

Prevalence of maternal complications and neonatal outcomes at a Midwest academic health center

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Keywords: Obesity, preeclampsia, cesarean, Midwest, obstetric outcomes, maternal complications, neonatal complications

Abstract

Introduction: The University of Iowa Hospitals and Clinics (UIHC) serves as the main referral center for Iowa and has seen increased delivery volumes following many hospital closures across the state. Maternal characteristics are also shifting as pre-pregnancy obesity of reproductive-age women is increasing nationally and in Iowa; average maternal age at first delivery has also increased over time. The aim of the current study was to characterize the outcomes of the delivering population at UIHC over a one-year period to better understand the population we serve, as well as compare our population to state and national delivering populations.

Methods: This study is a secondary analysis of a pre-existing prospectively gathered database related to COVID-19 in pregnancy. The current study included all pregnant patients who delivered or underwent procedures for a spontaneous or induced second-trimester

abortion on the labor and delivery unit at UIHC between May 1, 2020, and April 30, 2021. Demographic and clinical data including maternal characteristics, delivery information, maternal complications, and neonatal outcomes were obtained from the electronic medical record and double entered in a Research Electronic Data Capture (REDCap) database. Continuous and categorical variables were summarized using medians and ranges.

Results: The median maternal age among the 2497 delivering patients was 30 (IQR 26, 33). The median pre-delivery body mass index (BMI) was 32 (IQR 28, 37), which included 439 patients (17.6%) with BMI >40 at time of delivery. 1769 (70.8%) patients listed White as their self-defined race and 2275 (91.0%) listed English as their preferred language. 23% had hypertensive disease of pregnancy. The patients delivered a total of 2603 neonates, with 907 (34.8%) born by cesarean section. 18.7% of deliveries were preterm and 16.6% of neonates had low birth weight.

Please cite this paper as: Swartz SR, Kenne KA, Steffen HA, Bujimalla PV, Wendt LH, Jackson JB, Rysavy MB. Prevalence of maternal complications and neonatal outcomes at a Midwest academic health center. *Proc Obstet Gynecol.* 2023;12(1): Article 5 [12 p.]. Available from: <https://pubs.lib.uiowa.edu> Free full text article.

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Financial Disclosure: The authors report no conflict of interest.

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Discussion: *The delivering population at UIHC has a high rate of obesity and preeclampsia, both of which place patients at higher risk for other obstetric complications. The cesarean section rate was significantly higher than the national rate of 31.8% (p=0.0017). Understanding common complications in our changing population will better equip providers to care for these patients; providing these data also creates a resource for other researchers.*

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Introduction

The University of Iowa Hospitals and Clinics (UIHC) serves as a referral hospital for much of the state of Iowa and even into rural areas in surrounding states. Data from the UIHC patient discharge database show that in 2021, UIHC received over 400 transfers for complex maternal care. In 2021, over 63% of delivering patients came to UIHC from outside Johnson County. Delivery volumes have been steadily increasing since 2017, from about 2250 to nearly 2700 deliveries in 2021. Visits to obstetric and gynecologic clinics have also increased, from around 64,000 in 2017 to over 80,000 clinic visits in 2021.¹

Obstetric patients may be referred to UIHC for a variety of reasons, including high-risk pregnancy management, peripartum maternal or fetal complications, or for intrapartum care due to factors that may make delivery

risky at smaller hospitals. For example, many hospitals have gestational age-based recommendations for transferring patients in preterm labor based on available neonatal care resources. Other hospitals in the state have policies preventing them from delivering patients over a certain body mass index (BMI) due to risks of airway management with limited anesthesia resources. This restriction is especially relevant in the context of steadily rising rates of pre-pregnancy obesity among women of childbearing age. The national rate of maternal pre-pregnancy obesity increased from 26.1% to 29.0% in just three years between 2016 and 2019.² The rising prevalence of obesity amongst expecting mothers suggests that there may also be increasing rates of obesity-related complications, including gestational diabetes, gestational hypertension, preeclampsia, preterm birth, neurodevelopmental problems, and postpartum depression.^{3, 4}

Maternal age has also increased nationally⁵ and in the state⁶ in the past decade. From 2011 to 2020, the percentage of delivering patients under age 20 in the state of Iowa decreased from 7% to 4%, while the percentage of delivering patients ages 31-35 years increased from 22% to 26%, and the percentage of delivering patients over the age of 35 years increased from 7% to 10%.

Increased delivery volumes and changing maternal characteristics have likely altered the population of patients served by UIHC. The primary objective of the current study was to characterize the outcomes of the entire delivering

population over a one-year period. Our goal in publishing this study is to provide healthcare providers with an updated overview of our obstetric patient population and serve as baseline data for future researchers.

Methods

This study is a secondary analysis of a pre-existing prospectively gathered database related to COVID-19 infection in pregnancy. Prospective data were collected on all pregnant patients who delivered or underwent procedures for a spontaneous or induced second-trimester abortion on the labor and delivery unit at UIHC between May 1, 2020, and April 30, 2021. This study is part of a larger prospective cohort study on COVID-19 infection in pregnant women; data from the first several months of that study have been previously published, and methods for COVID-19 assay testing were described.⁷ Demographic and clinical data were obtained from the electronic medical record and double entered in a Research Electronic Data Capture (REDCap) database. Data were collected at the time of delivery. Demographic data including race and ethnicity were self-reported during the hospital registration process. The racial categories used correspond with the National Institutes of Health (NIH)'s racial and ethnic categories.⁸ Quantitative blood loss was calculated in accordance with university protocol.⁹ The Institutional Review Board (IRB) at the University of Iowa approved this

study (IRB #202004278). The project was internally funded.

Continuous and categorical variables were summarized using medians and inter-quartile ranges (IQR). Cesarean section rates were compared to national averages via a one-sample exact binomial test.

Results

A total of 2497 patients delivered or underwent procedures for a spontaneous pregnancy loss or termination between May 1, 2020, and April 30, 2021. One individual in the population delivered twice, both in May 2020 and April 2021. The median maternal age was 30 (IQR 26, 33) (Table 1). The median BMI at delivery was 32 (IQR 28, 37). Of delivering patients, 71% of patients were White (self-reported) and 91% listed English as their preferred language. 46% of patients were on Medicaid or Medicare. 2482 (99.4%) mothers had at least some prenatal care (defined as 1 or more documented prenatal visits). 739 mothers were primigravid, with a median age of 27.

15% of patients had either type 1, type 2, or gestational diabetes mellitus, though this number was 30% for patients with a delivery BMI >40 (Table 2). 259 (10.4%) patients were positive for antibodies to Sars-CoV-2, the virus that causes COVID-19, with positivity being defined as positive by both Roche and DiaSorin assays, as described in prior research.⁷

Table 1: Maternal Characteristics, Complications, and Delivery Information

Total Number of Patients	N = 2497 ¹
Maternal Age	30 (IQR 26, 33)
BMI (at delivery admission)	32 (IQR 28, 37)
Race	
White	1766 (70.7%)
AA/Black	305 (12.2%)
Black African	2 (<0.1%)
Hispanic/Latino	211 (8.5%)
American Indian/Alaska Native	6 (0.2%)
Native Hawaiian/Pacific Islander	5 (0.2%)
Asian	116 (4.6%)
Multiracial/ two or more races	54 (2.2%)
Unknown/Unspecified	1 (<0.1%)
Declines	31 (1.2%)
Gravidity (admission)	2 (IQR 1, 18)
Parity (admission)	1 (IQR 0, 11)
Living Children (admission)	1 (IQR 0, 13)
Patient Preferred Language	
English	2273 (91.0%)
Spanish	77 (3.1%)
French	59 (2.4%)
Arabic	27 (1.1%)
Other	61 (2.4%)
Insurance	
Private (only)	1286 (51.5%)
Medicaid/Medicare (any)	1140 (45.7%)
Other	3 (0.1%)
None	68 (2.7%)
Prenatal Care	
No	13 (0.5%)
Yes	2482 (99.4%)
Unknown	2 (<0.1%)
COVID-19 Antibody Status	
Negative	2238 (89.6%)
Positive	259 (10.4%)
HIV Status	
Negative	2492 (99.8%)
Positive	5 (0.2%)
Diabetes	
No	2113 (84.6%)
Type 1 diabetes	42 (1.7%)
Type 2 diabetes	54 (2.2%)
Gestational diabetes	288 (11.5%)
Asthma	
No	2146 (85.9%)
Yes	351 (14.1%)
Hypertensive disorder during pregnancy or delivery admission ²	
No	1912 (76.6%)
Chronic hypertension	181 (7.2%)

Gestational hypertension	196 (7.8%)
Pre-eclampsia without severe features	104 (4.2%)
Pre-eclampsia with severe features (including HELLP)	162 (6.5%)
Eclampsia	1 (<0.1%)
ICU admission	12 (0.5%)
Oxygen requirement	19 (0.8%)
Prolonged postpartum stay (>2 nights SVD, >3 nights CS)	105 (4.2%)
Endometritis (during delivery admission)	14 (0.6%)
Pyelonephritis (during delivery admission)	11 (0.4%)
Sepsis (during delivery admission)	0 (0%)
Thromboembolic Disease (DVT, PE)	3 (0.2%)
Maternal death	1 (<0.1%)
Number of fetuses	
Singleton	2393 (95.8%)
Twins	102 (4.1%)
Triplets	2 (<0.1%)
Gestational Age at Delivery	39w0d (IQR 37w3d, 39w5d)
Preterm birth	466 (18.7%)
Quantitative blood loss at delivery (mL)	325 (IQR 150, 687)
Postpartum hemorrhage (QBL >1000 mL)	437 (17.5%)
Preterm labor	325 (13.0%)
Premature rupture of membranes	246 (9.9%)
Morbidly adherent placenta (accreta, percreta, increta)	3 (0.1%)
Placental abruption	41 (1.6%)
Chorioamnionitis	167 (6.7%)
Non-reassuring fetal status	289 (11.6%)

¹Median (IQR); n (%)

²Percentages under this heading do not add up to 100% as individual patients could be included in more than one group.

Table 2: Diabetes and Hypertensive Disease in Patients with BMI >40

Patients with BMI >40	N = 439 ¹
Hypertensive disorder during pregnancy or delivery admission ²	
No	230 (52.4%)
Chronic hypertension	94 (21.4%)
Gestational hypertension	53 (12.1%)
Pre-eclampsia without severe features	27 (6.2%)
Pre-eclampsia with severe features (including HELLP)	64 (14.6%)
Eclampsia	1 (0.2%)
Diabetes	
No	307 (69.9%)
Type 1 diabetes	8 (1.8%)
Type 2 diabetes	36 (8.2%)
Gestational diabetes	88 (20.0%)
Quantitative blood loss at delivery (mL)	527 (IQR 219, 890)
Quantitative blood loss greater than 1000 mL	87 (19.8%)

¹n (%); Median (IQR)

²Percentages beneath this heading do not add up to 100% as individual patients could be included in more than one group.

23% of patients experienced gestational hypertension, preeclampsia without severe features, preeclampsia with severe features, or eclampsia during pregnancy or delivery admission. The patients delivered a total of 2603 neonates. Of total deliveries, 98% were live births. The 51 cases that were not live births represent intrauterine fetal demise (IUFD) (34 gestations), pregnancy-ending procedures for fetal

anomalies or health of the mother (12 gestations), or previable PPRM (5 gestations). The earliest gestational age captured in our population was 14w0d, which represented a D&E procedure for a missed abortion. Only 15 deliveries or procedures in the cohort were for patients at gestations <20 weeks. There were 24 instances of IUFD at >20 weeks (stillbirth rate 0.93%).

Table 3: Neonatal Outcomes

Total number of births	N = 2603 ¹
Live birth	2552 (98.0%)
Mode of delivery	
Vaginal	1554 (59.7%)
Assisted-vaginal (vacuum or forceps)	123 (4.7%)
Cesarean	907 (34.8)
D&C/ D&E	19 (0.7%)
Genitalia	
Female	1276 (49.0%)
Male	1309 (50.3%)
Unknown	18 (0.7%)
Birth Weight (grams)	3245 (IQR 2816, 3605)
Low Birth Weight	408 (15.7%)
Apgar (1 min)	8 (IQR 6, 9)
Apgar (5 min)	9 (IQR 8, 9)
Feeding plan	
Breast	1747 (67.1%)
Formula	380 (14.6%)
Both	406 (15.6%)
Not applicable	70 (2.7%)
Sepsis	131 (5.0%)
Hypoglycemia	604 (23.2%)
Malformations	350 (13.4%)
Cardiac	156 (44.6%)
Genitourinary	69 (19.7%)
Genetic/Syndromic	60 (17.1%)
Head and Neck	45 (12.9%)
Musculoskeletal	33 (9.4%)
Neuro/Brain	24 (6.9%)
Gastrointestinal	23 (6.6%)
Pulmonary	23 (6.6%)

¹n (%); Median (IQR)

In this study population, 34.8% of infants were born by cesarean section vs. 64.4% born by vaginal delivery. Of these vaginal deliveries, 4.7% were forceps- or vacuum-assisted. 81% of neonates were born at term, with term being defined as ≥ 37 w0d gestation. The average quantitative blood loss (QBL) at delivery was 325 mL, with QBL measured by standard protocol with 18% of patients experiencing postpartum hemorrhage, defined as ≥ 1000 mL QBL during delivery admission. There was one maternal death in our population with the cause of death being acute respiratory distress syndrome due to SARS-CoV-2 infection.

49% of neonates were female (Table 3). The median birth weight was 3245 g (2816, 3605). 16% of infants were born at low birth weight, defined as < 2500 g. Median APGAR scores at one and five minutes were 8 and 9, respectively. 24% of neonates were admitted to the neonatal intensive care unit (NICU), with 40.7% of these infants being preterm. Fetal malformations were relatively common, with 13% of neonates experiencing a documented malformation. The most common malformations were cardiac (45%) and genitourinary (20%). 67% of mothers indicated intention to exclusively breastfeed their infants.

Discussion

Women delivering at UIHC tend to be more obese than patients delivering across the United States. This finding likely reflects the trend of rising obesity in the US and in Iowa, and also reflects difficulties in caring for obese women at small hospitals with limited resources.

The median BMI of our population upon delivery admission was 32 (IQR 28, 37). A large tissue repository from pregnant women between 2010-2013 at UIHC showed an average pre-pregnancy BMI of 34.8,¹⁰ which is higher than the national average.⁵ This finding reflects that the population in Iowa was already more obese than the national average 10 years ago. Although the pre-pregnancy BMI represented in the biorepository is not directly comparable to the BMI at delivery that was captured in our population, the higher BMI at pre-pregnancy ten years ago suggests that the BMI has not increased substantially in UIHC's delivering population like it has at a national level.

Many studies on obesity in pregnancy have noted that obesity increases risk for obstetric complications including gestational diabetes, gestational hypertension, preeclampsia, preterm birth, neurodevelopmental problems, and postpartum depression.¹¹ Because many referrals occurred at time of delivery, we could not gather data on pre-pregnancy BMI. However, because BMI increases anywhere from 0.5-10 points on average during pregnancy,¹² we chose to look specifically at patients with BMI > 40 , assuming all or most of these women were in the 'obese' BMI category (> 30) prior to pregnancy. 17.6% of our obstetric population had a BMI > 40 at time of delivery. Diabetes and hypertension during pregnancy were much more likely to affect this group. These patients were also more likely to have a cesarean delivery when compared to patients with BMI ≤ 40 .

A population-based retrospective study of 120 million delivering women in the

United States from 2003 to 2010 showed that overall preeclampsia rates increased from 3.4% to 3.8%.¹³ The study showed that rates of preeclampsia with severe features increased with increasing maternal age, but preeclampsia without severe features decreased for women under 30 and increased for women ages 30-34. Preeclampsia was a common complication in our population, with a combined rate of preeclampsia without severe features and preeclampsia with severe features of 10.7%. This finding is higher than the 7.6% of patients seen in UIHC's biorepository study from 2010-2013, and much higher than the national rate in 2010 of 3.8%. This high rate of preeclampsia is likely affected by the large percentage of patients in our population with a BMI >40 and also may reflect hospital closures, as women with preeclampsia might be more likely to be transferred to UIHC for a higher level of care. It is also important to consider the role that COVID-19 infection may have had in these increased rates of preeclampsia. Multiple studies cite increased risk of preeclampsia in those who are affected by COVID-19 during pregnancy.^{14,15}

The cesarean rate in our population was 34.8%. This is increased from the rate of 30% between 2010-2013 reported in the above-mentioned biorepository study.¹⁰ The cesarean rate reflected in our population may be due to the high rate of obesity in our population and/or the large number of patients referred to UIHC for complex maternity care. The rate in our population is also higher than the national cesarean rate of 31.8% in 2020.⁵

Many smaller hospitals are unable to offer trial of labor after cesarean section (TOLAC) due to limited in-house anesthesia capability, so some patients travel to UIHC for TOLAC. While patients undergoing TOLAC are at a higher risk for cesarean in general,¹⁶ we did not specifically collect data on how many patients in this population had a prior cesarean delivery. Of note, cesarean section rates were specifically higher in our population of patients with BMI >40, which is consistent with prior studies.¹⁶

The rate of forceps- and vacuum-assisted delivery in our population was 4.7%, which is higher than national rates in recent years. A population-based study of US vital statistics from 2005-2013 showed that the rates of both forceps and vacuum-assisted deliveries were steadily decreasing.¹⁷ In 2013, operative deliveries with forceps or vacuum made up 3.3% of all deliveries in the US.¹⁸

The average age of our population (30) shows no significant change from the average maternal age of delivering patients at UIHC from 2010-2013, which was 29.¹⁰ In contrast, the average maternal age has steadily increased at both the state and national levels in recent years. In addition, the average age of primigravid patients in our population was 27, which mirrors the national average of primigravid patients, 27.1 years. This national average has been steadily increasing from 25.4 years at first birth in 2010.⁵

In our population, 71% of delivering patients were White. In the state of Iowa as a whole, this number is higher, with

90% of mothers delivering in 2020 identifying as White according to an Iowa Department of Public Health report.¹⁹ The reason for this difference was not studied, but it is worth noting that Iowa City and nearby Cedar Rapids are metropolitan areas with generally greater diversity than rural communities in the state. 46% of our study population had some form of Medicaid, which is higher than the state-reported statistics from 2016-2020 (40.7%).¹⁹ Nationally, 42% of births were covered by Medicaid in 2020.⁵ The higher rate of Medicaid in our population is likely due to UIHC being a public safety net hospital.

16% of our population delivered infants of low birth weight (defined as less than 2500 grams or 5 pounds, 8 ounces) compared to 6.9% of infants in the state, and 8.2% of infants nationally, who are born at low birth weight.^{5,19} 19% of our population was born preterm, at <37w0d gestation. Nationally, 10.2% of infants were born preterm in 2020.⁵ Given that UIHC is home to the only Level IV NICU in the state, these higher rates of preterm and low birth weight infants were anticipated.

Our stillbirth rate was 9.3 per 1000 births. This was more than twice the stillbirth rate in Iowa in 2020 and 2021 (4.5 per 1000 births for both years).²⁰ The national rate in 2020 was 5.74 per 1000 births. The much higher rate in our population could be due to UIHC being a referral center, caring for hundreds of patients each year who are transferred for complex maternal care.

Strengths of this study include prospective characterization of every birth over a one-year period. Double-

entered data with resolved discrepancies ensures accuracy of the collected data. A weakness of this study includes the single-center descriptive nature, so there is limited generalizability to other populations. Additionally, the study was originally designed to study associations between COVID-19 and pregnancy outcomes thus limiting associations that can be drawn about other outcomes. It is also unclear how the pandemic itself may have affected delivery volumes and other obstetric issues. Despite these limitations, it is relevant to describe one year of consecutive deliveries in our population as this creates an updated overview to inform both providers at our institution and across the state.

In conclusion, the delivering population at Iowa's only tertiary referral hospital has a high percentage of patients with obesity and preeclampsia, both of which put them at higher risk for additional obstetric complications including cesarean delivery, which was higher in our population than the national average. Nearly one in four neonates was admitted to the NICU and one in five was born preterm. Understanding the prevalence of these common maternal and neonatal complications in our population will better equip providers to care for these patients. Additionally, having these data of a one-year consecutive cohort will provide a resource for future research endeavors.

Acknowledgements

We thank Laura Nicks, Farah El-Zein, Claire Castaneda, Kathryn Marsden, Timothy Maxwell, and Ava Johnson for their assistance with specimen retrieval and storage and data entry.

Funding for the study was partly provided by the Mark Gilbert and Karen Simmonds Research gift Fund. This study was supported in part by the University of Iowa Clinical and Translational Science Award granted with funds from the NIH (UL1TR002537).

References

1. University of Iowa Hospitals and Clinics Patient Discharge and Patient Appointment and Scheduling Database, 2017-2022. University of Iowa Hospitals and Clinics. Updated November 9, 2022. Accessed February 8, 2023.
2. Driscoll AK, Gregory ECW. Increases in Prepregnancy Obesity: United States, 2016-2019. NCHS Data Brief. 2020 Nov;(392):1-8. PMID: 33270551. <https://www.cdc.gov/nchs/products/data/briefs/db392.htm>.
3. Marchi J, Berg M, Dencker A, Olander EK, Begley C. Risks associated with obesity in pregnancy, for the mother and baby: a systematic review of reviews. *Obes Rev*. 2015 Aug;16(8):621-38. <https://doi.org/10.1111/obr.12288>. Epub 2015 May 28. PMID: 26016557.
4. Castaneda C, Marsden K, Maxwell T, Ten Eyck P, Kuwaye D, Kenne KA, Merryman AS, Steffen HA, Swartz SR, Merrill AE, Krasowski MD, Jackson JB, Rysavy MB. Prevalence of maternal obesity at delivery and association with maternal and neonatal outcomes. *J Matern Fetal Neonatal Med*. 2022 Dec;35(25):8544-8551. <https://doi.org/10.1080/14767058.2021.1988563>. Epub 2021 Oct 12. PMID: 34641757.
5. Osterman M, Hamilton B, Martin JA, Driscoll AK, Valenzuela CP. Births: Final Data for 2020. *Natl Vital Stat Rep*. 2021 Feb;70(17):1-50. <https://doi.org/10.15620/cdc:112078>. PMID: 35157571.
6. Losch ME, Muilenburg RJ. Iowa Barriers to Prenatal Care Project. Iowa Department of Public Health, University of Northern Iowa Center for Social and Behavioral Research: 2020 Data Summary. 2021. <https://hhs.iowa.gov/Bureau-of-Family-Health/Maternal-Health/Maternal-Health-Dataand-Reports>.
7. Steffen HA, Swartz SR, Jackson JB, Kenne KA, Ten Eyck PP, Merryman AS, Castaneda CN, Marsden K, Maxwell T, Merrill AE, Krasowski MD, Rysavy MB. SARS-CoV-2 Infection during Pregnancy in a Rural Midwest All-delivery Cohort and Associated Maternal and Neonatal Outcomes. *Am J Perinatol*. 2021 May;38(6):614-621. <https://doi.org/10.1055/s-0041-1723938>. Epub 2021 Feb 21. PMID: 33611783.
8. Racial and Ethnic Categories and Definitions for NIH Diversity Programs and for Other Reporting Purposes. National Institutes of Health, Office of Extramural Research, 2015. Notice Number: NOT-OD-12-089. Accessed 5 January 2021. <https://grants.nih.gov/grants/guide/notice-files/not-od-15-089.html>.
9. Postpartum Hemorrhage Bundle, 2017. University of Iowa OBGYN Protocols and Guidelines. Accessed February 13, 2023.
10. Santillan MK, Leslie KK, Hamilton WS, Boese BJ, Ahuja M, Hunter SK, Santillan DA. "Collection of a lifetime: a practical approach to developing a longitudinal collection of women's healthcare biological samples". *Eur J Obstet Gynecol Reprod Biol*. 2014 Aug;179:94-9. <https://doi.org/10.1016/j.ejogrb.2014.05.023>. Epub 2014 Jun 2. PMID: 24965987; PMCID: PMC4148073.

11. American College of Obstetricians and Gynecologists' Committee on Practice Bulletins—Obstetrics. Obesity in Pregnancy: ACOG Practice Bulletin, Number 230. *Obstet Gynecol.* 2021 Jun 1;137(6):e128-e144. <https://doi.org/10.1097/AOG.0000000000004395>. PMID: 34011890.
12. Swank ML, Caughey AB, Farinelli CK, Main EK, Melsop KA, Gilbert WM, Chung JH. The impact of change in pregnancy body mass index on the development of gestational hypertensive disorders. *J Perinatol.* 2014 Mar;34(3):181-5. <https://doi.org/10.1038/jp.2013.168>. Epub 2014 Jan 2. PMID: 24384780.
13. Ananth CV, Keyes KM, Wapner RJ. Pre-eclampsia rates in the United States, 1980-2010: age-period-cohort analysis. *BMJ.* 2013 Nov 7;347:f6564. <https://doi.org/10.1136/bmj.f6564>. PMID: 24201165; PMCID: PMC3898425.
14. Villar J, Ariff S, Gunier RB, Thiruvengadam R, Rauch S, Kholin A, Roggero P, Prefumo F, do Vale MS, Cardona-Perez JA, Maiz N, Cetin I, Savasi V, Deruelle P, Easter SR, Sichitiu J, Soto Conti CP, Ernowati E, Mhatre M, Teji JS, Liu B, Capelli C, Oberto M, Salazar L, Gravett MG, Cavoretto PI, Nachinab VB, Galadanci H, Oros D, Ayede AI, Sentilhes L, Bako B, Savorani M, Cena H, García-May PK, Etuk S, Casale R, Abd-Elsalam S, Ikenoue S, Aminu MB, Vecciarelli C, Duro EA, Usman MA, John-Akinola Y, Nieto R, Ferrazi E, Bhutta ZA, Langer A, Kennedy SH, Papageorgiou AT. Maternal and Neonatal Morbidity and Mortality Among Pregnant Women With and Without COVID-19 Infection: The INTERCOVID Multinational Cohort Study. *JAMA Pediatr.* 2021 Aug 1;175(8):817-826. <https://doi.org/10.1001/jamapediatrics.2021.1050>. Erratum in: *JAMA Pediatr.* 2022 Jan 1;176(1):104. PMID: 33885740; PMCID: PMC8063132.
15. Wei SQ, Bilodeau-Bertrand M, Liu S, Auger N. The impact of COVID-19 on pregnancy outcomes: a systematic review and meta-analysis. *CMAJ.* 2021 Apr 19;193(16):E540-E548. <https://doi.org/10.1503/cmaj.202604>. Epub 2021 Mar 19. PMID: 33741725; PMCID: PMC8084555.
16. American College of Obstetricians and Gynecologists' Committee on Practice Bulletins—Obstetrics. Vaginal Birth After Cesarean Delivery: ACOG Practice Bulletin No. 205. *Obstet Gynecol.* 2019 Feb;133(2):e110-e127. <https://doi.org/10.1097/AOG.0000000000003078>. PMID: 30681543.
17. Merriam AA, Ananth CV, Wright JD, Siddiq Z, D'Alton ME, Friedman AM. Trends in operative vaginal delivery, 2005-2013: a population-based study. *BJOG.* 2017 Aug;124(9):1365-1372. <https://doi.org/10.1111/1471-0528.14553>. Epub 2017 Feb 25. PMID: 28236337.
18. American College of Obstetricians and Gynecologists' Committee on Practice Bulletins—Obstetrics. Operative Vaginal Birth: ACOG Practice Bulletin, Number 219. *Obstet Gynecol.* 2020 Apr;135(4):e149-e159. <https://doi.org/10.1097/AOG.0000000000003764>. PMID: 32217976.
19. Iowa Department of Public Health. Division of Health Promotion & Chronic Disease Prevention, Bureau of Family Health. Access to prenatal care, selected behaviors/conditions, and selected birth outcomes by Medicaid status, Iowa resident births 2016 – 2020. Des Moines: Iowa Department of Public Health. 2021. <https://hhs.iowa.gov/sites/default/files/po rtals/1/userfiles/88/report%20to%20med icaid%202021%20%28submitted%29.p df>.

20. Iowa Bureau of Health Statistics. Health Statistics - data and publications - preliminary data. Iowa Department of Human Services. Published February 2, 2023. Accessed February 14, 2023. . <https://hhs.iowa.gov/health-statistics/data/preliminary-data#fetal>.