HHS Public Access

Author manuscript

Am J Obstet Gynecol MFM. Author manuscript; available in PMC 2024 October 01.

Published in final edited form as:

Am J Obstet Gynecol MFM. 2023 October ; 5(10): 101077. doi:10.1016/j.ajogmf.2023.101077.

Delivery outcomes in a cohort of pregnant patients with COVID-19 with and without viral pneumonia

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Abstract

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B.D. and Y.T. share first authorship.

The authors report no conflict of interest.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.ajogmf.2023.101077.

BACKGROUND: Among pregnant people, COVID-19 can lead to adverse outcomes, but the specific pregnancy outcomes that are affected by the disease are unclear. In addition, the effect of the severity of COVID-19 on pregnancy outcomes has not been clearly identified.

OBJECTIVE: This study aimed to evaluate the associations between COVID-19 with and without viral pneumonia and cesarean delivery, preterm delivery, preeclampsia, and stillbirth.

STUDY DESIGN: We conducted a retrospective cohort study (April 2020–May 2021) of deliveries between 20 and 42 weeks of gestation from US hospitals in the Premier Healthcare Database. The primary outcomes were cesarean delivery, preterm delivery, preeclampsia, and still-birth. We used a viral pneumonia diagnosis (International Classification of Diseases -Tenth-Clinical Modification codes J12.8 and J12.9) to categorize patients by severity of COVID-19. Pregnancies were categorized into 3 groups: NOCOVID (no COVID-19), COVID (COVID-19 without viral pneumonia), and PNA (COVID-19 with viral pneumonia). Groups were balanced for risk factors by propensity-score matching.

RESULTS: A total of 814,649 deliveries from 853 US hospitals were included (NOCOVID: n=799,132; COVID: n=14,744; PNA: n=773). After propensity-score matching, the risks of cesarean delivery and preeclampsia were similar in the COVID group compared with the NOCOVID group (matched risk ratio, 0.97; 95% confidence interval, 0.94–1.00; and matched risk ratio, 1.02; 95% confidence interval, 0.96–1.07; respectively). The risks of preterm delivery and stillbirth were greater in the COVID group than in the NOCOVID group (matched risk ratio, 1.11; 95% confidence interval, 1.05–1.19; and matched risk ratio, 1.30; 95% confidence interval, 1.01–1.66; respectively). The risks of cesarean delivery, preeclampsia, and preterm delivery were higher in the PNA group than in the COVID group (matched risk ratio, 1.76; 95% confidence interval, 1.53–2.03; matched risk ratio, 1.37; 95% confidence interval, 1.08–1.74; and matched risk ratio, 3.33; 95% confidence interval, 2.56–4.33; respectively). The risk of stillbirth was similar in the PNA and COVID group (matched risk ratio, 1.17; 95% confidence interval, 0.40–3.44).

CONCLUSION: Within a large national cohort of hospitalized pregnant people, we found that the risk of some adverse delivery outcomes was elevated in people with COVID-19 with and without viral pneumonia, with much higher risks in the group with viral pneumonia.

Keywords

cesarean; coronavirus; COVID; COVID-19; fetal death; fetal demise; pneumonia; preeclampsia; pregnancy; pregnant; premature; preterm; SARS-CoV-2; Stillbirth; viral pneumonia

Introduction

COVID-19 can lead to adverse pregnancy outcomes, including hospitalization, intensive care unit admission, and preterm delivery.[1–3] However, the literature is inconsistent regarding the effects of COVID-19 on important pregnancy outcomes such as cesarean delivery, preterm delivery, preeclampsia, and stillbirth.[3–7]

COVID-19 is heterogeneous in its clinical impact, and differences in severity of disease may explain the disparate results of previous studies.[3–6,8] Many studies have examined the associations between COVID-19 and pregnancy outcomes,[8–10] but fewer studies have

described pregnancy outcomes after stratification of patients by severity of COVID-19.[11,12] Given the range of clinical presentations of COVID-19, stratification by severity is critical for understanding the impact of COVID-19 on pregnancy outcomes. For example, in a cohort of 1219 pregnant people with COVID-19, 42% of those with critical-severe disease, 15% of those with moderate-mild disease, and 12% of those with asymptomatic infection delivered preterm.[11] Our previous work using a large administrative data set shows that among pregnant patients with COVID-19, the diagnosis of viral pneumonia is useful for stratification of disease severity (among pregnant patients with COVID-19, 92% of those who died had viral pneumonia).[13]

The objective of this study was to estimate the effects of COVID-19 with and without viral pneumonia on cesarean delivery, preterm delivery, preeclampsia, and stillbirth.

Materials and Methods

We conducted a retrospective observational cohort study of people who delivered and were discharged from hospitals in the Premier Healthcare Database (“Premier Database”), an all-payer repository of claims and clinical data from >120 million US inpatient admissions.[14] The Premier Database includes community and academic hospitals from geographically diverse areas across the United States and captures approximately 20% of US hospital discharges. Premier internally validates all data before their release into the Premier Database. For most data elements, <1% of patient records have missing information, and for key elements, such as demographics and diagnostic information, <0.01% of data are missing.[15] COVID-19 has been previously studied using the Premier Database by several groups, including ours.[2,14,16] This study did not include personally identifiable information and was exempt from institutional review board review. We followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines.[17]

The study population included women aged 15 to 45 years with delivery of an infant between 20 and 42 weeks of gestation from April 2020 to May 2021. COVID-19 was defined by the ICD-10-CM (International Classification of Diseases, 10th Revision, Clinical Modification) diagnosis code U07.1.[1] This code was internally validated in the Premier Database against laboratory data and found to have a specificity of 98% and a sensitivity of 99% for laboratory-confirmed infection with SARS-CoV-2.[17] All admissions with discharge dates from April 2020 to May 2021 and present in the Premier Database as of the data extraction date of May 26, 2021 were included in the study.[15] Delivery of the infant was assessed using ICD-10-CM procedure codes (ie, 10D00Z0, 10D00Z1, 10D00Z2, 10D07Z3, 10D07Z4, 10D07Z5, 10D07Z6, 10D07Z7, 10D07Z8, 10E0XZZ). Appendix 1 lists all codes used. Gestational age was assigned using the “Z3A” ICD-10-CM code.[18]

Viral pneumonia corresponds to at least moderate illness according to the National Institutes of Health classification.[19] We used a viral pneumonia diagnosis (ICD-10-CM codes J12.8 and J12.9) to categorize patients by severity of COVID-19. Patients with a viral pneumonia diagnosis comprised 92% of the in-hospital deaths among pregnant people.[5,20] Pregnancies were categorized into 3 groups: NOCOVID (no COVID-19), COVID (COVID-19 without viral pneumonia), and PNA (COVID-19 with viral pneumonia).[13]

The primary outcomes were cesarean delivery, preterm delivery, preeclampsia, and stillbirth (Appendix 1).

The unit of analysis was defined as a unique delivery. For people with >1 delivery in the data set, only the first delivery was included. Health care encounters before and after the delivery encounter were not included. Descriptive statistics for patient and hospital characteristics were calculated using mean (SD), or frequency count (percentage). We used chi-square and Fisher exact tests to test for statistical differences between groups for categorical variables and *t* tests for continuous variables. To estimate the effect of asymptomatic and milder COVID-19, we selected people without viral pneumonia and compared those with COVID-19 (COVID) with those without COVID-19 (NOCOVID). To estimate the effect of severity of COVID-19 illness, we selected people with COVID-19 and viral pneumonia (PNA) compared with those with COVID-19 and without viral pneumonia (COVID).[19]

Propensity-score matching was used to reduce confounding of the associations between COVID-19 and pregnancy outcome. Propensity scores were calculated using the PSMATCH procedure with optimal fixed ratio 1:1 matching and exact matching of severely unbalanced covariates between groups. The covariates related to COVID-19 were selected a priori through literature review and expert clinical consensus. Propensity-score models were performed separately for each comparison using the same covariates. Balance among covariates was checked by using a standardized mean difference with a threshold of 0.25. This methodology has been validated and used in pregnancy- and COVID–19-related studies, including by our group.[13,21,22]

All models were matched for age, race and ethnicity, marital status, payer, hospital number of beds, hospital region, discharge season, and Elixhauser comorbidity score (Elixhauser ICD-10-CM classification system).[23,24] Race and ethnicity were included because they are associated with both COVID-19 infection and pregnancy outcomes.[25,26] In addition, matching was performed for the most common chronic comorbidities—obesity, hypertension (pregestational or gestational), diabetes mellitus (pregestational or gestational), and chronic pulmonary disease—using standardized Agency for Healthcare Research and Quality methodology and software.[23] Using present-on-admission Elixhauser comorbidities, we calculated unweighted (summed) Elixhauser comorbidity scores.[23,27,28] For severely unbalanced covariates, exact matching was performed (obesity, hypertension, diabetes mellitus, chronic lung disease, Elixhauser comorbidity score, race/ethnicity, marital status, payer, and discharge season).

To validate the viral pneumonia code for separation of asymptomatic and mild vs at least moderate COVID-19 (COVID vs PNA), we compared length of stay for each comparison. The risk ratios (RRs) and 95% confidence intervals (CIs) for each comparison were computed for the 4 outcomes, first with the unmatched full data set, then with the propensity score–matched subset. Two sensitivity analyses were performed to assess the effect of: (1) admission surveillance testing for SARS-CoV-2, and (2) admission for illness rather than admission only for delivery. For the first sensitivity analysis, we excluded deliveries in the earliest phase of the pandemic when not all labor and delivery units were performing universal SARS-CoV-2 testing (excluded before July 1, 2020).[29] For the second sensitivity

analysis, we included only full-term deliveries. All tests were 2-tailed, and *P* values <.05 were used for statistical significance testing. Analyses were performed using SAS, version 9.4 (SAS Institute Inc., Cary, NC).

Results

The cohort consisted of 814,649 pregnant people, of whom 799,132 (98.1%) were in the NOCOVID group, 14,744 (1.8%) were in the COVID group, and 773 (0.1%) were in the PNA group (Tables 1 and 2). Length of stay was 2.4 (2.3), 2.5 (2.4), and 8.7 (10.1) days in the NOCOVID, COVID, and PNA groups, respectively. Cesarean delivery occurred in 32.3% of the NOCOVID, 31.8% of the COVID, and 68.6% of the PNA group (Table 3). Preterm delivery occurred in 10.1% of the NOCOVID, 12.3% of the COVID, and 51.5% of the PNA group, respectively. Preeclampsia occurred in 14.3% of the NOCOVID, 15.4% of the COVID, and 28.7% of the PNA group. Stillbirth occurred in 0.6% of the NOCOVID, 0.9% of the COVID, and 1.3% of the PNA group.

After propensity-score matching, covariate imbalance between the groups was substantially reduced for all covariates in each comparison, indicating that matching produced groups with a highly similar distribution of risk factors. The balance of covariates included in the propensity-score models before and after matching is shown in Appendix 2. There was sufficient overlap in the distribution of propensity scores between groups, as shown in Appendix 3. Characteristics of pregnancies before and after matching are shown in Tables 1 and 2.

COVID-19 without viral pneumonia

To estimate the effect of COVID-19 without viral pneumonia on pregnancy outcomes, the COVID group was compared with the NOCOVID group after propensity-score matching. Mean length of stay was 2.5 days in both groups (SD 2.1 for NOCOVID, 2.4 for COVID; *P*=.892). The risks of cesarean delivery and preeclampsia were similar in the COVID group compared with the NOCOVID group (matched RR [mRR], 0.97; 95% CI, 0.94–1.00; and mRR, 1.02; 95% CI, 0.96–1.07; respectively) (Table 4). The risks of preterm delivery and stillbirth were greater in the COVID group than in the NOCOVID group (mRR, 1.11; 95% CI, 1.05–1.19; and mRR, 1.30; 95% CI, 1.01–1.66; respectively). In the sensitivity analysis excluding deliveries from April to June 2020, there was little effect on the results, except that the 95% CI for stillbirth widened to include the null value (mRR, 1.31; 95% CI, 0.99–1.73) (Appendix 4). In the sensitivity analysis excluding preterm deliveries, the mRR for stillbirth was reduced to 1.19 and not statistically significant (95% CI, 0.67–2.13) (Appendix 5).

COVID-19 with viral pneumonia

To estimate the effect of COVID-19 with viral pneumonia on pregnancy outcomes, the PNA group was compared with the COVID group after propensity-score matching. Mean length of stay was 2.5 (2.3) days in the COVID group and 7.6 (9.2) days in the PNA group (*P*<.001). The risks of cesarean delivery, preeclampsia, and preterm delivery were higher in the PNA group than in the COVID group (mRR, 1.76; 95% CI, 1.53–2.03; mRR, 1.37;

95% CI, 1.08–1.74; and mRR, 3.33; 95% CI, 2.56–4.33; respectively) (Table 4). The risk of stillbirth was similar in the PNA and COVID groups (mRR, 1.17; 95% CI, 0.40–3.44). In the sensitivity analysis excluding deliveries from April to June 2020, there was no effect on the results (Appendix 4). In the sensitivity analysis excluding preterm deliveries, the risk of cesarean delivery remained higher (mRR, 1.72; 95% CI, 1.38–2.15), the risk of preeclampsia was not statistically significantly different between groups (mRR, 1.23; 95% CI, 0.86–1.75), and there was 1 stillbirth (1/242; 0.3%) in the matched PNA and no stillbirths (0/242) in the matched COVID (Appendix 5).

Discussion

Principal findings

This study estimates the effects of COVID-19 with and without viral pneumonia on pregnancy outcomes. The highest risks of cesarean delivery, preterm delivery, preeclampsia, and stillbirth were in the group with COVID-19 with pneumonia, and risks of preterm delivery and stillbirth were slightly higher in the group with COVID-19 without pneumonia compared with the group without COVID-19.

Results

Cesarean delivery.—Among pregnant people with COVID-19, the risk of cesarean delivery was greater in people with pneumonia compared with people without pneumonia. This is consistent with previous studies showing a higher risk of cesarean delivery in people with COVID-19 compared with people without COVID-19.[4–6,30–33] This increase in cesarean delivery among people with COVID-19 pneumonia may be due to maternal distress and the need for controlled, expedited delivery.[5,34–36] We found no increased risk of cesarean delivery among people with COVID-19 without pneumonia compared with those without COVID-19. These opposing results may explain the heterogeneity of meta-analyses that did not stratify by severity of COVID-19 infection.[4,12,37–39]

Preterm delivery.—The risk of preterm delivery increased with disease severity. Those in the NOCOVID group had the lowest risk, with risks increasing in the COVID and PNA groups. These results are consistent with previous literature and demonstrate that even COVID-19 infection without viral pneumonia (ie, mild COVID-19) is associated with increased risk of preterm delivery.[3–5,30–33] We did not differentiate spontaneous vs indicated preterm deliveries; previous studies suggest that although most preterm deliveries are spontaneous, most of the excess preterm deliveries because of COVID-19 are indicated.[10]

Preeclampsia.—Among pregnant people with COVID-19, the risk of preeclampsia is greater among those with pneumonia compared with those without pneumonia. However, the risk of preeclampsia was similar between the COVID and NOCOVID group. Thus, the effect of COVID-19 on preeclampsia seems restricted to those with pneumonia. This is consistent with previous literature but clarifies the population at risk.[3,33]

Stillbirth.—The results of our study were consistent with those of previous studies showing increased risk of stillbirth among people with COVID-19.[3] People in the COVID group

had a higher risk of stillbirth compared with people without COVID-19. Restricting to people with COVID-19, the RR for stillbirth in people with vs without pneumonia was similar (1.17) but had a wide CI of 0.40 to 3.44 because of the small number of pregnant people admitted with COVID-19 and pneumonia. In addition, the risk of stillbirth was not statistically significantly different between the NOCOVID and COVID group in either sensitivity analysis, weakening the strength of the result. However, both sensitivity analyses decreased the population at risk and thus statistical power to detect differences between groups (eg, 81% of stillbirths were preterm, which is consistent with the known distribution by gestational age). Given the rarity of stillbirth and especially term stillbirth, a larger study is needed to further investigate the effect of COVID-19 on stillbirth.[3]

Clinical implications

The primary clinical implication of this study is that risks of COVID-19 are more strongly associated with viral pneumonia than with milder disease, but that milder disease also affects pregnancy outcomes. Cesarean delivery was common, but without significant differences between the NOCOVID and COVID group. However, over two-thirds of patients in the PNA group delivered via cesarean delivery (1.8 times the risk in the COVID group). Over half of the PNA group was delivered preterm (>3 times the risk of the COVID group). The difference between the NOCOVID and COVID group (mRR, 1.1) was much smaller and less clinically significant. Although our data set does not include vaccination status, it is important to note that vaccination protects against severe disease in pregnant patients.[40]

Research implications

The differential risks found in this study should be verified with a different study design to confirm the findings. All of the findings are nondirectional associations, and further research is needed to understand the biological mechanisms underlying these relationships, in which COVID-19 may cause adverse pregnancy outcomes, or a common cause may lead to both COVID-19 and adverse pregnancy outcomes.

Strengths and limitations

We used a hospital-based, national database of patient-level data, which has been used for studies of COVID-19 and pregnancy.[2,8,41–44] The Premier Database consists of a well-defined population, and the stratification we used has been validated in previous research.[2,45] Jering et al[8] used the Premier Database to compare outcomes of pregnant people with and without COVID-19, but did not stratify outcomes by disease severity.[8] This limitation was not unique to Jering et al[8]; several meta-analyses of pregnancy outcomes among people with and without COVID-19 did not stratify the outcomes by disease severity.[3–6,30–33] In addition, other studies compared patients with varying severity of COVID-19 with a single reference group of patients either without infection[12] or with asymptomatic infection.[11] Others compared COVID-19 with no COVID-19, asymptomatic with symptomatic, and/or mild with severe.[7,46] Only 1 previous study has compared mild COVID-19 with no COVID-19.[47] Our study used 2 references—no COVID-19 and COVID-19 without pneumonia—which allowed a better assessment of the specific risks associated with each classification of disease severity.

Our study is not without limitations. Determining the chronological order of each diagnosis (COVID-19 infection and measured outcomes) is not possible in the Premier Database because all diagnoses are finalized after patient discharge. Although we estimated severity of disease with the viral pneumonia diagnosis, this is only an approximation for more detailed information on symptom status and disease severity. However, we found that after matching, the NOCOVID and COVID group had a similar length of stay, suggesting that the COVID group comprised patients with asymptomatic or mild disease. Although laboratory test results were not available, the literature shows that COVID-19 diagnosis and laboratory-confirmed SARS-CoV-2 infection are strongly correlated.[17] However, when the infection occurred in pregnancy (at the time of delivery or earlier), and whether infections earlier in pregnancy were captured by the Premier Database cannot be determined. Because not all pregnant patients presenting for delivery in the early phase of the pandemic (April through June 2020) were tested for SARS-CoV-2, selective testing based on more serious clinical presentations (eg, stillbirth) may have biased the results. However, the sensitivity analysis excluding these deliveries found a similar estimate of increased risk with COVID-19, suggesting that targeted testing in the beginning of the pandemic did not bias the results. These data include people discharged from April 2020 to May 2021, and thus the results relate to the effects of wild-type and Alpha variants of SARS-CoV-2,[48] which may be different from the effects of the Delta and Omicron variants.[13,49] In addition, the study results cannot be generalized to patients who are not hospitalized. Misclassification of diagnosis codes and residual confounding may also affect results.

Conclusions

COVID-19 both with and without viral pneumonia is associated with adverse delivery outcomes, although COVID-19 with viral pneumonia is associated with the worst outcomes, with over half of deliveries preterm and two-thirds delivered by cesarean delivery.□

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

No financial support was received for this study.

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AJOG MFM at a Glance

Why was this study conducted?

This study aimed to identify the risk of adverse pregnancy outcomes associated with COVID-19—both the risks of infection vs no infection and the added risks with viral pneumonia

Key findings

The risk of preterm delivery was 10% higher in people with COVID-19 than in those without. The risk of stillbirth was 30% higher in people with COVID-19 than in those without. Among those with COVID-19, the risks of cesarean delivery, preeclampsia, and preterm delivery were higher in people with than in those without viral pneumonia.

What does this add to what is known?

COVID-19 both with and without viral pneumonia is associated with adverse pregnancy outcomes.

TABLE 1

Baseline characteristics in the unmatched and propensity score–matched people without viral pneumonia, with and without COVID-19

Characteristics	Unmatched			Matched		
	COVID: COVID-19 without pneumonia	NOCOVID: no COVID-19	*P* value	COVID: COVID-19 without pneumonia	NOCOVID: no COVID-19	*P* value
	(N=14,744)	(N=799,132)		(N=14,625)	(N=14,625)	
Age (y)	28.2 (5.9)	28.1 (5.8)	<.001	28.2 (5.9)	28.1 (5.8)	.135
Race and ethnicity						
Hispanic	5212 (35.3%)	141,800 (17.7%)	<.001	5173 (35.4%)	5173 (35.4%)	1.000
Non-Hispanic White	5346 (36.3%)	432,807 (54.2%)		5335 (36.5%)	5335 (36.5%)	
Non-Hispanic Black	2281 (15.5%)	116,021 (14.5%)		2255 (15.4%)	2255 (15.4%)	
Non-Hispanic Asian	451 (3.1%)	34,446 (4.3%)		432 (3.0%)	432 (3.0%)	
None of the above/unknown	1454 (9.9%)	74,058 (9.3%)		1430 (9.8%)	1430 (9.8%)	
Marital status						
Married	5648 (38.3%)	379,614 (47.5%)	<.001	5615 (38.4%)	5615 (38.4%) 1.000	<.001
Single	6895 (46.8%)	325,899 (40.8%)		6858 (46.9%)	6858 (46.9%)	
None of the above/unknown	2201 (14.9%)	93,619 (11.7%)		2152 (14.7%)	2152 (14.7%)	
Payer						
Public	8730 (59.2%)	344,449 (43.1%)	<.001	8672 (59.3%)	8672 (59.3%)	1.000
Private	5074 (34.4%)	405,089 (50.7%)		5044 (34.5%)	5044 (34.5%)	
Other	940 (6.4%)	49,594 (6.2%)		909 (6.2%)	909 (6.2%)	
Gestational age (wk)						
20–27	168 (1.1%)	6940 (0.9%)		167 (1.1%)	140 (1.0%)	
28–33	380 (2.6%)	16,669 (2.1%)		377 (2.6%)	335 (2.3%)	
34–36	1262 (8.6%)	57,269 (7.2%)		1241 (8.5%)	1128 (7.7%)	
37–42	12,934 (87.7%)	718,254 (89.9%)		12,840 (87.8%)	13,022 (89.0%)	
Hospital number of beds						
000–299	4476 (30.4%)	292,502 (36.6%)	<.001	4446 (30.4%)	4547 (31.1%)	.316
300–499	4829 (32.8%)	240,511 (30.1%)		4773 (32.6%)	4668 (31.9%)	
500+	5439 (36.9%)	266,119 (33.3%)		5406 (37.0%)	5410 (37.0%)	

Am J Obstet Gynecol MFM. Author manuscript; available in PMC 2024 October 01.

Characteristics	Unmatched			Matched		
	COVID: COVID-19 without pneumonia	NOCOVID: no COVID-19	*P* value	COVID: COVID-19 without pneumonia	NOCOVID: no COVID-19	*P* value
	(N=14,744)	(N=799,132)		(N=14,625)	(N=14,625)	
Discharge season[a]						
Spring 2020	1666 (11.3%)	136,722 (17.1%)	<.001	1632 (11.2%)	1632 (11.2%)	1.000
Summer 2020	3594 (24.4%)	209,528 (26.2%)		3580 (24.5%)	3580 (24.5%)	
Fall 2020	3260 (22.1%)	199,572 (25.0%)		3251 (22.2%)	3251 (22.2%)	
Winter 2020–21	5061 (34.3%)	173,901 (21.8%)		5020 (34.3%)	5020 (34.3%)	
Spring 2021	1163 (7.9%)	79,409 (9.9%)		1142 (7.8%)	1142 (7.8%)	
Hospital region						
Midwest	2814 (19.1%)	177,948 (22.3%)	<.001	2793 (19.1%)	2725 (18.6%)	.178
Northeast	2748 (18.6%)	109,648 (13.7%)		2693 (18.4%)	2665 (18.2%)	
South	6934 (47.0%)	373,446 (46.7%)		6909 (47.2%)	7089 (48.5%)	
West	2248 (15.2%)	138,090 (17.3%)		2230 (15.2%)	2146 (14.7%)	
Elixhauser score	0.8 (1.0)	0.8 (1.0)	.251	0 (0–1)	0 (0–1)	.972
Obesity	2462 (16.7%)	120,983 (15.1%)	<.001	2407 (16.5%)	2407 (16.5%)	1.000
Hypertension (pregestational or gestational)	465 (3.2%)	24,012 (3.0%)	.294	417 (2.9%)	417 (2.9%)	1.000
Diabetes mellitus (pregestational or gestational)	1785 (12.1%)	89,516 (11.2%)	<.001	1733 (11.8%)	1733 (11.8%)	1.000
Chronic pulmonary disease	831 (5.6%)	49,329 (6.2%)	.007	795 (5.4%)	795 (5.4%)	1.000

Data are mean (SD) or number (percentage) unless otherwise specified.

[a]Spring: March, April, May; summer: June, July, August; fall: September, October, November; winter: December, January, February.

TABLE 2

Baseline characteristics in the unmatched and propensity score–matched people with COVID-19, with and without viral pneumonia

	Unmatched			Matched		
	PNA: COVID-19 with pneumonia (N=773)	**COVID: COVID-19 without pneumonia (N=14,744)**	***P* value**	**PNA: COVID-19 with pneumonia (N=772)**	**COVID: COVID-19 without pneumonia (N=772)**	***P* value**
Age (y)	30.6 (6.2)	28.2 (6.0)	<.001	29.5 (6.1)	29.2 (5.7)	.485
Race and ethnicity						
Hispanic	286 (37.0%)	5212 (35.3%)	<.001	286 (37.0%)	294 (38.1%)	.829
Non-Hispanic White	203 (26.3%)	5346 (36.3%)		202 (26.2%)	194 (25.1%)	
Non-Hispanic Black	152 (19.7%)	2281 (15.5%)		152 (19.7%)	165 (21.4%)	
Non-Hispanic Asian	36 (4.7%)	451 (3.1%)		36 (4.7%)	33 (4.3%)	
None of the above/unknown	96 (12.4%)	1454 (9.9%)		96 (12.4%)	86 (11.1%)	
Marital status						
Married	322 (41.7%)	5648 (38.3%)	.162	322 (41.7%)	315 (40.8%)	.696
Single	338 (43.7%)	6895 (46.8%)		338 (43.8%)	333 (43.1%)	
None of the above/unknown	113 (14.6%)	2201 (14.9%)		112 (14.5%)	124 (16.1%)	
Payer						
Public	451 (58.3%)	8730 (59.2%)	.645	450 (58.3%)	449 (58.2%)	.936
Private	277 (35.8%)	5074 (34.4%)		277 (35.9%)	281 (36.4%)	
Other	45 (5.8%)	940 (6.4%)		45 (5.8%)	42 (5.4%)	
Gestational age (wk)						
20–27	29 (3.8%)	168 (1.1%)	<.001	29 (3.8%)	18 (2.3%)	.009
28–33	158 (20.4%)	380 (2.6%)		158 (20.5%)	29 (3.8%)	
34–36	211 (27.3%)	1262 (8.6%)		211 (27.3%)	80 (10.4%)	
37–42	375 (48.5%)	12,934 (87.7%)		374 (48.4%)	645 (83.5%)	
Hospital number of beds						
000–299	168 (21.7%)	4476 (30.4%)	<.001	168 (21.8%)	170 (22.0%)	.979
300–499	244 (31.6%)	4829 (32.8%)		243 (31.5%)	245 (31.7%)	
500+	361 (46.7%)	5439 (36.9%)		361 (46.8%)	357 (46.2%)	
Discharge season[a]						

	Unmatched			Matched		
	PNA: COVID-19 with pneumonia (N=773)	**COVID: COVID-19 without pneumonia (N=14,744)**	***P* value**	**PNA: COVID-19 with pneumonia (N=772)**	**COVID: COVID-19 without pneumonia (N=772)**	***P* value**
Spring 2020	134 (17.3%)	1666 (11.3%)	<.001	134 (17.4%)	132 (17.1%)	.933
Summer 2020	192 (24.8%)	3594 (24.4%)		191 (24.7%)	192 (24.9%)	
Fall 2020	119 (15.4%)	3260 (22.1%)		119 (15.4%)	120 (15.5%)	
Winter 2020–21	252 (32.6%)	5061 (34.3%)		252 (32.6%)	242 (31.3%)	
Spring 2021	76 (9.8%)	1163 (7.9%)		76 (9.8%)	86 (11.1%)	
Hospital region						
Midwest	142 (18.4%)	2814 (19.1%)	.011	142 (18.4%)	148 (19.2%)	.980
Northeast	124 (16.0%)	2748 (18.6%)		124 (16.1%)	123 (15.9%)	
South	357 (46.2%)	6934 (47.0%)		356 (46.1%)	350 (45.3%)	
West	150 (19.4%)	2248 (15.2%)		150 (19.4%)	151 (19.6%)	
Elixhauser score	1.8 (1.6)	0.8 (1.0)	<.001	1.1 (1.1)	1.1 (1.2)	.821
Obesity	283 (36.6%)	2462 (16.7%)	<.001	283 (36.7%)	289 (37.4%)	.752
Hypertension (pregestational or gestational)	75 (9.7%)	465 (3.2%)	<.001	75 (9.7%)	67 (8.7%)	.481
Diabetes mellitus (pregestational or gestational)	180 (23.3%)	1785 (12.1%)	<.001	180 (23.3%)	167 (21.6%)	.428
Chronic pulmonary disease	84 (10.9%)	831 (5.6%)	<.001	84 (10.9%)	92 (11.9%)	.522

Data are mean (SD) or number (percentage) unless otherwise specified.

[a]Spring: March, April, May; summer: June, July, August; fall: September, October, November; winter: December, January, February.

TABLE 3
Frequencies of delivery outcomes by COVID-19 group

Outcomes	NOCOVID: no COVID-19 (N=799,132)	COVID: COVID-19 without pneumonia (N=14,744)	PNA: COVID-19 with pneumonia (N=773)
Cesarean delivery	257,863 (32.3%)	4687 (31.8%)	530 (68.6%)
Preterm delivery	80,878 (10.1%)	1810 (12.3%)	398 (51.5%)
Preeclampsia	114,641 (14.3%)	2267 (15.4%)	222 (28.7%)
Stillbirth	5113 (0.6%)	140 (0.9%)	10 (1.3%)

TABLE 4

Absolute and relative risks of delivery outcomes by COVID-19 group after propensity-score matching

Outcomes	COVID: COVID-19 without pneumonia (N=14,625)	NOCOVID: no COVID-19 (N=14,625)	mRR (95% CI)[a]	PNA: COVID-19 with pneumonia (N=772)	COVID: COVID-19 without pneumonia (N=772)	mRR (95% CI)[b]
Cesarean delivery	4630 (31.7%)	4776 (32.7%)	0.97 (0.94–1.00)	529 (68.5%)	328 (42.5%)	1.76 (1.53–2.03)[c]
Preterm delivery	1785 (12.2%)	1603 (11.0%)	1.11 (1.05–1.19)[c]	398 (51.6%)	127 (16.5%)	3.33 (2.56–4.33)[c]
Preeclampsia	2228 (15.2%)	2196 (15.0%)	1.02 (0.96–1.07)	222 (28.8%)	164 (21.2%)	1.37 (1.08–1.74)[c]
Stillbirth	140 (0.9%)	108 (0.7%)	1.30 (1.01–1.66)[c]	10 (1.3%)	7 (0.9%)	1.17 (0.40–3.44)

CI, confidence interval; *mRR*, matched risk ratio.

[a]Reference=NOCOVID;

[b]Reference=COVID;

[c]Statistically significantly different compared to reference group.