American Journal of Cardiology*. 2010;105(1):3A-9A. doi:10.1016/j.amjcard.2009.10.007
10. Nabel EG. Cardiovascular Disease. Guttmacher AE, Collins FS, eds. *N Engl J Med*. 2003;349(1):60-72. doi:10.1056/NEJMra035098
11. Adhikary D, Barman S, Ranjan R, Stone H. A Systematic Review of Major Cardiovascular Risk Factors: A Growing Global Health Concern. *Cureus*. 2022;14(10): e30119. doi:10.7759/cureus.30119
12. Graham G. Disparities in Cardiovascular Disease Risk in the United States. *CCR*. 2015;11(3):238-245. doi:10.2174/1573403X11666141122220003
13. Kurian AK, Cardarelli KM. Racial and Ethnic Differences in Cardiovascular Disease Risk Factors: A Systematic Review. *Ethnicity & Disease*. 2007;17(1):143-152. https://www.jstor.org/stable/48667007
14. Vidal C, Polo R, Alvarez K, et al. Co-Occurrence of Posttraumatic Stress Disorder and Cardiovascular Disease Among Ethnic/Racial Groups in the United States. *Psychosom Med*. 2018;80(7):680-688. doi:10.1097/PSY.0000000000000601
15. Cooper DC, Trivedi RB, Nelson KM, et al. Post-traumatic Stress Disorder, Race/Ethnicity, and Coronary Artery Disease Among Older Patients with Depression. *J Racial and Ethnic Health Disparities*. 2014;1(3):163-170. doi:10.1007/s40615-014-0020-8

16. Hunter LD, Boer T, Saltzman LY. The Intersectionality of Sex and Race in the Relationship Between Posttraumatic Stress Disorder and Cardiovascular Disease: A Scoping Review. *Public Health Rev*. 2023;44:1605302. doi:10.3389/phrs.2023.1605302