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Pre-Delta, Delta, and Omicron Periods of the Coronavirus Disease 2019 (COVID-19) Pandemic and Health Outcomes During Delivery Hospitalization

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Abstract

OBJECTIVE: To examine the relationship between coronavirus disease 2019 (COVID-19) diagnosis at delivery and adverse maternal health and pregnancy outcomes during pre-Delta, Delta, and Omicron variant predominance, with a focus on the time period of Omicron variant predominance.

METHODS: We conducted a cross-sectional observational study with data from delivery hospitalizations in the Premier Healthcare Database from February 2020 to August 2023. The pre-Delta (February 2020–June 2021), Delta (July 2021–December 2021), and Omicron (January 2022–August 2023) periods of variant predominance were examined. Exposure to COVID-19 was identified by having a diagnostic code for COVID-19 during the delivery hospitalization. Adjusted prevalence ratios (aPRs) were calculated to compare the risks of adverse maternal and pregnancy outcomes for women with and without COVID-19 diagnoses at the time of delivery for each variant period.

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Regina M. Simeone disclosed previously owning Pfizer stock. Jeffrey Carlson disclosed previously owning Moderna stock. Laura Riley disclosed being an author for Up to Date (HSV, Rubella, Parvovirus), consultant to GSK and Pfizer, and consulted on Medscape education module. The other authors did not report any potential conflicts of interest.

RESULTS: Among 2,990,973 women with delivery hospitalizations, 1.9% (n = 56,618) had COVID-19 diagnoses noted at delivery admission discharge, including 26,053 during the Omicron period. Across all variant time periods, the prevalence of many adverse maternal and pregnancy outcomes during the delivery hospitalization was significantly higher for pregnant women with COVID-19 compared with pregnant women without COVID-19. In adjusted models, COVID-19 during the Omicron period was associated with significant increased risks for maternal sepsis (COVID-19: 0.4% vs no COVID-19: 0.1%; aPR 3.32, 95% CI, 2.70–4.08), acute respiratory distress syndrome (0.6% vs 0.1%; aPR 6.19, 95% CI, 5.26–7.29), shock (0.2% vs 0.1%; aPR 2.14, 95% CI, 1.62–2.84), renal failure (0.5% vs 0.2%; aPR 2.08, 95% CI, 1.73–2.49), intensive care unit admission (2.7% vs 1.7%; aPR 1.64, 95% CI, 1.52–1.77), mechanical ventilation (0.3% vs 0.1%; aPR 3.15, 95% CI, 2.52–3.93), in-hospital death (0.03% vs 0.01%; aPR 5.00, 95% CI, 2.30–10.90), stillbirth (0.7% vs 0.6%; aPR 1.17, 95% CI, 1.01–1.36), and preterm delivery (12.3% vs 9.6%; aPR 1.28, 95% CI, 1.24–1.33).

CONCLUSION: Despite the possibility of some level of immunity due to previous severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection, vaccination, or testing differences, risks of adverse outcomes associated with COVID-19 diagnosis at delivery remained elevated during the Omicron variant time period.

Pregnant women are at increased risk of developing severe coronavirus disease 2019 (COVID-19) complications and of dying compared with nonpregnant women.[1,2] As new severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) variants of concern emerge, data suggest the risk for adverse outcomes may differ by variant type. The Delta variant, which became the predominant strain in July 2021, was associated with increased risks of severe adverse maternal and infant outcomes compared with pre-Delta variants.[3–8] This difference in severity was thought to reflect the changing nature of the virus to induce more severe illness.[9]

Questions subsequently have arisen about whether SARS-COV-2 continues to have severe consequences that affect maternal and infant health. Several large studies conducted outside the United States demonstrate less severe maternal and infant outcomes during the Omicron period relative to the pre-Delta and Delta periods; however, the risks for severe adverse outcomes due to Omicron infection remained elevated relative to baseline.[5,10,11] In the United States, few studies have assessed the severity of COVID-19 during Omicron predominance; studies available are limited by small sample sizes.[12,13]

Using a large U.S. database of hospital admissions, we describe COVID-19 diagnosed among pregnant women at delivery hospitalization from the beginning of the COVID-19 outbreak through August 2023. We also estimate the risk of adverse outcomes among pregnant women with and without COVID-19 at the delivery hospitalization across the variant time periods, with a focus on the time of Omicron variant predominance.

METHODS

We performed a cross-sectional analysis of all delivery-related hospital admissions using the Premier Healthcare Database COVID-19 Release (https://premierinc.com/; release date August 28, 2023).[14] The Premier Healthcare Database is a comprehensive, service-based,

all-payer database that compiles discharge data from more than 1,419 nonprofit, community-based teaching hospitals and hospital systems from geographically varied areas, including both urban and rural areas. The Premier Healthcare Database represents approximately 20% of inpatient discharges in the United States. For this study, we included data from 912 hospitals with delivery hospitalizations in which COVID-19 diagnoses were being reliably reported from February 2020 to August 2023. The methods build on previously published reports. [4,15,16]

Diagnostic and procedure codes from the International Classification of Diseases, Tenth Revision (ICD-10) were used to identify obstetric delivery resulting in a singleton live birth or stillbirth and diagnosis-related codes among females aged 12–55 years, excluding gestations less than 20 weeks and those with missing gestational age (Appendix 1, available online at http://links.lww.com/AOG/D476). COVID-19 during delivery hospitalization was determined using ICD-10 codes U07.1 (COVID-19, virus identified) or B97.29 (other coronavirus as the cause of disease classified elsewhere). Among individuals with two delivery hospitalizations during the study period (identified as having an eligible delivery hospitalization code at least 6 months after a prior delivery), one admission was selected at random to be included in the analysis. Individuals with more than two delivery hospitalizations were excluded.

Adverse maternal outcomes and pregnancy outcomes were identified using ICD-10 diagnostic and procedure codes (Appendices 2 and 3, available online at http://links.lww.com/AOG/D476). The following maternal adverse outcomes were assessed: renal failure, cardiac event or outcome (including acute myocardial infarction, cardiomyopathy, heart failure, cardiac arrest, cardioversion, atrial fibrillation, ventricular tachycardia, ischemia, and pulmonary edema), thromboembolic disease (including deep vein thrombosis and other thromboembolic disease), acute respiratory distress syndrome (ARDS), shock, sepsis, intensive care unit (ICU) admission, mechanical ventilation, and in-hospital death. Admission to the ICU and mechanical ventilation were identified through a combination of ICD-10 procedure codes and hospital chargemaster records. A composite measure of any severe outcome included ICU admission, mechanical ventilation, or in-hospital death. Adverse pregnancy outcomes included stillbirth (fetal death or pregnancy loss at more than 20 weeks of gestation), preterm delivery (less than 37 weeks of gestation), and cesarean delivery. A composite measure of any of the pregnancy outcomes was also created, which includes stillbirth or preterm delivery.

Medical conditions were identified if an ICD-10 diagnosis or procedure code was present at the delivery hospitalization (Appendix 4, available online at http://links.lww.com/AOG/D476). Medical conditions included obesity, any diabetes (including type 1 and type 2, gestational diabetes, or unknown diabetes), prepregnancy diabetes, gestational diabetes, asthma, other chronic lung diseases (including chronic obstructive pulmonary disease, chronic respiratory failure, pulmonary fibrosis, cystic fibrosis, chronic bronchitis, obstructive sleep apnea, interstitial lung disease, or sarcoidosis), any hypertensive disorders of pregnancy (including chronic hypertension; gestational hypertension; chronic hypertension with superimposed preeclampsia; preeclampsia; eclampsia; or hemolysis, elevated liver

enzymes, and low platelet count [HELLP] syndrome), chronic hypertension, and gestational hypertension.

Demographic variables included maternal age, race and ethnicity (non-Hispanic Asian, non-Hispanic Black, Hispanic, non-Hispanic other, non-Hispanic White), primary insurance payer (Medicaid, private insurance, other, self-pay), hospital location (urban and rural based on U.S. Census, where block groups have a population density of at least 1,000 people/square mile and surrounding block groups a density of 500 people/square mile),[17] and hospital region (based on U.S. Census: Midwest, Northeast, South, West). Race and ethnicity, which were reported on claims data, were assessed in the study as a proxy for social injustices that might reflect differences in COVID-19 diagnosis.

This study was reviewed by the Centers for Disease Control and Prevention and was conducted consistent with applicable federal law and Centers for Disease Control and Prevention policy; the study was determined to meet the requirements of public health surveillance as defined in 45 CFR 46.102(l)(2) because all data were completely deidentified.

Demographic characteristics, medical conditions, adverse maternal outcomes, and pregnancy outcomes by variant period were summarized using frequencies. COVID-19 case counts were calculated using delivery hospital admission dates. Poisson regression models with robust standard errors were used to calculate the adjusted prevalence ratio (aPR) of adverse maternal and pregnancy outcomes at the delivery hospitalization by COVID-19 diagnosis for each time period of variant predominance. Regression models controlled for maternal age at delivery, obesity, diabetes, asthma, and chronic hypertension. Data were stratified by timing of variant predominance based on SARS-CoV-2 genomic surveillance.[18] When the percent of infections by a specific variant constituted more than 50% of sequenced isolates, it was determined to be the predominant variant.[18] This approach translated into three periods of study, including the pre-Delta period (February 2020–June 2021), the Delta period (July 2021–December 2021), and the Omicron period (January 2022–August 2023). Variant periods were classified using whole months because of data aggregation in the Premier Healthcare Database. Analyses were performed using R 4.1.2.

RESULTS

Overall, 2,990,973 pregnant women at delivery hospitalization were included. Maternal demographic characteristics are shown in Table 1. COVID-19 diagnosis was reported in 1.9% (n = 56,618) of individuals at delivery hospitalizations, including 20,031 during the pre-Delta period, 10,534 during the Delta period, and 26,053 during the Omicron period. COVID-19 diagnoses at delivery hospitalization peaked at the beginning of 2022, corresponding to the beginning of the period of Omicron predominance (Fig. 1).

The distribution of race and ethnicity among those with COVID-19 varied across variant periods. For all variant periods, the highest percentage of individuals diagnosed with COVID-19 were enrolled in Medicaid, were hospitalized at facilities in urban areas, and were in southern regions. The prevalence of most medical conditions at delivery

hospitalization was similar across variant periods, with hypertensive disorders of pregnancy and obesity most prevalent (Table 2). All adverse maternal outcomes occurred more frequently among pregnant individuals with COVID-19 compared with pregnant individuals without COVID-19. Adverse maternal and pregnancy outcomes were most prevalent during the Delta variant period and least prevalent during the Omicron variant period (Table 2). Prevalence of adverse maternal and pregnancy outcomes among women without COVID-19 remained similar across variant periods. Across all variant periods, the most prevalent adverse maternal outcomes associated with COVID-19 diagnosis were ARDS and ICU admission.

During the Omicron variant period, the risks of all adverse outcomes were significantly higher at delivery hospitalization in pregnant women with COVID-19 than in those without COVID-19 (Fig. 2 and Appendix 5; Appendix 5 available online at http://links.lww.com/AOG/D476). Specifically, compared with pregnant women without COVID-19, pregnant women with COVID-19 during the Omicron period were six times as likely to be diagnosed with ARDS (0.6% vs 0.1%; aPR 6.19, 95% CI, 5.26–7. 29), five times as likely to die during delivery hospitalization (0.03% vs 0.01%; aPR 5.00, 95% CI, 2.30–10.90), three times as likely to be diagnosed with sepsis (0.4% vs 0.1%; aPR 3.32, 95% CI, 2.70–4.08) or to receive mechanical ventilation (0.3% vs 0.1%; aPR 3. 15, 95% CI, 2.52–3.93), twice as likely to be diagnosed with shock (0.2% vs 0.1%; aPR 2.14, 95% CI, 1.62–2. 84) and renal failure (0.5% vs 0.2%; aPR 2.08, 95% CI, 1.73–2.49), and 64% more likely to be admitted to the ICU (2.7% vs 1.7%; aPR 1.64, 95% CI, 1.52–1.77). For pregnancy outcomes, pregnant women with COVID-19 were 28% more likely to deliver preterm (12.3% vs 9.6%; aPR 1.28, 95% CI, 1.24–1.33) and 17% more likely to have stillbirth (0.7% vs 0.6%; aPR 1.17, 95% CI, 1.01–1.36) than those without COVID-19 (Fig. 3 and Appendix 6; Appendix 6 available online at http://links.lww.com/AOG/D476).

DISCUSSION

Across all variant time periods, the prevalence of many adverse maternal and pregnancy outcomes at delivery hospitalization was significantly higher for pregnant women with COVID-19 compared with pregnant women without COVID-19. During the Omicron period, these associations with adverse outcomes were persistent despite what was perceived as a less virulent variant. Of the examined outcomes, COVID-19 was most strongly associated with increased prevalence of in-hospital death and ARDS during the Omicron time period, although these outcomes were rare.

Our finding of an association between COVID-19 and adverse outcomes during the Omicron variant period are consistent with studies conducted among pregnant women outside of the United States.[5,10] Overall, we observed lower magnitude of risks during the Omicron variant period relative to previous periods. These findings could be due to reduced virulence of the SARS-CoV-2 Omicron variant compared with previous variants or population-level immunity from vaccination and previous infection or both.[19] In a small study of unvaccinated and previously uninfected adults, people with SARS-CoV-2 infection during the Omicron variant period had lower absolute risk of acute symptomatic illness and were less likely to seek health care,[20] which suggests a lower virulence. One study, however,

found that disease severity and pregnancy complications were similar between the Omicron and Delta variant periods among unvaccinated pregnant women.[21]

This information on severity must be interpreted in context, because the prevalence of immunity from both vaccination and prior infection was much higher during Omicron variant predominance than during earlier periods. During the middle of the Delta period, on September 18, 2021, 57% of pregnant women in the Vaccine Safety Datalink had completed a COVID-19 vaccine primary series compared with 71% on March 5, 2022[22]; during January–March 2022, more than 90% of adult blood donors had evidence of vaccine- or infection-induced immunity or both to SARS-CoV-2. It is known that COVID-19 vaccines provide protection against hospitalization, including in pregnant women,[23] and provide protection against critical illness and death.[24,25]

There are several limitations to note. First, these data are based on COVID-19 diagnoses at the time of delivery hospitalization. Thus, infections occurring earlier in pregnancy and pregnancy outcomes not requiring delivery hospitalization (eg, spontaneous abortion or pregnancy termination) and individuals who have not delivered yet were not captured in these data. Second, individual genetic sequence information for infection is not available for this data set, limiting our ability to determine the variant of infection with high specificity, which may have resulted in misclassification of variant exposure. In accordance with similar analyses of SARS-COV-2 variants, nationally representative data on SARS-CoV-2 variant predominance were used to determine cutoffs for variant time periods. Using a 50% variant predominance will result in misclassification of variant exposure and could bias effect estimates within a given variant period in either direction. Lastly, information on previous infection and vaccination in the Premier Healthcare Database is limited, with less than 4% and 1% of hospitalizations having data on infection or vaccination reported, respectively; however, we expect rates of prior infection and vaccination to be higher during the Omicron period.

Also, COVID-19 testing and screening practices may have changed over time. Accordingly, we do not provide statistical comparisons of prevalence across variant periods because estimates would be biased. Additionally, our findings may underestimate the risks of SARS-COV-2 infection for adverse maternal and pregnancy outcomes during the Omicron period for immunologically naïve pregnant persons, though this population is likely small.[26]

This analysis demonstrates continued risks to maternal and infant health during the Omicron period and can be used to inform pregnant people and health care clinicians about the ongoing risks of COVID-19 during pregnancy. These findings underscore the importance of continued surveillance, research, and monitoring of maternal, pregnancy, and infant outcomes as new variants emerge. Since the national COVID-19 public health emergency ended on May 11, 2023,[27] analyses of large hospital data sets are important to ascertain COVID-19 diagnoses in pregnant people given that case-level data will not be reported to health departments.

Prevention of SARS-COV-2 infection with standard precautions during pregnancy remains a critical prevention strategy, with known benefits to both pregnant persons and infants.

Vaccination during pregnancy has been shown to not only protect against severe maternal illness, but also to provide protection against hospitalization for infants up to 6 months of age. Vaccination is well established to be safe and effective for both the pregnant person and fetus; however, immunity wanes over time.[28] Pregnant people and those planning pregnancy should continue to stay up to date with recommended COVID-19 vaccines to protect themselves and their infants.[29]

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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The following text focuses on pregnancy-related or -associated events. It makes use of concepts or descriptions that align with the traditional gender definitions by using concepts such as “maternal,” “pregnant women,” or “women.” However, the concepts described are translatable to all persons who experience a pregnancy, regardless of their gender identity. In this analysis, we limited delivery hospitalizations to females and so have used “pregnant women” when referring to this analysis.

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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Each author has confirmed compliance with the journal’s requirements for authorship.

REFERENCES

1. Allotey J, Stallings E, Bonet M, Yap M, Chatterjee S, Kew T, et al. Clinical manifestations, risk factors, and maternal and perinatal outcomes of coronavirus disease 2019 in pregnancy: living systematic review and meta-analysis. BMJ 2020;370: m3320. doi: 10.1136/bmj.m3320
2. Zambrano LD, Ellington S, Strid P, Galang RR, Oduyebo T, Tong VT, et al. Update: characteristics of symptomatic women of reproductive age with laboratory-confirmed SARS-CoV-2 infection by pregnancy status—United States, January 22–October 3, 2020. MMWR Morb Mortal Wkly Rep 2020;69: 1641–7. doi: 10.15585/mmwr.mm6944e3 [PubMed: 33151921]
3. Craig A, Judge-Golden C, Moyett J, Ramey-Collier K, Hughes BL, Dotters-Katz SK. Pregnancy outcomes by pandemic wave among pregnant individuals with COVID-19 infection [abstract]. Am J Obstet Gynecol 2023;228:S781–2. doi: 10.1016/j.ajog.2022.11.133
4. DeSisto CL, Wallace B, Simeone RM, Polen K, Ko JY, Mean-ey-Delman D, et al. Risk for stillbirth among women with and without COVID-19 at delivery hospitalization—United States, March 2020–September 2021. MMWR Morb Mortal Wkly Rep 2021;70:1640–5. doi: 10.15585/mmwr.mm7047e1 [PubMed: 34818318]
5. Favre G, Maisonneuve E, Pomar L, Daire C, Poncelet C, Quibel T, et al. Maternal and perinatal outcomes following pre-Delta, Delta, and Omicron SARS-CoV-2 variants infection among unvaccinated pregnant women in France and Switzerland: a prospective cohort study using the COVI-PREG registry. Lancet Reg Health Eur 2023;26:100569. doi: 10.1016/j.lanepe.2022.100569
6. Judge-Golden C, Craig A, Moyett J, Ramey-Collier K, Hughes B,Dotters-Katz S. Disease severity across pandemic waves among pregnant individuals with COVID-19 [abstract]. Am J Obstet Gynecol 2023;228:S782–3. doi: 10.1016/j.ajog.2022.11.135

7. Kim H, Kim HS, Kim HM, Kim MJ, Kwon KT, Cha HH, et al. Impact of vaccination and the Omicron variant on COVID-19 severity in pregnant women. Am J Infect Control 2023;51:351–3. doi: 10.1016/j.ajic.2022.07.023 [PubMed: 35921943]
8. Shoji K, Tsuzuki S, Akiyama T, Matsunaga N, Asai Y, Suzuki S,et al. Comparison of clinical characteristics of COVID-19 in pregnant women between the Delta and Omicron variants of concern predominant periods. J Infect Chemother 2023;29:33–8. doi: 10.1016/j.jiac.2022.09.005 [PubMed: 36103949]
9. Mahase E. Covid-19: what do we know about Omicron sub-lineages? BMJ 2022;376:0358. doi: 10.1136/bmj.o358
10. Stock SJ, Moore E, Calvert C, Carruthers J, Denny C, Donaghy J, et al. Pregnancy outcomes after SARS-CoV-2 infection in periods dominated by Delta and Omicron variants in Scotland: a population-based cohort study. Lancet Respir Med 2022;10:1129–36. doi: 10.1016/S2213-2600(22)00360-5 [PubMed: 36216011]
11. Villar J, Soto Conti CP, Gunier RB, Ariff S, Craik R, Cavoretto PI, et al. Pregnancy outcomes and vaccine effectiveness during the period of Omicron as the variant of concern, INTERCOVID-2022: a multinational, observational study. Lancet 2023;401:447–57. doi: 10.1016/S0140-6736(22)02467-9 [PubMed: 36669520]
12. Gulersen M, Alvarez A, Rochelson B, Blitz MJ. Preterm birth and severe maternal morbidity associated with SARS-CoV-2 infection during the Omicron wave. Am J Obstet Gynecol MFM 2022;4:100712. doi: 10.1016/j.ajogmf.2022.100712
13. Seasely AR, Blanchard CT, Arora N, Battarbee AN, Casey BM, Dionne-Odom J, et al. Maternal and perinatal outcomes associated with the Omicron variant of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection. Obstet Gynecol 2022;140:262–5. doi: 10.1097/AOG.0000000000004849 [PubMed: 35852277]
14. PINC AI™ Applied Sciences. PINC AI healthcare database: data that informs and performs (white paper). Accessed March 21, 2023. https://offers.premierinc.com/rs/381-NBB-525/images/Premier-Healthcare-Database-Whitepaper-Final.pdf
15. Ko JY, DeSisto CL, Simeone RM, Ellington S, Galang RR, Oduyebo T, et al. Adverse pregnancy outcomes, maternal complications, and severe illness among US delivery hospitalizations with and without a coronavirus disease 2019 (COVID-19) diagnosis. Clin Infect Dis 2021;73(suppl 1):S24–31. doi: 10.1093/cid/ciab344 [PubMed: 33977298]
16. Simeone RM, Downing KF, Wallace B, Galang RR, DeSisto CL, Tong VT, et al. Changes in rates of adverse pregnancy outcomes during the COVID-19 pandemic: a cross-sectional study in the United States, 2019–2020. J Perinatol 2022;42:617–23. doi: 10.1038/s41372-022-01327-3 [PubMed: 35169228]
17. Federal Register. 2020 Census qualifying urban areas and final criteria clarifications. Accessed August 2, 2023. https://www.federalregister.gov/documents/2022/12/29/2022-28286/2020-census-qualifying-urban-areas-and-final-criteria-clarifications
18. Lambrou AS, Shirk P, Steele MK, Paul P, Paden CR, Cadwell B,et al. Genomic surveillance for SARS-CoV-2 variants: predominance of the Delta (B.1.617.2) and Omicron (B.1.1.529) variants—United States, June 2021–January 2022. MMWR Morb Mortal Wkly Rep 2022;71:206–11. doi: 10.15585/mmwr.mm7106a4 [PubMed: 35143464]
19. Adjei S, Hong K, Molinari NAM, Bull-Otterson L, Ajani UA, Gundlapalli AV, et al. Mortality risk among patients hospitalized primarily for COVID-19 during the Omicron and Delta variant pandemic periods—United States, April 2020–June 2022. MMWR Morb Mortal Wkly Rep 2022;71:1182–9. doi: 10.15585/mmwr.mm7137a4 [PubMed: 36107788]
20. Doll MK, Waghmare A, Heit A, Levenson Shakoor B, Kimball LE, Ozbek N, et al. Acute and postacute COVID-19 outcomes among immunologically naive adults during Delta vs Omicron waves. JAMA Netw Open 2023;6:e231181. doi: 10.1001/jama-networkopen.2023.1181
21. Birol Ilter P, Prasad S, Mutlu MA, Tekin AB, O'Brien P, von Dadelszen P, et al. Maternal and perinatal outcomes of SARS-CoV-2 infection in unvaccinated pregnancies during Delta and Omicron waves. Ultrasound Obstet Gynecol 2022;60:96–102. doi: 10.1002/uog.24916 [PubMed: 35441407]
22. Centers for Disease Control and Prevention. COVID data tracker. Accessed May 18, 2023. https://covid.cdc.gov/covid-data-tracker

23. Schrag SJ, Verani JR, Dixon BE, Page JM, Butterfield KA, Gaglani M, et al. Estimation of COVID-19 mRNA vaccine effectiveness against medically attended COVID-19 in pregnancy during periods of Delta and Omicron variant predominance in the United States. JAMA Netw Open 2022;5: e2233273. doi: 10.1001/jamanetworkopen.2022.33273

24. DeCuir J, Surie D, Zhu Y, Gaglani M, Ginde AA, Douin DJ, et al. Effectiveness of monovalent mRNA COVID-19 vaccination in preventing COVID-19–associated invasive mechanical ventilation and death among immunocompetent adults during the Omicron variant period—IVY network, 19 U.S. states, February 1, 2022–January 31, 2023. MMWR Morb Mortal Wkly Rep 2023;72:463–8. doi: 10.15585/mmwr.mm7217a3 [PubMed: 37104244]

25. Link-Gelles R, Ciesla AA, Fleming-Dutra KE, Smith ZR, Britton A, Wiegand RE, et al. Effectiveness of bivalent mRNA vaccines in preventing symptomatic SARS-CoV-2 infection—increasing community access to testing program, United States, September–November 2022. MMWR Morb Mortal Wkly Rep 2022;71:1526–30. doi: 10.15585/mmwr.mm7148e1 [PubMed: 36454688]

26. Jones JM, Manrique IM, Stone MS, Grebe E, Saa P, Germanio CD, et al. Estimates of SARS-CoV-2 seroprevalence and incidence of primary SARS-CoV-2 infections among blood donors, by COVID-19 vaccination status—United States, April 2021–September 2022. MMWR Morb Mortal Wkly Rep 2023;72:601–5. doi: 10.15585/mmwr.mm7222a3 [PubMed: 37262007]

27. Silk BJ, Scobie HM, Duck WM, Palmer T, Ahmad FB, Binder AM, et al. COVID-19 surveillance after expiration of the public health emergency declaration—United States, May 11, 2023. MMWR Morb Mortal Wkly Rep 2023;72:523–8. doi: 10.15585/mmwr.mm7219e1 [PubMed: 37167154]

28. Fleming-Dutra KE, Zauche LH, Roper LE, Ellington SR, Olson CK, Sharma AJ, et al. Safety and effectiveness of maternal COVID-19 vaccines among pregnant people and infants. Obstet Gynecol Clin North Am 2023;50:279–97. doi: 10.1016/j.ogc.2023.02.003 [PubMed: 37149310]

29. Moulia DL, Wallace M, Roper LE, Godfrey M, Rosenblum HG, Link-Gelles R, et al. Interim recommendations for use of bivalent mRNA COVID-19 vaccines for persons aged ≥6 months—United States, April 2023. MMWR Morb Mortal Wkly Rep 2023;72:657–62. doi: 10.15585/mmwr.mm7224a3 [PubMed: 37319020]

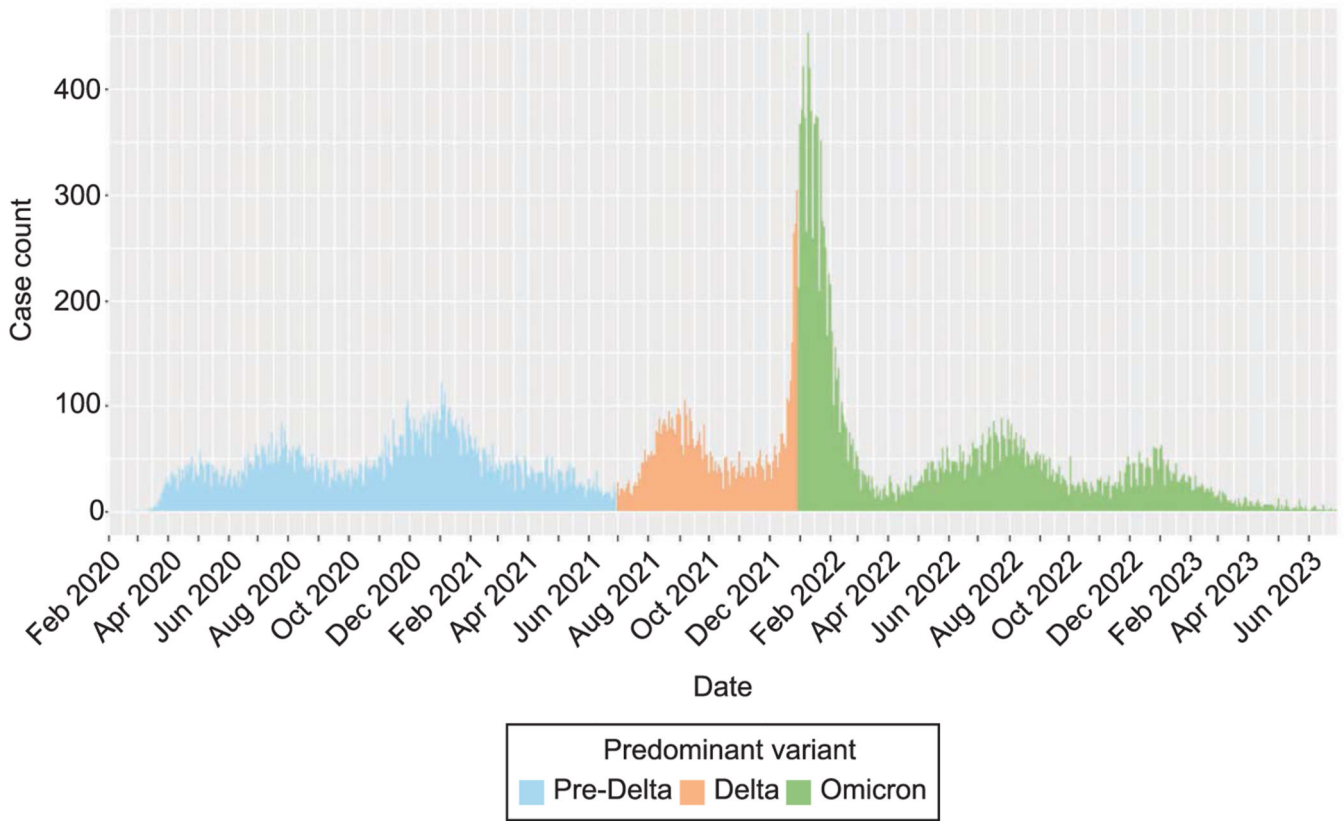

Fig. 1.

Daily coronavirus disease 2019 (COVID-19) diagnoses during delivery hospitalization, Premier Healthcare Database, February 2020–June 2023. Data for July and August are censored to account for lag in reporting.

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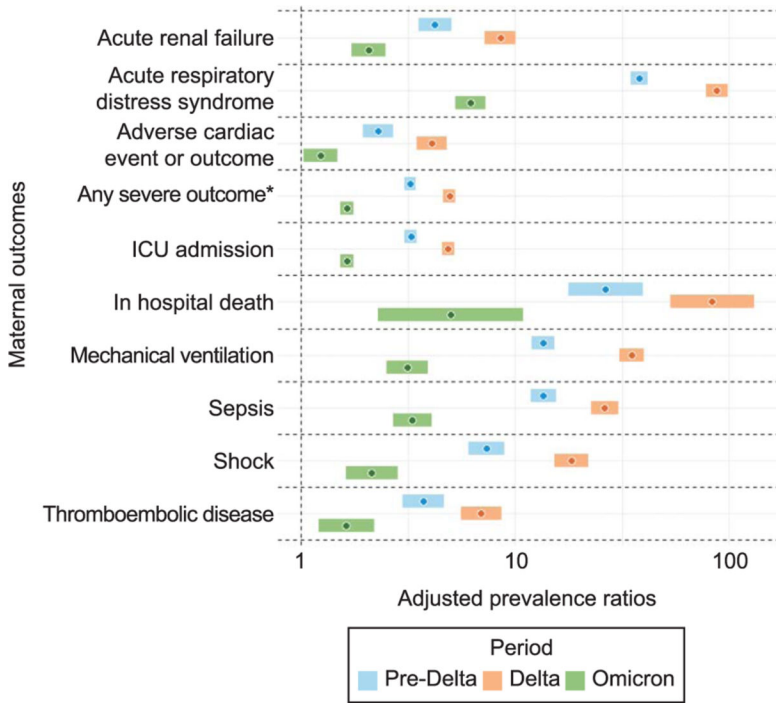

Fig. 2.

Risk of adverse outcomes* in pregnant women by coronavirus disease 2019 (COVID-19) variant predominance, Premier Healthcare Database, February 2020–August 2023.

*Includes intensive care unit (ICU) admission, mechanical ventilation, and death. Prevalence ratios were adjusted for maternal age, obesity, diabetes, asthma, and chronic hypertension. *Dots* represent prevalence ratios, and bars represent the 95% CIs for those effect estimates.

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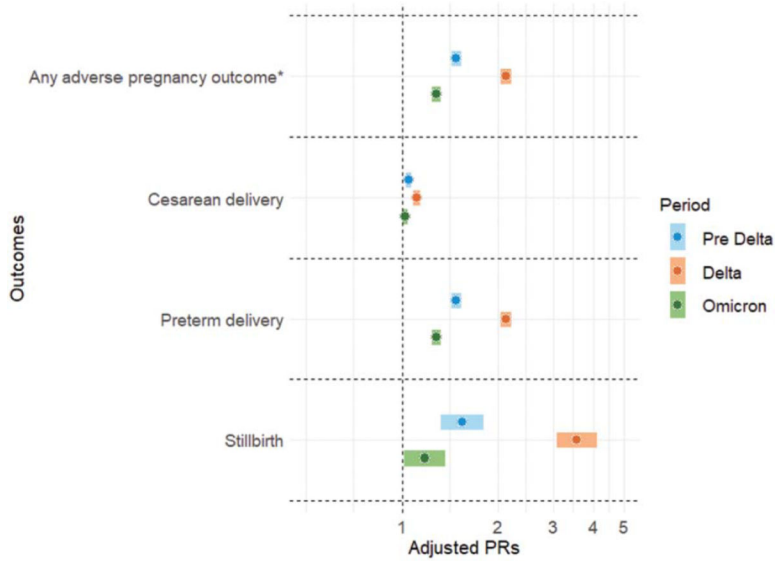

Fig. 3.

Risk of pregnancy outcomes* by coronavirus disease 2019 (COVID-19) variant predominance, Premier Healthcare Database, February 2020–August 2023. *Includes preterm delivery and stillbirth. Prevalence ratios were adjusted for maternal age, obesity, diabetes, asthma, and chronic hypertension. Dots represent prevalence ratios (PRs), and bars represent the 95% CIs for those effect estimates.

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Table 1.

Demographic Characteristics, Premier Healthcare Database, February 2020–August 2023 *

	Pre-Delta Period		Delta Period		Omicron Period	
	COVID-19 (n = 20,031)	**No COVID-19 (n = 1,200,927)**	**COVID-19 (n = 10,534)**	**No COVID-19 (n = 462,938)**	**COVID-19 (n = 26,053)**	**No COVID-19 (n = 1,270,490)**
Age (y)	28.4 ± 6.08 28.0 (13.0, 50.0)	29.3 ± 5.80 29.0 (12.0, 55.0)	28.5 ± 5.93 28.0 (13.0, 51.0)	29.4 ± 5.78 30.0 (12.0, 55.0)	29.0 ± 6.01 29.0 (12.0, 55.0)	29.4 ± 5.82 29.0 (12.0, 55.0)
Length of stay (d)	2.88 ± 3.73	2.47 ± 1.96	3.53 ± 6.20	2.52 ± 2.02	2.67 ± 2.56	2.55 ± 1.96
0–1	3,138 (15.7)	189,930 (15.8)	1,453 (13.8)	67,768 (14.6)	3,833 (14.7)	176,128 (13.9)
2–4	15,312 (76.4)	961,524 (80.1)	7,837 (74.4)	374,272 (80.8)	20,638 (79.2)	1,032,572 (81.3)
5 or more	1,581 (7.9)	49,473 (4.1)	1,244 (11.8)	20,898 (4.5)	1,582 (6.1)	61,791 (4.9)
Race and ethnicity						
Non-Hispanic Asian	683 (3.4)	59,406 (4.9)	305 (2.9)	22,105 (4.8)	1,283 (4.9)	63,153 (5.0)
Non-Hispanic Black	3,189 (15.9)	177,150 (14.8)	2,087 (19.8)	67,921 (14.7)	3,974 (15.3)	182,964 (14.4)
Hispanic	7,233 (36.1)	228,577 (19.0)	2,593 (24.6)	99,285 (21.4)	7,472 (28.7)	289,732 (22.8)
Non-Hispanic Other †	1,325 (6.6)	70,505 (5.9)	584 (5.5)	23,120 (5.0)	1,414 (5.4)	61,316 (4.8)
Non-Hispanic White	6,762 (33.8)	627,675 (52.3)	4,607 (43.7)	235,000 (50.8)	10,769 (41.3)	629,097 (49.5)
Missing	839 (4.2)	37,614 (3.1)	358 (3.4)	15,507 (3.3)	1,141 (4.4)	44,228 (3.5)
Primary payer						
Medicaid	11,977 (59.8)	517,759 (43.1)	5,668 (53.8)	195,326 (42.2)	13,530 (51.9)	538,444 (42.4)
Other ‡	759 (3.8)	56,860 (4.7)	425 (4.0)	22,356 (4.8)	1,044 (4.0)	60,968 (4.8)
Private	6,868 (34.3)	607,053 (50.5)	4,251 (40.4)	237,567 (51.3)	11,019 (42.3)	649,007 (51.1)
Self-pay	427 (2.1)	19,255 (1.6)	190 (1.8)	7,689 (1.7)	460 (1.8)	22,071 (1.7)
Hospital location						
Rural	1,883 (9.4)	133,843 (11.1)	1,196 (11.4)	49,871 (10.8)	2,691 (10.3)	137,376 (10.8)
Urban	18,148 (90.6)	1,067,084 (88.9)	9,338 (88.6)	413,067 (89.2)	23,362 (89.7)	1,133,114 (89.2)
Hospital region						
Midwest	3,361 (16.8)	242,030 (20.2)	2,168 (20.6)	97,902 (21.1)	4,927 (18.9)	259,380 (20.4)
Northeast	4,246 (21.2)	192,782 (16.1)	1,487 (14.1)	68,539 (14.8)	5,149 (19.8)	178,983 (14.1)
South	8,378 (41.8)	520,323 (43.3)	4,777 (45.3)	200,107 (43.2)	9,807 (37.6)	568,176 (44.7)
West	4,046 (20.2)	245,792 (20.5)	2,102 (20.0)	96,390 (20.8)	6,170 (23.7)	263,951 (20.8)

COVID-19, coronavirus disease 2019.

Data are mean ± SD, median (minimum, maximum), or n (%).

[*] Data represent COVID-19 diagnoses during delivery hospitalization. Pre-Delta, February 2020–June 2021; Delta July 2021–December 2021; Omicron, January 2022–August 2023.

[†] Includes individuals not reporting Hispanic ethnicity and not defined as Asian, Black, or White.

[‡] Includes data that are not missing and do not fit into a category for primary payer.

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Table 2.

Medical Conditions, Adverse Maternal Outcomes, and Pregnancy Outcomes Among Pregnant Women by Coronavirus Disease 2019 (COVID-19) Status During Delivery Hospitalization, Premier Healthcare Database, February 2020–August 2023

	Pre-Delta Period		Delta Period		Omicron Period	
	COVID-19 (n = 20,031)	**No COVID-19 (n = 1,200,927)**	**COVID-19 (n = 10,534)**	**No COVID-19 (n = 462,938)**	**COVID-19 (n = 26,053)**	**No COVID-19 (n = 1,270,490)**
Medical condition						
Obesity	3,453 (17.2)	180,604 (15.0)	1,883 (17.9)	71,981 (15.5)	4,512 (17.3)	212,026 (16.7)
Diabetes (any)	2,579 (12.9)	135,902 (11.3)	1,195 (11.3)	54,207 (11.7)	3,158 (12.1)	145,577 (11.5)
Prepregnancy diabetes	418 (2.1)	17,500 (1.5)	193 (1.8)	7,117 (1.5)	492 (1.9)	20,879 (1.6)
Gestational diabetes	2,177 (10.9)	118,881 (9.9)	1,011 (9.6)	47,310 (10.2)	2,678 (10.3)	125,367 (9.9)
Asthma	1,256 (6.3)	75,544 (6.3)	882 (8.4)	30,394 (6.6)	1,880 (7.2)	83,625 (6.6)
Other chronic lung disease	66 (0.3)	2,683 (0.2)	53 (0.5)	1,115 (0.2)	76 (0.3)	3,090 (0.2)
HDP (any)	3,760 (18.8)	205,023 (17.1)	2,052 (19.5)	84,699 (18.3)	5,474 (21.0)	253,771 (20.0)
Chronic hypertension	649 (3.2)	42,706 (3.6)	390 (3.7)	17,904 (3.9)	999 (3.8)	51,220 (4.0)
Gestational hypertension	1,430 (7.1)	93,635 (7.8)	761 (7.2)	38,335 (8.3)	2,264 (8.7)	116,949 (9.2)
Maternal outcome						
Acute renal failure	134 (0.7)	1,893 (0.2)	161 (1.5)	820 (0.2)	119 (0.5)	2,784 (0.2)
Adverse cardiac event or outcome	148 (0.7)	3,935 (0.3)	152 (1.4)	1,641 (0.4)	118 (0.5)	4,678 (0.4)
Thromboembolic disease	81 (0.4)	1,339 (0.1)	92 (0.9)	590 (0.1)	44 (0.2)	1,326 (0.1)
ARDS	694 (3.5)	1,094 (0.1)	808 (7.7)	403 (0.1)	162 (0.6)	1,264 (0.1)
Shock	114 (0.6)	964 (0.1)	156 (1.5)	381 (0.1)	51 (0.2)	1,171 (0.1)
Sepsis	261 (1.3)	1,129 (0.1)	287 (2.7)	464 (0.1)	95 (0.4)	1,382 (0.1)
Any severe outcome *	977 (4.9)	17,849 (1.5)	860 (8.2)	7,518 (1.6)	725 (2.8)	21,305(1.7)
ICU admission	957 (4.8)	17,395 (1.4)	838 (8.0)	7,405 (1.6)	713 (2.7)	21,002 (1.7)
Mechanical ventilation	315 (1.6)	1,412 (0.1)	371 (3.5)	468 (0.1)	83 (0.3)	1,287 (0.1)
In-hospital death	34 (0.2)	79 (0.007)	51 (0.5)	28 (0.006)	7 (0.03)	69 (0.005)
Pregnancy outcome						
Any adverse pregnancy outcome †	2,788 (13.9)	112,276 (9.3)	2,140 (20.3)	44,137 (9.5)	3,244 (12.5)	123,048 (9.7)
Stillbirth	165 (0.8)	6,454 (0.5)	192 (1.8)	2,393 (0.5)	176 (0.7)	7,348 (0.6)
Preterm delivery	2,751 (13.7)	110,735 (9.2)	2,112 (20.0)	43,568 (9.4)	3,209 (12.3)	121,428 (9.6)

	Pre-Delta Period		Delta Period		Omicron Period	
	COVID-19 (n = 20,031)	**No COVID-19 (n = 1,200,927)**	**COVID-19 (n = 10,534)**	**No COVID-19 (n = 462,938)**	**COVID-19 (n = 26,053)**	**No COVID-19 (n = 1,270,490)**
Cesarean delivery	6,655 (33.2)	385,768 (32.1)	3,695 (35.1)	148,246 (32.0)	8,424 (32.3)	404,627 (31.8)

COVID-19, coronavirus disease 2019; HDP, hypertensive disorder of pregnancy; ARDS, acute respiratory distress syndrome; ICU, intensive care unit.

Data are n (%).

*Includes ICU admission, mechanical ventilation, or in-hospital death.

†Includes stillbirth or preterm delivery.

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