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Post-traumatic stress disorder, anxiety, and depression among adults with congenital heart defects

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Abstract

Background: Due to invasive treatments and stressors related to heart health, adults with congenital heart defects (CHDs) may have an increased risk of post-traumatic stress disorder (PTSD), anxiety, and/or depressive disorders. Our objectives were to estimate the prevalence of these disorders among individuals with CHDs.

Methods: Using IBM[®] MarketScan[®] Databases, we identified adults age 18–49 years with 2 outpatient anxiety/depressive disorder claims on separate dates or 1 inpatient anxiety/depressive disorder claim in 2017. CHDs were defined as 2 outpatient CHD claims 30 days apart or 1 inpatient CHD claim documented in 2007–2017. We used log-binomial regression to estimate adjusted prevalence ratios (aPR) and 95% confidence intervals (CI) for associations between CHDs and anxiety/depressive disorders.

Results: Of 13,807 adults with CHDs, 12.4% were diagnosed with an anxiety or depressive disorder. Adults with CHDs, compared to the 5,408,094 without CHDs, had higher prevalence of PTSD (0.8% vs. 0.5%; aPR: 1.5 [CI: 1.2–1.8]), anxiety disorders (9.9% vs. 7.5%; aPR: 1.3 [CI: 1.3–1.4]), and depressive disorders (6.3% vs. 4.9%; aPR: 1.3 [CI: 1.2–1.4]). Among individuals

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AUTHOR CONTRIBUTIONS

Regina M. Simeone lead the conceptualization and design of the study, analysis, and writing of the manuscript. Karrie F. Downing made substantial contributions to the conceptualization, data validation, and reviewing and editing of the manuscript. Sherry L. Farr was involved in the conceptualization and design of the study, and drafting and editing of the manuscript. William V. Bobo, Scott D. Gross, and Amber D. Khanna were involved in the conceptualization of the study and reviewing and editing of the manuscript. All authors were involved in revising the manuscript critically during the review process. All authors approved the final manuscript version submitted.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

with CHDs, female sex (aPR range: 1.6–3.3) and inpatient admission (aPR range 1.1–1.9) were associated with anxiety/depressive disorders.

Conclusion: Over 1 in 8 adults with CHDs had diagnosed PTSD and/or other anxiety/depressive disorders, 30–50% higher than adults without CHDs. PTSD was rare, but three times more common in women with CHDs than men. Screening and referral for services for these conditions in people with CHDs may be beneficial.

Keywords

anxiety; congenital heart; depression; MarketScan; post-traumatic stress disorder

1 | INTRODUCTION

Congenital heart defects (CHDs) affect approximately 1% of births, and range in severity and treatment invasiveness (Stout et al., 2019; Warnes et al., 2008a). Approximately 90% of those born with CHDs are expected to survive into adulthood (Moons, Bovijn, Budts, Belmans, & Gewillig, 2010; Tennant, Pearce, Bythell, & Rankin, 2010), with the population of U.S. adults living with CHDs estimated at over 1.4 million (Gilboa et al., 2016; Gilboa, Salemi, Nembhard, Fixler, & Correa, 2010). Adults with CHDs may require additional surgeries and procedures (Nasr, Faraoni, Valente, & DiNardo, 2017; Warnes et al., 2008a), experience cardiac events at higher rates than the general population (Warnes et al., 2008a), and have higher risk of neurocognitive dysfunction (Cohen & Earing, 2018; Heinz et al., 2018; Ilardi, Ono, McCartney, Book, & Stringer, 2017; Jackson, Misiti, Bridge, Daniels, & Vannatta, 2015). Many children with CHDs experience significant mental distress, including anxiety and depression (Gonzalez et al., 2021), potentially contributing to mental health concerns as adults.

Due to childhood experiences, stressors related to worsening heart health (Gurvitz et al., 2020), need for surgical intervention in adulthood (Berghammer, Karlsson, Ekman, Eriksson, & Dellborg, 2013; Bromberg, Beasley, D'Angelo, Landzberg, & DeMaso, 2003; Deng et al., 2016; Kovacs et al., 2009), and potential limitations in cognitive functioning and employment potential (Cohen & Earing, 2018; Jackson et al., 2015; Kamphuis et al., 2002), adults living with CHDs may have an increased risk of anxiety and/or depressive disorders (Jackson, Leslie, & Hondorp, 2018; Kovacs et al., 2009; Warnes et al., 2008b). Post-traumatic stress disorder (PTSD) is a trauma- or stress-related disorder that can occur after experiencing threatened death or serious injury (American Psychiatric Association, 2013, 2020). Invasive medical treatments experienced in childhood and adulthood might also increase the risk of PTSD in adults with CHDs (Meentken, van Beynum, Legerstee, Helbing, & Utens, 2017).

Increased levels of mood and anxiety disorders among adults with CHDs compared to the general population have been observed (Bromberg et al., 2003; Gleason et al., 2019; Horner, Liberthson, & Jellinek, 2000; Kovacs et al., 2009; Westhoff-Bleck et al., 2016). However, only two clinic-based studies have examined prevalence of PTSD in adults with CHDs (Deng et al., 2016; Eslami, 2017). Most individuals with CHDs fall out of specialized cardiac care in young adulthood, limiting the generalizability of previous findings (Gurvitz

et al., 2013). Outside of specialized cardiac care, the burden of mental health conditions, including PTSD, and patterns of mental health treatment in adults with CHDs are not well understood (Agarwal et al., 2019; Khanna et al., 2019). We analyzed 2017 healthcare claims data for privately insured individuals with and without CHDs, to assess the prevalence of diagnosed PTSD, anxiety, and depressive disorders. Our objectives were to determine if the prevalence of these conditions among adults with CHDs is higher than adults without CHDs, examine factors associated with diagnosed anxiety and depressive disorders, and examine patterns of mental health treatment.

2 | METHODS

We used claims data from the IBM[®] MarketScan[®] Commercial Research Database. Healthcare encounter claims from January 1, 2007 through December 31, 2017 were used to identify individuals with a diagnosis of CHDs or chromosomal anomaly. Claims from January 1, 2017 through December 31, 2017 were used to identify cohort members with anxiety, which includes PTSD, and depressive disorders. These data include inpatient and outpatient encounters with diagnosis and procedure codes, outpatient pharmacy claims, and enrollment data from large employers and health plans across the United States who provide healthcare coverage for approximately 40 million individuals and their dependents, on average, each year. Limited demographic characteristics are provided. Because the data are deidentified, the Centers for Disease Control and Prevention deemed this study to be research not involving human subjects and therefore did not need review by an institutional review board.

We included individuals aged 18–49 years at the beginning of 2017 who were enrolled for at least 11 months in an employer sponsored health plan with complete prescription drug and mental health/substance abuse records in 2017. We limited our sample to individuals <50 years of age to minimize misclassification of acquired heart disease coded as CHDs. Individuals were excluded from this sample if they had a diagnosed chromosomal anomaly (International Classification of Diseases, Ninth/Tenth Revision, Clinical Modification [ICD-9-CM]: 758.**; ICD-10-CM: Q90–Q99) at any point between 2007 and 2017, if they had no inpatient or outpatient healthcare encounters during 2017, or if they had a diagnosis of only an atrial septal defect (ICD-9-CM: 745.5; ICD-10-CM: Q21.1) or CHDs of “other” severity at any point between 2007 and 2017, as identified by Glidewell et al. (2018), as these nonspecific codes have been found to have lower positive predictive values than codes for more severe CHDs (Broberg et al., 2015; Khan et al., 2018; Steiner et al., 2018).

We considered an individual to have CHDs if, between January 2007 and December 2017, he or she had at least one inpatient claim with ICD-9-CM or ICD-10-CM CHD codes or at least two outpatient claims with such codes that were more than 30 days apart (Tables S1 and S2) (Downing et al., 2020; Grosse, Boulet, Grant, Hulihan, & Faughnan, 2014; Halasa et al., 2007; Woods, Boulet, Texter, Yates, & Kerlin, 2019). We classified individuals as having severe or nonsevere CHDs. Severe CHDs were those that generally require invasive interventions in the first year of life (Tables S1 and S2, Supporting Information) (Glidewell et al., 2018).

The Centers for Medicare & Medicaid Services Chronic Conditions Data Warehouse (CCW) provides ICD-10-CM algorithms, which include valid ICD-10-CM codes and number/types of claims to qualify as having a depressive, anxiety, or PTSD disorder (Centers for Medicare & Medicaid Services, 2020). These algorithms require one inpatient or two other nondrug claims of any service type at least 1 day apart during a 2-year period (Centers for Medicare & Medicaid Services, 2020) (Table S3). The ICD-10-CM codes for PTSD were also included in the CCW definition of anxiety disorders. Individuals could therefore have ICD-10-CM codes for anxiety disorders, but not PTSD, but all individuals with PTSD diagnosis codes were also included among individuals with anxiety disorder diagnosis codes. Individuals who had only one outpatient claim, or more than one outpatient claim recorded on the same day during 2017 for anxiety or depressive disorders were excluded from the analysis.

Among all individuals with an anxiety or depressive disorder, we examined the percentage who filled one or more outpatient prescriptions for antianxiety or antidepressant medication in 2017 (Table S4). We additionally identified receipt of mental health services in 2017, using procedure codes indicating a diagnostic or therapeutic encounter (Table S5, referred to hereafter as receipt of “psychosocial treatment”).

We estimated the 2017 administrative prevalence of diagnosed PTSD, anxiety, and depressive disorders among individuals with and without CHDs, both overall and by severity of CHDs. We report distributions by age, sex, and region of residence. In addition, we report healthcare utilization in 2017, including outpatient encounters without receipt of psychosocial treatment (Table S5), any inpatient admissions, and inpatient or outpatient encounters with a surgical (typically occurring in an operating room and involving skin incision), catheterization (invasive, nonsurgical), or other noninvasive (e.g., imaging, stress testing) cardiovascular procedure code (Table S6). We used log-binomial regression to examine adjusted prevalence ratios (aPR) of diagnosed PTSD, anxiety disorders, and depressive disorders in 2017 comparing individuals with and without CHDs. Models were adjusted for categorical age (18–29 years, 30–39 years, 40–49 years), sex, and region of residence. To assess factors associated with diagnosed anxiety or depressive disorders among those with CHDs, we used log-binomial regression to estimate aPRs for the presence of a diagnosed anxiety or depressive disorder using patient characteristics and their healthcare utilization as the exposures. Models were adjusted for subsets of confounders based on the factor of interest: categorical age, sex, region, and total outpatient encounters without psychosocial treatment. Region of residence was missing for 0.3% of individuals; these individuals were kept in the analytic sample but were excluded from models that adjusted for region. Among all individuals with a diagnosed anxiety or depressive disorder, we assessed the percentage who filled a prescription for an antianxiety or antidepressant medication, had an outpatient encounter that included psychosocial treatment, or both, stratified by presence of CHDs.

Two supplemental analyses were conducted. First, we limited our analytic sample to individuals who, in 2017, were enrolled in a noncapitated health insurance plan. Capitated health insurance plans are those in which doctors or hospitals are paid a fixed amount per patient and are not always directly tied to the diagnoses and services an individual

receives. Because of this, diagnosis and procedures may be coded less accurately in capitated, compared to fee-for-service insurance plans (Landon & Mechanic, 2017). Second, to identify potential differences by age, we conducted analyses stratified by age groups (18–29 years, 30–39 years, and 40–49 years). All analyses were conducted in SAS, Version 9.4 (SAS Institute, Cary NC).

3 | RESULTS

We found 7,140,720 individuals aged 18 to 49 years who were enrolled for at least 11 months in a health plan with prescription drug and mental health/substance abuse claims inclusion in 2017. A total of 5,421,901 individuals met all remaining inclusion criteria and were included in the analytic sample (Figure 1). Of those, 13,807 (0.3%) individuals had eligible CHDs that met diagnosis criteria between 2007 and 2017, hereafter referred to as having “CHDs.” Among individuals with CHDs, 3,977 (28.8%) had severe CHDs (Table 1). Compared to individuals without CHDs, individuals with CHDs were younger, more likely to be male, more likely to reside in the Northeast region, have increased numbers of outpatient encounters without psychosocial treatment in 2017, were more likely to have an inpatient admission in 2017, and were more likely to have at least one surgical, catheterization, or noninvasive cardiovascular procedure in 2017 (Table 1). Compared to individuals with nonsevere CHDs, individuals with severe CHDs were more likely to be younger, reside in the North Central or South regions, and have at least one surgical, catheterization, or noninvasive cardiovascular procedure in 2017.

Of adults with CHDs, 12.4% had a diagnosed anxiety or depressive disorder in 2017, compared to 9.7% of adults without CHDs (aPR: 1.3, 95% confidence interval [CI]: 1.2–1.4; Table 2). Among adults with CHDs, 0.8% had a PTSD diagnosis, compared to 0.5% of adults without CHDs (aPR: 1.5, CI: 1.2–1.8). Additionally, 9.9% had an anxiety disorder diagnosis (vs. 7.5% of adults without CHDs; aPR: 1.3, CI: 1.3–1.4) and 6.3% had a depressive disorder diagnosis (vs. 4.9% of adults without CHDs; aPR: 1.3, CI: 1.2–1.4). Individuals with severe CHDs had similar prevalence of anxiety and depressive disorders as individuals with nonsevere CHDs (Table 2). Stratified analyses of individuals with severe and nonsevere CHDs (vs. no CHDs) yielded results that were similar to the main analyses that included all individuals with CHDs. Adults with severe CHDs had slightly higher aPRs for these outcomes than adults with nonsevere CHDs, but confidence intervals overlapped.

Among adults with CHDs, several factors were associated with increased prevalence of diagnosed PTSD (Table 3). Women were over three times as likely to have diagnosed PTSD compared to men (aPR: 3.3, CI: 2.1–5.1). Increasing outpatient encounters without psychosocial treatment and having a 2017 inpatient admission were associated with increased prevalence of PTSD. These patterns were observed for depressive disorders and anxiety disorders overall. Individuals with a surgical cardiovascular procedure had slightly elevated risk of any mental health disorders, depressive, and anxiety disorders, but associations were not significant.

Over 90% of adults with diagnosed anxiety or depressive disorders received psychosocial treatment and/or antianxiety and/or antidepressant medication dispensed in 2017, regardless

of their CHDs status (Table 4). Over 97% of adults with CHDs and PTSD received some sort of treatment in 2017, higher than adults with anxiety or depression diagnoses (Table 4). Further, adults with PTSD and CHDs had slightly higher prevalence of both psychosocial treatment and antianxiety/antidepressant medication than adults without CHDs (not significant). Among adults with anxiety diagnoses, adults with CHDs were slightly more likely to have both psychosocial treatment and antianxiety/antidepressant medication than adults without CHDs, and slightly less likely to have only psychosocial treatment or antianxiety/antidepressant medication use.

When we excluded 566,768 individuals with capitated health insurance plans from the analysis, results were similar to those from the main analysis (Tables S7–S9). When examining any anxiety or depressive disorders stratified by age, aPRs in all age strata had similar estimated associations between CHDs and anxiety or depressive disorders (aPR point estimates ranged from 1.2 to 1.4; individuals aged 30–39 years with severe CHDs had slightly higher prevalence of depressive disorders [aPR: 1.5; CI: 1.2, 1.8]) (Supplemental Table 12). However, when examining PTSD, individuals aged 18–29 years had lower estimated aPRs (range 1.0 to 1.5) compared to individuals aged 30–39 (range 1.5 to 2.3) and aged 40–49 (range 1.4–2.1) (Table S12). When examining factors associated with anxiety and depressive disorders among individuals with CHDs, similar patterns were present for most factors in all age groups (Tables S13–S15). There were some exceptions: having an inpatient admission in 2017 was associated with a lower prevalence of anxiety disorders (aPR: 0.7; CI: 0.5, 0.9) and depressive disorders (aPR: 0.7, CI: 0.5, 0.9) among individuals aged 30–39 years compared to individuals aged 18–29 and 40–49 years (aPR ranges 1.3–1.8) (Tables S13 and S14). Surgical, catheterization, and noninvasive procedures had higher aPRs in age stratified analyses compared to the main analysis, but to achieve model convergence, could not be adjusted for the same confounders as in the main analysis.

4 | DISCUSSION

Our study of privately insured adults indicated that 12% of adults with CHDs had diagnosed anxiety disorders, including PTSD, or depressive disorders and they were more likely to have these disorders compared to adults without CHDs. This increased prevalence persisted when examining PTSD with or without codes for depressive and other anxiety disorders (CHDs: 0.8%; no CHDs 0.5%), anxiety disorders with or without codes for depressive disorders (CHDs: 9.9%; no CHDs 7.5%) and depressive disorders with or without codes for anxiety disorders (CHDs: 6.3%; no CHDs: 4.9%). Among individuals with a diagnosed anxiety or depressive disorder, almost all received treatment. Among adults with CHDs, increasing numbers of outpatient healthcare encounters and hospitalization in 2017 were associated with increased prevalence of PTSD, anxiety disorders and depressive disorders. Additionally, women with CHDs were more likely than men to have anxiety and depressive disorders, most strikingly for PTSD, with over three times the prevalence of a PTSD diagnosis. This finding aligns with others that indicate women have higher rates of most mental illness and PTSD compared to men, possibly due to increased lifetime experience of associated risk factors (Olf, 2017; Riecher-Rossler, 2017).

Few studies have investigated the frequency of PTSD in adults with CHDs. Invasive medical CHDs treatment and hospitalization in childhood and adolescence may be stressful and contribute to persistent stress reactions throughout childhood and into adulthood (Meentken et al., 2017). Additionally, the cumulative burden of treatment and cardiac health could contribute to the development of PTSD in adults (Alonzo, 2000). In a study of 134 adults with CHDs treated at an adult CHDs clinic in the United States, Deng et al. (2016) found that 11% met criteria for elevated PTSD symptoms related to their CHDs or its treatment and that 21% met criteria for elevated PTSD symptoms overall. In a hospital-based study of 347 adults with CHDs from Iran, Eslami reported that 52% met criteria for likely PTSD (vs. 48% of adults without CHDs) (Eslami, 2017). Our analysis of over 13,000 privately insured individuals found increased prevalence among adults with CHDs. We observed a much lower prevalence of diagnosed PTSD, indicating differences in prevalence of PTSD among adults receiving congenital cardiac care compared to adults with CHDs in the general population, or an underdiagnosis of the condition in administrative data.

Our findings can be considered alongside at least two other U.S.-based studies, neither of which examined PTSD individually. In a cohort of adults with CHDs ascertained from medical records and claims data between 2011 and 2013, Khanna et al. (2019) identified mental health encounters over a three-year period. Over 33% of adults with CHDs had a mental health encounter. Among adults with CHDs, having at least two cardiac procedures between 2011 and 2013 was associated with increased prevalence of anxiety (odds ratio [OR]: 3.4, CI: 2.9–4.0) and mood disorders (OR: 3.6, CI: 3.1–4.2). Unlike our study, Khanna et al. did not have a comparison group of adults without CHDs. Agarwal et al. used MarketScan data from 2010–2016 to identify adults aged 18–64 with one or more CHDs-related ICD codes and matched them to adults without CHDs. Psychiatric disorders were 1.5 times higher (95% CI: 1.35–1.65) among adults with CHDs (Agarwal et al., 2019). However, they did not examine PTSD or anxiety, examined depression and psychosis as a single outcome, and did not examine mental health treatment. Our study adds to the literature by assessing prevalence and risk factors for PTSD, anxiety and depressive disorders in the adult CHDs population as compared with a group of adults without CHDs, using a more specific CHDs case definition, and examining mental health treatment.

This analysis benefitted from a large, nationwide sample of over 13,000 individuals with CHDs. This allowed us to examine the rarely investigated (in this population) outcome of diagnosed PTSD, and allowed comparisons between individuals with and without CHDs, and by severity. However, MarketScan data are a convenience sample of privately insured individuals and their dependents, and we limited our sample to those with employer sponsored health plans, mental health coverage, prescription coverage, and at least 11 months of enrollment, so our results may not be generalizable to U.S. populations lacking commercial health insurance. Moreover, persons with CHDs likely have higher healthcare utilization than those without CHDs, giving more opportunities for mental health disorders to be detected, diagnosed, and treated. The increased prevalence of anxiety and depressive disorders could be partially explained by detection bias. An important limitation is that use of administrative data can lead to misclassification of both the exposure, and the outcome (Khan et al., 2018). Further, there could be additional life events and stressors not

documented in administrative data that contribute to the development of PTSD, depression, or anxiety disorders in people with CHDs.

While our estimate of the prevalence of depressive disorders among adults without CHDs is similar to the past-year prevalence of a major depressive episode reported by the National Institute of Mental Health (NIMH), our estimate of the prevalence of anxiety disorders is lower than that reported by the NIMH (National Institute of Mental Health, 2017, 2019). This could suggest anxiety disorders may not be captured as well as depressive disorders in administrative data. Additionally, individuals seeking mental health care could be paying out of pocket, which would not be captured in these data. The use of ICD codes to identify adults with CHDs can incorrectly classify adults without CHDs as having CHDs. In particular, singular outpatient codes may have a positive predictive value as low as 50% (Khan et al., 2018). For this reason, we required at least two outpatient codes to identify CHDs, and excluded individuals with nonspecific codes. Our algorithm identified 0.3% of the privately insured analytic sample with inpatient or outpatient care to have CHDs, similar to other publications using administrative data (Glidewell et al., 2021), but less than the estimated 0.6% of U.S. adults estimated to be living with CHDs (Gilboa et al., 2016). This could indicate that our algorithm missed individuals with CHDs, or that individuals with CHDs did not have their CHD documented at their healthcare encounters or were not using healthcare, or had insurance other than what was included here.

We applied algorithms to increase the specificity of classification mental health disorders (Centers for Medicare & Medicaid Services, 2020). However, we could have excluded individuals with depressive/anxiety disorders who did not meet the respective criteria. Although we excluded individuals with diagnostic codes for chromosomal anomalies, adults with CHDs and undiagnosed genetic conditions may have been included (Burchill, Greenway, Silversides, & Mital, 2011). We may have also inadvertently excluded individuals who received genetic testing during pregnancy or as part of a diagnostic workup. A final limitation is that variables unavailable in the MarketScan data (e.g., race/ethnicity, education, and socioeconomic status) may be important confounders or effect modifiers. Specifically, racial and ethnic minorities experience similar levels of mental illness as white adults, but have less access to and report lower utilization of mental health care (National Institute of Mental Health, n.d.; Substance Abuse and Mental Health Services Administration, 2015).

Current estimates suggest that over 1.4 million adults live with CHDs in the United States, and that population is expected to grow (Gilboa et al., 2016). Findings from this study are consistent with others that have observed a higher prevalence of mental illness in individuals with CHDs, and add to the existing literature by examining PTSD and mental health treatment. Future research should consider incorporating the impact of race and other social determinants of health on mental health outcomes in adults with CHDs. Understanding best practices for screening, diagnosis, and treatment of anxiety and depressive disorders in adults with CHDs, including ways to mitigate risk, especially before and after hospitalization, may help improve the mental health of this growing population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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DATA AVAILABILITY STATEMENT

The authors cannot make data and study materials available to other investigators for purposes of reproducing the results because of licensing restrictions. Interested parties, however, could obtain and license the data by contacting IBM MarketScan Research Databases. SAS code is available upon request.

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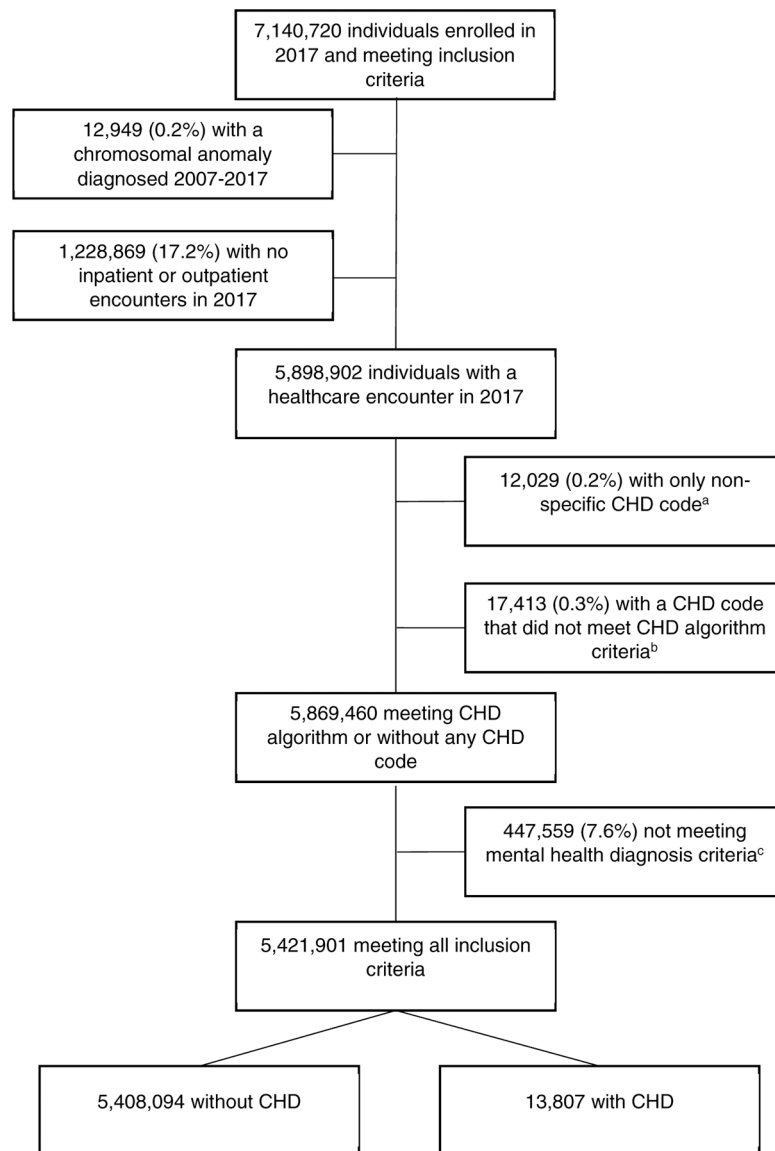


FIGURE 1.

Counts of individuals meeting inclusion and exclusion criteria, IBM MarketScan[®] Commercial Databases, 2017. ^aCHD(s): Congenital heart defect(s), defined by ICD-9-CM or ICD-10-CM inpatient and outpatient codes between 2007 and 2017. ^bIndividuals were considered to have a CHD if they had at least two ICD codes more than 30 days apart in outpatient encounter data, or at least one ICD code in inpatient encounter data. ^cAt least one inpatient or 2 outpatient ICD-10-CM codes diagnosed on separate days for depressive or anxiety disorders diagnosed in 2017

TABLE 1
 Characteristics of adults with and without CHDs, MarketScan® Commercial Database, 2017

Characteristics	Category	Any CHDs ^a		No CHDs ^a		Chi square <i>p</i> -value	Severe CHDs		Nonsevere CHDs		Chi square <i>p</i> -value
		<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)		<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	
Total		13,807	5,408,094				3,977	9,830			
Age ^b	18–29	6,101 (44.2)	1,834,118 (33.9)			<.0001	2,005 (50.4)	4,096 (41.7)			<.0001
	30–39	3,731 (27.0)	1,623,249 (30.0)				1,157 (29.1)	2,574 (26.2)			
	40–49	3,975 (28.8)	1,950,727 (36.1)				815 (20.5)	3,160 (32.1)			
Sex	Female	7,046 (51.0)	3,014,883 (55.7)			<.0001	2,024 (50.9)	5,022 (51.1)			.8348
	Male	6,761 (49.0)	2,393,211 (44.3)				1,953 (49.1)	4,808 (48.9)			
Region of residence	Northeast	3,412 (24.8)	1,026,338 (19.0)			<.0001	848 (21.4)	2,564 (26.2)			<.0001
	North Central	3,176 (23.1)	1,258,393 (23.3)				1,007 (25.4)	2,169 (22.1)			
	South	5,039 (36.6)	2,239,758 (41.5)				1,480 (37.3)	3,559 (36.3)			
	West	2,137 (15.5)	866,985 (16.1)				632 (15.9)	1,505 (15.4)			
	Missing	43 (0)	16,620 (0)				10 (0)	33 (0)			
Outpatient encounters without mental health psychosocial treatment ^c	0 encounters	26 (0.2)	20,448 (0.4)			<.0001	6 (0.2)	20 (0.2)			.5176
	1–5 encounters	5,232 (37.9)	3,089,281 (57.1)				1,468 (36.9)	3,764 (38.3)			
	6–10 encounters	3,302 (23.9)	1,136,957 (21.0)				957 (24.1)	2,345 (23.9)			
	11–15 encounters	1,862 (13.5)	493,536 (9.1)				532 (13.4)	1,330 (13.5)			
	16–20 encounters	1,092 (7.9)	255,469 (4.7)				331 (8.3)	761 (7.7)			
	More than 20 encounters	2,293 (16.6)	412,403 (7.6)				683 (17.2)	1,610 (16.4)			
Inpatient admission ^c	Yes	1,738 (12.6)	274,812 (5.1)			<.0001	539 (13.6)	1,199 (12.2)			.0297
	No	12,069 (87.4)	5,133,282 (94.9)				3,438 (86.4)	8,631 (87.8)			
Surgical cardiovascular encounter ^{c,d}	0	13,538 (98.1)	5,405,933 (100.0)			<.0001	3,888 (97.8)	9,650 (98.2)			.1174
	1+	269 (1.9)	2,161 (0.04)				89 (2.2)	180 (1.8)			
Catheterization cardiovascular encounter ^{c,d}	0	13,305 (96.4)	5,393,201 (99.7)			<.0001	3,686 (92.7)	9,619 (97.9)			<.0001
	1	390 (2.8)	10,198 (0.2)				222 (5.6)	168 (1.7)			
	2+	112 (0.8)	4,695 (0.1)				69 (1.7)	43 (0.4)			
Noninvasive cardiovascular encounter ^{c,d}	0	5,799 (42.0)	4,699,637 (86.9)			<.0001	1,057 (26.6)	4,742 (48.2)			<.0001

Characteristics	Category	Any CHDs ^a		No CHDs ^a		Severe CHDs		Nonsevere CHDs		Chi square <i>p</i> -value
		<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	
	1	4,204 (30.4)	520,531 (9.6)	1,350 (33.9)	2,854 (29.0)					
	2+	3,804 (27.6)	187,926 (3.5)	1,570 (39.5)	2,234 (22.7)					

Note: Boldface indicates statistical significance at $\alpha < .05$.

Abbreviation: CHD, congenital heart defect.

^aCHDs were defined using International Classification of Disease (ICD) 9 and 10 codes. Individuals were considered to have CHDs if they had at least two ICD codes separated by at least 30 days in outpatient encounter data, or at least one ICD code in inpatient encounter data. Individuals were considered to have severe CHDs if they had ICD codes for common truncus, transposition of the great arteries, complete transposition of the great arteries not otherwise specific, double outlet right ventricle or incomplete transposition of the great arteries, corrected transposition of the great arteries, other transposition of the great arteries, tetralogy of Fallot, single ventricle or cor triloculare, endocardial cushion defect, endocardial cushion defect unspecified, atrial septal defect primum, endocardial cushion defect other specified, pulmonary valve atresia or absence, tricuspid atresia, stenosis or absence, hypoplastic left heart syndrome, interrupted aortic arch, total anomalous pulmonary venous return.

^bAge as of January 1, 2017.

^cIn 2017.

^dAny inpatient or outpatient encounter that included cardiovascular procedure code.

TABLE 2

Association of CHDs with diagnosed anxiety, PTSD, and/or depressive disorder, MarketScan® Commercial Database, 2017

Condition	No CHDs n (%)	Any CHDs ^a n (%)	Any severe CHDs ^a n (%)	Any nonsevere CHDs n (%)	Any CHDs aPR ^b (95% CI)	Severe CHDs aPR ^b (95% CI)	Nonsevere CHDs aPR ^b (95% CI)
Total N	5,408,094	13,807	3,977	9,830			
Any anxiety or depressive disorder ^c	523,022 (9.7)	1,713 (12.4)	513 (12.9)	1,200 (12.2)	1.3 (1.2–1.4)	1.3 (1.2–1.5)	1.3 (1.2–1.3)
Anxiety disorder	403,164 (7.5)	1,371 (9.9)	398 (10.0)	973 (9.9)	1.3 (1.3–1.4)	1.3 (1.2–1.5)	1.3 (1.3–1.4)
Post-traumatic stress disorder ^c	29,206 (0.5)	110 (0.8)	34 (0.9)	76 (0.8)	1.5 (1.2–1.8)	1.6 (1.1–2.2)	1.4 (1.2–1.8)
Depressive disorder	267,644 (4.9)	871 (6.3)	269 (6.8)	602 (6.1)	1.3 (1.2–1.4)	1.4 (1.2–1.5)	1.3 (1.2–1.4)

Note: Boldface indicates statistical significance at $\alpha < .05$.

Abbreviations: aPR, adjusted prevalence ratio; CHD, congenital heart defect; CI, confidence interval; PTSD, post-traumatic stress disorder.

^a CHDs were defined using International Classification of Disease (ICD) 9 and 10 codes; Individuals were considered to have CHDs if they had at least two ICD codes separated by at least 30 days in outpatient encounter data, or at least one ICD code in inpatient encounter data. Individuals were considered to have severe CHDs if they had ICD codes for common truncus, transposition of the great arteries, complete transposition of the great arteries not otherwise specific, double outlet right ventricle or incomplete transposition of the great arteries, corrected transposition of the great arteries, other transposition of the great arteries, tetralogy of Fallot, single ventricle or cor triloculare, endocardial cushion defect, endocardial cushion defect unspecified, atrial septal defect primum, endocardial cushion defect other specified, pulmonary valve atresia or absence, tricuspid atresia, stenosis or absence, hypoplastic left heart syndrome, interrupted aortic arch, total anomalous pulmonary venous return.

^b For all models comparison is adults without a congenital heart defect diagnosis; models are adjusted for categorical age at the beginning of 2017 (18–29 years, 30–39 years, 40–49 years), sex, and region of residence.

^c Any anxiety or depressive disorder includes any individual with a diagnosis of an anxiety or depressive disorder in 2017; the codes for post-traumatic stress disorder are also included in the codes used to identify individuals with anxiety disorder.

TABLE 3

Associations between mental health conditions and characteristics among adults with CHDs, MarketScan® Commercial Database, 2017

Characteristics	Any anxiety or depressive disorder ^a			Post-traumatic stress disorder ^a			Anxiety disorder			Depressive disorder		
	n (%)	aPR ^b (95% CI)	n (%)	aPR ^b (95% CI)	n (%)	aPR ^b (95% CI)	n (%)	aPR ^b (95% CI)	n (%)	aPR ^b (95% CI)	n (%)	aPR ^b (95% CI)
Congenital heart defect severity ^c												
Severe CHDs	513 (12.9)	1.1 (1.0, 1.2)	34 (0.9)	1.1 (0.7, 1.7)	398 (10.0)	1.0 (0.9, 1.1)	269 (6.8)	1.1 (1.0, 1.3)	602 (6.1)	Ref		
Nonsevere CHDs	1,200 (12.2)	Ref	76 (0.8)	Ref	973 (9.9)	Ref						
Age ^d												
18–29	756 (12.4)	1.0 (0.9, 1.1)	44 (0.7)	0.9 (0.6, 1.5)	619 (10.1)	1.1 (0.9, 1.2)	384 (6.3)	1.0 (0.9, 1.2)	384 (6.3)	1.0 (0.9, 1.2)		
30–39	454 (12.2)	0.9 (0.8, 1.0)	35 (0.9)	1.1 (0.7, 1.7)	368 (9.9)	1.0 (0.8, 1.1)	233 (6.2)	0.9 (0.8, 1.1)	233 (6.2)	0.9 (0.8, 1.1)		
40–49	503 (12.7)	Ref	31 (0.8)	Ref	384 (9.7)	Ref	254 (6.4)	Ref	254 (6.4)	Ref		
Sex												
Female	1,067 (15.1)	1.6 (1.5, 1.8)	85 (1.2)	3.3 (2.1, 5.1)	868 (12.3)	1.7 (1.5, 1.9)	555 (7.9)	1.7 (1.5, 2.0)	555 (7.9)	1.7 (1.5, 2.0)		
Male	646 (9.6)	Ref	25 (0.4)	Ref	503 (7.4)	Ref	316 (4.7)	Ref	316 (4.7)	Ref		
Region of residence												
Northeast	476 (14.0)	1.2 (1.0, 1.4)	27 (0.8)	0.8 (0.5, 1.4)	376 (11.0)	1.2 (1.0, 1.4)	228 (6.7)	1.0 (0.8, 1.2)	228 (6.7)	1.0 (0.8, 1.2)		
North Central	391 (12.3)	1.1 (0.9, 1.3)	32 (1.0)	1.0 (0.6, 1.8)	316 (9.9)	1.1 (0.9, 1.3)	211 (6.6)	1.0 (0.8, 1.3)	211 (6.6)	1.0 (0.8, 1.3)		
South	591 (11.7)	1.0 (0.9, 1.2)	28 (0.6)	0.5 (0.3, 0.9)	471 (9.3)	1.0 (0.8, 1.2)	285 (5.7)	0.8 (0.7, 1.0)	285 (5.7)	0.8 (0.7, 1.0)		
West	252 (11.8)	Ref	23 (1.1)	Ref	206 (9.6)	Ref	145 (6.8)	Ref	145 (6.8)	Ref		
Outpatient encounters without mental health psychosocial treatment ^e												
1–5 encounters	280 (5.4)	Ref	12 (0.2)	Ref	209 (4.0)	Ref	136 (2.6)	Ref	136 (2.6)	Ref		
6–10 encounters	360 (10.9)	2.0 (1.7, 2.3)	17 (0.5)	2.1 (1.0, 4.4)	287 (8.7)	2.2 (1.8, 2.6)	155 (4.7)	1.8 (1.4, 2.3)	155 (4.7)	1.8 (1.4, 2.3)		
11–15 encounters	288 (15.5)	2.9 (2.4, 3.3)	16 (0.9)	3.3 (1.6, 7.1)	228 (12.2)	3.0 (2.5, 3.6)	151 (8.1)	3.1 (2.5, 3.9)	151 (8.1)	3.1 (2.5, 3.9)		
16–20 encounters	204 (18.7)	3.4 (2.9, 4.1)	11 (1.0)	3.8 (1.7, 8.7)	167 (15.3)	3.8 (3.1, 4.6)	109 (10.0)	3.8 (2.9, 4.8)	109 (10.0)	3.8 (2.9, 4.8)		
More than 20 encounters	571 (24.9)	4.6 (4.0, 5.3)	53 (2.3)	8.8 (4.7, 16.6)	472 (20.6)	5.2 (4.4, 6.0)	316 (13.8)	5.3 (4.3, 6.4)	316 (13.8)	5.3 (4.3, 6.4)		
Inpatient admission ^f												
Yes	381 (21.9)	1.1 (1.0, 1.3)	41 (2.4)	1.9 (1.2, 2.9)	310 (17.8)	1.1 (1.0, 1.3)	223 (12.8)	1.3 (1.1, 1.5)	223 (12.8)	1.3 (1.1, 1.5)		
No	1,332 (11.0)	Ref	69 (0.6)	Ref	1,061 (8.8)	Ref	648 (5.4)	Ref	648 (5.4)	Ref		
Surgical cardiovascular encounter ^{f,g}												

Characteristics	Any anxiety or depressive disorder ^d			Post-traumatic stress disorder ^d			Anxiety disorder			Depressive disorder		
	n (%)	aPR ^b (95% CI)	n (%)	aPR ^b (95% CI)	n (%)	aPR ^b (95% CI)	n (%)	aPR ^b (95% CI)	n (%)	aPR ^b (95% CI)		
0 encounters	1,649 (12.2)	Ref	107 (0.8)	Ref	1,318 (9.7)	Ref	838 (6.2)	Ref	838 (6.2)	Ref		
1 encounter	64 (23.8)	1.2 (1.0, 1.5)	3 (1.1)	0.8 (0.2, 2.5)	53 (19.7)	1.3 (1.0, 1.6)	33 (12.3)	1.2 (0.9, 1.7)	33 (12.3)	1.2 (0.9, 1.7)		
Catheterization cardiovascular encounter ^{f,g}												
0 encounters	1,625 (12.2)	Ref	105 (0.8)	Ref	1,299 (9.8)	Ref	824 (6.2)	Ref	824 (6.2)	Ref		
1 encounter	62 (15.9)	0.9 (0.7, 1.2)	3 (0.8)	0.6 (0.2, 1.9)	50 (12.8)	0.9 (0.7, 1.2)	33 (8.5)	0.9 (0.6, 1.3)	33 (8.5)	0.9 (0.6, 1.3)		
2 encounters	26 (23.2)	1.1 (0.8, 1.5)	2 (1.8)	1.1 (0.3, 4.4)	22 (19.6)	1.1 (0.8, 1.7)	14 (12.5)	1.1 (0.7, 1.8)	14 (12.5)	1.1 (0.7, 1.8)		
Noninvasive cardiovascular encounter ^{f,g}												
0 encounters	622 (10.7)	Ref	42 (0.7)	Ref	496 (8.6)	Ref	318 (5.5)	Ref	318 (5.5)	Ref		
1 encounter	458 (10.9)	0.9 (0.8, 1.0)	24 (0.6)	0.7 (0.4, 1.2)	348 (8.3)	0.9 (0.8, 1.0)	232 (5.5)	0.9 (0.8, 1.1)	232 (5.5)	0.9 (0.8, 1.1)		
2 encounters	633 (16.6)	1.0 (0.9, 1.1)	44 (1.2)	0.9 (0.6, 1.4)	527 (13.9)	1.0 (0.9, 1.2)	321 (8.4)	0.9 (0.8, 1.1)	321 (8.4)	0.9 (0.8, 1.1)		

Note: Boldface indicates statistical significance at $\alpha < .05$.

Abbreviations: aPR, adjusted prevalence ratio; CHD, congenital heart defects; CI, confidence interval.

^aPost-traumatic stress disorder is a subset of anxiety disorders.

^bAdjusted prevalence ratios: Type of congenital heart defect and outpatient encounters without mental health counseling adjusted for categorical age (18–29 years, 30–39 years, 40–49 years), sex, and region; Age adjusted for sex and region; Sex adjusted for categorical age and region, Region adjusted for categorical age and sex; Inpatient admissions and Encounter with cardiovascular procedures adjusted for categorical age, sex, region, and total outpatient encounters without psychosocial treatment.

^cIndividuals were considered to have severe CHDs if they had ICD codes for common truncus, transposition of the great arteries, complete transposition of the great arteries not otherwise specific, double outlet right ventricle or incomplete transposition of the great arteries, corrected transposition of the great arteries, other transposition of the great arteries, tetralogy of Fallot, single ventricle or cor triloculare, endocardial cushion defect, endocardial cushion defect unspecified, atrial septal defect primum, endocardial cushion defect other specified, pulmonary valve atresia or absence, tricuspid atresia stenosis or absence, hypoplastic left heart syndrome, interrupted aortic arch, total anomalous pulmonary venous return.

^dAge as of January 1, 2017.

^eAmong individuals with at least one outpatient encounter without psychosocial treatment.

^fIn 2017.

^gAny inpatient or outpatient encounter that included a cardiovascular procedure code.

Treatment characteristics of adults with a mental health diagnosis, MarketScan® Commercial Database, 2017

TABLE 4

Category	Post-traumatic stress disorder ^a			Anxiety			Depression		
	CHDs ^b		p-value ^c	CHDs ^b		p-value ^c	CHDs ^b		p-value ^c
	n (%)	No CHDs n (%)		n (%)	No CHDs n (%)		n (%)	No CHDs n (%)	
Total	110 (69.1)	29,206 18,643 (63.8)	.2176	1,368 573 (41.8)	403,164 152,437 (37.8)	.0224	871 458 (52.6)	267,644 128,909 (48.2)	.0290
Both psychosocial treatment and antianxiety/antidepressant medication	76 (69.1)	18,643 (63.8)	.2176	573 (41.8)	152,437 (37.8)	.0224	458 (52.6)	128,909 (48.2)	.0290
Antianxiety/antidepressant only	15 (13.6)	3,191 (10.9)		528 (38.5)	166,682 (41.3)		279 (32.0)	90,188 (33.7)	
Psychosocial treatment only	16 (14.6)	6,630 (22.7)		176 (12.8)	56,212 (13.9)		98 (11.3)	37,557 (14.0)	
Neither psychosocial treatment or antianxiety/antidepressant medication	3 (2.7)	742 (2.5)		94 (6.9)	27,833 (6.9)		36 (4.1)	10,990 (4.1)	

Note: Boldface indicates statistical significance at $\alpha < .05$.

Abbreviation: CHD, congenital heart defect.

^a Post-traumatic stress disorder is a subset of anxiety disorders.

^b CHDs were defined using International Classification of Disease (ICD) 9 and 10 codes; Individuals were considered to have CHDs if they had at least two ICD codes separated by at least 30 days in outpatient encounter data, or at least one ICD code in inpatient encounter data.

^c Chi-square p-value.