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What is driving the decreased incidence of preterm birth during the COVID-19 pandemic?

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Condensation: There is a decrease in preterm birth during the COVID-19 pandemic; decreases in spontaneous preterm births were limited to deliveries with more indicators of advantage.

Short Title: Differential decreases in spontaneous preterm birth during COVID-19

AJOG at a Glance:

A. This study explored potential causes of the decrease in preterm birth during the COVID-19 pandemic through stratification.

B. Decreases in preterm birth occurred in the full population. When evaluating subpopulations, decreases in *spontaneous* preterm births were limited to women with more indicators of advantage.

C. This study not only confirms a decrease in preterm birth during COVID-19, but further provides the ability to assess differential impact of COVID-response regulations on subpopulations.

Keywords: Coronavirus, spontaneous preterm birth, disparities, regulations

Abstract

Background: Institutions across the world have observed a decrease in preterm birth during the COVID-19 pandemic. The reason for this reduction remains unknown.

Objective: We sought to explore potential causes of the decrease in preterm birth exploring three hypotheses: 1. Do women who are more likely to be able to work from home incur less physical and/or emotional stress resulting in longer gestation? 2. Does the effect of COVID-19 on preterm birth vary by race? 3. Is the change provider driven?

Study Design: Using a retrospective cohort of all singleton deliveries at a single tertiary care center, we compared deliveries prior to COVID-19 (1/1/2018-1/31/2020) to those occurring during the pandemic (4/1/2020-10/27/2020). Comparisons were made pre- and post-COVID using Pearson's chi-square or t-tests as appropriate. Preterm birth, defined as delivery at <37 weeks' gestation, was analyzed overall then further classified into spontaneous and indicated. The population was then stratified by: 1. Insurance type and neighborhood disadvantage, 2. Race, and 3. Provider type. Provider type was classified as within an OPC, a clinic that provides prenatal care to those eligible for Medical Assistance, compared with non-OPC.

Results: In a population of 17,687 pre-COVID deliveries, and 5,396 post-COVID deliveries, there was a significant decrease in overall preterm birth (11.1 vs. 10.1%; p=0.039). Both spontaneous and indicated preterm deliveries decreased in the full population. When stratified, decreases in *spontaneous* preterm birth pre- versus post-COVID, were limited to deliveries to women from more advantaged neighborhoods (most advantaged: 4.4 vs. 3.8%; least advantaged: 7.2 vs. 7.4%), white mothers (white: 5.6 vs. 4.7%; black: 6.6 vs. 7.1%), and those receiving care from non-OPC providers (non-OPC providers: 5.5 vs 4.8%; OPC-providers: 6.3 vs 6.7%).

Conclusions: Preterm birth has decreased during the COVID-19 pandemic. Decreases in spontaneous preterm birth were limited to deliveries in white women, living in more advantaged neighborhoods and delivered by non-OPC providers. COVID-19 response regulations may have disproportional benefits to women with more indicators of advantage.

Introduction

The COVID -19 pandemic has affected specific populations across the globe in a variety of unexpected ways. In the obstetric realm, there has been an unanticipated decrease in preterm birth (PTB) both in the US(1) and internationally(2–6).

Though the decrease in PTB is interesting and critical to public health, the cause for the decreased incidence is unknown. Preterm birth is clinically and mechanistically heterogeneous and this complexity has contributed to limited prevention strategies. Exploring the effects of the care environment during the COVID era has the potential to elucidate opportunities for prevention.

The first case of COVID-19 in Pennsylvania was confirmed on March 6th, 2020. Subsequently, a statewide shutdown order was enacted, requiring residents to begin social distancing and to close all non-essential businesses. At the University of Pittsburgh Medical Center (UPMC), protocols were enacted, and measures were taken to increase telemedicine opportunities for virtual care and prepare the system for a potential COVID surge. These necessary safety precautions impacted pregnant women in many ways. Thousands of home blood pressure monitors were disseminated to our population of pregnant women and the majority of routine prenatal care appointments were conducted via video visit.

Both state-wide and UPMC-specific COVID responses were executed quickly allowing little time for tailoring to distinct subpopulations. At our UPMC delivery hospital, we have access to a large clinical data warehouse capturing more than 11,000 deliveries annually. We are well-poised to explore potential contributors to the decrease in PTB during the COVID-19 pandemic.

To do so, we addressed three hypotheses: 1. Do women who are more likely to be able to work from home incur less physical and/or emotional stress resulting in longer gestation? 2. Does the effect of COVID-19 on PTB vary by race? 3. Is the change provider driven? Put otherwise, is the decrease in preterm birth iatrogenic and reflective merely of a trade-off between spontaneous and indicated PTB and a consequence of provider behavior?

Materials and Methods

We analyzed a retrospective cohort of all singleton deliveries occurring at ≥20 weeks at UPMC Magee-Womens Hospital from January 1st, 2018 through October 27th, 2020. Magee-Womens Hospital is the delivery hospital within UPMC, the largest health system in Pennsylvania. This study was exempt from Institutional Review Board approval as it was conducted under our institution's quality improvement initiative for clinical process assessment and improvement.

Using a clinical data warehouse, we captured both prenatal and delivery characteristics documented in the electronic health record. Prenatal care was defined as any visit at a UPMC facility between pregnancy start, calculated using gestational age, and delivery. Prenatal fetal non-stress tests and biophysical profiles were identified using CPT codes. Each woman's address (zip+4) at time of delivery was used to classify her neighborhood's area deprivation index (ADI).(7,8)

We defined pre-COVID as January 1st, 2018 through January 31st, 2020; post-COVID as April 1st through October 27th, 2020. February and March 2020 were excluded as a washout period as cases were not yet identified in Pennsylvania, but regulations were beginning to roll out over these two months.

Outcome:

Gestational age is documented in the clinical data warehouse at time of delivery using a combination of last menstrual period and updates from ultrasound measurement. Infants with missing gestational age were excluded (~1%). We further classified preterm delivery (<37 weeks) into early (<34 weeks), very early (<28 weeks), and indicated versus spontaneous. Delivery forms completed by the obstetric staff were used to define inductions and indication for induction. Deliveries with 'Induced' documented as the *Labor Onset* without 'PROM' as the *Induction Indication* were considered indicated. We further classified any preterm, cesarean delivery with a missing *Labor Onset* as indicated. All others are assumed to be spontaneous. The *Induction Indication* field captured the reason for the induction.

Analysis:

Because the period effect of the COVID-19 pandemic is the exposure and cannot be modified, there were no true confounders of the relationship. We therefore chose to evaluate the pandemic period's effect in subpopulations to explore if groups were affected differentially by COVID responses and regulations. We tested three stratifications to explore our hypotheses, by: 1. Insurance and neighborhood disadvantage, 2. Race, 3. Provider type.

Insurance was classified as commercial or public (Medicaid/Medicare) at the time of delivery. Women categorized as self-pay were excluded (n=442). Area depravation index (ADI) is widely used in studying health disparities as a measure of the economic and social disadvantage of neighborhoods across the US.(7) Using ADI, each neighborhood is ranked from 1 to 100 with 100 indicating the most disadvantaged areas.(7,8) Race was self-reported at the time of delivery. Stratification was limited to black and white to assess the comparison between our two largest

race groups. At our institution, OPC Clinic locations are hospital- and neighborhood-based prenatal clinics that function under the Healthy Beginnings Plus program. Healthy Beginnings Plus is Pennsylvania's effort to assist low-income, pregnant women who are eligible for Medical Assistance (MA) in having a positive prenatal care experience. Healthy Beginnings Plus expands maternity services that can be reimbursed by the MA Program. The intent of Healthy Beginnings Plus is to render services that meet women's psychosocial needs in addition to rendering traditional medical/obstetric services. Federal legislation permits Pennsylvania to extend MA eligibility to pregnant women with family incomes up to 185 percent of federal poverty guidelines. Pregnant clients may elect to participate in Healthy Beginnings Plus or receive their prenatal care in the traditional MA system.

Comparisons pre- and post-COVID were made in each subgroup using Pearson’s chi-2 and t-tests as appropriate. As a sensitivity analysis, all comparisons were repeated after excluding 120 neonatal deaths, then excluding 7 women who tested positive for COVID-19 during delivery admission.

Results:

Our retrospective cohort of 23,083 singleton deliveries, was comprised of 17,687 deliveries prior to the pandemic (January 2018-January 2020), and 5,396 after the pandemic (April-October 2020). A total of 1,454 deliveries occurred during the washout period were not included, along with 270 deliveries with missing gestational age and 1 at less than 20 weeks.

Across all subgroups and stratifications, there were there were less biophysical profiles completed prenatally and increased inductions post-COVID. Figure 1 displays the gestational age in weeks at time of delivery for all deliveries. The notable higher percentage of deliveries at

39 weeks post-COVID, likely results from increases in elective induction of labor aimed at controlling patient flow and in accordance with the ARRIVE trial.

In the full population, there was a decrease in PTB (11.1 vs. 10.1%; p=0.039), early PTB (3.6 vs. 3.1%; p=0.092), and both indicated and spontaneous PTB. In the post-COVID period there are more deliveries to white women, commercially insured deliveries, with corresponding fewer OPC Clinic providers, and lower ADIs indicating patients from more advantaged neighborhoods.

When stratifying by commercial (n=14,048; pre-COVID=10,642; post-COVID=3,406) versus public (n=8,593; pre-COVID=6,704; post-COVID=1,889) insurance as a surrogate of socioeconomic status, the commercially insured deliveries had no significant decreases in PTB despite a trend towards less spontaneous PTB (4.4 vs 3.7%; p=0.11). In the Medicaid/Medicare population, there was a significant decrease in PTB (14.9 vs 12.8%, p=0.022) driven by indicated PTB (7.3 vs 5.7%; p=0.017). Spontaneous PTB rate slightly decreased in the Medicaid/Medicare population (7.6 vs 7.1%; p=0.53).

ADI was classified into three equal groups with tertile 1 representing the most advantaged neighborhoods (ADI 1-52) and tertile 3 including the most disadvantaged (ADI 76-100). A total of 21,563 (T1=9,197; T2=5,827; T3=6,539) were included in this analysis, excluding 1,520 deliveries missing neighborhood ADI. Though patterns of non-statistically significant decreases in PTB overall were similar in the most and least disadvantaged neighborhoods, the most disadvantaged areas demonstrated an increase in spontaneous PTB (7.2 vs. 7.4%; p=0.79), whereas the more advantaged areas experienced a decrease (tertile 1: 4.4 vs 3.8%, p=0.68; tertile 2: 5.7 vs 4.7%, p=0.14).

The full population was comprised of 16,092 deliveries to white women (pre-COVID=12,247; post-COVID=3,845), and 4,656 to black women (pre-COVID=3,641; post-COVID=1,015). Patterns of overall PTB were similar by race, both demonstrating a decrease in PTB. However, white women demonstrated a significant decrease in spontaneous PTB (5.6 vs. 4.7%; p=0.047) as opposed to nearly equal rates in the black women pre- and post-pandemic (6.6 vs. 7.1%; p=0.57).

Finally, 19,232 deliveries were performed by non-OPC providers (pre-COVID=14,622; post-COVID=4,610) and 3,851 delivered by OPC Clinic providers (pre-COVID=3,065; post-COVID=786). Trends were consistent by clinic type with statistically insignificant decreases in PTB pre- and post-COVID. Similar to stratification by race, those delivering in non-OPC clinics had a marked decrease in spontaneous PTBs (5.5 vs 4.8%; p=0.038), whereas the OPC clinic spontaneous PTB rate remained about unchanged (6.3 vs 6.7%; p=0.67).

Results were consistent when excluding 120 neonatal deaths prior to delivery discharge, and when excluding 7 deliveries testing positive for COVID-19.

Discussion

Principal findings

Decreased incidence of births at <37 weeks was consistent by insurance type, neighborhood disadvantage, race, and provider clinic type. Interestingly, trends of decreasing *spontaneous* preterm birth, though not statistically significant, were limited to the more advantaged neighborhoods, white, and non-OPC provider subpopulations. Black women, living in the most disadvantaged neighborhoods, or delivered by OPC-providers demonstrated no change or increase in spontaneous preterm birth.

Results

Our findings are consistent with recent work identifying a decrease in preterm birth in the US during the COVID-19 pandemic (Table 6).(1) Decreased incidence at our institutions were similar in magnitude: 12.6 pre- to 9.9% post-COVID at Thomas Jefferson University Hospital compared with 11.1 pre- to 10.1% post-COVID at UPMC Magee-Womens Hospital. These authors also demonstrated a similar trend for decreases in both indicated and spontaneous preterm birth. Interestingly, a second study in the United States found a decrease in spontaneous PTB that was similarly confined to white women(9). A third paper supporting this disparity, conducted in the Netherlands, observed that reductions in PTB were limited to neighborhoods with higher socioeconomic indicators(4). Of the studies thus far finding no significant reduction, the first did demonstrate a decrease in deliveries at <28 weeks(2); the second examined a population of only 127 PTBs post-COVID(10); the third took place in Nepal, a dramatically different care environment, where they experienced a 50% reduction in deliveries at a hospital overall which could significantly impact results(11).

With nearly four times the number of post-COVID deliveries, our findings not only strengthen previous work demonstrating a decrease in PTB, but allow us to explore possible explanations through stratification.

Clinical Implications

Decreased incidence of spontaneous PTB in only the white, advantaged populations, speaks to the above hypotheses that certain COVID responses may be more likely to benefit these populations. Using the broad implementation of work-from-home mandates as an example, we speculate that the decreased stress of not commuting or not being exposed to other people and

infections in the workplace towards the end of pregnancy is desirable. Assuming that women with more indicators of advantage are more likely to work from home, it is possible they are reaping these benefits disproportionately.

Importantly, it is also possible that working from home results in more emotional stress, particularly for those caring for family while quarantined. Moreover, much of the extant literature encourages increased physical activity during pregnancy(12) as it is not thought to increase the risk of preterm delivery.(13) Thus, differences in leisure-time or work-related physical activity are unlikely contributors to our observed effect.

As more births continue during the pandemic, the differential rates in these subpopulations will likely become clearer.

Research Implications

Regarding work-from-home policies, additional research with more accurate quantification of employment requirements and associated physical and emotional stress is needed. Our classifications are broad markers and may not truly reflect those with the ability to work from home, nor can we differentiate physical versus emotional stressors.

We also propose assessing other stress-related obstetric complications during the pandemic. Comorbidities like preeclampsia, anxiety, and depression can be evaluated as indicators if changes in stress are contributing to this PTB decline. The role of COVID infection itself must also be explored as we had only 7 positive cases during delivery admission at our institution during the study period. Across the UPMC system, nearly 2,000 patients were hospitalized testing positive for COVID-19 during the study period; 57 of which were admitted to Magee-Womens Hospital.

Strengths and Limitations

A notable strength is our ability to employ an existing clinical data warehouse, but this has inherent limitations. First, the retrospective nature of the design prohibits us from establishing causality of the association. We were also forced to rely on surrogates of advantage that are captured in the electronic health record, based on zip+4 and census tract level data. We also did not have access to fetal deaths and miscarriages and therefore included only live births. Documentation and missingness of the measures used in this study did not vary pre- and post-pandemic.

The shift in racial composition of deliveries at our institution is also noteworthy. There is a slight trend for more deliveries to white women as compared with black women over the three-year period. This may reflect changes in the population demographics of the service area or use of other hospital networks. Importantly, this change would not impact our findings. Finally, some of our results may be redundant across strata as there is overlap and collinearity between subpopulations. Black women are more likely to be insured by Medicaid, live in more disadvantaged neighborhoods, and be delivered by an OPC provider. We included each stratification as the individual qualifiers may have differential impact. There are other factors, not directly represented in our dataset, that may have causal implication for our observed findings. For example, the issues associated with a more disadvantaged neighborhood could represent an effect of associated phenomenon, such as greenspace access or environmental pollution.

Conclusions

The frequency of preterm birth is decreasing during the COVID-19 pandemic. Decreases are not attributable to provider behavior, but perhaps are a result of COVID-responses that differentially benefit women who reside in more advantaged neighborhoods.

Bibliography

1. Berghella V, Boelig R, Roman A, Burd J, Anderson K. Decreased incidence of preterm birth during coronavirus disease 2019 pandemic. American Journal of Obstetrics & Gynecology MFM. 2020 Nov;2(4):100258.
2. Hedermann G, Hedley PL, Bækvad-Hansen M, Hjalgrim H, Rostgaard K, Poorisrisak P, et al. Danish premature birth rates during the COVID-19 lockdown. Arch Dis Child Fetal Neonatal Ed. 2021 Jan;106(1):93–95.
3. Philip RK, Purtill H, Reidy E, Daly M, Imcha M, McGrath D, et al. Unprecedented reduction in births of very low birthweight (VLBW) and extremely low birthweight (ELBW) infants during the COVID-19 lockdown in Ireland: a "natural experiment" allowing analysis of data from the prior two decades. BMJ Glob Health. 2020;5(9).
4. Been JV, Burgos Ochoa L, Bertens LCM, Schoenmakers S, Steegers EAP, Reiss IKM. Impact of COVID-19 mitigation measures on the incidence of preterm birth: a national quasi-experimental study. Lancet Public Health. 2020 Oct 14;5(11):e604–e611.
5. Meyer R, Bart Y, Tsur A, Yinon Y, Friedrich L, Maixner N, et al. A marked decrease in preterm deliveries during the coronavirus disease 2019 pandemic. Am J Obstet Gynecol. 2020 Oct 15;
6. Maeda Y, Nakamura M, Ninomiya H, Ogawa K, Sago H, Miyawaki A. Trends in intensive neonatal care during the COVID-19 outbreak in Japan. Arch Dis Child Fetal Neonatal Ed. 2020 Nov 23;
7. Kind AJH, Buckingham WR. Making Neighborhood-Disadvantage Metrics Accessible - The Neighborhood Atlas. N Engl J Med. 2018 Jun 28;378(26):2456–2458.
8. Neighborhood Atlas - Home [Internet]. [cited 2020 Dec 16]. Available from: https://www.neighborhoodatlas.medicine.wisc.edu/
9. Handley SC, Mullin AM, Elovitz MA, Gerson KD, Montoya-Williams D, Lorch SA, et al. Changes in Preterm Birth Phenotypes and Stillbirth at 2 Philadelphia Hospitals During the SARS-CoV-2 Pandemic, March-June 2020. JAMA. 2021 Jan 5;325(1):87–89.

10. Khalil A, von Dadelszen P, Draycott T, Ugwumadu A, O'Brien P, Magee L. Change in the Incidence of Stillbirth and Preterm Delivery During the COVID-19 Pandemic. JAMA. 2020 Jul 10;

11. Kc A, Gurung R, Kinney MV, Sunny AK, Moinuddin M, Basnet O, et al. Effect of the COVID-19 pandemic response on intrapartum care, stillbirth, and neonatal mortality outcomes in Nepal: a prospective observational study. Lancet Glob Health. 2020 Aug 10;8(10):e1273–e1281.

12. ACOG committee opinion no. 650: physical activity and exercise during pregnancy and the postpartum period. Obstet Gynecol. 2015 Dec;126(6):e135–42.

13. Di Mascio D, Magro-Malosso ER, Saccone G, Marhefka GD, Berghella V. Exercise during pregnancy in normal-weight women and risk of preterm birth: a systematic review and meta-analysis of randomized controlled trials. Am J Obstet Gynecol. 2016 Nov;215(5):561–571.

Table 1. Delivery characteristics of singleton deliveries at Magee pre- and post-COVID (n=23,083).

Factor	**Pre-COVID Regulation 01/01/2018 to 01/31/2020 n (%)**	**Post-COVID Regulations 04/01/2020 to 10/27/2020 n (%)**	p-value
N	17,687	5,396	
	Demographics		
Self-reported race			**0.011**
Other	1,800 (10.2%)	536 (9.9%)	
White	12,246 (69.2%)	3,845 (71.3%)	
Black	3,641 (20.6%)	1,015 (18.8%)	
Insurance	10,642 (60.2%)		**<0.001**
Commercial	6,526 (36.9%)	3,406 (63.1%)	
Medicaid	178 (1.0%)	1,851 (34.3%)	
Medicare	341 (1.9%)	38 (0.7%)	
Self-Pay/ Other		101 (1.9%)	
Prenatal Care	16,989 (96.1%)	5,173 (95.9%)	0.54
Prenatal NST	3,536 (20.0%)	1,158 (21.5%)	**0.019**
Prenatal Biophysical Profile	3,362 (19.0%)	835 (15.5%)	**<0.001**
Last PNV with OPC Clinic	3,066 (17.3%)	786 (14.6%)	**<0.001**
C-Section	5,410 (30.6%)	1,615 (29.9%)	0.36
OB/Gyn or Midwife Attending	17,066 (96.5%)	5,217 (96.7%)	0.50
	Outcomes		
PTB (<37 weeks)	1,963 (11.1%)	545 (10.1%)	**0.039**
EPTB (<34 weeks)	639 (3.6%)	169 (3.1%)	0.092
VEPTB (<28 weeks)	176 (1.0%)	45 (0.8%)	0.29
Indicated PTB	959 (5.4%)	273 (5.1%)	0.30
Spontaneous PTB	1,004 (5.7%)	272 (5.0%)	0.074
Overall Inductions	6,079 (34.4%)	2,098 (38.9%)	**<0.001**
Preterm induction indication [b]			
Preeclampsia	237 (24.7%)	61 (22.3%)	0.42
Gestational HTN	21 (2.2%)	7 (2.6%)	0.71
GDM	11 (1.1%)	3 (1.1%)	0.95
FGR	21 (2.2%)	2 (0.7%)	0.12
Area Deprivation Index [Mean (SD)] [c]	57.6 (26.6)	56.5 (26.4)	**0.014**

[a] February and March are a washout period and excluded.

[b] Percent of preterm inductions.

[c] ADI is missing for 7% (n=1,520) of deliveries.

[d] Pearson's chi-squared, Two sample t test as appropriate.

NST= non-stress test; PNV=prenatal visit; OB/Gyn=obstetrician/gynecologist; PTB=preterm birth; EPTB=early preterm birth; VEPTB=very early preterm birth; HTN=hypertension; GDM=gestational diabetes; FGR=fetal growth restriction; SD=standard deviation

Table 2. Delivery characteristics of singleton deliveries at Magee pre- and post-COVID (n=22,641); by insurance type.

Factor	**Pre-COVID Regulation 01/01/2018 to 01/31/2020 n (%)**	**Post-COVID Regulations 04/01/2020 to 10/27/2020 n (%)**	p-value
	Commercial (n=14,048)		
N	10,642	3,406	
Self-reported race			0.075
Other	1,193 (11.2%)	344 (10.1%)	
White	8,591 (80.7%)	2,809 (82.5%)	
Black	858 (8.1%)	253 (7.4%)	
Prenatal Care	10,422 (97.9%)	3,343 (98.2%)	0.43
Prenatal NST	2,660 (25.0%)	868 (25.5%)	0.57
Prenatal Biophysical Profile	1,894 (17.8%)	517 (15.2%)	**<0.001**
Last PNV with OPC Clinic	407 (3.8%)	131 (3.8%)	0.95
C-Section	3,232 (30.4%)	1,044 (30.7%)	0.76
OB/Gyn or Midwife Attending	10,467 (98.4%)	3,325 (97.6%)	**0.005**
PTB (<37 weeks)	910 (8.6%)	290 (8.5%)	0.95
EPTB (<34 weeks)	276 (2.6%)	92 (2.7%)	0.73
VEPTB (<28 weeks)	66 (0.6%)	21 (0.6%)	0.98
Indicated PTB	445 (4.2%)	163 (4.8%)	0.13
Spontaneous PTB	465 (4.4%)	127 (3.7%)	0.11
Overall Inductions	3,679 (34.6%)	1,372 (40.3%)	**<0.001**
Preterm induction indication [c]			
Preeclampsia	108 (24.3%)	39 (23.9%)	0.93
Gestational HTN	12 (2.7%)	3 (1.8%)	0.55
GDM	7 (1.6%)	1 (0.6%)	0.36
FGR	6 (1.3%)	1 (0.6%)	0.45
Area Deprivation Index [Mean (SD)][d]	47.5 (24.3)	47.3 (24.1)	0.60
	Medicare/Medicaid (n=8,593)		
N	6,704	1,889	
Self-reported race			
Other	555 (8.3%)	173 (9.2%)	0.44
White	3,419 (51.0%)	964 (51.0%)	
Black	2,730 (40.7%)	752 (39.8%)	

Insurance			
Medicaid	6,526 (97.3%)	1,851 (98.0%)	0.115
Medicare	178 (2.7%)	38 (2.0%)	
Prenatal Care	6,278 (93.6%)	1,750 (92.6%)	0.12
Prenatal NST	824 (12.3%)	271 (14.3%)	**0.018**
Prenatal Biophysical Profile	1,415 (21.1%)	305 (16.1%)	**<0.001**
Last PNV with OPC Clinic	2,604 (38.8%)	644 (34.1%)	**<0.001**
C-Section	2,112 (31.5%)	550 (29.1%)	**0.047**
OB/Gyn or Midwife Attending	6,280 (93.7%)	1,795 (95.0%)	**0.030**
PTB (<37 weeks)	1,000 (14.9%)	242 (12.8%)	**0.022**
EPTB (<34 weeks)	345 (5.1%)	72 (3.8%)	**0.017**
VEPTB (<28 weeks)	102 (1.5%)	23 (1.2%)	0.33
Indicated PTB	492 (7.3%)	107 (5.7%)	**0.012**
Spontaneous PTB	508 (7.6%)	135 (7.1%)	0.53
Overall Inductions	2278 (34.0%)	692 (36.6%)	**0.032**
Preterm induction indication [c]			
Preeclampsia	122 (24.8%)	21 (19.6%)	0.26
Gestational HTN	8 (1.6%)	4 (3.7%)	0.16
GDM	4 (0.8%)	2 (1.9%)	0.32
FGR	15 (3.0%)	1 (0.9%)	0.22
Area Deprivation Index [Mean (SD)][d]	74.1 (21.6)	73.8 (21.3)	0.61

[a] February and March are a washout period and excluded.

[b] Pearson's chi-squared, Two sample t test as appropriate.

[c] Percent of preterm inductions.

[d] ADI is missing for 7% (n=1,520) of deliveries.

NST= non-stress test; PNV=prenatal visit; OB/Gyn=obstetrician/gynecologist; PTB=preterm birth; EPTB=early preterm birth; VEPTB=very early preterm birth; HTN=hypertension; GDM=gestational diabetes; FGR=fetal growth restriction; SD=standard deviation

Table 3. Delivery characteristics of singleton deliveries at Magee pre- and post-COVID (n=21,563); by ADI Tertile.

Factor	**Pre-COVID Regulation 01/01/2018 to 01/31/2020 n (%)**	**Post-COVID Regulations 04/01/2020 to 10/27/2020 n (%)**	p-value
	ADI Tertile 1 (1-52)		
N	7034	2163	
Self-reported race			
Other	844 (12.0%)	222 (10.3%)	0.066
White	5,923 (84.2%)	1,865 (86.2%)	
Black	267 (3.8%)	76 (3.5%)	
Insurance			
Commercial	5,902 (83.9%)	1,851 (85.6%)	**0.050**
Medicaid	970 (13.8%)	266 (12.3%)	
Medicare	32 (0.5%)	3 (0.1%)	
Self-Pay/ Other	130 (1.8%)	43 (2.0%)	
Prenatal Care	6,850 (97.4%)	2,114 (97.7%)	0.36
Prenatal NST	1,745 (24.8%)	558 (25.8%)	0.35
Prenatal Biophysical Profile	1,246 (17.7%)	313 (14.5%)	**<0.001**
Last PNV with OPC Clinic	309 (4.4%)	74 (3.4%)	**0.048**
C-Section	2,071 (29.4%)	653 (30.2%)	0.51
OB/Gyn or Midwife Attending	6,887 (97.9%)	2,118 (97.9%)	0.98
PTB (<37 weeks)	565 (8.0%)	170 (7.9%)	0.80
EPTB (<34 weeks)	161 (2.3%)	46 (2.1%)	0.66
VEPTB (<28 weeks)	40 (0.6%)	14 (0.6%)	0.68
Indicated PTB	259 (3.7%)	88 (4.1%)	0.41
Spontaneous PTB	306 (4.4%)	82 (3.8%)	0.26
Overall Inductions	2,346 (33.4%)	829 (38.3%)	**<0.001**
Preterm induction indication [c]			
Preeclampsia	56 (21.6%)	18 (20.5%)	0.82
Gestational HTN	5 (1.9%)	3 (3.4%)	0.42
GDM	3 (1.2%)	1 (1.1%)	0.99
FGR	4 (1.5%)	0 (0.0%)	0.24
Area Deprivation Index [Mean (SD)]	31.8 (13.2)	31.9 (13.3)	0.67
	ADI Teritile 2 (ADI 53 to 75)		
N	4442	1385	
Self-reported race			
Other	410 (9.2%)	139 (10.0%)	0.17
White	3,401 (76.6%)	1,075 (77.6%)	
Black	631 (14.2%)	171 (12.3%)	
Insurance	2,690 (60.6%)	870 (62.8%)	0.26
Commercial	1,603 (36.1%)	476 (34.4%)	
Medicaid	41 (0.9%)	7 (0.5%)	

Medicare	108 (2.4%)	32 (2.3%)	
Self-Pay/ Other			
Prenatal Care	4,252 (95.7%)	1,329 (96.0%)	0.71
Prenatal NST	905 (20.4%)	300 (21.7%)	0.30
Prenatal Biophysical Profile	838 (18.9%)	208 (15.0%)	**0.001**
Last PNV with OPC Clinic	672 (15.1%)	160 (11.6%)	**<0.001**
C-Section	1,373 (30.9%)	408 (29.5%)	0.31
OB/Gyn or Midwife Attending	4,290 (96.6%)	1,349 (97.4%)	0.13
PTB (<37 weeks)	532 (12.0%)	140 (10.1%)	0.057
EPTB (<34 weeks)	166 (3.7%)	46 (3.3%)	0.47
VEPTB (<28 weeks)	51 (1.1%)	7 (0.5%)	**0.035**
Indicated PTB	277 (6.2%)	75 (5.4%)	0.26
Spontaneous PTB	255 (5.7%)	65 (4.7%)	0.14
Overall Inductions	1,584 (35.7%)	576 (41.6%)	**<0.001**
Preterm induction indication [c]			
Preeclampsia	71 (25.6%)	18 (24.0%)	0.77
Gestational HTN	9 (3.2%)	2 (2.7%)	0.80
GDM	3 (1.1%)	1 (1.3%)	0.86
FGR	10 (3.6%)	1 (1.3%)	0.31
Area Deprivation Index [Mean (SD)]	64.1 (6.7)	63.9 (6.7)	0.26
	ADI Tertile 3 (75 to 100)		
N	5130	1409	
Self-reported race			
Other	382 (7.4%)	118 (8.4%)	0.51
White	2,264 (44.1%)	614 (43.6%)	
Black	2,484 (48.4%)	677 (48.0%)	
Insurance			
Commercial	1,500 (29.2%)	435 (30.9%)	0.60
Medicaid	3,475 (67.7%)	928 (65.9%)	
Medicare	88 (1.7%)	25 (1.8%)	
Self-Pay/ Other	67 (1.3%)	21 (1.5%)	
Prenatal Care	4,879 (95.1%)	1,317 (93.5%)	**0.015**
Prenatal NST	688 (13.4%)	206 (14.6%)	0.24
Prenatal Biophysical Profile	1,069 (20.8%)	249 (17.7%)	**0.009**
Last PNV with OPC Clinic	1,858 (36.2%)	478 (33.9%)	0.11
C-Section	1,631 (31.8%)	411 (29.2%)	0.060
OB/Gyn or Midwife Attending	4,844 (94.4%)	1,333 (94.6%)	0.79
PTB (<37 weeks)	715 (13.9%)	187 (13.3%)	0.52
EPTB (<34 weeks)	251 (4.9%)	59 (4.2%)	0.27
VEPTB (<28 weeks)	68 (1.3%)	17 (1.2%)	0.73
Indicated PTB	347 (6.8%)	83 (5.9%)	0.24
Spontaneous PTB	368 (7.2%)	104 (7.4%)	0.79
Overall Inductions	1,767 (34.4%)	523 (37.1%)	0.062
Preterm induction indication [d]	95 (27.4%)	21 (25.3%)	0.70
Preeclampsia	5 (1.4%)	2 (2.4%)	0.53

Gestational HTN	5 (1.4%)	0 (0.0%)	0.27
GDM	7 (2.0%)	1 (1.2%)	0.62
FGR			
Area Deprivation Index [Mean (SD)]	88.5 (7.2)	88.6 (7.1)	0.50

[a] February and March are a washout period and excluded.

[b] Pearson's chi-squared, Two sample t test as appropriate.

[c] Percent of preterm inductions.

ADI=area deprivation index; NST= non-stress test; PNV=prenatal visit; OB/Gyn=obstetrician/gynecologist; PTB=preterm birth; EPTB=early preterm birth; VEPTB=very early preterm birth; HTN=hypertension; GDM=gestational diabetes; FGR=fetal growth restriction; SD=standard deviation

Table 4. Delivery characteristics of singleton deliveries at Magee pre- and post-COVID (n=20,748); by race.

Factor	**Pre-COVID Regulation 01/01/2018 to 01/31/2020 n (%)**	**Post-COVID Regulations 04/01/2020 to 10/27/2020 n (%)**	p-value
	White (n=16,092)		
N	12247	3845	
Insurance			
Commercial	8,591 (70.1%)	2,809 (73.1%)	**0.002**
Medicaid	3,319 (27.1%)	945 (24.6%)	
Medicare	100 (0.8%)	19 (0.5%)	
Self-Pay/ Other	237 (1.9%)	72 (1.9%)	
Prenatal Care	11,837 (96.7%)	3,714 (96.6%)	0.86
Prenatal NST	2,857 (23.3%)	940 (24.4%)	0.15
Prenatal Biophysical Profile	2,309 (18.9%)	577 (15.0%)	**<0.001**
Last PNV with OPC Clinic	1021 (8.3%)	240 (6.2%)	**<0.001**
C-Section	3714 (30.3%)	1,137 (29.6%)	0.37
OB/Gyn or Midwife Attending	11,958 (97.6%)	3,763 (97.9%)	0.41
PTB (<37 weeks)	1,323 (10.8%)	378 (9.8%)	0.087
EPTB (<34 weeks)	416 (3.4%)	115 (3.0%)	0.22
VEPTB (<28 weeks)	100 (0.8%)	28 (0.7%)	0.59
Indicated PTB	642 (5.2%)	196 (5.1%)	0.72
Spontaneous PTB	681 (5.6%)	182 (4.7%)	**0.047**
Overall Inductions	4,324 (35.3%)	1,569 (40.8%)	**<0.001**
Preterm induction indication [c]			
Preeclampsia	165 (25.7%)	43 (21.9%)	0.29
Gestational HTN	17 (2.6%)	7 (3.6%)	0.50
GDM	6 (0.9%)	2 (1.0%)	0.91
FGR	15 (2.3%)	2 (1.0%)	0.25
Area Deprivation Index [Mean (SD)]	51.5 (24.6)	50.4 (24.2)	**0.020**
	Black (n=4,656)		
N	3641	1015	
Insurance			
Commercial	858 (23.6%)	253 (24.9%)	0.31
Medicaid	2653 (72.9%)	737 (72.6%)	
Medicare	77 (2.1%)	15 (1.5%)	
Self-Pay/ Other	53 (1.5%)	10 (1.0%)	
Prenatal Care	3506 (96.3%)	969 (95.5%)	0.23
Prenatal NST	342 (9.4%)	103 (10.1%)	0.47
Prenatal Biophysical Profile	772 (21.2%)	181 (17.8%)	**0.019**
Last PNV with OPC Clinic	1784 (49.0%)	465 (45.8%)	0.073
C-Section	1135 (31.2%)	299 (29.5%)	0.30
OB/Gyn or Midwife Attending	3421 (94.0%)	953 (93.9%)	0.94

PTB (<37 weeks)	487 (13.4%)	130 (12.8%)	0.64
EPTB (<34 weeks)	174 (4.8%)	46 (4.5%)	0.74
VEPTB (<28 weeks)	63 (1.7%)	15 (1.5%)	0.58
Indicated PTB	247 (6.8%)	58 (5.7%)	0.22
Spontaneous PTB	240 (6.6%)	72 (7.1%)	0.57
Overall Inductions	1232 (33.8%)	358 (35.3%)	0.39
Preterm induction indication [c]			
Preeclampsia	62 (25.1%)	15 (25.9%)	0.90
Gestational HTN	4 (1.6%)	0 (0.0%)	0.33
GDM	4 (1.6%)	1 (1.7%)	0.95
FGR	6 (2.4%)	0 (0.0%)	0.23
Area Deprivation Index [Mean (SD)]	81.3 (19.0)	81.2 (19.67)	0.83

[a] February and March are a washout period and excluded.

[b] Pearson's chi-squared, Two sample t test as appropriate.

[c] Percent of preterm inductions.

NST= non-stress test; PNV=prenatal visit; OB/Gyn=obstetrician/gynecologist; PTB=preterm birth; EPTB=early preterm birth; VEPTB=very early preterm birth; HTN=hypertension; GDM=gestational diabetes; FGR=fetal growth restriction; SD=standard deviation

Table 5. Delivery characteristics of singleton deliveries at Magee pre- and post-COVID (n=23,083); by provider clinic type.

Factor	**Pre-COVID Regulation 01/01/2018 to 01/31/2020 n (%)**	**Post-COVID Regulations 04/01/2020 to 10/27/2020 n (%)**	p-value
Non-OPC Clinic (n=19,232)			
N	14622	4610	
Self-reported race			
Other	1,539 (10.5%)	455 (9.9%)	0.13
White	11,226 (76.8%)	3,605 (78.2%)	
Black	1,857 (12.7%)	550 (11.9%)	
Insurance			
Commercial	10,235 (70.0%)	3,275 (71.0%)	0.37
Medicaid	3,992 (27.3%)	1,219 (26.4%)	
Medicare	109 (0.7%)	26 (0.6%)	
Self Pay/Other	286 (2.0%)	90 (2.0%)	
Prenatal NST	3,526 (24.1%)	1,157 (25.1%)	0.18
Prenatal Biophysical Profile	2,713 (18.6%)	712 (15.4%)	**<0.001**
C-Section	4,487 (30.7%)	1,394 (30.2%)	0.56
OB/Gyn or Midwife Attending	14,109 (96.5%)	4,472 (97.0%)	0.092
PTB (<37 weeks)	1,580 (10.8%)	458 (9.9%)	0.094
EPTB (<34 weeks)	528 (3.6%)	143 (3.1%)	0.10
VEPTB (<28 weeks)	135 (0.9%)	38 (0.8%)	0.53
Indicated PTB	770 (5.3%)	239 (5.2%)	0.83
Spontaneous PTB	810 (5.5%)	219 (4.8%)	**0.038**
Overall Inductions	4,974 (34.0%)	1,808 (39.2%)	**<0.001**
Preterm induction indication [c]			
Preeclampsia	187 (24.3%)	50 (20.9%)	0.28
Gestational HTN	20 (2.6%)	7 (2.9%)	0.78
GDM	8 (1.0%)	3 (1.3%)	0.78
FGR	14 (1.8%)	2 (0.8%)	0.29
Area Deprivation Index [Mean (SD)]	53.4 (25.8)	52.8 (25.4)	0.17
OPC Clinic (n=3,851)			
N	3065	786	
Self-reported race			
Other	260 (8.5%)	81 (10.3%)	0.14
White	1021 (33.3%)	240 (30.5%)	
Black	1784 (58.2%)	465 (59.2%)	
Insurance			
Commercial	407 (13.3%)	131 (16.7%)	0.054
Medicaid	2,534 (82.7%)	632 (80.4%)	
Medicare	69 (2.3%)	12 (1.5%)	
Self Pay/Other	55 (1.8%)	11 (1.4%)	

Prenatal NST	10 (0.3%)	1 (0.1%)	0.35
Prenatal Biophysical Profile	649 (21.2%)	123 (15.6%)	**<0.001**
C-Section	923 (30.1%)	221 (28.1%)	0.27
OB/Gyn or Midwife Attending	2,957 (96.5%)	745 (94.8%)	**0.028**
PTB (<37 weeks)	383 (12.5%)	87 (11.1%)	0.28
EPTB (<34 weeks)	111 (3.6%)	26 (3.3%)	0.67
VEPTB (<28 weeks)	41 (1.3%)	7 (0.9%)	0.31
Indicated PTB	189 (6.2%)	34 (4.3%)	**0.049**
Spontaneous PTB	194 (6.3%)	53 (6.7%)	0.67
Overall Inductions	1,105 (36.1%)	290 (36.9%)	0.66
Preterm induction indication [c]			
Preeclampsia	50 (26.5%)	11 (32.4%)	0.48
Gestational HTN	1 (0.5%)	0 (0.0%)	0.67
GDM	3 (1.6%)	0 (0.0%)	0.46
FGR	7 (3.7%)	0 (0.0%)	0.25
Area Deprivation Index [Mean (SD)]	78.1 (19.7)	79.2 (19.6)	0.19

[a] February and March are a washout period and excluded.

[b] Pearson's chi-squared, Two sample t test as appropriate.

[c] Percent of preterm inductions.

NST= non-stress test; PNV=prenatal visit; OB/Gyn=obstetrician/gynecologist; PTB=preterm birth; EPTB=early preterm birth; VEPTB=very early preterm birth; HTN=hypertension; GDM=gestational diabetes; FGR=fetal growth restriction; SD=standard deviation

Table 6. Summary of literature to date evaluating preterm birth rates during the COVID-19 pandemic.

Study	Country	Pre-COVID Timeframe (PTB/Total)	Post-COVID Timeframe (PTB/Total)	Spont	Singletons	Method	Results	Conclusions
Been, et al. (4)[a]	Netherlands	March 9th -July 16th, 2010-2019 X/1,010,152	March 9th-July 16th, 2020 X/56,720	No.	Yes.	Difference in difference approach.	unadjOR= 0.84 (0.73, 0.97)	Reductions in PTB, limited to neighborhoods of higher socioeconomic status.
Berghella, et al. (1)	United States	March 1st-July 31st, 2019 115/911 *Spontaneous:* 59/911	March 1st-July 31st, 2020 118/1,197 *Spontaneous*: 57/1197	Yes.	No.	Multivariate logistic regression. Adjusted for race/ethnicity.	adjOR= 0.75 (0.57, 0.99) *Spontaneous*: adjOR= 0.75 (0.52,1.10)	25% decrease in odds of PTB. No statistically significant difference in spontaneous PTB.
Handley, et al. (9)	United States	March 1st-June 30st, 2018-2019 617/5,907 *Spontaneous*: 315/5,907	March 1st-June 30st, 2020 283/3,007 *Spontaneous*: 135/3,007	Yes.	Yes.	Marginal effects models. Adjusted for birth month, age, parity, BMI, race/ethnicity, marital status, smoking and insurance status. Stratified by race.	adjRD= -1.1 (-2.4, 0.2) *Spontaneous*: adjRD= -0.8 (-1.8, 0.2)	No significant decrease in overall PTB. Significant decrease in spontaneous PTB in white women only. [adjRD= −1.4 (−2.8 to −0.1)].
Hedermann, et al. (2)	Denmark	March 12th – April 14th, 2015-	March 12th – April 14th, 2020	No.	Yes.	Prevalence proportion study.	unadjOR= 0.95[b]	No significant decrease in overall

		2019 1,317/26,018	249/5,162					PTB. Decrease in births at <28 weeks [unadj OR= 0.09 (0.01,0.40)].
KC, et al. (11)	Nepal	January 1st- March 20th, 2020 2,125/13,189	March 21st- May 30th, 2020 1,342/7,165	No.	Yes.	Adjusted for complication during admission, ethnicity, maternal age.	adjOR= 1.30 (1.20-1.40) unadjOR= 1.198 (1.113, 1.125)	Significant increase in overall PTB. Significant decline in births at a hospital.
Khalil, et al. (10)	United Kingdom	October 1st, 2019- January 31st, 2020 113/1,655	February 1st- June 14th, 2020 127/1,692	No.	No.	Mann-Whitney and Fisher exact tests.	unadjRD= -0.68 (-2.43, 1.07)	No significant decrease in overall PTB.
Philip, et al. (3)	Ireland	January 1st- April 30th, 2001-2019 210/29,324 VLBW	January 1st- April 30th, 2020 3/1,381 VLBW	No.	No.	Poisson regression analysis.	Rate Ratio*= 3.77 (1.21, 11.75) *VLBW using 2020 as referent	Significant 73% decrease in the incidence of VLBW infants (used as a surrogate of PTB and gestational age).

PTB= preterm birth (<37 weeks' gestation); spont= spontaneous; unadj= unadjusted; adj= adjusted; OR= odds ratio; RD= risk difference; VLBW= very low birth weight

[a] Referring to primary analysis using March 9th regulation cutoffs with 4-month follow-up. Crude counts of preterm births pre- and post- March 9th are not available in this manuscript.

[b] No confidence interval as OR was calculated by hand.

Figure 1. Gestational age at delivery for all singleton deliveries at Magee pre- and post-COVID (n=23,083).