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Postpartum Psychosis during Delivery Hospitalizations and Postpartum Readmissions, 2016-2019

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IRB   Given that this study involved a de-identified and publicly available dataset, the Institutional Review Board review by both Columbia University and the University of California, San Francisco deemed this exempt from review.

Condensation

Postpartum psychosis is increasing during postpartum readmissions and associated with a wide range of obstetric and medical comorbidities.

AJOG at a Glance

A. Why was the study conducted?

To determine trends in and risk factors for postpartum psychosis during delivery hospitalizations and postpartum readmissions.

B. What are the key findings?

Readmissions with postpartum psychosis increased significantly over the study period and were associated with a broad range of mental health and medical conditions.

C. What does the study add to what is already known?

Postpartum psychosis is increasing during postpartum readmissions and associated with a wide range of obstetric and medical comorbidities.

ABSTRACT

BACKGROUND: Up-to-date data on population-level risk factors for postpartum psychosis is limited though increasing substance use disorders, psychiatric disorders, autoimmune disorders, and other medical comorbidities in the obstetric population may be contributing to increased baseline risk for postpartum psychosis.

OBJECTIVE: To determine trends in and risk factors for postpartum psychosis during delivery hospitalizations and postpartum readmissions.

STUDY DESIGN: Analyzing the 2016-2019 Nationwide Readmission Database, this repeated cross sectional study identified diagnoses of postpartum psychosis during delivery hospitalizations and postpartum readmissions within 60 days of discharge. The relationship between demographic, clinical, and hospital level factors present at delivery and postpartum psychosis was analyzed with logistic regression models with adjusted odds ratios (aORs) with 95% CIs as measures of association. Separate models were created for postpartum psychosis diagnoses at delivery and during a postpartum readmission. Temporal trends in diagnoses were analyzed with joinpoint regression to determine the average annual percent change (AAPC) with 95% CIs.

RESULTS: Of 12,334,506 deliveries in the analysis 13,894 (1.1 per 1000) carried a diagnosis of postpartum psychosis during the delivery hospitalization and 7,128 (0.6 per 1000) had a 60-day postpartum readmission with postpartum psychosis. Readmissions with postpartum psychosis increased significantly over the study period (p=0.046). The majority of readmissions with a postpartum psychosis diagnosis occurred 0-10 days (43% of readmissions) or 11-20 days after discharge (18% of readmissions). Clinical factors with the highest adjusted odds for postpartum psychosis readmission included delivery postpartum psychosis (aOR 5.8, 95% CI 4.2, 8.0),

depression disorder (aOR 3.7, 95% CI 3.3, 4.2), bipolar spectrum disorder (OR 2.9, 95% CI 2.3, 3.5), and schizophrenia spectrum disorder (aOR 2.9, 95% CI 2.1, 4.0). In models analyzing postpartum psychosis diagnoses at delivery, risk factors associated with the highest odds included anxiety disorder (aOR 3.9, 95% CI 3.5, 4.2), schizophrenia spectrum disorder (aOR 2.5, 95% CI 1.9, 3.4), bipolar disorder (aOR 1.8, 95% CI 1.6, 2.1), stillbirth (OR 3.6, 95% CI 3.1, 4.2), and substance use disorder (OR 1.7, 95% CI 1.6, 1.9). Chronic conditions such as pregestational diabetes, obesity, and substance use were also associated with delivery and readmission postpartum psychosis.

CONCLUSION: Postpartum psychosis is increasing during postpartum readmissions and associated with a wide range of obstetric and medical comorbidities. Close follow up care after delivery for other medical and obstetric diagnoses may represent an opportunity to identify postpartum psychiatric conditions including postpartum psychosis.

INTRODUCTION

Postpartum psychosis occurs after approximately 1 per 1000 births[1,2] and is one of the most serious postpartum mental health conditions. Postpartum psychosis carries risk of significant morbidity including hospitalization, increased suicidality, prolonged psychiatric disability, and infanticide.[1] Risk factors for postpartum psychosis include previous mental health condition diagnoses such as bipolar disorder and schizophrenia as well as demographic characteristics.[3] Up-to-date data on population-level risk factors for postpartum psychosis is limited though increasing substance use disorders, psychiatric disorders, autoimmune disorders, and other medical comorbidities in the obstetric population may be contributing to increased baseline risk for postpartum psychosis.[4-8] Given limited recent data, the purpose of this study was to investigate risk factors for postpartum psychosis during delivery hospitalizations and in the two months after delivery.

METHODS

Data Source

The Nationwide Readmissions Database (NRD) from the Healthcare Cost and Utilize Project (HCUP) was used to identify delivery hospitalizations from 2016 to 2019 for this repeated cross-sectional study. The NRD is an all-payer database with data collected on a state level capable of tracking patients across hospital admissions within a state within a given year. The data can be used to create national estimates of readmissions for the insured and uninsured. The NRD includes public and community hospitals and academic medical centers.[9] It has been used

across a wide number of medical and surgical subspecialties to evaluate readmission hospitalizations including within obstetrics.[10-14] Unweighted, the NRD contains data from approximately 18 million hospitalizations a year.[9] Data in the NRD can be weighted to provide national estimate calculations of all patient readmissions and represent approximately 36 million US discharges annually; these weights were used in this analysis. In 2019, 30 geographically dispersed states contributed data to the NRD, accounting for 62% of US residents and 60% of all US hospitalizations.[15]

Study Population

Delivery hospitalizations were identified based on ICD-10-CM diagnosis codes using approaches that ascertain more than 95% of deliveries.[16,17] Women age 15-54 years were included in the analysis. Women with postpartum psychosis were identified based on ICD-10-CM code F53.1. As the primary outcome of the study, we assessed readmission for postpartum psychosis within 60 days of discharge from a delivery hospitalization. As a secondary outcome, we assessed postpartum psychosis diagnoses during the delivery hospitalization. Readmissions were identified using HCUP methodology; the NRD includes patient linkage numbers that identify discharges belonging to the same individual within a given state within the same calendar year. If there was more than one readmission for postpartum psychosis during the first 60 days after delivery hospitalization, only the first readmission was included in the analysis. Because the NRD datasets are year-based and cannot be linked, only delivery hospitalizations with discharge occurring from 1 January through 31 October for each year were included. Delivery hospitalizations during November and December were not included because readmissions for

the subsequent 60 days could not be fully ascertained. To maintain patient privacy cell sizes ≤10 are not reported per the HCUP data use agreement.

Patient and hospital characteristics

Demographic, medical, obstetric and hospital factors available in the NRD possibly associated with readmission for postpartum psychosis and present during the delivery hospitalization were analyzed. Demographic factors included payer information, maternal age (categorized as 15–19, 20–29, 30–34, 35–39, and 40–54 years of age), and median household income quartile based on ZIP code. Hospital factors included hospital bed volume (small, medium, large based on HCUP criteria) and hospital teaching status (metropolitan teaching, non-metropolitan, and metropolitan non-teaching based on HCUP criteria). Obstetric conditions identified using ICD-10-CM codes included: mode of delivery (cesarean delivery versus vaginal delivery), multiple gestation, hypertensive disorders of pregnancy, stillbirth, preterm delivery, and postpartum hemorrhage. Chronic conditions included chronic hypertension, pregestational diabetes, asthma, obesity, autoimmune conditions, psychiatric diagnoses including depressive disorder, anxiety disorder, bipolar spectrum disorder, and schizophrenia spectrum disorder, and substance used disorder including cannabis use disorder, opioid use disorder, alcohol use disorder, cocaine use disorder and other drug use disorders.

Analysis

Analysis of demographic, hospital, and obstetric and medical risk factors were conducted to describe the differences in baseline characteristics between patients with and without

readmissions for postpartum psychosis within 60-days of delivery hospitalization discharge. For these comparisons, we stratified deliveries by presence or absence of readmission with postpartum psychosis and calculated the absolute standardized mean difference (SMD) with a value of >10% considered as a meaningful difference between each subgroup.[23] Time from discharge to readmission was also ascertained and reported. The association between obstetrical factors, chronic conditions, and demographic and hospital factors and readmission was analyzed with unadjusted logistic regression models with unadjusted odds ratios (ORs) with 95% confidence intervals (CI) as measures of association. Multivariable logistic regression models were fit with readmission as the outcome adjusted by the aforementioned obstetrical factors, chronic conditions, and demographic and hospital factors. Measures of association were described using adjusted odds ratios (aORs) with 95% confidence intervals (CI). The analyses were then repeated for the presence of postpartum psychosis diagnoses during the delivery hospitalization. A sensitivity for readmissions with postpartum psychosis was performed excluding deliveries with postpartum psychosis during the delivery hospitalization. Trends analysis for both delivery and readmission postpartum psychosis during the study period (2016-2019) was performed using the National Cancer Institute's Joinpoint Regression Program (version 4.8.0.1).[18,19] This program employs linear segmented regression and logarithmic transformation to determine the average annual percent change (AAPC) with 95% CIs. All analyses were conducted using SAS 9.4 (Cary, NC) and the NCI's Joinpoint Regression Program. We followed the Strengthening the Reporting of Observational Studies in Epidemiology guidelines for cohort studies for this analysis.[24] This study was deemed exempt by the

university institutional review boards given the de-identified and publicly available nature of the data.

RESULTS

From 2016 to 2019, there were an estimated 12,334,506 deliveries included in the analysis of which 13,894 (1.1 per 1000) carried a diagnosis of postpartum psychosis during the delivery hospitalization and 7,128 (0.6 per 1000) had a 60-day postpartum readmission with the diagnosis (**Table 1**). The majority of readmissions with a postpartum psychosis diagnosis occurred 0-10 days (43% of readmissions) or 11-20 days after discharge (18% of readmissions) (**Figure 1**). In adjusted analyses, the associations between many risk factors and readmission postpartum psychosis were of lesser magnitude than in the setting of delivery hospitalization postpartum psychosis.

Demographic characteristics associated with increased risk for readmission with postpartum psychosis included Medicare (OR 5.1, 95% CI 4.1,6.4) and Medicaid (OR 1.8, 95% CI 1.6, 1.9) compared to commercial insurance and lowest compared to highest ZIP code income quartile (OR 1.8, 95% CI 1.6, 2.0) (**Table 2**). Clinical factors associated with postpartum psychosis readmissions included postpartum psychosis at delivery (OR 11.1, 95% CI 8.1, 15.2), schizophrenia spectrum disorder (OR 12.8, 95% CI 9.7, 16.8), bipolar spectrum disorder (OR 6.0, 95% CI 5.1, 7.2), depression disorder (OR 6.5, 95% CI 6.0, 7.1), anxiety disorder (OR 5.1, 95% CI 4.6, 5.5), and substance use disorder (OR 3.2, 95% CI 2.8, 3.6). Medical conditions such as pregestational diabetes, chronic hypertension, asthma, obesity, and autoimmune conditions

and obstetric conditions including hypertensive disorders of pregnancy, stillbirth, preterm delivery, and postpartum hemorrhage were also associated with increased risk.

In adjusted analyses for readmission with postpartum psychosis, increased odds were retained for the above risk factors but generally attenuated. Clinical factors with the highest adjusted odds for postpartum psychosis readmission included delivery postpartum psychosis (aOR 5.8, 95% CI 4.2, 8.0), depression disorder (aOR 3.7, 95% CI 3.3, 4.2), bipolar spectrum disorder (OR 2.9, 95% CI 2.3, 3.5), and schizophrenia spectrum disorder (aOR 2.9, 95% CI 2.1, 4.0). In the sensitivity analysis restricted to deliveries without a postpartum psychosis diagnosis, estimates were similar (**Table 2**).

In models analyzing postpartum psychosis diagnoses at delivery, risk factors associated with the highest odds included anxiety disorder (OR 5.2, 95% CI 4.9, 5.6), depression disorder (OR 3.1, 95% CI 2.8, 3.4), schizophrenia spectrum disorder (OR 8.0, 95% CI 6.2, 10.4), bipolar disorder (OR 4.6, 95% CI 4.0, 5.3), stillbirth (OR 3.9, 95% CI 3.4, 4.5), and substance use disorder (OR 3.0, 95% CI 2.7, 3.3). In adjusted analyses, these associations were attenuated but still present (**Table 2**). Other risk factors associated with delivery postpartum psychosis in adjusted analyses included Medicaid compared to commercial insurance, chronic conditions such as pregestational diabetes, asthma, obesity, and autoimmune conditions, obstetric complications such as postpartum hemorrhage and hypertensive disorders of pregnancy, and cesarean compared to vaginal delivery.

Analyzing trends with the Joinpoint Regression Program, both delivery hospitalizations (AAPC 15.3%, 95% CI -4.7%, 39.5%, p=0.09) and postpartum readmissions with postpartum

psychosis (AAPC 8.6%, 95% CI 0.4%, 17.4%, p=0.046) increased although the AAPC for only the latter was significant (**Figure 2**).

DISCUSSION

Principal Findings

In this study, postpartum psychosis diagnoses during delivery hospitalizations and readmissions increased between 2016 and 2019 although the average annual percent change was significant only for the latter. Postpartum psychosis was associated with a wide range of medical conditions and obstetrical complications with the largest effects seen for comorbid psychiatric diagnoses such as anxiety disorder, bipolar spectrum disorder, and schizophrenia spectrum disorder.

Results in the Context of What is Known

This analysis demonstrated a wide range of risk factors associated with postpartum psychosis. That postpartum psychosis was associated with traumatic events such as stillbirth and preterm birth as well as conditions such as pre-eclampsia that may represent immune dysregulation suggests that there may be many pathways to this condition. That the diagnosis was associated with low socioeconomic status supports that stressors of poverty may contribute to psychiatric morbidity.[20,21] Some associations may be due to unmeasured confounding. The association with Medicare insurance may be secondary to Medicare eligibility criteria for this population which includes underlying disability from a range of conditions that may be associated with the outcome.

Clinical Implications

While postpartum psychosis was associated with a wide range of demographic, obstetrical, and medical risk factors, postpartum psychosis diagnoses were rare, and increased odds associated with individual risk factors were generally modest. Given these epidemiologic characteristics, only small absolute risks for postpartum psychosis can be attributed to individual risk factors which in turn are unlikely to be useful in identifying patients at high risk for the diagnosis. That many of the diagnoses associated with postpartum psychosis are associated with other adverse delivery and postpartum complications does support closer follow up for these patients in the first weeks after delivery.

Research Implications

That patients with postpartum psychosis were more likely to have Medicare or Medicaid insurance, live in a ZIP code with lower median income, have concurrent substance use disorders, and have psychiatric diagnoses supports that patients at higher risk for postpartum psychosis may have more limited resources and may face barriers to timely and optimal postpartum care. Further research is indicated to identify at risk patients, evaluate mechanisms by which these risk factors may cause risk for postpartum psychosis, and optimize risk reduction and treatment.

Strengths and Weaknesses

In interpreting these findings there are several important limitations. First, trends and outcomes were limited to 2016 to 2019. ICD-10-CM, introduced into the NRD in the third quarter of 2015, includes coding specific to postpartum psychosis. The previous diagnosis framework, ICD-9-CM, did not include a specific code. Given this code transition we did not analyze postpartum psychosis before 2016, and are limited in analysis of trends for this outcome. Second, we relied on administrative hospital discharge data.[22] Administrative data has known limitations including misclassification and under-ascertainment. We were not able to review clinical records to confirm diagnoses. Third, the NRD has several limitations including not being able to capture readmissions that occur in a different state. It is possible that some readmissions may have been missed secondary to a readmission in another state. Fourth, we were precluded from analyzing deliveries occurring in November and December to ensure two months of postpartum readmission ascertainment. Fifth, we were not able to analyze outpatient data including pharmacy benefits, outpatient visits, and emergency department utilization. This additional information may have been useful in further characterizing these diagnoses. Sixth, this study cannot prove causation and many risk factors identified may be markers for risk rather than causal. Seventh, because race and ethnicity data are not provided we cannot assess disparities. Eighth, the trends we noted may due to increased ascertainment, diagnosis, and screening of mental health disorders rather than true increases in disease burden. Ninth, we are not able to determine if postpartum psychosis was the primary indication for readmission. Tenth, the trends analysis is limited by the short study duration.

Strengths of the study include a large sample weighted to produce national estimates that allowed estimates to be made between exposures and rare outcomes, that the NRD does

allow patients to be followed across hospitalizations through time, that the population estimates for postpartum psychosis were similar to prior studies, and that it is appropriate use billing data to analyze disease burden and trends.

Conclusion

In conclusion, this analysis found an increasing prevalence of postpartum psychosis over the study period, and an association between postpartum psychosis and a wide spectrum of obstetric and medical comorbidities. Close follow up care after delivery for other medical and obstetric diagnoses may represent an opportunity to identify postpartum psychiatric conditions including postpartum psychosis.

REFERENCES

1.	VanderKruik R, Barreix M, Chou D, et al. The global prevalence of postpartum psychosis: a systematic review. BMC Psychiatry 2017;17:272.
2.	Harlow BL, Vitonis AF, Sparen P, Cnattingius S, Joffe H, Hultman CM. Incidence of hospitalization for postpartum psychotic and bipolar episodes in women with and without prior prepregnancy or prenatal psychiatric hospitalizations. Arch Gen Psychiatry 2007;64:42-8.
3.	Jones I, Craddock N. Familiality of the puerperal trigger in bipolar disorder: results of a family study. Am J Psychiatry 2001;158:913-7.
4.	Miller BJ, Goldsmith DR. Towards an Immunophenotype of Schizophrenia: Progress, Potential Mechanisms, and Future Directions. Neuropsychopharmacology 2017;42:299-317.
5.	Tabacco S, Ludovisi M, D'Alfonso A, et al. Perinatal mental illness and autoimmune diseases: a qualitative sistematic review. Minerva Obstet Gynecol 2022.
6.	Logue TC, Wen T, Ogundimu OE, et al. Delivery hospitalizations with substance use disorder diagnoses. Am J Obstet Gynecol 2022;227:100-2.
7.	Logue TC, Wen T, Monk C, et al. Trends in and complications associated with mental health condition diagnoses during delivery hospitalizations. Am J Obstet Gynecol 2022;226:405 e1- e16.
8.	Dinse GE, Parks CG, Weinberg CR, et al. Increasing Prevalence of Antinuclear Antibodies in the United States. Arthritis Rheumatol 2020;72:1026-35.

9.   Agency for Healthcare Research and Quality Healthcare Cost and Utilization Project (HCUP). Introduction to the HCIP Nationwide Readmissions Database (NRD) 2010-2015. November
2017. 2017. (Accessed July 1, 2019, at https://www.hcup-us.ahrq.gov/db/nation/nrd/Introduction_NRD_2010-2015.pdf.)

10.   Kurtz SM, Lau EC, Ong KL, Adler EM, Kolisek FR, Manley MT. Which Clinical and Patient Factors Influence the National Economic Burden of Hospital Readmissions After Total Joint Arthroplasty? Clin Orthop Relat Res 2017;475:2926-37.

11.   Wen T, Wright JD, Goffman D, et al. Postpartum venous thromboembolism readmissions in the United States. Am J Obstet Gynecol 2018;219:401.e1-.e14.

12.   Wen T, Yu VX, Wright JD, et al. Postpartum length of stay and risk for readmission among women with preeclampsia. J Matern Fetal Neonatal Med 2020;33:1086-94.

13.   Wen T, Overton EE, Sheen JJ, et al. Risk for postpartum readmissions and associated complications based on maternal age. J Matern Fetal Neonatal Med 2021;34:1375-81.

14.   Fein A, Wen T, Wright JD, et al. Postpartum hemorrhage and risk for postpartum readmission. J Matern Fetal Neonatal Med 2021;34:187-94.

15.   Healthcare Cost and Utilization Project. Overview of the Nationwide Readmissions Database. Accessed September 8, 2022. Available at https://hcup-us.ahrq.gov/nrdoverview.jsp.
.

16.   Kuklina E, Whiteman M, Hillis S, Jameieson D, Meikle S, Posner S. An enhanced method for identifying obstetric deliveries: implications for estimating maternal morbidity. Matern Child Health J 2008;12:469-77.

17.   Clapp MA, James KE, Friedman AM. Identification of Delivery Encounters Using International Classification of Diseases, Tenth Revision, Diagnosis and Procedure Codes. Obstet Gynecol 2020;136:765-7.

18.   Joinpoint Trend Analysis Software. 2020. 2020, at https://surveillance.cancer.gov/joinpoint/.)

19.   Grohskopf LA, Sokolow LZ, Broder KR, Walter EB, Fry AM, Jernigan DB. Prevention and Control of Seasonal Influenza with Vaccines: Recommendations of the Advisory Committee on Immunization Practices-United States, 2018-19 Influenza Season. MMWR Recomm Rep 2018;67:1-20.

20.   Gur RE, Moore TM, Rosen AFG, Barzilay R, Roalf DR, Calkins ME, Ruparel K, Scott JC, Almasy L, Satterthwaite TD, Shinohara RT, Gur RC. Burden of Environmental Adversity Associated With Psychopathology, Maturation, and Brain Behavior Parameters in Youths. JAMA Psychiatry. 2019 Sep 1;76(9):966-975. doi: 10.1001/jamapsychiatry.2019.0943. PMID: 31141099; PMCID: PMC6547104.

21.   Luo Y, Zhang L, He P, Pang L, Guo C, Zheng X. Individual-level and area-level socioeconomic status (SES) and schizophrenia: cross-sectional analyses using the evidence from 1.9 million Chinese adults. BMJ Open. 2019 Sep 4;9(9):e026532. doi: 10.1136/bmjopen-2018-026532. PMID: 31488464; PMCID: PMC6731895.

22.   Burns EM, Rigby E, Mamidanna R, et al. Systematic review of discharge coding accuracy. J Public Health (Oxf) 2012;34:138-48.

Table 1. Demographics of delivery hospitalizations based on delivery and postpartum psychosis diagnoses

| | Delivery Hospitalization Postpartum Psychosis | | | | 60-day Psychosis Readmission | | | |
| | Psychosis present | | Psychosis absent | | No Readmission | | Readmission | |
	N	%	N	%	N	%	N	%
Maternal age								
15-19 years old	723	5.2%	650,434	5.3%	650,614	5.3%	544	7.6%
20-24 years old	3,045	21.9%	2,408,082	19.6%	2,409,394	19.6%	1,733	24.3%
25-29 years old	3,939	28.4%	3,602,525	29.2%	3,604,640	29.2%	1,825	25.6%
30-34 years old	3,741	26.9%	3,506,332	28.5%	3,508,422	28.5%	1,651	23.2%
35-39 years old	2,017	14.5%	1,767,529	14.4%	1,768,463	14.4%	1,083	15.2%
40-44 years old	429	3.1%	385,710	3.1%	385,847	3.1%	292	4.1%
Payer Status								
Medicare	195	1.4%	98,816	0.8%	98,796	0.8%	216	3.0%
Medicaid	6,932	49.9%	5,116,931	41.5%	5,120,032	41.5%	3,832	53.8%
Commercial insurance	6,148	44.3%	6,540,842	53.1%	6,544,197	53.1%	2,793	39.2%
Self-pay	187	1.4%	184,555	1.5%	184,643	1.5%	98	1.4%
No Charge	NS	0.0%	6,222	0.1%	6,229	0.1%	NS	0.0%
Other	412	3.0%	358,254	2.9%	358,488	2.9%	179	2.5%
Missing	NS	0.1%	14,992	0.1%	14,996	0.1%	NS	0.2%
Median Income Quartile by ZIP Code								
Income Quartile 1 (lowest)	4,266	30.7%	3,374,564	27.4%	3,376,465	27.4%	2,364	33.2%
Income Quartile 2	3,761	27.1%	3,212,392	26.1%	3,214,075	26.1%	2,078	29.2%
Income Quartile 3	3,374	24.3%	3,105,025	25.2%	3,106,780	25.2%	1,620	22.7%
Income Quartile 4 (highest)	2,396	17.2%	2,541,217	20.6%	2,542,601	20.6%	1,012	14.2%
Missing	100	0.7%	87,414	0.7%	87,460	0.7%	53	0.7%
Clinical Factors								
Pregestational diabetes	340	2.4%	150,404	1.2%	150,498	1.2%	246	3.5%
Chronic hypertension	459	3.3%	282,539	2.3%	282,600	2.3%	397	5.6%
Hypertensive disorders of pregnancy	2,225	16.0%	1,385,720	11.3%	1,386,363	11.3%	1,583	22.2%
Asthma	1,30	9.4%	663,374	5.4%	663,955	5.4%	726	10.2%

		7							%
Obesity		1,951	14.0%	1,232,169	10.0%	1,232,911	10.0%	1,210	17.0%
Autoimmune conditions		246	1.8%	127,751	1.0%	127,878	1.0%	119	1.7%
Anxiety disorder		2,830	20.4%	577,099	4.7%	578,510	4.7%	1,419	19.9%
Depression disorder		1,446	10.4%	447,969	3.6%	448,007	3.6%	1,407	19.8%
Bipolar spectrum disorder		523	3.8%	103,047	0.8%	103,224	0.8%	346	4.9%
Schizophrenia spectrum disorder		129	0.9%	14,371	0.1%	14,395	0.1%	105	1.5%
Substance use		1,063	7.7%	329,874	2.7%	330,368	2.7%	569	8.0%
Multiple gestation		481	3.5%	235,207	1.9%	235,438	1.9%	250	3.5%
Stillbirth		451	3.3%	105,036	0.9%	105,345	0.9%	142	2.0%
Preterm delivery		1,119	8.1%	560,646	4.6%	561,061	4.6%	704	9.9%
Postpartum psychosis at delivery		n/a	n/a	n/a	n/a	13,808	0.1%	87	1.2%
Postpartum hemorrhage		764	5.5%	454,432	3.7%	454,775	3.7%	421	5.9%
Mode of Delivery									
Nonoperative vaginal delivery		7,351	52.9%	7,882,180	64.0%	7,885,985	64.0%	3,546	49.8%
Operative vaginal delivery		379	2.7%	497,122	4.0%	497,218	4.0%	283	4.0%
Primary cesarean		2,752	19.8%	2,063,333	16.8%	2,064,093	16.7%	1,991	27.9%
Repeat cesarean		3,414	24.6%	1,877,978	15.2%	1,880,084	15.3%	1,308	18.4%
Hospital location/teaching status									
Metropolitan non-teaching		2,570	18.5%	2,554,213	20.7%	2,555,533	20.7%	1,251	17.6%
Metropolitan teaching		9,837	70.8%	8,611,148	69.9%	8,615,813	69.9%	5,172	72.6%
Non-metropolitan		1,489	10.7%	1,155,251	9.4%	1,156,035	9.4%	704	9.9%
Hospital beds volume									
Small		2,528	18.2%	2,077,004	16.9%	2,078,366	16.9%	1,165	16.4%
Medium		3,863	27.8%	3,500,787	28.4%	3,502,870	28.4%	1,780	25.0%
Large		7,505	54.0%	6,742,821	54.7%	6,746,144	54.7%	4,182	58.7%
Year									
2016		3,060	22.0%	3,166,046	25.7%	3,167,443	25.7%	1,662	23.3%
2017		3,094	22.3%	3,096,153	25.1%	3,097,572	25.1%	1,675	23.5%

2018	3,302	23.8%	3,046,691	24.7%	3,048,226	24.7%	1,768	24.8%
2019	4,440	32.0%	3,011,722	24.4%	3,014,140	24.5%	2,022	28.4%

NS, number suppressed due to small cell sizes ≤10.

Table 2: Unadjusted and adjusted analyses for postpartum psychosis diagnoses during delivery and postpartum readmissions

	Delivery hospitalization				Postpartum readmission				Postpartum readmission (sensitivity)	
	Unadjusted model		Adjusted model		Unadjusted model		Adjusted model		Adjusted model	
	OR	95% CI	aOR	95% CI	OR	95% CI	aOR	95% CI	aOR	95% CI
Maternal age										
15-19 years old	1.02	0.89, 1.16	1.05	0.92, 1.2	1.65	1.41, 1.93	1.51	1.29, 1.78	1.53	1.3, 1.79
20-24 years old	1.16	1.08, 1.24	1.15	1.07, 1.24	1.42	1.29, 1.57	1.34	1.21, 1.48	1.35	1.22, 1.49
25-29 years old	Reference		Reference		Reference		Reference		Reference	
30-34 years old	0.98	0.91, 1.04	0.99	0.93, 1.06	0.93	0.84, 1.03	0.98	0.89, 1.09	0.98	0.89, 1.09
35-39 years old	1.04	0.96, 1.13	1.01	0.93, 1.1	1.21	1.08, 1.35	1.20	1.07, 1.34	1.19	1.06, 1.33
40-44 years old	1.02	0.88, 1.17	0.94	0.81, 1.08	1.50	1.25, 1.78	1.33	1.11, 1.59	1.32	1.1, 1.58
Payer Status										
Medicare	2.10	1.66, 2.66	1.19	0.94, 1.50	5.12	4.11, 6.36	2.42	1.94, 3.02	2.43	1.94, 3.05
Medicaid	1.44	1.36, 1.53	1.25	1.18, 1.33	1.75	1.63, 1.89	1.43	1.31, 1.55	1.42	1.31, 1.55
Commercial insurance	Reference		Reference		Reference		Reference		Reference	
Self-pay	1.08	0.86, 1.35	1.04	0.83, 1.31	1.25	0.89, 1.74	1.23	0.88, 1.72	1.24	0.89, 1.74
No Charge	1.05	0.34, 3.21	0.96	0.31, 2.96	n/a	n/a	n/a	n/a	n/a	n/a

	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Other	1.22	1.02, 1.46	1.16	0.97, 1.37	1.17	0.94, 1.45	1.1	0.88, 1.37	1.11	0.89, 1.38
Median Income Quartile by ZIP Code										
Income Quartile 1 (lowest)	1.34	1.21, 1.48	1.00	0.99, 1.22	1.76	1.57, 1.97	1.29	1.14, 1.46	1.28	1.14, 1.45
Income Quartile 2	1.24	1.14, 1.36	1.08	0.99, 1.18	1.63	1.45, 1.82	1.32	1.17, 1.49	1.32	1.18, 1.49
Income Quartile 3	1.15	1.06, 1.26	1.06	0.97, 1.15	1.31	1.17, 1.47	1.15	1.03, 1.29	1.15	1.02, 1.29
Income Quartile 4 (highest)	Reference		Reference		Reference		Reference		Reference	
Clinical Factors										
Pregestational diabetes	2.03	1.73, 2.38	1.24	1.05, 1.47	2.90	2.41, 3.48	1.35	1.11, 1.65	1.36	1.11, 1.65
Chronic hypertension	1.45	1.26, 1.68	1.09	0.94, 1.26	2.52	2.17, 2.92	1.89	1.62, 2.21	1.86	1.59, 2.18
Hypertensive disorders of pregnancy	1.50	1.40, 1.61	1.25	1.17, 1.35	2.25	2.07, 2.45	1.75	1.6, 1.91	1.75	1.6, 1.92
Asthma	1.83	1.67, 1.99	1.24	1.13, 1.36	1.99	1.77, 2.24	1.15	1.01, 1.3	1.15	1.02, 1.3
Obesity	1.47	1.36, 1.59	1.09	1.01, 1.18	1.84	1.68, 2.02	1.16	1.05, 1.28	1.15	1.05, 1.27
Autoimmune conditions	1.72	1.41, 2.1	1.37	1.12, 1.68	1.62	1.26, 2.09	1.15	0.88, 1.51	1.12	0.86, 1.45
Anxiety disorder	5.20	4.87, 5.56	3.86	3.51, 4.23	5.05	4.61, 5.53	2.06	1.81, 2.35	2.07	1.81, 2.36
Depression disorder	3.08	2.81, 3.37	1.25	1.11, 1.41	6.52	5.97, 7.13	3.71	3.29, 4.2	3.78	3.34, 4.28
Bipolar spectrum disorder	4.64	4.04, 5.34	1.81	1.55, 2.13	6.04	5.07, 7.20	2.87	2.33, 3.54	2.97	2.41, 3.66
Schizophrenia spectrum disorder	7.99	6.15, 10.39	2.54	1.91, 3.38	12.75	9.66, 16.81	2.89	2.12, 3.96	2.88	2.1, 3.95
Substance use disorder	3.01	2.73, 3.32	1.74	1.56, 1.93	3.15	2.75, 3.60	1.49	1.29, 1.72	1.49	1.3, 1.72

Multiple gestation	1.84	1.61, 2.11	1.35	1.18, 1.56	1.87	1.53, 2.29	1.12	0.91, 1.37	1.12	0.91, 1.38
Stillbirth	3.90	3.38, 4.51	3.63	3.13, 4.2	2.36	1.82, 3.05	1.95	1.50, 2.52	2.03	1.57, 2.64
Preterm delivery	1.84	1.67, 2.02	1.47	1.33, 1.62	2.30	2.04, 2.59	1.70	1.50, 1.92	1.67	1.48, 1.89
Delivery postpartum psychosis	n/a	n/a	n/a	n/a	11.07	8.06, 15.20	5.78	4.18, 7.97	n/a	n/a
Postpartum hemorrhage	1.52	1.37, 1.69	1.41	1.27, 1.57	1.64	1.41, 1.91	1.42	1.22, 1.66	1.42	1.21, 1.66
Mode of Delivery										
Nonoperative vaginal delivery	Reference		Reference		Reference		Reference		Reference	
Operative vaginal delivery	0.82	0.70, 0.95	0.84	0.72, 0.98	1.26	1.05, 1.52	1.30	1.08, 1.56	1.30	1.08, 1.56
Primary cesarean	1.43	1.33, 1.54	1.32	1.23, 1.42	2.15	1.97, 2.34	1.83	1.68, 2.00	1.83	1.67, 2.00
Repeat cesarean	1.95	1.83, 2.07	1.92	1.79, 2.04	1.55	1.41, 1.70	1.45	1.31, 1.59	1.44	1.34, 1.59
Hospital location/teaching status										
Metropolitan teaching	1.14	1.03, 1.25	1.02	0.93, 1.13	1.23	1.11, 1.35	1.07	0.97, 1.18	1.08	0.98, 1.19
Metropolitan non-teaching	1.28	1.13, 1.45	1.20	1.06, 1.36	1.24	1.08, 1.44	1.08	0.94, 1.26	1.1	0.95, 1.27
Non-metropolitan	Reference		Reference		Reference		Reference		Reference	
Hospital bed volume										
Small	1.10	0.99, 1.23	1.1	0.99, 1.23	1.10	0.98, 1.24	1.13	1.01, 1.26	1.13	1.01, 1.26
Medium	Reference		Reference		Reference		Reference		Reference	
Large	1.01	0.92, 1.11	0.96	0.87, 1.06	1.22	1.11, 1.34	1.14	1.04, 1.25	1.14	1.04, 1.25
Year										
2016	Reference		Reference		Reference		Reference		Reference	
2017	1.03	0.91, 1.17	0.99	0.88, 1.12	1.03	0.91, 1.17	0.98	0.87,	0.98	0.87,

|	OR	95% CI	aOR	95% CI	OR	95% CI	aOR	95% CI	aOR	95% CI
2018	1.12	0.99, 1.27	1.05	0.93, 1.18	1.11	0.98, 1.25	1.01	1.11 0.90, 1.14 1.00	1.01	1.11 0.89, 1.14 0.99
2019	1.53	1.35, 1.72	1.38	1.23, 1.55	1.28	1.13, 1.44	1.12	1.00, 1.26	1.12	0.99, 1.26

OR, odds ratio. *aOR*, adjusted odds ratio. The sensitivity analysis for postpartum readmissions excluded patients with a diagnosis of postpartum psychosis at delivery.

Figure 1. Time to readmission for postpartum psychosis after delivery hospitalization discharge.
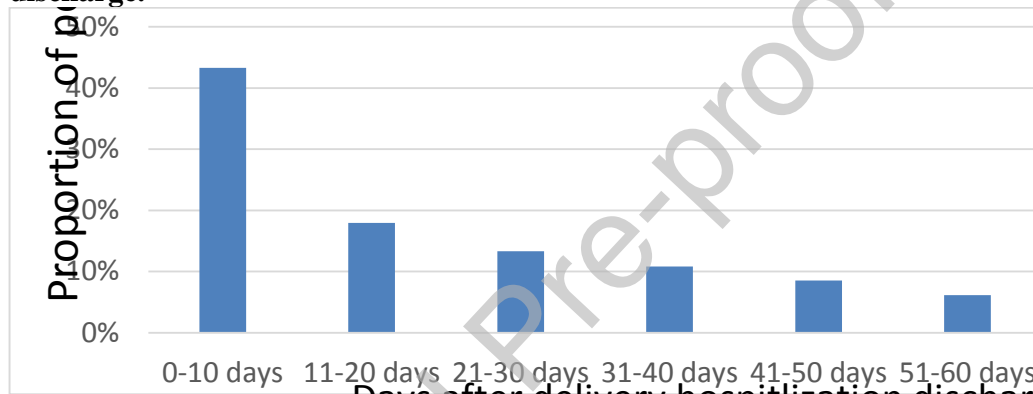
Legend. The figure demonstrates the proportion of deliveries occurring at each 10 day interval after delivery hospitalization discharge.

Figure 2. Delivery and postpartum readmissions with postpartum psychosis diagnoses per 10,000 delivery hospitalizations
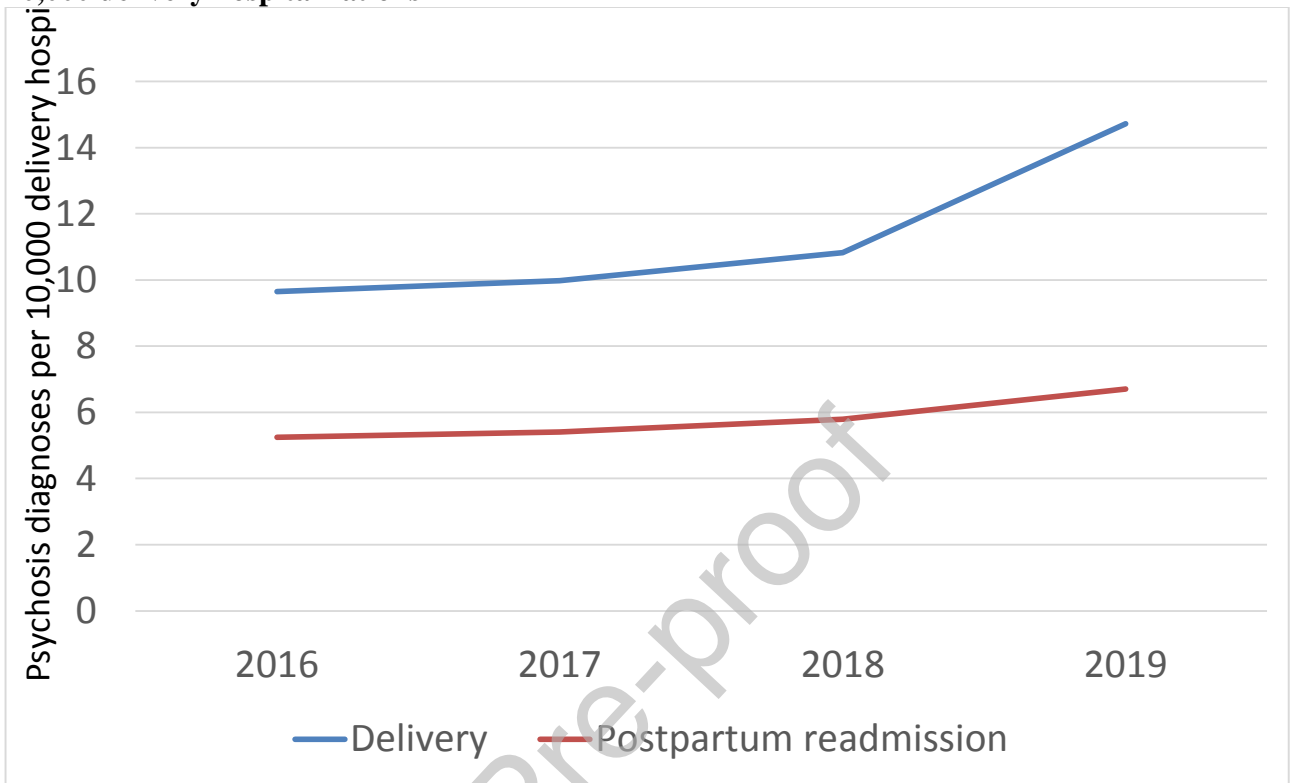
Legend. The figure demonstrates trends delivery and postpartum readmissions with postpartum psychosis diagnoses