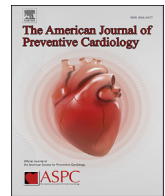




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Original Research

## Mental health disorders among patients with acute myocardial infarction in the United States



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### ABSTRACT

**Objective:** To assess the prevalence, temporal trends and sex- and racial/ethnic differences in the burden of mental health disorders (MHD) and outcomes among patients with myocardial infarction (MI) in the United States.

**Methods:** Using the National Inpatient Sample Database, we evaluated a contemporary cohort of patients hospitalized for acute MI in the United States over 10 years period from 2008 to 2017. We used multivariable logistic regression analysis for in-hospital outcomes, yearly trends and estimated annual percent change (APC) in odds of MHD among MI patients.

**Results:** We included a total sample of 6,117,804 hospitalizations for MI (ST elevation MI in 30.4%), with a mean age of  $67.2 \pm 0.04$  years and 39% females. Major depression (6.2%) and anxiety disorders (6.0%) were the most common MHD, followed by bipolar disorder (0.9%), schizophrenia/psychotic disorders (0.8%) and post-traumatic stress disorder (PTSD) (0.3%). Between 2008 and 2017, the prevalences significantly increased for major depression (4.7%–7.4%, APC +6.2%,  $p < .001$ ), anxiety disorders (3.2%–8.9%, APC +13.5%,  $p < .001$ ), PTSD (0.2%–0.6%, +12.5%,  $p < .001$ ) and bipolar disorder (0.7%–1.0%, APC +4.0%,  $p < .001$ ). Significant sex- and racial/ethnic-differences were also noted. Major depression, bipolar disorder or schizophrenia/psychotic disorders were associated with a lower likelihood of coronary revascularization.

**Conclusion:** MHD are common among patients with acute MI and there was a concerning increase in the prevalence of major depression, bipolar disorder, anxiety disorders and PTSD over this 10-year period. Focused mental health interventions are warranted to address the increasing burden of comorbid MHD among acute MI.

### 1. Introduction

Mental health is often given less priority in medicine, where the main focus is often on treating the disease rather than the whole patient [1]. The increasing evidence supporting the association of mental health disorders (MHD) and cardiovascular disease (CVD) has prompted the American Heart Association to include major depression and bipolar disorder as moderate-risk conditions associated with accelerated atherosclerosis and early CVD [2]. However, there is a paucity of data on the burden of MHD among patients with acute CVD.

Understanding sex- and racial/ethnic-differences and trends in the prevalence of MHD among patients presenting with acute CVD are necessary for healthcare teams and policymakers to identify vulnerable groups that need attention, and formulate appropriate strategies for comprehensive care to simultaneously address mind and body disorders to achieve better outcomes. In this study, we assessed the temporal trends and the sex- and racial/ethnic-differences in the prevalence of major forms of MHD, and the association of MHD and in-hospital outcomes among a contemporary cohort of patients hospitalized for acute myocardial infarction (MI) in the United States (US) over a decade from 2008 through 2017.

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## 2. Methods

### 2.1. Data source

We utilized the National Inpatient Sample (NIS) developed by the Healthcare Cost and Utilization Project (HCUP) for this study [3]. We analyzed the most contemporarily available data for a period of 10 years from 2008 through 2017. More details about the NIS and data extraction are provided as **Supplemental Methods**. Institutional research board approval and informed patient consent for study participation were not required, as the NIS contains de-identified patient information that is publicly available for analysis.

### 2.2. Inclusion/exclusions and definitions

We included all adult (age  $\geq 18$  years) hospitalizations with a principal diagnosis of acute ST-elevation MI or non-ST elevation MI using appropriate International Classification of Diseases (ICD) diagnoses codes (eTable 1). Major depression, bipolar disorder, anxiety disorder, post-traumatic stress disorder (PTSD), and schizophrenia/psychotic disorders were the MHD included in this study. We assessed the average and yearly prevalence of comorbid diagnosis of MHD stratified by sex and race/ethnicity. The race/ethnicity groups included are Non-Hispanic Blacks (NHB), Non-Hispanic Whites (NHW), Hispanics, Asian or Pacific Islander (PI) and Native American (NA) [4].

### 2.3. Statistical analysis

All analyses were performed using STATA-16 (StataCorp, TX), and stratified weighted data were utilized to obtain nationwide estimates. Continuous variables were reported as mean with standard deviation and compared using the Student t-test, and the categorical variables were reported as proportions and compared using the Chi-square test. We used multiple logistic regression analysis for yearly trends with the year of admission as the independent variable along with specific MHD of interest as the dependent variable. The yearly prevalence of MHD was obtained using *marginal effects* following multiple regression analysis. The annual percent change (APC) in the Odds of the MHD was estimated as equal to  $(\text{Odds ratio}-1) \times 100$  and reported along with *P*trend to provide a quantitative estimation. Trends in the prevalence of various MHD between various subgroups of interest were compared using a subgroup-year interaction term in the regression model and reported as *P*interaction. Similarly, the yearly trends in coronary revascularization and in-hospital mortality were assessed.

We performed a further analysis with 3 falsification endpoints which are presumed to be unrelated to the primary outcome of temporal trends in the prevalence of MHD among acute MI hospitalizations to validate that the annual trends in MHD are not just because of better diagnostic coding strategies. The falsification endpoints assessed were the trends in the prevalence of hyperlipidemia, anemia and peripheral arterial disease among acute MI hospitalizations in the US over the same time period.

The association of various types of MHD and odds of coronary revascularization and in-hospital mortality were analyzed using multi-variable logistic regression analysis adjusted for demographic (age, sex, race/ethnicity), social (income, rural residential location, insurance status), hospital characteristics (teaching hospital status, urban hospital location, bed size) and clinical characteristics (comorbidities including obesity, anemia, diabetes mellitus, hypertension, hyperlipidemia, chronic liver disease, chronic kidney disease, dialysis dependence, pulmonary vascular disease, chronic obstructive pulmonary disease, prior MI/coronary revascularization and prior stroke).

## 3. Results

### 3.1. Baseline characteristics

We included a total of 6,117,804 patients with MI hospitalization during 2008–2017 (STEMI 30.4%, NSTEMI 69.6%); the study sample had a mean age of  $67.2 \pm 0.04$  years and 39% were females. The baseline demographic, clinical and hospital characteristics of the study population stratified by MHD are provided in Table 1.

### 3.2. The overall prevalence and temporal trends of various types of MHD

Over the 10-year study period, major depression (6.2%) and anxiety disorder (6.0%) were the most common MHD, followed by bipolar disorder (0.9%), schizophrenia/psychotic disorders (0.8%) and PTSD (0.3%). From 2008 to 2017, the prevalences significantly increased for major depression (4.7%–7.4%, APC +6.2%), anxiety (3.2%–8.9%, APC +13.5%), PTSD (0.2%–0.6%, +12.5%) and bipolar disorder (0.7%–1.0%, APC +4.0%), while the schizophrenia/psychotic disorders showed a downtrend (0.8%–0.6%, APC -2.6%) (Fig. 1, eTable 2). These findings were further substantiated with the stable trends in the prevalence of specific falsification endpoints during the same period of study [hyperlipidemia (58.0%–59.0%, APC +2.5%,  $p = 0.1$ ), anemia (2.8%–2.8%, APC -0.01%,  $p = 0.2$ ) and peripheral arterial disease (9.8%–9.6%, APC -0.02,  $p = 0.1$ ) (eFigure 1, eTable 2)].

### 3.3. Sex differences

All categories of MHD were more prevalent among females compared to males except PTSD which was more prevalent among males (eFigure 2, A-B, eTable 3). The prevalence of major depression and anxiety disorders showed a larger increase among females compared to males, whereas the prevalence of bipolar disorder and PTSD increased among both sexes similarly (eFigure 2, A-B, eTable 3). While the females experienced a decline in the prevalence of schizophrenia/psychotic disorders it did not change significantly among males (eFigure 2, A-B, eTable 3).

### 3.4. Racial/ethnic differences

The prevalence of major depression was largest among NHW; however, the largest increase was seen among NA (eFigure 3, A-E, eTable 4). Bipolar disorder was more common among NHW and NHB with a steady increase in the prevalence across the study period. Anxiety disorders were most common among NHW with all races having a significant increase in the prevalence of anxiety disorders with the largest increase among NHB. The NHB groups had the highest overall prevalence of schizophrenia/psychotic disorders (1.5%) whereas PTSD was most common among NA (0.5%); however, NHB groups had the largest increase in the prevalence of PTSD among all races (0.1%–0.5%, APC +18.5%,  $p < .001$ ) (eFigure 3, A-E, eTable 4).

### 3.5. MHD and index hospital coronary revascularization

Patients with schizophrenia/psychotic disorders had the lowest average coronary revascularization rate (37.6%) (Table 2) (Fig. 2A). Over the study period, the coronary revascularization rate increased across all categories of MHD except among patients with schizophrenia/psychotic disorders and PTSD (eTable 5). In adjusted analyses, a comorbid diagnosis of major depression [adjusted OR 0.80 (95% confidence interval (CI) 0.72–0.88)], bipolar disorder [0.69 (0.65–0.72)] and schizophrenia/psychotic disorders [0.50 (0.47–0.52)] were significantly associated with lower odds of coronary revascularization for acute MI compared to those without any MHD (Table 2). These findings were consistent in age-stratified regression analysis (eTable 6).

**Table 1**

Baseline characteristics of study population stratified by mental health disorders: the National Inpatient Sample of patients with acute myocardial infarction from 2008 to 2017.

Patient characteristics	No mental health disorders (n = 4,088,062)	Mental health disorders					*p value
		Major depression (n = 269,641)	Bipolar disorder (n = 40,738)	Anxiety disorders (n = 358,885)	Schizophrenia and other psychotic disorders (n = 46,577)	Post-traumatic stress disorder (n = 18,168)	
Mean age (years)±SD	70.52 ± 0.1	67.6 ± 0.1	58.8 ± 0.1	65.1 ± 0.1	66.8 ± 0.2	59.7 ± 0.2	<.001
Female (%)	40.0	53.2	45.2	56.0	43.2	21.2	<.001
<b>Race</b>							
White (%)	77.6	83.8	83.0	86.2	68.7	82.2	<.001
Black (%)	10.7	8.1	11.2	6.2	21.5	11.4	
Hispanic (%)	8.7	6.7	5.0	6.5	7.9	5.2	
Asian (%)	3.0	1.3	0.8	1.1	1.8	1.2	
Rural residential location (%)	21.2	21.6	19.1	22.2	20.6	22.0	<.001
<b>Type of insurance</b>							
Medicare (%)	66.4	64.4	55.3	57.4	72.4	56.9	<.001
Medicaid (%)	5.2	8.6	19.6	10.2	17.0	15.1	
Private (%)	24.7	23.0	18.9	27.3	7.9	23.0	
Uninsured/self-paid (%)	3.6	3.9	6.2	5.1	2.7	5.1	
Teaching hospital (%)	53.7	55.5	55.9	55.8	54.0	60.7	<.001
Urban hospital location (%)	90.3	89.7	91.1	89.3	88.8	91.1	<.001
<b>Income quartile for the residential ZIP code</b>							
0-25th percentile	28.1	28.6	34.3	30.5	39.2	31.4	<.001
26th-50th percentile	27.0	27.5	27.2	27.6	26.7	30.0	
51st-75th percentile	24.0	24.3	22.1	23.4	20.4	24.2	
76th-100th percentile	20.8	19.6	16.4	18.5	13.7	14.8	
Anemia (%)	3.0	3.4	2.6	2.9	3.4	2.5	<.001
Obesity (%)	3.5	4.3	4.1	5.6	2.5	6.2	<.001
Diabetes mellitus (%)	39.8	40.9	40.6	33.6	38.9	35.4	<.001
Hyperlipidemia (%)	56.8	62.3	57.2	62.8	46.2	63.0	<.001
Hypertension (%)	74.0	76.3	70.4	75.9	72.4	74.0	<.001
Liver disease (%)	2.7	2.5	3.8	2.0	3.4	4.0	<.001
Chronic kidney disease (%)	22.6	19.2	14.0	14.0	17.6	11.2	<.001
Hemodialysis dependence (%)	0.6	0.5	0.3	0.4	0.4	0.2	<.001
Pulmonary vascular disease (%)	4.9	4.2	3.0	3.8	4.2	2.8	<.001
COPD (%)	18.8	26.5	30.9	27.9	29.4	29.1	<.001
Peripheral arterial disease (%)	10.0	11.0	7.2	9.4	8.4	9.3	<.001
Dementia (%)	1.9	2.9	1.9	2.1	3.9	1.1	<.001
Prior MI (%)	10.4	11.8	11.6	11.4	9.2	13.9	<.001
Prior CABG (%)	8.0	7.1	5.6	5.8	4.3	6.2	<.001
Prior PCI (%)	11.4	11.4	11.4	10.9	6.9	12.6	<.001
Prior stroke (%)	5.2	6.3	5.1	5.1	5.6	4.0	<.001
STEMI (%)	28.1	24.6	28.0	24.1	24.9	26.8	<.001
NSTEMI (%)	71.8	75.4	72.0	75.8	75.0	73.2	<.001
PCI (%)	42.7	40.5	39.2	43.3	30.5	42.8	<.001
CABG (%)	8.6	6.1	5.7	7.2	7.1	9.8	<.001
Duration of hospitalization (days) ± SD	4.94 ± 0.02	4.46 ± 0.02	4.47 ± 0.06	4.09 ± 0.02	5.7 ± 0.1	4.0 ± 0.1	<.001

Abbreviations: CABG: coronary artery bypass grafting; COPD: chronic obstructive pulmonary disease; NSTEMI: non-ST elevation myocardial infarction; STEMI: ST elevation myocardial infarction; SD: standard deviation.

\*p-value represents the comparison of the distribution of various demographic variables and other medical comorbidities among the study population stratified by the presence of various mental health disorders.

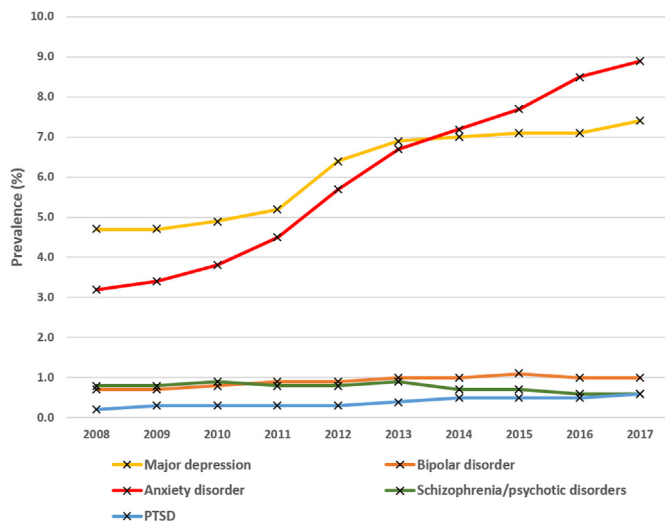
### 3.6. MHD and in-hospital mortality

The average in-hospital mortality of the entire study cohort was 5.1%. The average in-hospital mortality rate was highest among patients without any MHD (6.4%) and lowest among patients with comorbid anxiety disorders (2.6%) and PTSD (2.6%) (Table 2) Fig. 2B). The in-hospital mortality following acute MI decreased across the study period among all categories of MHD except among those with a co-morbid diagnosis of bipolar disorder and schizophrenia/psychotic disorders (eTable 7). Compared to patients with no diagnosis of MHD, patients with various types of MHD had lower odds of in-hospital mortality (Table 2). The odds of lower in-hospital mortality among patients with

MHD compared to those without any MHD weakened with increasing age on age-stratified regression analysis (eTable 6).

## 4. Discussion

In this study, we report certain key findings in regards to the sex- and racial/ethnic-differences in the temporal trends and prevalence of MHD, and their in-hospital outcomes, among a contemporary cohort of patients hospitalized for acute MI in the US from 2008 through 2017. First, major depression and anxiety were the predominant MHD among patients hospitalized with acute MI. Second, there was a consistent but variable degree of increase in the prevalence of MHD. Notably, the prevalence of



**Fig. 1.** Temporal trends in the prevalence of mental health disorders among patients with acute myocardial infarction.

Figure shows the trends in the yearly prevalence of major depression, bipolar disorder, anxiety disorders, schizophrenia/psychotic disorders and PTSD from 2008-2017 among patients hospitalized with acute MI. Abbreviations: PTSD = post-traumatic stress disorder

major depression, anxiety disorders and PTSD almost doubled during the study period. Third, there were significant sex- and racial/ethnic-differences in the burden and temporal trends in the prevalence of MHD among patients with acute MI. Fourth, a comorbid diagnosis of major depression, bipolar, or schizophrenia/psychotic disorders were significantly associated with a lower likelihood of index hospital coronary revascularization, even though a co-diagnosis of MHD was associated with a lower risk of in-hospital mortality.

**4.1. Overall burden and trends in MHD**

We found that major depression and anxiety disorders followed by bipolar disorder are the major MHD among patients hospitalized with acute MI. The prevalence of major depression and anxiety disorders has almost doubled among acute MI patients; also, bipolar disorder showed a consistent and significant increase (42%) over the decade. While the general prevalence of depression among US adults remains unchanged over the recent years [5], there are consistent reports of a significant increase in the community prevalence of the bipolar disorder among

adults, particularly youths [6,7], which is thought to be likely due to increased awareness among medical providers about this previously under-recognized diagnosis [6]. This concerning increase in the prevalence of major depression and bipolar disorder among patients with acute MI needs special attention as they are important but often under-estimated as risk factors for CVD [8]. Depression and bipolar disorder have been upgraded as moderate risk factors for early CVD because of a strong association between these diseases [2]. Adults with major depression are at 3-fold higher prevalence of CVD and those with bipolar are at 5-fold increased risk of CVD at an age 7.5–14 years younger than the adults without mood disorders [2,9,10]. Often mood disorders tend to be under-recognized among young adults and lead to inadequate treatment and adverse outcomes [2,9]. Our study findings corroborate with other reports that anxiety disorders are increasingly been found as a co-morbid diagnosis along with other medical and MHD over time due to increased awareness and screening for stress disorders [11]. Even though the isolated impact of anxiety disorders on CVD is not well established, the rising prevalence of anxiety disorders among patients with acute MI is concerning as few studies suggest a strong association between CVD and anxiety disorders [12]. A recent study showed that women with anxiety disorders but no prior CVD were more likely to have myocardial ischemia compared to those without anxiety [13]. It is plausible that anxiety symptoms could overlap or mask symptoms of CVD leading to delays in referral and optimal treatment [13].

**4.2. Sex and race/ethnic trends in MHD**

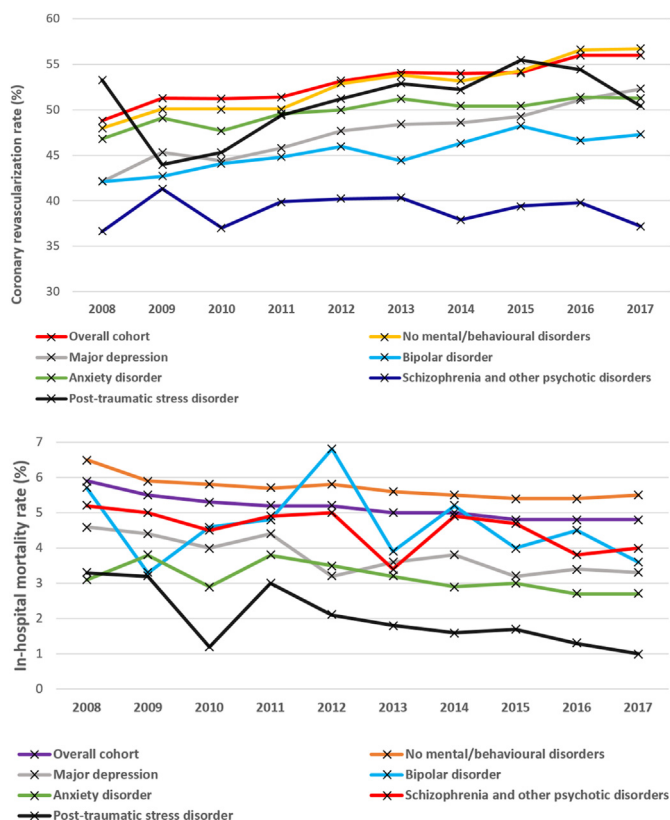
Our study found significant sex- and racial/ethnic-differences in the prevalence of MHD among acute MI patients. Females suffer from major depression, anxiety disorders and bipolar disorder disorders almost twice as often as males. Even though the uptrend in the prevalence was noted across all subgroups, the females had the largest increase in the prevalence of these disorders. NHW followed by Hispanics and NA were the most affected with mood disorders and anxiety disorders, and they constituted a significant share of the rising trends in these disorders. Although all races experienced a significant increase in the prevalence of major depression, NA experienced that largest increase. The health needs and mental health of NA have historically been understudied, underfunded and understaffed [14]. Interestingly, Asians/PI had the lowest prevalence of MHD when compared to other races/ethnicities. This finding is consistent with prior reports of lower rates of utilization of mental health services by Asians; however, it is unclear whether this is truly due to the lower prevalence of the disorders because of better psychological resilience of people of Asian descent or under-diagnosis of these disorders among Asian descendants [15]. It could also be due to the

**Table 2**

Multivariable-adjusted logistic regression analysis of the association of mental health disorders and coronary revascularization and in-hospital mortality among acute myocardial infarction patients from 2008 to 2017 in United States.

	In-hospital mortality						
	Overall, %	Unadjusted OR	95% CI	p value	*Adjusted OR	95% CI	p value
No mental health disorders	6.4	Ref	ref	ref	ref	ref	ref
Major depression	3.4	0.56	0.54–0.59	<.001	0.64	0.61–0.67	<.001
Bipolar disorder	4.3	0.47	0.41–0.53	<.001	0.68	0.59–0.78	<.001
Anxiety disorders	2.6	0.39	0.37–0.41	<.001	0.50	0.48–0.53	<.001
Schizophrenia and other psychotic disorders	4.5	0.77	0.70–0.84	<.001	0.80	0.72–0.88	<.001
Post-traumatic stress disorder	2.6	0.24	0.19–0.31	<.001	0.36	0.26–0.50	<.001
Coronary revascularization							
	Overall, %	Unadjusted OR	95% CI	p value	*Adjusted OR	95% CI	p value
No mental health disorders	50.6	Ref	ref	ref	ref	ref	ref
Major depression	46.1	0.86	0.84–0.88	<.001	0.80	0.78–0.82	<.001
Bipolar disorder	44.9	0.90	0.85–0.94	<.001	0.69	0.65–0.72	<.001
Anxiety disorders	50.5	1.02	1.00–1.04	0.01	1.00	0.95–1.04	0.9
Schizophrenia and other psychotic disorders	37.6	0.54	0.51–0.56	<.001	0.50	0.47–0.52	<.001
Post-traumatic stress disorder	52.6	1.18	1.08–1.27	<.001	1.08	0.97–1.17	<.001

Abbreviations: CI: confidence interval; OR: odds ratio.



**Fig. 2.** A and B. Differences in the temporal trends of the coronary revascularization (A) and in-hospital mortality (B) among patients with acute myocardial infarction stratified by mental health disorders. Figure shows the differences in the temporal trends of the coronary revascularization and in-hospital mortality among patients with acute myocardial infarction stratified by various types of mental health disorders.

fact that the expression of emotional distress may be different in Asians and other racial-ethnic minority groups [16]. The prevalence of PTSD was highest among NA and the largest increase was seen among NHB. NA and NHB are the two racial/ethnic groups that have experienced ‘historical trauma’ among other social injustices [17,18]. Interventions to address the mental health of these groups should be rooted in trauma-informed and culturally responsive care [19].

**4.3. Impact of specific types of MHD**

It is concerning that patients with major depression and bipolar disorder were less likely to receive coronary revascularization during an index hospitalization for acute MI. Few other studies have shown similar findings among patients with major depression [20–22]. Provider biases, possible late presentation and logistical challenges in providing optimal invasive care (such as if severely depressed or bipolar patients decline an offered option of coronary revascularization) are possible reasons for a lower rate of coronary revascularization among these cohorts. Also, we found that the in-hospital mortality among patients with bipolar disorder with acute MI remained unchanged over the decade while it had a consistent decline among other cohorts. Together with these facts and an alarming increase in the prevalence of major depression and bipolar disorder among patients with acute MI, it is vitally important for comprehensive care of these patients with a goal to achieve optimal revascularization rates.

Schizophrenia/psychotic disorders and PTSD were the least prevalent MHD among patients with acute MI. Schizophrenia is associated with a

higher risk of acute MI among younger adults [23]. Consistent with prior reports [24,25], in our study, we found that the patients with schizophrenia/psychotic disorders were the least likely to get coronary revascularization following acute MI and there was no increase in coronary revascularization rate unlike other cohorts. While other data from the NIS from an earlier time from (2004–2014) found that patients with schizophrenia with acute MI were at increased odds of in-hospital mortality [OR 1.10 (95% CI 1.04–1.16) [25], we found that schizophrenia was associated with lower in-hospital mortality (OR 0.80 (0.72–0.88) during the years 2008–2017, compared to those without MHD. This apparent mortality paradox is discussed more below; however, our findings were notable that the in-hospital mortality following acute MI in this group has not declined over the decade. Our study findings are important for prompt recognition of comorbid schizophrenia/psychotic disorders among adults with acute MI and provide appropriate care without any treatment bias for optimal outcomes in this small, but vulnerable group.

PTSD is a well-recognized condition found to be common among acute MI survivors as well as a risk factor for acute MI [26,27]. Poorer health care and lifestyle [28], abnormal autonomic response [29,30] and heightened inflammatory state [31] are some of the mechanisms suggested to explain the association of PTSD and CVD. We found a 3-fold increase in the prevalence of PTSD among acute MI patients over the 10-year period. It is crucial to address PTSD as a risk factor and an outcome among acute MI survivors.

**4.4. In-hospital mortality among patients with MHD**

There was a seemingly paradoxical lower risk of in-hospital mortality among patients with MHD compared to those without MHD among our study population. These differences in the mortality risks were less apparent with increasing age on age-stratified analysis signifying a short-term survival advantage that the younger age adds to patients with MHD. Similar findings have been demonstrated among other studies examining short-term outcomes (up to 30-days) among patients with MHD [20–22, 32]. However, it is intriguing that those patients who suffer from MHD have developed acute MI at an early age compared to their non-MHD counterparts and this seems to be likely due to premature CVD associated with various MHD [2,33]. Also, multiple studies examining the long-term ( $\geq 1$  year) outcomes of acute coronary syndromes among patients with MHD have found significantly lower survival compared to those with no MHD [34–38]. The lower rates of coronary revascularization and poor after-care among patients with MHD [37] could have been the reason for poor long-term survival among these patients.

**4.5. Clinical and public health implications**

The increasing burden of MHD among acute MI patients in the US signifies the importance of comprehensive assessment of CVD risk factor profile including the psychological, mental, social and ethnic risks of the individual rather than just traditional atherosclerotic risk factors. Moreover, MHD are often ignored when it comes to cardiovascular prevention strategies because of a lack of awareness about the implications of MHD among patients with CVD like lesser odds of coronary revascularization and consequent poorer long-term outcomes due to factors like inadequate self-care, non-adherence to medications and follow-ups, as well as unfamiliarity with the potential psychological interventions that could potentially improve overall outcomes. Our findings are particularly important in the light of recent evidence suggestive of interventions like exercise training and cardiac rehabilitation to help improve psychological risk factors and reduces stress-related mortality among patients with CVD [39,40]. While clinicians may feel inadequately trained to address MHD themselves, it is worthwhile to utilize a team-based approach to care and involve psychologists, psychotherapists, and other behavioral therapists as indicated.

#### 4.6. Strengths and limitations

Our study adds significantly to the knowledge of the MHD and CVD by comprehensively reporting the overall prevalence and trends with detailed sex- and racial/ethnic-differences in the prevalence of major MHD and in-hospital outcomes in a nationally representative contemporary cohort of acute MI patients. Our findings will enable cardiovascular clinicians, psychiatrists, policymakers and preventive experts to identify the types of MHD which need immediate attention, racial/ethnic groups which need special care, and implement policies to tackle the hostile combination of MHD and CVD to improve the holistic health of the individual as well as further risk reduction in cardiovascular mortality and morbidity.

Our study has certain limitations. Our study findings apply to hospitalized adults with acute MI. This could underestimate the true prevalence of MHD among patients with stable CVD. The increase in the prevalence of MHD could be because of more frequent coding in recent years when compared to previous years. However, we further validated our analysis with falsification endpoints which reinforces the trueness of our study findings of rising burden of MHD among acute MI patients as we did not find a corresponding increase in the prevalence of 3 falsification endpoints. In addition, it is possible that the increased awareness about MHD in the community and the providers to screen for MHD among inpatients would have contributed to increased diagnosis and hence the rising prevalence of various types of MHD. Nevertheless, our study provides a detailed assessment of the burden of MHD among acute MI hospitalizations and it emphasizes the importance of clinicians to address the mental health comorbidities for overall improved outcomes. Reliance on administrative data to extract MHD diagnosis can potentially lead to miscoding errors; however, we have used accurate ICD-9 and ICD-10 codes with appropriate statistical tools as recommended by HCUP to enable a longitudinal analysis of comorbid diagnoses to obtain national estimates limiting any such errors. ICD-9 and ICD-10 CM codes are the most comprehensive classification system of MHD to date. Prior systematic reviews have found that use of administrative dataset for analyzing MHDs are fairly accurate with an average positive predictive value of 76% [41]. Also, the NIS database has been extensively used to identify sex- and race/ethnicity-based differential outcomes and prevalence of diseases over time in other reports [42]. Lastly, we were unable to assess the impact of MHD on the long-term outcomes following acute MI because of the nature of the dataset which tracks only the in-hospital events and outcomes.

#### 5. Conclusion

Mental health disorders are common among patients hospitalized with acute MI. Over this 10-year period, there was a concerning increase in the prevalence of most forms of MHD, mainly the prevalence of major depression, bipolar disorder, anxiety disorders and PTSD. A comorbid diagnosis of major depression, bipolar disorder and schizophrenia/psychotic disorders was associated with a lower likelihood of index hospital coronary revascularization. Acute MI patients with comorbid MHD should be provided with comprehensive care for better long-term outcomes even though the evidence behind the use of various behavioral interventions to improve survival and quality of life among patients with MHD is still limited.

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#### Conflicts of interest

All authors have no relevant conflicts of interest.

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#### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ajpc.2020.100133>.

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