OBSTETRICS

Trends in and complications associated with mental health condition diagnoses during delivery hospitalizations

Teresa C. Logue, MPH; Timothy Wen, MD, MPH; Catherine Monk, PhD; Jean Guglielminotti, MD, PhD; Yongmei Huang, MD, MPH; Jason D. Wright, MD; Mary E. D'Alton, MD; Alexander M. Friedman, MD, MPH

BACKGROUND: Mental health conditions during delivery hospitalizations are not well characterized.

OBJECTIVE: This study aimed to characterize the prevalence of maternal mental health condition diagnoses and associated risk during delivery hospitalizations in the United States.

STUDY DESIGN: The 2000 to 2018 National Inpatient Sample was used for this repeated cross-sectional analysis. Delivery hospitalizations of women aged 15 to 54 years with and without mental health condition diagnoses, including depressive disorder, anxiety disorder, bipolar spectrum disorder, and schizophrenia spectrum disorder, were identified. Temporal trends in mental health condition diagnoses during delivery hospitalizations were determined using the National Cancer Institute's Joinpoint Regression Program to estimate the average annual percent change with 95% confidence intervals. The trends in chronic conditions associated with mental health condition diagnoses, including asthma, pregestational diabetes mellitus, chronic hypertension, obesity, and substance use, were analyzed. The association between mental health conditions and the following adverse outcomes was determined: (1) severe maternal morbidity, (2) preeclampsia or gestational hypertension, (3) preterm delivery, (4) postpartum hemorrhage, (5) cesarean delivery, and (6) maternal mortality. Regression models for each outcome were performed with unadjusted and adjusted risk ratios as measures of effects.

RESULTS: Of 73,109,791 delivery hospitalizations, 2,316,963 (3.2%) had ≥1 associated mental health condition diagnosis. The proportion of delivery hospitalizations with a mental health condition increased from 0.6% in 2000 to 7.3% in 2018 (average annual percent change, 11.4%; 95% confidence interval, 10.3%—12.6%). Among deliveries in women with a mental health condition diagnosis, chronic health conditions, including asthma, pregestational diabetes mellitus, chronic hypertension, obesity, and substance use, increased from 14.9% in 2000 to 38.5% in 2018. Deliveries to women with a mental health condition diagnosis were associated with severe maternal morbidity (risk ratio, 1.88; 95% confidence interval, 1.86—1.90), preeclampsia and gestational hypertension (risk ratio, 1.59; 95% confidence interval, 1.58—1.60), preterm delivery (risk ratio, 1.35; 95% confidence interval, 1.35—1.36), postpartum hemorrhage (risk ratio, 1.37; 95% confidence interval, 1.36—1.38), cesarean delivery (risk ratio, 1.20; 95% confidence interval, 1.20—1.20), and maternal death (risk ratio, 1.31; 95% confidence interval, 1.12—1.56). The increased risk was retained in adjusted models.

CONCLUSION: The proportion of delivery hospitalizations with mental health condition diagnoses increased significantly throughout the study period. Mental health condition diagnoses were associated with other underlying chronic health conditions and a modestly increased risk of a range of adverse outcomes. The findings suggested that mental health conditions are an important risk factor in adverse maternal outcomes.

Key words: depression, maternal mental health, maternal outcomes, severe maternal morbidity

Introduction

Mental health conditions, including depressive and anxiety disorders, are common among pregnant and postpartum women.[1—4] Moreover, bipolar and schizophrenia disorders may affect a small but significant proportion of the obstetrical population.[5] Maternal mental health conditions are associated with a range of adverse outcomes, including preterm birth, preeclampsia, cesarean delivery, and maternal mortality.[6—14] In addition, maternal mental health conditions are associated with severe morbidity.[15,16] In the general population, mental health conditions are often comorbid with chronic medical conditions and are increasing among younger adults.[17,18] There is a large range of estimates of the prevalence of mental health conditions during pregnancy. However, currently, there are limited data through 2018 on population-level trends in mental health conditions during delivery hospitalizations, their association with comorbid chronic conditions, and risks of adverse outcomes.[19] Previous studies demonstrated rising diagnoses of anxiety and depression during deliveries.[19,20]

To this end, we conducted a serial cross-sectional analysis of a national database to (1) describe trends in the prevalence of depressive disorders, anxiety disorder, bipolar spectrum disorder, and schizophrenia spectrum disorder diagnoses during delivery hospitalizations; (2) to determine to what degree other chronic health conditions, such as diabetes mellitus and chronic hypertension, are present with mental health conditions; and (3) to evaluate whether mental health is associated with increased risk of adverse outcomes.

Materials and Methods

Data source

We queried the National Inpatient Sample (NIS) for delivery hospitalization data from 2000 to 2018 for this

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AJOG at a Glance

Why was this study conducted?

This study aimed to determine the trends and outcomes associated with mental health condition diagnoses during delivery hospitalizations.

Key findings

During the study period, the diagnoses of mental health conditions increased 1097%. Mental health conditions were associated with increasing comorbidity and risk of adverse maternal and obstetrical outcomes.

What does this add to what is known?

Our findings suggested that mental health conditions are an increasingly important risk factor for adverse maternal outcomes.

serial cross-sectional analysis.[21] The NIS is a publicly available, all-payer dataset maintained by the Healthcare Cost and Utilization Project that captures data from >7 million inpatient hospitalizations annually.[22] It approximates a stratified sample of 20% of all hospitals in the United States; when weighted to account for the survey design, the data produce national estimates. Specific weights for evaluating temporal trends in the NIS were applied in this study.[23]

We abstracted International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes for hospitalizations that occurred from January 2000 to December 2014. The transition to International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) diagnosis and procedure codes occurred on October 1, 2015; for the year 2015, we included both ICD-9-CM and ICD-10-CM codes. For the years 2016 to 2018, ICD-10-CM codes were used. For our analyses, ICD-9-CM codes were converted to their ICD-10-CM equivalents by using the Centers for Medicare and Medicaid Services' General Equivalence Mappings and reviewing diagnosis groups reported in the literature.[15,24,25]

Study objectives

This study had 3 objectives. The first objective was to estimate the prevalence of common maternal mental health condition diagnoses during delivery hospitalizations, including depressive disorder, anxiety disorder, bipolar spectrum disorder, and schizophrenia spectrum disorder, and evaluate temporal trends in these conditions from 2000 to 2018. We sought to determine whether the prevalence of these diagnoses during delivery hospitalization was increasing in recent years, as these diagnoses have increased among the overall reproductive-age population.[18]

The second objective was to determine whether risks of the following adverse maternal outcomes were associated with mental health condition diagnosis at delivery: (1) severe maternal morbidity, (2) preeclampsia or gestational hypertension, (3) preterm delivery, (4) postpartum hemorrhage, (5) cesarean delivery, and (6) maternal mortality. We defined severe maternal morbidity using composite measures developed by the Centers for Disease Control and Prevention (CDC) and identified through ICD-9-CM and ICD-10-CM codes.[26] This composite measure includes 21 diagnoses and procedures, including blood transfusion, shock, stroke, heart failure, and sepsis, among other conditions; because blood transfusion alone is unlikely to have long-term health consequences and most transfusion diagnosis codes during delivery hospitalizations are not representative of large-volume transfusion associated with major hemorrhage, we excluded transfusion from the composite.[27] Therefore, we evaluated the risk of the 20 remaining diagnoses and procedures.

The third objective was to determine whether deliveries with mental health conditions were increasingly likely to be associated with the following diagnoses throughout the study period: pregestational diabetes mellitus, chronic hypertension, obesity, asthma, and substance use.

Finally, as an ancillary objective, we aimed to determine whether there was an interaction between mental health conditions and chronic health conditions, such as pregestational diabetes mellitus, chronic hypertension, obesity, asthma, and substance use in the risk of severe maternal morbidity (Supplemental Table 1).

Subjects, demographics, comorbid conditions, and hospital characteristics

We included women aged 15 to 54 years in the NIS who were hospitalized for delivery from 2000 to 2018. Delivery hospitalizations were identified using algorithms of ICD-9-CM and ICD-10-CM codes that have previously been shown to capture >95% of deliveries.[28,29] We defined 4 categories of maternal mental health conditions: (1) depressive disorder, (2) anxiety disorder, (3) bipolar spectrum disorder, and (4) schizophrenia spectrum disorder using ICD-9-CM and ICD-10-CM coding groups. These coding groups were ascertained from research by the Mental Health Research Network (MHRN) that demonstrated that the transition from ICD-9-CM to ICD-10-CM seems to have minimal impact on estimates of prevalence for most mental health conditions.[25]

Demographic factors included year of delivery, maternal race and ethnicity, payer (Medicaid, private, Medicare, other, or uninsured), and ZIP code income quartile. Hospital-level factors included location and teaching status (urban teaching, urban nonteaching, and rural) and geographic region (Northeast, Midwest, South, or West). We included obesity, asthma, chronic hypertension, pregestational diabetes mellitus, and substance use as comorbid chronic conditions in our analysis (Supplemental Table 1). These conditions are all associated with adverse outcomes in pregnancy and may be

more common among women with mental health conditions.[30] Substance abuse coding groups for alcohol abuse, opioid use disorder, cannabis, cocaine, and other drugs were ascertained from the MHRN (Supplemental Table 1).

Statistical analysis

For the first objective, evaluating the prevalence of mental health diagnoses during delivery hospitalizations, we reported the proportion of deliveries with (1) depressive disorder, (2) anxiety disorder, (3) bipolar spectrum disorder, (4) schizophrenia spectrum disorder, or (5) any one or more of 4 mental health conditions.

To evaluate temporal trends in mental health conditions at delivery, we conducted a trends analysis from 2000 to 2018 using the National Cancer Institute's Joinpoint Regression Program (version 4.8.0.1).[31–34] This program fits joinpoint models to trends in data to identify changes in trends, test whether those changes are statistically significant, calculate the annual percentage change (APC) between trend-change points, and estimate the average annual percentage change (AAPC) throughout the study period. The AAPC summarizes the average APCs throughout the study interval; it is calculated as the weighted average of APCs from the joinpoint regression model with weights equal to the APC interval length.[35,36] Results are presented as the AAPC with 95% confidence intervals (CIs).

For our second objective, evaluating the association between mental health condition diagnoses and adverse maternal outcomes, we created unadjusted and adjusted log-linear regression models with Poisson distribution and log link with robust error variances for each of the outcomes of interest with unadjusted risk ratios (RR) and adjusted RRs (aRRs) with 95% CIs as measures of association.[37] The unadjusted models compared the risk of each adverse outcome during delivery hospitalizations based on the presence vs absence of mental health condition diagnoses. The adjusted models compared the risk of each adverse outcome during delivery hospitalizations based on the presence vs absence of mental health condition diagnoses controlling for demographics (maternal age, payer, ZIP code income quartile, and maternal race and ethnicity) and hospital-level factors (hospital location and region). In addition, the adjusted model for severe maternal morbidity was adjusted for underlying comorbid conditions, including asthma, pregestational diabetes mellitus, chronic hypertension, obesity, and substance use. An adjusted model for maternal mortality was not performed because of the small number of maternal deaths.

For the ancillary objective, evaluating the interactions between chronic health conditions, such as pregestational diabetes mellitus, chronic hypertension, obesity, asthma, and substance use, and risk of severe maternal morbidity, we performed stratified analyses dividing the study population into 2 groups: (1) hospitalizations with mental health condition diagnoses and (2) hospitalizations without mental health condition diagnoses. For each group, we analyzed the relationship between asthma, pregestational diabetes mellitus, chronic hypertension, obesity, and substance use and risk of severe maternal morbidity with unadjusted and adjusted log-linear regression models with Poisson distribution and log link with robust error variances. We sought to determine whether unadjusted RRs and aRRs associated with asthma, pregestational diabetes mellitus, chronic hypertension, obesity, and substance use were higher among deliveries with mental health condition diagnoses. Adjusted models included maternal age, maternal race and ethnicity, payer, ZIP code income quartile, and hospital location and region and the 5 chronic conditions (asthma, chronic hypertension, pregestational diabetes mellitus, obesity, and substance use).

For the third analysis determining whether trends in pregestational diabetes mellitus, chronic hypertension, obesity, asthma, and substance use among women with mental health condition diagnoses increased over time, we used joinpoint models to calculate the AAPCs for each condition.

Standardized mean difference (SMD) was used for demographic comparisons based on the presence vs absence of a mental health condition with $\geq$0.1 (10%) considered to be a meaningful difference.[38] Aside from the trend analyses performed with the Joinpoint Regression Program, all analyses were performed using SAS (version 9.4; SAS Institute, Cary, NC). We followed the Strengthening the Reporting of Observational Studies in Epidemiology guidelines for cross-sectional studies for this analysis.[39] This study was granted an exemption from the Columbia University's institutional review board (IRB-AAAE8144), as the NIS is publicly available and does not contain personally identifiable information.

Results

Of an estimated 73,109,791 delivery hospitalizations from 2000 to 2018, 2,316,963 (3.2%) had $\geq$1 associated mental health condition diagnosis (Table 1). The proportion of delivery hospitalizations with a mental health condition grew from 0.6% in 2000 to 7.3% in 2018—a 1097% increase overall with an AAPC of 11.4% (95% CI, 10.3%−12.6%) on joinpoint regression analysis (Figure 1). The proportion of delivery hospitalizations with depressive disorder increased from 0.40% in 2000 to 3.63% in 2018 (AAPC, 9.1%; 95% CI, 7.6−10.5). The proportion of delivery hospitalizations with anxiety disorder rose from 0.11% to 4.78% from 2000 to 2018 (AAPC, 22.5%; 95% CI, 21.7−23.3). The proportion of delivery hospitalizations with bipolar spectrum disorder grew from 0.09% to 0.80% (AAPC, 9.5%; 95% CI, 7.2−11.9), and the proportion with schizophrenia spectrum disorder rose from 0.02% to 0.12% (AAPC, 8.3; 95% CI, 7.7−9.0) from 2000 to 2018.

Mental health condition diagnoses were more common among deliveries to non-Hispanic White women and less common among deliveries to Hispanic women (SMD, 42.8% for maternal race), to women with Medicaid and Medicare insurance compared with women with commercial insurance (SMD, 18.2% for payer), and to women

TABLE 1
Characteristics of the study population by maternal mental health conditions

Characteristic	No mental health condition	≥1 mental health condition	Absolute SMD (%)	Depressive disorder	Anxiety disorder	Bipolar spectrum disorder	Schizophrenia spectrum disorder
Demographics							
Year of delivery			0.61 (61.5)				
2000	3,791,581 (5.3)	23,268 (1.0)		15,321 (1.1)	4387 (0.5)	3367 (1)	894 (2.0)
2001	3,719,643 (5.3)	30,150 (1.3)		20,061 (1.5)	5745 (0.6)	4464 (1.3)	1014 (2.3)
2002	3,862,967 (5.5)	40,438 (1.8)		27,404 (2.0)	7852 (0.8)	5444 (1.6)	1174 (2.7)
2003	3,810,295 (5.4)	51,768 (2.2)		35,980 (2.7)	9515 (1.0)	7012 (2.1)	1193 (2.7)
2004	3,930,660 (5.6)	68,339 (3.0)		47,318 (3.5)	13,654 (1.4)	8898 (2.7)	1626 (3.7)
2005	3,930,088 (5.6)	79,252 (3.4)		54,388 (4.0)	15,936 (1.7)	11,110 (3.3)	1793 (4.1)
2006	3,978,175 (5.6)	82,328 (3.6)		55,399 (4.1)	16,101 (1.7)	13,100 (3.9)	1911 (4.4)
2007	4,227,639 (6.0)	100,901 (4.4)		66,663 (4.9)	21,127 (2.2)	16,239 (4.8)	2085 (4.8)
2008	3,899,391 (5.5)	112,649 (4.9)		71,562 (5.3)	26,669 (2.8)	18,964 (5.7)	1828 (4.2)
2009	3,805,851 (5.4)	111,215 (4.8)		68,875 (5.1)	26,092 (2.7)	20,121 (6.0)	2242 (5.1)
2010	3,556,728 (5.0)	128,424 (5.5)		79,873 (5.9)	32,025 (3.3)	22,843 (6.8)	2333 (5.3)
2011	3,514,841 (5.0)	132,351 (5.7)		81,235 (6.0)	38,707 (4.0)	21,970 (6.5)	2289 (5.2)
2012	3,610,281 (5.1)	139,395 (6.0)		82,025 (6.1)	52,645 (5.5)	22,995 (6.9)	2645 (6.0)
2013	3,575,168 (5.1)	152,855 (6.6)		88,730 (6.6)	65,720 (6.9)	24,175 (7.2)	2875 (6.6)
2014	3,610,180 (5.1)	174,245 (7.5)		100,955 (7.5)	81,110 (8.5)	26,205 (7.8)	3150 (7.2)
2015	3,551,260 (5.0)	186,805 (8.1)		104,730 (7.8)	96,265 (10.0)	26,875 (8.0)	3155 (7.2)
2016	3,577,836 (5.1)	204,650 (8.8)		101,930 (7.6)	123,455 (12.9)	25,965 (7.7)	3625 (8.3)
2017	3,470,106 (4.9)	232,725 (10.0)		115,945 (8.6)	148,100 (15.5)	26,770 (8.0)	3700 (8.4)
2018	3,370,139 (4.8)	265,205 (11.5)		131,950 (9.8)	173,750 (18.1)	29,250 (8.7)	4300 (9.8)
Maternal race			0.43 (42.8)				
Non-Hispanic White	3,0704,622 (43.4)	1,451,923 (62.7)		818,243 (60.6)	665,395 (69.4)	206,537 (61.5)	15,136 (34.5)
Non-Hispanic Black	8,165,805 (11.5)	232,067 (10.0)		131,534 (9.7)	72,937 (7.6)	50,225 (15.0)	16,641 (38.0)
Hispanic	13,597,104 (19.2)	224,933 (9.7)		140,410 (10.4)	87,826 (9.2)	24,878 (7.4)	4436 (10.1)
Other	6,485,692 (9.2)	106,386 (4.6)		62,219 (4.6)	44,019 (4.6)	12,401 (3.7)	2485 (5.7)
Unknown	11,839,605 (16.7)	301,652 (13.0)		197,938 (14.7)	88,676 (9.3)	41,726 (12.4)	5132 (11.7)

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(continued)

TABLE 1
Characteristics of the study population by maternal mental health conditions *(continued)*

Characteristic	No mental health condition	≥1 mental health condition	Absolute SMD (%)	Depressive disorder	Anxiety disorder	Bipolar spectrum disorder	Schizophrenia spectrum disorder
Maternal age (y)			0.09 (9.5)				
15–19	6,203,875 (8.8)	155,456 (6.7)		90,872 (6.7)	44,848 (4.7)	38,701 (11.5)	2900 (6.6)
20–24	16,562,553 (23.4)	502,983 (21.7)		292,211 (21.6)	182,138 (19.0)	99,943 (29.8)	10,618 (24.2)
25–29	19,756,191 (27.9)	644,836 (27.8)		372,700 (27.6)	274,046 (28.6)	92,394 (27.5)	12,015 (27.4)
30–34	17,663,422 (25.0)	609,675 (26.3)		352,557 (26.1)	279,549 (29.2)	66,079 (19.7)	10,096 (23.0)
35–39	8,642,675 (12.2)	324,633 (14.0)		193,868 (14.4)	144,273 (15.1)	31,380 (9.4)	6218 (14.2)
40–54	1,964,113 (2.8)	79,378 (3.4)		48,136 (3.6)	34,000 (3.6)	7270 (2.2)	1984 (4.5)
Payer			0.18 (18.2)				
Medicare	359,740 (0.5)	63,534 (2.7)		24,715 (1.8)	20,001 (2.1)	25,873 (7.7)	8234 (18.8)
Medicaid	29,129,665 (41.2)	1,046,657 (45.2)		601,909 (44.6)	388,379 (40.5)	211,583 (63.0)	28,909 (66.0)
Private insurance	36,999,629 (52.3)	1,099,003 (47.4)		658,246 (48.8)	508,340 (53.0)	83,993 (25.0)	4565 (10.4)
Self-pay	2,204,548 (3.1)	35,006 (1.5)		21,554 (1.6)	11,722 (1.2)	5031 (1.5)	1049 (2.4)
No charge	132,557 (0.2)	1739 (0.1)		1194 (0.1)	463 (0.1)	219 (0.1)	53 (0.1)
Other	1,849,446 (2.6)	66,806 (2.9)		40,051 (3.0)	28,386 (3.0)	8510 (2.5)	950 (2.2)
Unknown	117,243 (0.2)	4216 (0.2)		2674 (0.2)	1563 (0.2)	557 (0.2)	70 (0.2)
ZIP code income quartile			0.12 (11.7)				
Income quartile 1	16,795,415 (23.7)	567,003 (24.5)		319,995 (23.7)	213,356 (22.3)	112,012 (33.36)	19,859 (45.3)
Income quartile 2	17,088,172 (24.1)	596,338 (25.7)		351,565 (26.0)	241,370 (25.2)	92,059 (27.42)	10,807 (24.7)
Income quartile 3	17,203,549 (24.3)	597,970 (25.8)		355,531 (26.3)	255,547 (26.7)	74,786 (22.27)	7445 (17.0)
Income quartile 4	18,583,607 (26.3)	524,499 (22.6)		305,388 (22.6)	238,438 (24.9)	51,102 (15.22)	4266 (9.7)
Unknown	1,122,085 (1.6)	31,151 (1.3)		17,865 (1.3)	10,142 (1.1)	5808 (1.73)	1453 (3.3)
Chronic health conditions							
Any chronic condition	6,365,283 (9.0)	710,224 (30.7)	0.56 (56.5)	398,585 (29.5)	309,514 (32.3)	133,559 (39.8)	18,882 (43.1)
Obesity	2,739,204 (3.9)	268,793 (11.6)	0.29 (29.3)	155,359 (11.5)	127,865 (13.3)	40,321 (12.0)	5128 (11.7)
Pregestational diabetes mellitus	617,971 (0.8)	46,391 (2.0)	0.10 (9.5)	27,461 (2.0)	17,347 (1.8)	8466 (2.5)	1978 (4.5)
Chronic hypertension	928,905 (1.4)	77,884 (3.4)	0.14 (13.6)	43,523 (3.2)	35,174 (3.7)	11,923 (3.6)	2134 (4.9)
Asthma	1,939,919 (2.7)	281,724 (12.2)	0.36 (36.5)	157,629 (11.7)	122,507 (12.8)	54,659 (16.3)	6457 (14.7)
Substance use	880,212 (1.2)	191,346 (8.3)	0.33 (33.4)	100,232 (7.4)	76,924 (8.0)	53,244 (15.9)	9045 (20.6)

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TABLE 1
Characteristics of the study population by maternal mental health conditions *(continued)*

Characteristic	No mental health condition	≥1 mental health condition	Absolute SMD (%)	Depressive disorder	Anxiety disorder	Bipolar spectrum disorder	Schizophrenia spectrum disorder
Hospital factors							
Hospital location			0.22 (22.0)				
Rural	7,904,971 (11.1)	246,221 (10.6)		148,411 (11.0)	91,867 (9.6)	38,794 (11.6)	3735 (8.5)
Urban nonteaching	26,830,713 (37.9)	642,894 (27.8)		378,010 (28.0)	241,625 (25.2)	95,718 (28.5)	9130 (20.8)
Urban teaching	35,836,071 (50.6)	1,421,488 (61.4)		819,987 (60.7)	623,820 (65.1)	200,071 (59.6)	30,791 (70.3)
Missing	221,073 (0.31)	6359 (0.27)		3936 (0.3)	1542 (0.2)	1184 (0.4)	173 (0.4)
Region			0.18 (18.4)				
Northeast	11,412,668 (16.1)	455,756 (19.7)		263,348 (19.5)	195,949 (20.4)	63,384 (18.9)	7537 (17.2)
Midwest	14,954,227 (21.1)	607,806 (26.2)		376,462 (27.9)	241,379 (25.2)	84,913 (25.3)	9944 (22.7)
South	26,921,560 (38.0)	743,078 (32.1)		407,669 (30.2)	307,052 (32.0)	124,357 (37.0)	17,604 (40.2)
West	17,504,374 (24.7)	510,321 (22.0)		302,865 (22.4)	214,474 (22.4)	63,113 (18.8)	8744 (20.0)

Data are presented as number (percentage), unless otherwise indicated. SMD was calculated for comparison of 0 vs ≥1 mental health condition. Demographic, chronic health conditions, and hospital factors differed significantly based on the presence or absence of a mental health condition ($P<.01$) based on modified Rao-Scott chi-square test.

SMD, standardized mean difference; *ZIP*, Zone Improvement Plan.

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from lower ZIP code income quartiles compared with women from higher ZIP code income quartiles (SMD, 11.7%) (Table 1). Moreover, deliveries occurring at urban teaching hospitals (SMD, 22.0% for hospital location) and in the Northeast (SMD, 18.4% for region) were more likely to be associated with mental health condition diagnoses.

Compared with deliveries without a mental health condition diagnosis, deliveries with mental health conditions diagnoses were more likely to be associated with ≥1 chronic health condition (30.7% vs 9.0%; SMD, 56.5%) (Figures 2 and 3). Deliveries with a mental health conditions diagnosis were more likely to be associated with obesity (11.6% vs 3.9%; SMD, 29.3%), pregestational diabetes mellitus (2.0% vs 0.8%; SMD, 9.5%), chronic hypertension (3.4% vs 1.4%; SMD, 13.6%), asthma (12.2% vs 2.7%; SMD, 36.5%), and substance abuse (8.3% vs 1.2%) (Table 1). Among deliveries with a mental health condition diagnosis, the proportion of deliveries with a chronic health condition increased from 14.9% in 2000 to 38.5% in 2018 (Figure 2). In comparison, among deliveries without a mental health condition diagnosis, the proportion of deliveries with a chronic health condition increased from 3.6% in 2000 to 17.5% in 2018 (Figure 3).

In unadjusted analyses, a mental health condition diagnosis was associated with an increased risk of all adverse maternal outcomes (Table 2; Supplemental Table 2). These associations retained significance after adjustment. In adjusted analyses, mental health condition diagnoses were associated with an increased risk of nontransfusion severe maternal morbidity (aRR, 1.54; 95% CI, 1.52−1.56), preeclampsia and gestational hypertension (aRR, 1.51; 95% CI, 1.50−1.52), preterm delivery (aRR, 1.32; 95% CI, 1.31−1.32), postpartum hemorrhage (aRR, 1.34; 95% CI, 1.33−1.35), and cesarean delivery (aRR, 1.18; 95% CI, 1.18−1.19).

In the stratified analyses for severe maternal morbidity, chronic health conditions were associated with a higher risk of severe maternal morbidity when mental health disorder diagnoses were

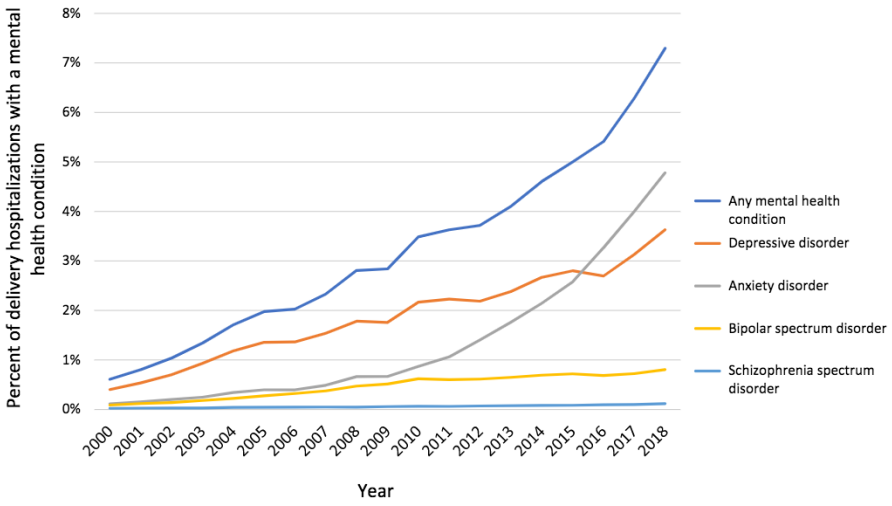
present (Table 3). The unadjusted risk associated with severe maternal morbidity was higher for asthma (RR, 1.17 [95% CI, 1.13–1.21] vs 1.72 [95% CI, 1.69–1.74]), chronic hypertension (RR, 1.64 [95% CI, 1.56–1.73] vs 1.98 [95% CI, 1.94–2.01]), pregestational diabetes mellitus (RR, 2.44 [95% CI, 2.31–2.58] vs 2.77 [95% CI, 2.72–2.82]), obesity (RR, 1.54 [95% CI, 1.50–1.59] vs 1.96 [95% CI, 1.95–1.99]), and substance abuse (RR, 1.39 [95% CI 1.34–1.44] vs 1.79 [95% CI, 1.76–1.83]) among deliveries with mental health disorder diagnoses. The increased risks of adverse outcomes associated with chronic health conditions in the setting of mental health disorder diagnoses were retained in the adjusted analyses.

Discussion

Main findings

In this serial cross-sectional study, there were 4 main findings. The first main finding was that the proportion of delivery hospitalizations with ≥1 mental health condition diagnosis increased >10-fold throughout the study period from 2000 to 2018. Although most of this increase was because of increased diagnoses of anxiety disorder and depressive disorder, findings noted by previous studies,[19,20] bipolar and schizophrenia spectrum disorder diagnoses also increased significantly throughout the study period. The second main finding was that mental health condition diagnoses were associated with a modestly increased risk of a range of adverse maternal and obstetrical outcomes. The third main finding was that mental health conditions were increasingly associated with underlying chronic health conditions, such that nearly 40% of hospitalizations with a mental health condition diagnosis had a diagnosis of pregestational diabetes mellitus, obesity, chronic hypertension, asthma, or substance abuse by the end of the study period. The fourth main finding was that in the setting of mental health condition diagnoses, underlying health conditions were associated with a greater magnitude of risk of severe maternal morbidity.

FIGURE 1
Proportion of deliveries with a mental health condition by year



The figure demonstrates the proportion of delivery hospitalizations with a mental health condition by year. The AAPC rates were as follows: 11.4% (95% CI, 10.3–12.6) for any mental health condition, 9.1% (95% CI, 7.6–10.5) for depressive disorder, 22.5% (95% CI, 21.7–23.3) for anxiety disorder, 9.5% (95% CI, 7.2–11.9) for bipolar spectrum disorder, and 8.3% (95% CI, 7.7–9.0) for schizophrenia spectrum disorder.

AAPC, average annual percent change; *CI*, confidence interval.

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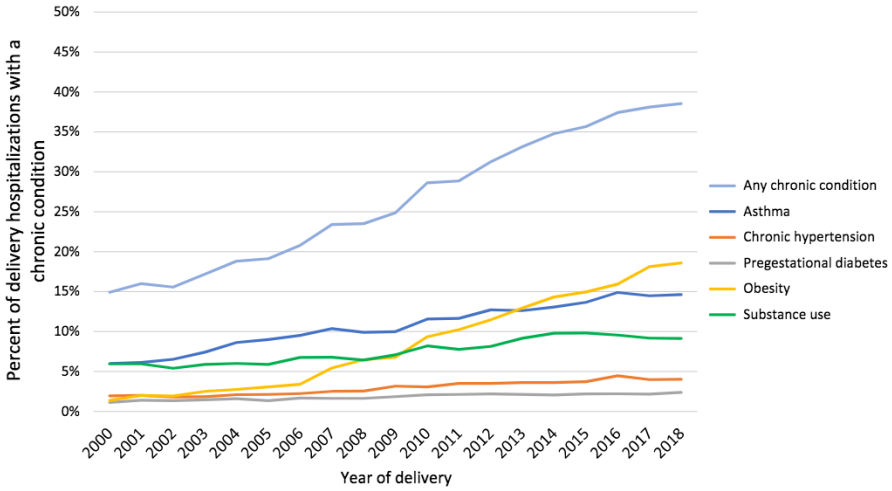
FIGURE 2
Chronic conditions among deliveries with mental health condition diagnoses



The figure demonstrates the proportion of delivery hospitalizations with a chronic condition among women with a mental health condition diagnosis by year. The AAPC rates were as follows: 5.4% (95% CI, 4.9–6.0) for any chronic condition, 4.3% (95% CI, 3.8–4.9) for asthma, 4.9% (95% CI, 4.0–5.9) for chronic hypertension, 3.1% (95% CI, 2.4–3.9) for pregestational diabetes mellitus, 12.5% (95% CI, 10.7–14.3) for obesity, and 3.4% (95% CI, 2.6–4.2) for substance use.

AAPC, average annual percent change; *CI*, confidence interval.

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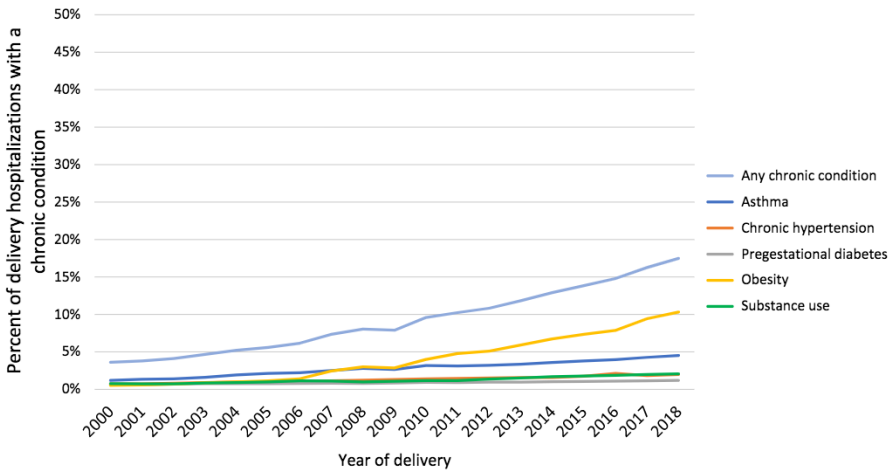
FIGURE 3
Chronic conditions among deliveries without mental health condition diagnose



The figure demonstrates the proportion of delivery hospitalizations with a chronic condition among women without a mental health condition by year. The AAPC rates were as follows: 9.2% (95% CI, 8.8—9.6) for any chronic condition, 6.8% (95% CI, 6.0—7.6) for asthma, 5.8% (95% CI, 5.3—6.3) for chronic hypertension, 3.4% (95% CI, 3.1—3.7) for pregestational diabetes mellitus, 16.7% (95% CI, 14.8—18.6) for obesity, and 6.2% (95% CI, 5.5—6.9).

AAPC, average annual percent change; *CI*, confidence interval.

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Clinical interpretation

The relationship between mental health conditions and other underlying health conditions is complex and multidirectional,[40,41] and causation cannot be inferred from our study given the cross-sectional data source. However, findings from this analysis supported that mental health conditions are of increasing clinical significance in the obstetrical population as they are becoming more prevalent in absolute terms and in relation to other chronic conditions. The increased risk from conditions such as chronic hypertension, pregestational diabetes mellitus, obesity, substance abuse, and asthma that was seen in the setting of mental health condition diagnoses may be a consequence of mental health conditions functioning as an obstacle to disease-specific optimal care, which may indicate a need for more intensive surveillance and management during pregnancy. Moreover, mental health conditions may be associated with poorer preconceptional healthcare as patients with these diagnoses may be less likely to access optimal nonobstetrical medical care.[42,43] Finally, it is possible that untreated or inadequately treated mental health disorders contribute to chronic health conditions through multisystem dysregulation (via the hypothalamic-pituitary-adrenal axis and immune functioning) and compromised lifestyle factors (including diet, sleep, and physical exercise).[44,45] Further research is needed to determine to what degree the prevalence of and risk associated with mental health condition conditions are associated with social determinants of health and other complicated exposures.

Although available evidence supports screening for mental health conditions in pregnancy, the optimal timing and frequency of screening have not yet been established.[46] The American College of Obstetricians and Gynecologists recommends screening for depression and anxiety symptoms at least once perinatally and once after birth, with the initiation of treatment or referral to mental health services for women who screen positive for mental health conditions.[47] The American Psychiatric Association supports screening for mood and anxiety disorders at least twice during pregnancy and bipolar disorder at least once.[48] Mental health conditions are underdiagnosed and undertreated in pregnancy,[49,50] and optimization of screening, diagnosis, and management before and during pregnancy could improve maternal outcomes. Further research is needed to determine to what

TABLE 2
Unadjusted and adjusted risks of adverse outcomes in the setting of a maternal mental health condition

Outcome	RR (95% CI)	Adjusted RR (95% CI)
Adverse outcomes		
Severe maternal morbidity excluding transfusion	1.88 (1.86—1.90)	1.54 (1.52—1.56)
Preeclampsia and gestational hypertension	1.59 (1.58—1.60)	1.51 (1.50—1.52)
Preterm delivery	1.35 (1.35—1.36)	1.32 (1.31—1.32)
Postpartum hemorrhage	1.37 (1.36—1.38)	1.34 (1.33—1.35)
Cesarean delivery	1.20 (1.20—1.20)	1.18 (1.18—1.19)
Maternal death	1.32 (1.12—1.56)	N/A

Estimates in the table demonstrate risks in the presence vs absence of a maternal mental health condition. All adjusted models include maternal age, race, payer, ZIP code income quartile, and hospital location and region. In addition, adjusted models for severe maternal morbidity include presence of chronic comorbidities (asthma, pregestational diabetes mellitus, chronic hypertension, obesity, and/or substance use). Adjusted analyses were not performed for maternal death given the small numerators involved.

CI, confidence interval; *N/A*, not available; *RR*, risk ratio; *ZIP*, Zone Improvement Plan.

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degree improved identification and management of these conditions mitigate maternal and obstetrical risks.

Strengths and limitations

This study was subject to several limitations. First, our analysis was based on administrative hospital discharge data only; the NIS does not capture information on other healthcare encounters, such as outpatient, hospital, or emergency department visits. We could not assess the management of mental health conditions during pregnancy, including prescription of medications or psychotherapy, and we could not comment on their severity or whether management was successful. Second, the unit of analysis in the NIS was acute care hospitalizations.[51] We could not account for multiple delivery hospitalizations to individual women in our modeling. Third, given the cross-sectional nature of the data, we could not make causal inferences about the association between mental health and chronic conditions or between mental health conditions and adverse outcomes. Fourth, concerns related to administrative data included under ascertainment and misclassification. We could not exclude the possibility that, to some degree, mental health conditions may be more "risk markers" that cluster with morbidity and mortality-associated demographic and chronic conditions rather than risk factors in and of themselves. Fifth, billing diagnoses do not include granular clinical details and criteria related to diagnoses. Given this lack of detail, we were limited inferentially in determining to what degree increased diagnoses were associated with truly increased prevalence of mental health disorders vs better ascertainment throughout the study period. An increase in the diagnoses throughout the study period may be secondary to improved ascertainment. For the same reason, we were limited in interpreting our finding that delivery hospitalizations were more likely to be associated with mental health conditions in non-Hispanic White women than in non-Hispanic Black women (similar to previous analyses in the NIS[19]), whereas other studies have shown higher screen-positive rates of mental health conditions among pregnant non-Hispanic Black women.[52,53] For a significant proportion of the population, race was unknown, limiting inference related to race. Sixth, the study period of analysis included 2 major changes in the NIS database, the first consisting of a change in the sampling approach in 2012 and the second a change in diagnosis and procedure coding in 2015.[22] These study limitations supported the importance of further research to characterize trends in the prevalence of psychiatric diseases during pregnancy and associated risks and the complex role of social determinants of health.

Study strengths included the use of a database specifically designed to produce national estimates and analyze temporal trends, a long study interval that allowed us to ascertain trends over time, and contemporary data through 2018. In addition, our analysis was powered to detect associations among mental health conditions, chronic conditions, and a range of adverse outcomes, including rare complications. Furthermore, these findings were compatible with other large recent analyses, demonstrating a nearly 50% increase in mental health conditions among reproductive women aged 18 to 34 years from 2013 to 2016.[54]

TABLE 3
Stratified analyses for severe morbidity based on the presence or absence of a maternal mental health condition

Variable	Maternal mental health condition absent RR (95% CI)	Maternal mental health condition present RR (95% CI)
Risk factor		
Asthma	1.17 (1.13–1.21)	1.72 (1.69–1.74)
Chronic hypertension	1.64 (1.56–1.73)	1.98 (1.94–2.01)
Pregestational diabetes mellitus	2.44 (2.31–2.58)	2.77 (2.72–2.82)
Obesity	1.54 (1.50–1.59)	1.97 (1.95–1.99)
Substance use	1.39 (1.34–1.44)	1.79 (1.76–1.83)
	Adjusted RR (95% CI)	Adjusted RR (95% CI)
Risk factor		
Asthma	1.10 (1.07–1.14)	1.58 (1.55–1.60)
Chronic hypertension	1.27 (1.21–1.34)	1.50 (1.48–1.53)
Pregestational diabetes mellitus	1.91 (1.81–2.02)	2.23 (2.19–2.27)
Obesity	1.36 (1.31–1.40)	1.70 (1.68–1.72)
Substance use	1.27 (1.22–1.32)	1.63 (1.60–1.66)

Adjusted models were performed stratified for the presence or absence of maternal mental health conditions. Both adjusted models include maternal age, maternal race, payer, ZIP code income quartile, hospital location and region, and 5 chronic health conditions (asthma, chronic hypertension, pregestational diabetes mellitus, obesity, and substance abuse).

CI, confidence interval; *RR*, risk ratio; *ZIP*, Zone Improvement Plan.

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Conclusion

This study found that the proportion of delivery hospitalizations of women with mental health condition diagnoses has increased significantly. Mental health condition diagnoses were associated with other underlying chronic health conditions and a modestly increased risk of a range of adverse outcomes. In the setting of mental health condition diagnoses, underlying health conditions were associated with a greater magnitude of risk of severe maternal morbidity. These findings suggested that mental health conditions are an increasingly

important risk factor in adverse maternal and obstetrical outcomes. ■

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Author and article information

From the Department of Obstetrics and Gynecology, Columbia University Irving Medical Center, New York, NY (Ms Logue and Drs Monk, Huang, Wright, D'Alton, and Friedman); Department of Obstetrics and Gynecology, University of California San Francisco, San Francisco, CA (Dr Wen); New York State Psychiatric Institute, New York, NY (Dr Monk); and Department of Anesthesiology, Columbia University Irving Medical Center, New York, NY (Dr Guglielminotti).

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Corresponding author: Alexander M. Friedman, MD, MPH. amf2104@cumc.columbia.edu

SUPPLEMENTAL TABLE 1
Diagnosis and procedure codes used in the analysis

Variable	ICD-9-CM	ICD-10-CM
Comorbid medical and obstetrical factors		
Obesity	278.x, 649.x, 793.91, V85.3x, V85.4x, V85.5x	09122x, Z683x, Z684x, E660, E6601, E6609, E661, E662, E668, E669
Pregestational diabetes mellitus	249.x–250.x, 648.0x, excluding 648.8x	E0800, E0801, E0810, E0811, E0821, E0822, E0829, E08311, E08319, E083211, E083212, E083213, E083219, E083291, E083292, E083293, E083299, E083311, E083312, E083313, E083319, E083391, E083392, E083393, E083399, E083411, E083412, E083413, E083419, E083491, E083492, E083493, E083499, E083511, E083512, E083513, E083519, E083521, E083522, E083523, E083529, E083531, E083532, E083533, E083539, E083541, E083542, E083543, E083549, E083551, E083552, E083553, E083559, E083591, E083592, E083593, E083599, E0836, E0837X1, E0837X2, E0837X3, E0837X9, E0839, E0840, E0841, E0842, E0843, E0844, E0849, E0851, E0852, E0859, E08610, E08618, E08620, E08621, E08622, E08628, E08630, E08638, E08641, E08649, E0865, E0869, E088, E089, E0900, E0901, E0910, E0911, E0921, E0922, E0929, E09311, E09319, E093211, E093212, E093213, E093219, E093291, E093292, E093293, E093299, E093311, E093312, E093313, E093319, E093391, E093392, E093393, E093399, E093411, E093412, E093413, E093419, E093491, E093492, E093493, E093499, E093511, E093512, E093513, E093519, E093521, E093522, E093523, E093529, E093531, E093532, E093533, E093539, E093541, E093542, E093543, E093549, E093551, E093552, E093553, E093559, E093591, E093592, E093593, E093599, E0936, E0937X1, E0937X2, E0937X3, E0937X9, E0939, E0940, E0941, E0942, E0943, E0944, E0949, E0951, E0952, E0959, E09610, E09618, E09620, E09621, E09622, E09628, E09630, E09638, E09641, E09649, E0965, E0969, E098, E099, E1010, E1011, E1021, E1022, E1029, E10311, E10319, E103211, E103212, E103213, E103219, E103291, E103292, E103293, E103299, E103311, E103312, E103313, E103319, E103391, E103392, E103393, E103399, E103411, E103412, E103413, E103419, E103491, E103492, E103493, E103499, E103511, E103512, E103513, E103519, E103521, E103522, E103523, E103529, E103531, E103532, E103533, E103539, E103541, E103542, E103543, E103549, E103551, E103552, E103553, E103559, E103591, E103592, E103593, E103599, E1036, E1037X1, E1037X2, E1037X3, E1037X9, E1039, E1040, E1041, E1042, E1043, E1044, E1049, E1051, E1052, E1059, E10610, E10618, E10620, E10621, E10622, E10628, E10630, E10638, E10641, E10649, E1065, E1069, E108, E109, E1100, E1101, E1110, E1111, E1121, E1122, E1129, E11311, E11319, E113211, E113212, E113213, E113219, E113291, E113292, E113293, E113299, E113311, E113312, E113313, E113319, E113391, E113392, E113393, E113399, E113411, E113412, E113413, E113419, E113491, E113492, E113493, E113499, E113511, E113512, E113513, E113519, E113521, E113522, E113523, E113529, E113531, E113532, E113533,

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SUPPLEMENTAL TABLE 1
Diagnosis and procedure codes used in the analysis *(continued)*

Variable	ICD-9-CM	ICD-10-CM
		E113539, E113541, E113542, E113543, E113549, E113551, E113552, E113553, E113559, E113591, E113592, E113593, E113599, E1136, E1137X1, E1137X2, E1137X3, E1137X9, E1139, E1140, E1141, E1142, E1143, E1144, E1149, E1151, E1152, E1159, E11610, E11618, E11620, E11621, E11622, E11628, E11630, E11638, E11641, E11649, E1165, E1169, E118, E119, E1300, E1301, E1310, E1311, E1321, E1322, E1329, E13311, E13319, E133211, E133212, E133213, E133219, E133291, E133292, E133293, E133299, E133311, E133312, E133313, E133319, E133391, E133392, E133393, E133399, E133411, E133412, E133413, E133419, E133491, E133492, E133493, E133499, E133511, E133512, E133513, E133519, E133521, 133522, E133523, E133529, E133531, E133532, E133533, E133539, E133541, E133542, E133543, E133549, E133551, E133552, E133553, E133559, E133591, E133592, E133593, E133599, E1336, E1337X1, E1337X2, E1337X3, E1337X9, E1339, E1340, E1341, E1342, E1343, E1344, E1349, E1351, E1352, E1359, E13610, E13618, E13620, E13621, E13622, E13628, E13630, E13638, E13641, E13649, E1365, E1369, E138, E139, 024011, 024012, 024013, 02402, 02403, 024111, 024112, 024113, 02412, 02413, 024311, 024312, 024313, 02432, 02433, 024811, 024812, 024813, 02482, 02483, 024911, 024912, 024913, 02492, 02493
Chronic hypertension	401.xx—405.xx, 642.xx (excluding 642.3x, 642.4x, 642.5x, 642.7x)	I10, I110, I119, I120, I129, I130, I1310, I1311, I132, I150, I151, I152, I158, I159, I160, I161, I169, N262, O10011, O10012, O10013, O10019, 01002, 01003, 010111, 010112, 010113, 010119, 01012, 01013, 010211, 010212, 010213, 010219, 01022, 01023, 010311, 010312, 010313, 010319, 01032, 01033, 010411, 010412, 010413, 010419, 01042, 01043, 010911, 010912, 010913, 010919, 01092, 01093, 0111, 0112, 0113, 0114, 0115, 0119
Asthma	493.x	J45.x
Substance abuse	30303, 30393, 30503, 2910, 2911, 2912, 2913, 2914, 2915, 29181, 29182, 29189, 2919, 30300, 30301, 30302, 30390, 30391, 30392, 30500, 30501, 30502, 30403, 30473, 30553, 30400, 30401, 30402, 30470, 30471, 30472, 30550, 30551, 30552, 30423, 30563, 30420, 30421, 30422, 30560, 30561, 30562, 30433, 30523, 30430, 30431, 30432, 30520, 30521, 30522, 30413, 30443, 30453, 30463, 30483, 30493, 30533, 30543, 30573, 30583, 30593, 2920, 29211, 29212, 2922, 29281, 29282, 29283, 29284, 29289, 2929, 30410, 30411, 30412, 30440, 30441, 30442, 30450, 30451, 30452, 30460, 30461, 30462, 30480, 30481, 30482, 30490, 30491, 30492, 30530, 30531, 30532, 30540, 30541, 30542, 30570, 30571, 30572, 30580, 30581, 30582, 30590, 30591, 30592	F1021, F1010, F10120, F10121, F10129, F1014, F10150, F10151, F10159, F10180, F10181, F10182, F10188, F1019, F1020, F10220, F10221, F10229, F10230, F10231, F10232, F10239, F1024, F10250, F10251, F10259, F1026, F1027, F10280, F10281, F10282, F10288, F1029, F10920, F10921, F10929, F1094, F10950, F10951, F10959, F1096, F1097, F10980, F10981, F10982, F10988, F1099, F1121, F1110, F11120, F11121, F11122, F11129, F1114, F11150, F11151, F11159, F11181, F11182, F11188, F1119, F1120, F11220, F11221, F11222, F11229, F1123, F1124, F11250, F11251, F11259, F11281, F11282, F11288, F1129, F1190, F11920, F11921, F11922, F11929, F1193, F1194, F11950, F11951, F11959, F11981, F11982, F11988, F1199, F1421, F1410, F14120, F14121, F14122, F14129, F1414, F14150, F14151, F14159, F14180, F14181, F14182, F14188, F1419, F1420, F14220, F14221, F14222, F14229, F1423, F1424, F14250,

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SUPPLEMENTAL TABLE 1
Diagnosis and procedure codes used in the analysis *(continued)*

Variable	ICD-9-CM	ICD-10-CM
		F14251, F14259, F14280, F14281, F14282, F14288, F1429, F1490, F14920, F14921, F14922, F14929, F1494, F14950, F14951, F14959, F14980, F14981, F14982, F14988, F1499, F1221, F1210, F12120, F12121, F12122, F12129, F12150, F12151, F12159, F12180, F12188, F1219, F1220, F12220, F12221, F12222, F12229, F12250, F12251, F12259, F12280, F12288, F1229, F1290, F12920, F12921, F12922, F12929, F12950, F12951, F12959, F12980, F12988, F1299, F1321, F1521, F1621, F1821, F1921, F1310, F13120, F13121, F13129, F1314, F13150, F13151, F13159, F13180, F13181, F13182, F13188, F1319, F1320, F13220, F13221, F13229, F13230, F13231, F13232, F13239, F1324, F13250, F13251, F13259, F1326, F1327, F13280, F13281, F13282, F13288, F1329, F1390, F13920, F13921, F13929, F13930, F13931, F13932, F13939, F1394, F13950, F13951, F13959, F1396, F1397, F13980, F13981, F13982, F13988, F1399, F1510, F15120, F15121, F15122, F15129, F1514, F15150, F15151, F15159, F15180, F15181, F15182, F15188, F1519, F1520, F15220, F15221, F15222, F15229, F1523, F1524, F15250, F15251, F15259, F15280, F15281, F15282, F15288, F1529, F1590, F15920, F15921, F15922, F15929, F1593, F1594, F15950, F15951, F15959, F15980, F15981, F15982, F15988, F1599, F1610, F16120, F16121, F16122, F16129, F1614, F16150, F16151, F16159, F16180, F16183, F16188, F1619, F1620, F16220, F16221, F16229, F1624, F16250, F16251, F16259, F16280, F16283, F16288, F1629, F1690, F16920, F16921, F16929, F1694, F16950, F16951, F16959, F16980, F16983, F16988, F1699, F1810, F18120, F18121, F18129, F1814, F18150, F18151, F18159, F1817, F18180, F18188, F1819, F1820, F18220, F18221, F18229, F1824, F18250, F18251, F18259, F1827, F18280, F18288, F1829, F1890, F18920, F18921, F18929, F1894, F18950, F18951, F18959, F1897, F18980, F18988, F1899, F1910, F19120, F19121, F19122, F19129, F1914, F19150, F19151, F19159, F1916, F1917, F19180, F19181, F19182, F19188, F1919, F1920, F19220, F19221, F19222, F19229, F19230, F19231, F19232, F19239, F1924, F19250, F19251, F19259, F1926, F1927, F19280, F19281, F19282, F19288, F1929, F1990, F19920, F19921, F19922, F19929, F19930, F19931, F19932, F19939, F1994, F19950, F19951, F19959, F1996, F1997, F19980, F19981, F19982, F19988, F1999
Adverse outcomes		
Preeclampsia and gestational hypertension	642.3x, 642.4x, 642.5x, 642.7x	0141x, 0142x, 0150x, 0140x, 0149x, 013x, 011x
Preterm delivery	644.2x	0601xXx, 0600x, 0470x
Postpartum hemorrhage	666.x	072x

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SUPPLEMENTAL TABLE 1
Diagnosis and procedure codes used in the analysis *(continued)*

Variable	ICD-9-CM	ICD-10-CM
Cesarean delivery	669.7x	10D00Z0, 10D00Z1, 10D00Z2
Mental health conditions		
Anxiety disorder	30000, 30001, 30002, 30009, 30020, 30021, 30022, 30023, 30029, 3003, 30921, 30924, 30981	F4000, F4001, F4002, F4010, F4011, F40210, F40218, F40220, F40228, F40230, F40231, F40232, F40233, F40240, F40241, F40242, F40243, F40248, F40290, F40291, F40298, F408, F409, F410, F411, F413, F418, F419, F42, F422, F423, F424, F428, F429, F4310, F4311, F4312, F4322, F930
Bipolar spectrum disorder	29600, 29601, 29602, 29603, 29604, 29605, 29606, 29610, 29611, 29612, 29613, 29614, 29615, 29616, 29640, 29641, 29642, 29643, 29644, 29645, 29646, 29650, 29651, 29652, 29653, 29654, 29655, 29656, 29660, 29661, 29662, 29663, 29664, 29665, 29666, 2967, 29680, 29681, 29689, 30111	F3010, F3011, F3012, F3013, F302, F303, F304, F308, F309, F310, F3110, F3111, F3112, F3113, F312, F3130, F3131, F3132, F314, F315, F3160, F3161, F3162, F3163, F3164, F3170, F3171, F3172, F3173, F3174, F3175, F3176, F3177, F3178, F3181, F3189, F319, F340
Depressive disorder	29620, 29621, 29622, 29623, 29624, 29625, 29626, 29630, 29631, 29632, 29633, 29634, 29635, 29636, 29682, 2980, 3004, 30112, 30113, 3090, 3091, 30928, 311	F320, F321, F322, F323, F324, F325, F328, F329, F330, F331, F332, F333, F3340, F3341, F3342, F338, F339, F341, F4321, F4323
Schizophrenia spectrum disorder	29500, 29501, 29502, 29503, 29504, 29505, 29510, 29511, 29512, 29513, 29514, 29515, 29520, 29521, 29522, 29523, 29524, 29525, 29530, 29531, 29532, 29533, 29534, 29535, 29540, 29541, 29542, 29543, 29544, 29545, 29550, 29551, 29552, 29553, 29554, 29555, 29560, 29561, 29562, 29563, 29564, 29565, 29570, 29571, 29572, 29573, 29574, 29575, 29580, 29581, 29582, 29583, 29584, 29585, 29590, 29591, 29592, 29593, 29594, 29595	F200, F201, F202, F203, F205, F2081, F2089, F209, F250, F251, F258, F259

ICD-9-CM and ICD-10-CM codes for severe maternal morbidity were ascertained from the Centers for Disease Control and Prevention available at: https://www.cdc.gov/reproductivehealth/maternalinfanthealth/smm/severe-morbidity-ICD.htm

ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; *ICD-10*, International Classification of Diseases, Tenth Revision, Clinical Modification.

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SUPPLEMENTAL TABLE 2
Outcomes by presence or absence of maternal mental health conditions

Outcome	No mental health condition, n (%)	Maternal mental health condition, n (%)
Adverse outcomes		
Severe maternal morbidity	472,113 (0.67)	29,037 (1.25)
Preeclampsia and gestational hypertension	5,349,129 (7.56)	278,500 (12.02)
Preterm delivery	4,611,737 (6.51)	204,312 (8.82)
Postpartum hemorrhage	2,089,095 (2.95)	93,402 (4.03)
Cesarean delivery	21,712,537 (30.67)	852,773 (36.81)
Maternal death	3448 (0.005%)	149 (0.006)

Severe maternal morbidity was based on a composite from the Centers for Disease Control and Prevention, excluding transfusion.
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