Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Original Article

Impact of the Coronavirus Disease 2019 Pandemic on Obstetric Interventions at a Public Hospital

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A B S T R A C T

Introduction: In response to the coronavirus disease 2019 (COVID-19) pandemic, health systems quickly implemented changes in care delivery with a goal of balancing patient-focused obstetric care with the need to protect pregnant persons and health care providers from infection. Yet, there is no consensus within the scientific community on the impact these measures have on obstetric outcomes in vulnerable populations. We aimed to assess the impact of the COVID-19 pandemic on rates of obstetric procedures and severe maternal morbidity (SMM) among births at an urban safety net institution.

Methods: We used an interrupted time series design to calculate risk ratios (RRs) and 95% confidence intervals (CIs) comparing monthly rates of labor induction, cesarean births (overall and among nulliparous, term, singleton, vertex births), operative vaginal births, and SMM among births occurring at a public hospital before (March 1, 2016, to February 29, 2020) and during (March 1, 2020, to May 31, 2021) the COVID-19 pandemic.

Results: There were 10,714 and 2,736 births in the prepandemic and postpandemic periods, respectively. Overall, the rates of obstetric interventions and SMM were constant over the two time periods. There were no significant differences in rates of labor induction (42% during prepandemic period vs. 45% during pandemic period; RR, 1.12; 95% CI, 0.93–1.34), operative vaginal births (5% vs. 6%; RR, 1.24; 95% CI, 0.88–1.76), cesarean births (28% vs. 33%; RR, 1.10; 95% CI, 0.94–1.28), or nulliparous, term, singleton, vertex cesarean births (24% vs. 31%; RR, 1.27; 95% CI, 0.92–1.74). Rates of SMM (7% vs. 8%; RR, 1.19; 95% CI, 0.86–1.65) were also unchanged.

Conclusions: Our findings indicate that the rapid implementation of measures to reduce viral transmission in the labor and delivery setting did not materially affect routine clinical management or rates of serious maternal complications.

On March 11, 2020 the World Health Organization declared coronavirus disease 2019 (COVID-19), the disease caused by the new coronavirus, severe acute respiratory syndrome (SARS-CoV2), a pandemic (Centers for Disease Control and Prevention, n.d.). Public health officials promptly recommended spatial distancing and physical isolation (Haffajee & Mello, 2020; Mehrotra, Ray, Brockmeyer, Barnett, & Bender, 2020). These recommendations, in conjunction with the morbidity and mortality associated with the virus itself, had far-reaching effects on nearly every aspect of society, from human behavior to health care delivery. Health systems rapidly responded to calls for spatial distancing by deferring elective procedures and decreasing in-person visits, opting instead for virtual platforms. Health care consumers were hesitant to seek care out of fear of contracting the virus while visiting health care facilities (Lange et al., 2020; Oseran et al., 2020). Pregnant patients were particularly vulnerable to these changes because they require frequent health system contact throughout the gestational period as well as hands-on care at birth; furthermore, pregnant persons are at increased risk for coronavirus-associated pregnancy complications (Rasmussen, Smulian, Lednicky, Wen, & Jamieson, 2020; Villar et al., 2021).

Inpatient labor and delivery facilities implemented several measures to limit virus spread and reduce length of hospital stay

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after birth. Limiting visitors, universal masking, universal COVID screening, and isolating suspected and confirmed COVID-19 cases were among the most commonly adopted practices to reduce person-to-person spread (Palatnik & McIntosh, 2020). Although not widely adopted, some facilities encouraged providers to limit the frequency and duration of room visits, including those for intrapartum ultrasound examinations and digital cervical examinations (Boelig et al., 2020; Pountoukidou et al., 2021). Other institutions suggested shortening the second stage of labor by performing operative vaginal births (using forceps or a vacuum device) in eligible patients to limit the amount of time visitors and practitioners are exposed to respiratory secretions (Boelig et al., 2020; Pountoukidou et al., 2021; Stephens, Barton, Bentum, Blackwell, & Sibai, 2020). Finally, many labor and delivery departments opted to delay elective cesarean sections, giving priority to those with medical indications (Boelig et al., 2020; Pountoukidou et al., 2021).

Studies on the impact of pandemic-related guidelines on maternal outcomes have reached different conclusions. The bulk of the research identified no change in the rates of obstetrical interventions, including inductions, cesarean births, and operative vaginal births, although other studies identified varying positive and negative trends in rates of cesarean births (Been et al., 2020; Berghella, Boelig, Roman, Burd, & Anderson, 2020; Bhatia et al., 2021; Chmielewska et al., 2021; Cuestas et al., 2021; Einarsdóttir, Swift, & Zoega 2021; Gemmill et al., 2021; Khalil et al., 2020; Mor et al., 2021; Sinnot et al., 2021). In addition to the conflicting conclusions, a majority of the studies are based internationally and may not reflect obstetric practices of U.S. physicians. Of the few U.S. studies assessing obstetric outcomes, the uninsured and communities of color are underrepresented, yet bear a disproportionate burden of maternal morbidity and mortality and face social and structural barriers to accessing quality and timely health care (Leonard, Main, Scott, Profit, & Carmichael, 2019). In addition, nearly all of the existing studies assess the impact of COVID-19–related policies on maternal outcomes using a pre/post design that cannot account for preexisting trends in outcomes that are unrelated to the pandemic (Justman et al., 2020; Feldman et al., 2021; Haber, Clarke-Deelder, Salomon, Feller, & Stuart, 2021).

The aim of this project was to use an interrupted time series design to compare the rate of obstetric procedures (inductions, cesarean births, and operative vaginal births) and severe maternal morbidity (SMM) among births at a safety net institution before (March 1, 2016, to February 29, 2020) and during (March 1, 2020, to May 31, 2021) the pandemic.

Methods

Data Collection

We used data from a longitudinal, automated electronic medical record abstraction system that includes information on inpatient and outpatient diagnostic and procedure codes, laboratory data, medication orders, obstetric and surgical history, and other patient characteristics to form a comprehensive picture of health outcomes across the pregnancy and postpartum period. We included all births (live and stillborn) occurring between March 1, 2016, and May 31, 2021, the most recent data available at the time of analysis. Information on maternal characteristics (age, self-reported race/ethnicity, insurance type, parity, plurality, and comorbid conditions) was extracted from the electronic medical record. Comorbid conditions (chronic diabetes, gestational diabetes, chronic hypertension, gestational hypertension or preeclampsia without severe features, preeclampsia with severe features, asthma, and obesity) were identified using *International Classification of Diseases,* Tenth Revision (ICD-10) diagnosis codes reported at time of birth (Appendix).

Outcomes

The outcomes of interest were labor induction (stimulation of uterine contractions before onset of spontaneous labor), operative vaginal birth (applying direct traction on fetal skull via forceps or vacuum), cesarean birth (overall and among nulliparous term, singleton, vertex (NTSV) births), and SMM. NTSV cesarean birth rate evaluates the proportion of nulliparous (first pregnancy), term (>37 weeks of gestation), singleton (single, rather than multiple, gestation), vertex (head down fetal position at birth) births via cesarean section. Because NTSV births are considered low risk, the outcome offers a standardized way to assess how patients are triaged for cesarean births (Joint Commission, 2021). Labor induction, operative vaginal birth, and cesarean birth were identified using ICD-10 procedure codes, and SMM was defined using the Centers for Disease Control and Prevention criteria, which include 21 indicators based on ICD-10 diagnosis and procedure codes (Appendix; Centers for Disease Control and Prevention, *n*.d.). We included SMM recorded during the birth hospitalization. As blood transfusions are a potential source of false-positive SMM cases, we constructed a secondary measure of non-transfusion SMM that excluded SMM owing to blood transfusion alone (Himes & Bodnar, 2020; Main et al., 2016). We did not separate COVID-related sequalae from SMM estimates.

Statistical Analysis

We used χ^2 and t tests to compare the distribution of demographic and clinical characteristics between births occurring in the prepandemic vs. pandemic time periods. We calculated monthly rates for each outcome of interest by dividing the number of births with the outcome by the total number of births occurring each month (based on date of admission). We used an interrupted time-series design with segmented Poisson regression models to estimate risk ratios (RRs) and 95% confidence intervals (CIs) comparing rates of each outcome before the pandemic (from March 1, 2016, through February 29, 2020) and during the pandemic (from March 1, 2020, through May 31, 2021). For the outcome of labor induction, we used quasi-Poisson models with a cubic spline to account for overdispersion and negative autocorrelation. For all models, we assumed no lag and a level and slope change a priori, given that changes in obstetric practices at our institution were rapidly implemented in early March 2020 after a marked increase in COVID-19 cases across the state and the governor's declaration of a public health state of emergency on March 12, 2020. We used plots of residuals and partial autocorrelation functions as well as Durbin–Watson tests to assess autocorrelation (Greene, Kilpatrick, Wong, Ozimek, & Naqvi, 2020). To assess our assumption of no lag, we conducted a sensitivity analysis assuming a 1-month lag. To examine the more immediate impact of the COVID-19 pandemic, we conducted a sensitivity analysis using individual-level data for births occurring between December 1, 2019, and May 31, 2020 (3 months before and after the pandemic). Using a regression discontinuity approach with log binomial regression models (Bor, Moscoe, Mutevedzi, Newell, & Bärnighausen 2014), we

Table 1
Demographic and Clinical Characteristics of Births Before and During the Coronavirus Disease 2019 Pandemic

Characteristic	Prepandemic Period (March 1, 2016 to February 29, 2020)	Pandemic Period (March 2020 to May 31, 2021)	*p* Value
No. of births	10,714	2,736	
Mean maternal age	27.4 ± 6.4	27.7 ± 6.4	.006
Age category, years			.03
<20	1,143 (10.7)	259 (9.5)	
20–34	7,954 (74.2)	2,007 (73.4)	
35–39	1,228 (11.5)	357 (13.1)	
>40	389 (3.6)	113 (4.1)	
Race/ethnicity			<.0001
Hispanic	2,083 (19.4)	419 (15.3)	
Non-Hispanic			
Asian	253 (2.4)	53 (1.9)	
Black	7,739 (72.2)	2,077 (75.9)	
White	303 (2.8)	73 (2.7)	
Multiracial	84 (0.9)	39 (1.4)	
Other	184 (1.7)	24 (0.9)	
Unknown/missing	68 (0.6)	51 (1.9)	
Insurance			<.0001
Private	813 (7.6)	287 (10.5)	
Public	9,216 (86.0)	2,366 (86.5)	
Self-pay	684 (6.4)	81 (3.0)	
Parity			0.04
0	3,441 (32.3)	941 (34.5)	
1	2,659 (25.0)	689 (25.2)	
≥2	4,557 (42.8)	1,101 (40.3)	
Missing	57	5	
Multiple gestation	208 (1.9)	57 (2.1)	0.63
Chronic diabetes	320 (3.0)	75 (2.7)	0.50
Gestational diabetes	633 (5.9)	223 (8.2)	<.0001
Chronic hypertension	1,116 (10.4)	336 (12.3)	0.005
Gestational hypertension or preeclampsia without severe features	1,440 (13.4)	365 (13.3)	0.89
Preeclampsia with severe features	583 (5.4)	190 (6.9)	0.003
Asthma	1,579 (14.7)	505 (18.5)	<.0001
Obesity	1,219 (11.4)	536 (19.6)	<.0001

Values are mean ± standard deviation or number (%).

estimated crude and adjusted RRs and 95% CIs for the association between the outcomes of interest and prepandemic and post-pandemic time periods (from December 1, 2019, through February 29, 2020, and from March 1, 2020, through May 31, 2020, respectively). We considered March 1, 2020, as the cutoff date and adjusted for age, race and ethnicity, parity, and insurance status. The models included a binary indicator of timing of birth (before vs. after the pandemic), a continuous measure of time before/after the pandemic (centered on the cutoff date), the interaction of these two variables, and the confounders described above. The only variables with missing data in our study were race/ethnicity and parity (<1%). SAS version 9.4 (SAS Institute, Cary, NC) was used for all analyses. The study was approved by the Emory Institutional Review Board.

Results

A total of 13,450 births were included in the analysis, including 10,714 births occurring between March 1, 2016, and February 29, 2020, and 2,736 births occurring between March 2020, and May 31, 2021. Demographics and clinical characteristics of our study population are shown in Table 1. Most births (>72%) occurring in both the prepandemic and pandemic time periods were among non-Hispanic Black patients. Notably, births to Hispanic patients decreased from 19.4% before the pandemic to 15.3% during the pandemic ($p < .001$). Approximately 86% of births in both time periods were among pregnant persons who were publicly insured; however, the proportion of births with private insurance increased from 7.6% to 10.5% ($p < .0001$). Compared with the prepandemic period, the prevalence of gestational diabetes (5.9% during the prepandemic period vs. 8.2% during the pandemic period; $p < .0001$), chronic hypertension (10.4% vs. 12.3%; $p = .005$), preeclampsia with severe features (5.4% vs. 6.9%; $p < .003$), asthma (14.7% vs. 18.5%; $p < .0001$), and obesity (11.4% vs. 19.6%; $p < .0001$) was higher among patients giving birth during the pandemic. A total of 2,152 patients had at least one COVID-19 test during their birth admission; of those, 126 (5.9%) were positive.

The rate of labor induction was constant between the prepandemic and pandemic periods (42.4% vs. 45.0%; RR, 1.12; 95% CI, 0.93–1.34) (Table 2 and Figure 1). Likewise, we found no change in rates of cesarean births (28.2% vs. 33.4; RR, 1.10; 95% CI, 0.94–1.28) and NTSV cesarean births (23.7% vs. 30.6%; RR, 1.27; 95% CI, 0.92–1.74). Relative to the rates of inductions and cesarean births seen in both time frames, the rate of operative vaginal births was low before and during the pandemic, with a minimal change in rate observed during the pandemic (4.7% vs. 5.9%; RR, 1.24; 95% CI, 0.88–1.76). Furthermore, no change was noted in the rates of SMM (6.7% vs. 8.3%; RR, 1.19; 95% CI, 0.86–1.65) and nontransfusion SMM (4.1% vs. 4.7%; RR, 0.92; 95% CI, 0.60–1.41). When we accounted for a 1-month lag, results were consistent with main analysis (Supplementary Table 1). When we used a regression discontinuity approach to examine changes in outcomes in the first 3 months after the COVID-19 pandemic, we again found no differences; however, estimates were imprecise for operative vaginal births, NTSV cesarean births, and SMM (Supplementary Table 2).

Table 2
Rates of Obstetric Interventions and Severe Maternal Morbidity Among Births Before and During the Coronavirus Disease 2019 Pandemic

Outcome	Pre Pandemic Period (March 1, 2016 to February 29, 2020)		Pandemic Period (March 1, 2020 to May 31, 2021)		Risk Ratio (95% CI)
	No.	Rate per 100 Births (95% CI)	No.	Rate per 100 Births (95% CI)	
Inductions	4,541/10,714	42.4 (41.2–43.6)	1,231/2,736	45.0 (42.6–47.6)	1.12 (0.93–1.34)
Operative vaginal birth	500/10,714	4.7 (4.3–5.1)	161/2,736	5.9 (5.0–6.9)	1.24 (0.88–1.76)
Cesarean birth	3,024/10,714	28.2 (27.2–29.3)	913/2,736	33.4 (31.3–35.6)	1.10 (0.94–1.28)
NTSV cesarean birth*	665/2,801	23.7 (22.0–25.6)	222/726	30.6 (26.8–34.9)	1.27 (0.92–1.74)
SMM	715/10,714	6.7 (6.2–7.2)	227/2,736	8.3 (7.3–9.5)	1.19 (0.86–1.65)
Nontransfusion SMM	443/10,714	4.1 (3.8–4.5)	128/2,736	4.7 (3.9–5.6)	0.92 (0.60–1.41)

Abbreviations: CI, confidence interval; SMM, severe maternal morbidity; NTSV, nulliparous, transverse, singleton, vertex.
* Restricted to births that were nulliparous, term (≥37 weeks gestation), single gestation, and vertex position.

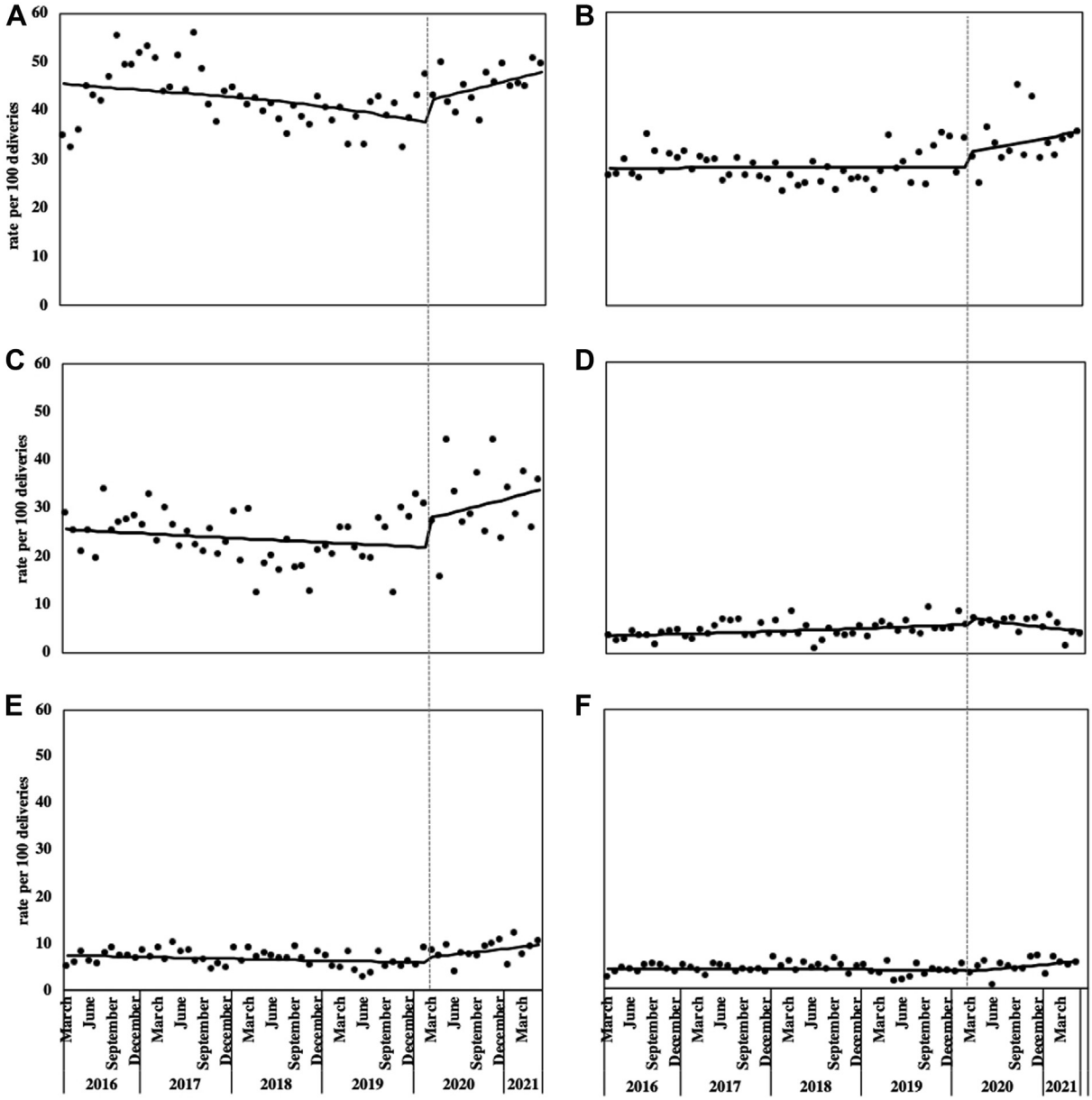

Figure 1. Scatter plots showing monthly variation in rates of obstetric outcomes at public hospital before the pandemic (between March 1, 2016, and February 29, 2020) and during the pandemic (between March 1, 2020, and May 31, 2021). (A) Inductions. (B) Cesarean birth. (C) Nulliparous, term, singleton, vertex (NTSV). (D) Operative vaginal birth. (E) Severe maternal morbidity (SMM). (F) Non-transfusion severe maternal morbidity. *Circles represent observed monthly rate and solid line represents predicted rate.

Discussion

Our study assessed the impact of the COVID-19 pandemic on the rates of labor and delivery procedures and SMM in a predominantly publicly insured and Black and Hispanic patient population. An interrupted time series analysis revealed no significant effects of the COVID-19 pandemic on rates of labor inductions, operative vaginal births, cesarean births (including NTSV births), or SMM.

Previous literature evaluating the rates of obstetric interventions during the COVID-19 pandemic is inconclusive. Many international studies found no impact of the COVID-19 pandemic on rates of inductions, cesarean births, or operative vaginal births (Been et al., 2020; Berghella et al., 2020; Chmielewska et al., 2021; Cuestas et al., 2021; Khalil et al., 2020; Mor et al., 2021). However, one Icelandic study reported a decrease in the overall cesarean section rate, with a particular decrease in the elective cesarean rate, which may have been related to strategies implemented to mitigate virus spread, such as delaying elective procedures (Einarsdóttir et al., 2021). In contrast, Bhatia et al. (2021) described an increase in the overall cesarean rate during the COVID-19 pandemic across six hospitals in the United Kingdom.

Similar to the lack of consensus abroad, there does not seem to be agreement between studies in the United States. Data from a large academic hospital in Boston revealed a decrease in cesarean births and an increase in induction rate without an increase in elective inductions (Sinnott, Freret, Clapp, Reiff, & Little, 2021). In contrast, a study of obstetric outcomes at a hospital in New York City found no changes in rates of cesarean or vaginal births, but did identify a decrease in operative vaginal births during the pandemic, which they attributed to the hands-off approach of practitioners to reduce virus transmission (Feldman et al., 2021). Our study suggests that the COVID-19 pandemic had no impact on obstetric interventions, which is most consistent with findings described by Greene et al. (2020) in a study of patients in in Los Angeles. The authors also investigated the pandemic's effects on SMM and found a comparable baseline rate to that observed at our institution (approximately 6%). Similar to our study, they found no change in the rate of SMM during the COVID-19 pandemic (Greene et al., 2020).

We found that the rates of certain comorbid conditions increased in our study population over the two time periods. One possible explanation for this finding is that overall rates of chronic conditions have been increasing among pregnant and reproductive-aged persons over time (Flores, Bandoli, Chambers, Schatz, & Palmsten, 2020; Main et al., 2020; Metcalfe et al., 2018). Furthermore, there is some evidence that COVID-19 infection may increase the risk for preeclampsia and gestational diabetes (Ghesquiere et al., 2020; Papageorghiou et al., 2021). Another contributing factor may be shifts in the composition of our patient population during the pandemic. We observed a decrease in births to Hispanic patients, who tend to have lower rates of hypertensive disorders of pregnancy (Ghosh et al., 2014; Noddin, Bradley, & Wolfberg, 2021). Finally, increased rates of home births during the COVID-19 pandemic have been reported and presumably occur among healthier patients (Gregory et al., 2021).

In evaluating outcomes at a safety net institution, we highlight a diverse and socially vulnerable population that has been excluded from the developing literature on obstetric outcomes during the pandemic. Our findings suggest that routine clinical management was unchanged and maternal outcomes remained stable despite the rapid adoption of virus mitigation strategies in a population with high rates of SARS-COV-2 infection (approximately 9%) (Joseph et al., 2020). A strength of this study was the use of 14 months of pandemic-exposed data, which enabled us to gain insight into long-term impacts the pandemic may have on our patient population. Additionally, we included a diverse and socially vulnerable population that may be differentially impacted by barriers to accessing health care, particularly in the context of a global pandemic. Our study is further strengthened by the use of interrupted time series analysis rather than a pre/post study design, thereby limiting selection bias and confounding factors between the two populations being assessed (Bernal, Cummins, & Gasparrini, 2017).

Our study must also be considered in the context of its limitations. Because we studied a single health care center, the generalizability of our results is limited, and our findings may not be indicative of patterns that exist in the wider population. However, the single-center study design may also be considered a strength. By focusing on the effects of the COVID-19 pandemic at a safety-net institution, we found that obstetric outcomes remained stable with no increase in SMM in a community that has high baseline rates of pregnancy complications, including SMM (Boulet et al., 2020). Another important limitation to consider is the validity of billing codes to identify diagnoses and procedures. Sigakis et al. (2016) found that the accuracy of ICD codes defining SMM at birth varies depending on whether objective laboratory findings or clinical signs and symptoms are used to support the code (Johnson & Nelson, 2013). Finally, we did not separately identify SMM owing to COVID-19 infection, which may have influenced our observed SMM rate (Villar et al., 2021).

Implications for Practice and/or Policy

The COVID-19 pandemic has emphasized the importance of public health emergency preparedness in the obstetric care setting where pregnant persons require frequent medical contact throughout pregnancy and the postpartum period. In this study, we show that the use of low burden, low-cost interventions—universal mask wearing, spacing in waiting rooms, delaying elective cesarean births, and limiting visitors—to mitigate spread of infection can be instrumental in maintaining positive maternal outcomes in a patient population at a high baseline risk for poor pregnancy outcomes during a pandemic. This finding is in agreement with previous literature showing that interventions to limit infection can be effective in maintaining the standard of care across patient populations of varying racial and socioeconomic backgrounds during public health emergencies (Been et al., 2020; Cuestas et al., 2021; Chmielewska et al., 2021).

In preparation for future outbreaks, obstetric care providers should work with their hospital's leadership to formulate disaster preparedness guidelines for optimizing triage of laboring persons and allocation of resources (e.g., personal protective equipment) in cases of limited supply and staffing placement. Furthermore, special consideration should be given to the impact of limiting patient visitors in the labor and delivery setting. Burgess, Breman, Bradley, Dada, and Burcher (2021) found that nearly one in five of pregnant persons giving birth at a facility disagree with the visitor restriction policy. Another study evaluating patient experiences with visitor restrictions during the COVID-19 pandemic revealed that pregnant persons of color are disproportionately affected by the limitation of

visitors. Patents described how such limitations eliminate key supporters and advocates in patients' labor and birth processes, giving way to in-hospital mistreatment and racism (Altman et al., 2021). Considering the successful implementation of virtual platforms in other settings of obstetric care, providing universal access to in-unit technology with video and audio capability would allow patients to interact with their support network regardless of personal means (Fryer, Delgado, Foti, Reid, & Marshall, 2020).

Considering the increasing trend in comorbid conditions among pregnant persons giving birth at our hospital, it is imperative that we continue work on patient–provider, local, and state levels to ensure all patients are receiving comprehensive health care that addresses all of their medical needs. By seeking innovative strategies to connect our most vulnerable patients with the subspecialty care they need, we can further minimize maternal morbidity related to COVID-19 infection and beyond.

Conclusions

Here, we show that even with the rapid implementation of safety measures to reduce SARS-CoV-2 transmission in the labor and delivery setting at our public safety net institution, routine clinical management was delivered safely without compromising patient outcomes or morbidity. The persistence of COVID-19 in our communities today and the amplification of health and economic inequities in the wake of the pandemic underscores the potential for the long-term exacerbation of health disparities among socially vulnerable populations. Future studies are needed to evaluate the direct and indirect effects of the pandemic on maternal health outcomes in diverse populations.

Supplementary Data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.whi.2022.08.003.

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