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Impact of the COVID-19 pandemic on perinatal care and outcomes in the United States: An interrupted time series analysis

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Abstract

Background: Hospitals quickly adapted perinatal care to mitigate SARS-CoV-2 transmission at the onset of the COVID-19 pandemic. The objective of this study was to estimate the impact of pandemic-related hospital policy changes on perinatal care and outcomes in one region of the United States.

Methods: This interrupted time series analysis used retrospective data from consecutive singleton births at 15 hospitals in the Pacific Northwest from 2017 to 2020. The primary outcomes were those hypothesized to be affected by pandemic-related hospital policies and included labor induction, epidural use, oxytocin augmentation, mode of delivery, and early discharge (<48 hours after cesarean and <24 hours after vaginal births). Secondary outcomes included preterm birth, severe maternal morbidity, low 5-minute Apgar score, neonatal intensive care unit (NICU) admission, and 30-day readmission. Segmented Poisson regression models estimated the outcome level shift changes after the pandemic onset, controlling for underlying trends, seasonality, and stratifying by parity.

Results: No statistically significant changes were detected in intrapartum interventions or mode of delivery after onset of the pandemic. Early discharge increased for all births following cesarean and vaginal birth. Newborn readmission rates increased but only among nulliparas (aRR: 1.49, 95%CI: 1.17, 1.91). Among multiparas, decreases were observed in preterm birth (aRR: 0.90, 95%CI: 0.84, 0.96), low 5-minute Apgar score (aRR: 0.75, 95%CI: 0.68, 0.81), and term NICU admission rates (aRR: 0.85, 95%CI: 0.80, 0.91).

Conclusions: Increases in early discharge and newborn readmission rates among nulliparas suggest a need for more postpartum support during the pandemic. Decreases in preterm birth and term NICU admission among multiparas may have implications beyond the pandemic and deserve further study.

KEYWORDS
coronavirus disease 2019, labor and delivery, perinatal care

1 | INTRODUCTION

At the onset of the coronavirus disease 2019 (COVID-19) pandemic, the United States (US) health care system quickly adapted perinatal care to mitigate virus transmission risks. As a result, a wide array of policy and practice changes were rapidly introduced to protect the health of birthing persons, newborns, and health care workers. The published guidelines were wide-ranging and included context-dependent recommendations based on available resources and staffing, as well as local infection rates.[1] These included restricting birthing support persons,[2-5] reducing hospital stay through acceleration of labor and early discharge,[1,6,7] decreasing the number of antenatal or postpartum visits, and increasing use of telehealth.[8] There are ongoing concerns about the potential impact of pandemic-related hospital policy changes resulting in an increased use of obstetric interventions, including labor augmentation, elective cesarean birth and operative vaginal birth, and their associated risks.[4,7,9]

Most studies assessing perinatal outcomes since the onset of the COVID-19 pandemic have focused on manifestations of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) among pregnant people and newborns,[10] but studies focusing on indirect pandemic-related changes to perinatal care and outcomes are more limited. Studies measuring the collateral effects of pandemic-related changes to perinatal care in the US to date have been restricted to a single-site, conducted early in the pandemic when infection rates were relatively low, or compared a prepandemic to a pandemic period without controlling for underlying trends.[11] Failure to account for underlying trends could result in a positive or negative impact if the trend was already increasing or decreasing, respectively, prepandemic. In addition, previous studies did not stratify analyses by parity despite known differences in many obstetric outcomes by parity.[12]

The aim of this study was to determine whether COVID-19 pandemic-related hospital policies and practices were associated with changes in perinatal care and outcomes utilizing an interrupted time series (ITS) analysis with a multicenter birth cohort in the Pacific Northwest.

2 | METHODS

2.1 | Study population

This retrospective cohort study included all singleton births of 20^{+0} to 42^{+6} weeks' gestation occurring at fifteen hospitals participating in a perinatal quality improvement collaborative in the Pacific Northwest, the Obstetrical Care Outcomes Assessment Program (OB COAP), from January 1, 2017, through December 31, 2020. OB COAP captures consecutive births at participating hospitals with no sampling. The study included hospitals located in urban, suburban, and rural settings with neonatal levels of care I–IV. Clinical patient data for OB COAP were acquired through a combination of direct uploading from the hospitals' electronic health records and chart abstraction by trained data abstractors. Real-time data quality and validation checks were undertaken to minimize the risk of misclassification due to data entry errors. More details about OB COAP data are published elsewhere.[13] The Western-Copernicus Group Institutional Review Board (IRB) deemed research using de-identified OB COAP data as exempt from IRB review.

2.2 | Outcomes

The primary outcomes of interest were obstetric interventions and perinatal outcomes that we hypothesized could have increased as a result of pandemic-related policies that restricted the number of birthing support persons and aimed at accelerating labor and shortening length of hospital stay.[1] These included any labor inductions (medically indicated or elective), epidural use, oxytocin augmentation of spontaneous labor, cesarean birth, operative vaginal birth (forceps or vacuum), and early discharge (defined as postpartum stay <48 hours after cesarean birth and <24 hours after vaginal birth). Elective induction was defined as any elective or nonmedically indicated induction of labor at less than 41^{+0} weeks' gestation. Births from two hospitals (n = 13 121) with incomplete recording of oxytocin and epidural use were set to missing and omitted from the models for these outcomes.

The secondary outcomes were obstetric quality indicators that we hypothesized may have been affected by pandemic-related changes in hospital policies and environmental, psychosocial, or behavioral changes. These outcomes included preterm birth (<37 weeks' gestation), severe maternal morbidity (SMM), low 5-minute Apgar score (<7), neonatal intensive care unit (NICU) admission, and maternal and newborn readmission within 30 days of discharge. SMM was defined as one or more of the following conditions during the birth hospitalization: blood transfusion, hysterectomy, disseminated intravascular coagulation, eclampsia, thromboembolism, or amniotic fluid embolism (ie, the Centers for Disease Control and Prevention SMM indicators available in the OB COAP database).

2.3 | Statistical analysis

Descriptive characteristics of the study population were examined for births occurring prepandemic (January 1, 2017-February 29, 2020) and during the pandemic (March

1, 2020-December 31, 2020) using proportions and 95% Wald confidence intervals (CI) for categorical variables and median and interquartile ranges (IQR) for continuous variables with non-normal distributions. An ITS analysis was conducted to estimate level changes in the outcomes of interest after the COVID-19 pandemic onset while controlling for the overall trend in the same outcomes over time. Interrupted time series analysis, one of the strongest quasi-experimental designs, is a statistical tool that uses time series data to evaluate public health interventions introduced at the population level over a clearly defined time period.[14-18] In this study, the "intervention" was defined as the onset of the COVID-19 pandemic (March 1, 2020) because of the start of containment and closure policies and larger health systems adaptations in the region in early March 2020.[19] For an impact model, we hypothesized a priori an immediate level change in outcomes after the onset of the pandemic without a lag period and a consistent baseline time trend (no slope change) because of the following reasons: the abruptness of health service disruptions and city and statewide shutdowns at the pandemic onset, the relatively stable trends in OB COAP data over time,[13] and the increase in burden of SARS-CoV-2 cases and deaths in the region through December 2020.

For this analysis, anonymized patient-level data were aggregated into monthly counts of total births and monthly counts of the outcome measures. Segmented regression was used to estimate level shift of outcomes by including a prepandemic-versus-pandemic period binary indicator to compare births in the prepandemic (coded 0) to the pandemic period (coded 1) with a baseline slope term to control for secular trends. We fit a Poisson regression model with Newey-West standard errors to account for autocorrelation and heteroscedasticity to estimate rate ratios (RR) and corresponding 95% CIs.[14,20,21] Given the patterns of seasonality for perinatal outcomes,[22] we included a Fourier term based on the month of year that included two sine/cosine pairs.[23] In all analyses, autocorrelation was assessed through visual inspection of complete and partial autocorrelation function plots and calculation of the Durbin-Watson statistic.[14,17,24] All analyses were stratified by parity given the differential clinical outcomes of nulliparous and multiparous birthing people and the potential for their care to be differentially affected during the pandemic. Finally, we plotted the temporal trends in the outcomes of interest which were derived from the segmented regression models. Analyses were conducted in R Version 4.0.2.[25]

3 | RESULTS

During the study period of January 1, 2017, to December 31, 2020, there were 103 434 total births in the OB COAP database. After restricting the sample to singleton births and excluding gestational ages below 20 weeks or above 43 weeks, there were 99 422 births in the final cohort: 78 718 in the prepandemic period and 20 704 in the pandemic period (Appendix 1).

Table 1 shows study population characteristics during the prepandemic and pandemic periods. The majority of nulliparas were aged 20-34 years of age (79%) in both time periods, whereas over one-quarter of multiparas were older than 35 years of age in both time periods (Table 1). A higher proportion of multiparas had Medicaid insurance in the prepandemic and pandemic periods (42% and 40%, respectively) compared with nulliparas (27% and 25%, respectively). The proportion of births with incomplete prenatal care for nulliparas remained similar in both time periods (3%) and increased slightly for multiparas during the pandemic (6% vs 4%). The median BMI at delivery was similar by parity and stayed consistent across time periods (Table 1).

Although there were increases in the proportion of births with any labor induction (medically indicated or elective), elective labor induction, epidural, and oxytocin augmentation of spontaneous labor after the pandemic onset for nulliparas (Table 2), the ITS analysis found there were no significant level shifts in these obstetric interventions associated with the pandemic onset while controlling for underlying trends (Table 3). There was a modest increase in operative vaginal birth rates among nulliparas (aRR: 1.12, 95% CI: 1.00, 1.26) that was not statistically significant ($P = 0.07$), and there was no significant change in cesarean birth rates (Table 3). There was a 49% increase in newborn readmission rates (aRR: 1.49, 95% CI: 1.17, 1.91) among nulliparas during the pandemic compared with the prepandemic period (Table 3, Figure 1). The average newborn readmission rate was 2% prepandemic, and the ITS predicted increase was to 2.3% during the pandemic.

Despite proportional increases in obstetric interventions during the pandemic among multiparas (Table 2), the ITS analysis found the pandemic period was not associated with any significant level shifts in labor induction, epidural or oxytocin augmentation for multiparas (Table 3). We also observed no significant changes in cesarean birth or operative vaginal birth for multiparas (Table 3). However, we found that the pandemic period was associated with a 10% reduction in preterm birth risk (aRR: 0.90, 95% CI: 0.84, 0.96) in contrast to the prepandemic period (Table 3, Figure 1). In addition, there was a 25% reduction in low 5-minute Apgar score risk (aRR: 0.75, 9% CI: 0.68, 0.81) and a 15% decrease in NICU admission risk among term births (aRR: 0.85, 95% CI: 0.80, 0.91) in multiparas during the pandemic compared with the prepandemic period (Table 3, Figure 1).

The pandemic was associated with increases in early discharge irrespective of parity. For nulliparas, there was

TABLE 1 Characteristics of the study population before and during the COVID-19 pandemic period

	Nulliparous		Multiparous	
	Prepandemic period	Pandemic period	Prepandemic period	Pandemic period
Characteristics	% (95% Wald CI)	% (95% Wald CI)	% (95% Wald CI)	% (95% Wald CI)
No.	31 586	8697	47 132	12 007
Race/ethnicity of birthing person				
American Indian/Alaskan Native	1.1 (1.0-1.3)	1.1 (0.9-1.3)	1.6 (1.5-1.7)	1.5 (1.3-1.8)
Asian	21.6 (21.1-22.1)	21.9 (21.0-22.9)	15.5 (15.2-15.9)	15.7 (15.1-16.4)
Latinx	13.3 (12.9-13.7)	13.4 (12.7-14.2)	19.3 (19.0-19.7)	20.2 (19.5-21.0)
Native Hawaiian/Other Pacific Islander	1.4 (1.2-1.5)	1.3 (1.1-1.6)	2.1 (1.9-2.2)	2.4 (2.1-2.7)
Non-Hispanic Black	5.0 (4.8-5.3)	5.2 (4.7-5.7)	6.4 (6.2-6.6)	6.6 (6.2-7.1)
Non-Hispanic White	53.6 (53.1-54.2)	53.1 (52.0-54.2)	51.2 (50.7-51.6)	49.3 (48.4-50.3)
Other/Multi-ethnicity	4.0 (3.8-4.2)	3.9 (3.5-4.4)	3.9 (3.7-4.1)	4.1 (3.8-4.5)
Missing [N(%)]	708 (2.2)	611 (7.0)	869 (1.8)	657 (5.5)
Age, y				
<20	6.4 (6.2-6.7)	5.4 (5.0-5.9)	0.7 (0.6-0.8)	0.6 (0.4-0.7)
20-34	79.2 (78.8-79.7)	79.2 (78.3-80.1)	71.2 (70.7-71.6)	69.6 (68.8-70.4)
35-39	12.0 (11.6-12.3)	12.6 (11.9-13.3)	23.1 (22.7-23.5)	24.2 (23.4-25.0)
40+	2.4 (2.24-2.6)	2.8 (2.4-3.1)	5.1 (4.9-5.3)	5.7 (5.3-6.1)
Missing [N(%)]	8 (0.03)	5 (0.1)	18 (0.04)	9 (0.1)
Medicaid insurance[a]	27.4 (26.9-27.9)	24.9 (24.0-25.9)	41.7 (41.3-42.2)	40.1 (39.2-41.0)
Incomplete/absent prenatal care[a]	2.9 (2.7-3.1)	3.0 (2.7-3.4)	4.1 (4.0-4.3)	5.7 (5.3-6.2)
BMI at delivery (kg/m^2) [Median (IQR)][a]	31 (7.9)	31.4 (8.3)	30.2 (7.5)	30.4 (7.7)

Abbreviation: BMI, body mass index.

[a]Missing: 359 (0.9%) nulliparas missing on Medicaid status, 207 (0.5%) nulliparas missing on incomplete prenatal care, 990 (2.4%) nulliparas missing on BMI. 669 (1%) multiparas missing on Medicaid status, 137 (0.2%) multiparas missing on incomplete prenatal care, 1953 (3.3%) multiparas missing on BMI.

a 36% increase in rates of early discharge after cesarean birth (aRR: 1.36, 95% CI: 1.20, 1.55) and 44% increase in rates of early discharge after vaginal birth (aRR: 1.44, 95% CI: 1.20, 1.73) in the pandemic compared with the prepandemic period (Table 3, Figure 2). For multiparas, there was a 41% increase in rates of early discharge after cesarean birth (aRR: 1.41, 95% CI: 1.31, 1.51) and 31% increase in early discharge after vaginal birth (aRR: 1.31, 95% CI: 1.16, 1.48) in the pandemic period compared with the prepandemic period (Table 3, Figure 2). We observed no significant changes in severe maternal morbidity or maternal readmissions for all birthing people (Table 3).

4 | DISCUSSION

This multi-site study in the Pacific Northwest found no major changes in obstetric interventions and found some changes in perinatal outcomes after the onset of pandemic-related hospital policy changes. Early discharge increased for all birthing people independent of delivery mode. Importantly, newborn readmissions substantially increased only for nulliparas, suggesting people giving birth for the first time may need more postpartum support during the pandemic. Multiparas experienced some improved outcomes including reductions in rates of preterm birth, low 5-minute Apgar scores, and NICU admissions among term births.

Other studies have similarly found increases in early discharge[26-29] reflecting pandemic-related recommendations to minimize hospital length of stay.[1] Two of these studies also examined readmissions and did not report any changes in postnatal readmissions; however, both of these analyses were pre-post study designs that did not control for confounders or underlying trends.[28,29] A notable strength of ITS compared with pre-post designs is accounting for secular trends of the outcome of

TABLE 2 Perinatal care practices and outcomes before and during the COVID-19 pandemic, by parity

	Nulliparous		Multiparous	
	Prepandemic period	Pandemic period	Prepandemic period	Pandemic period
	No. (%)	No. (%)	No. (%)	No. (%)
Total	31 586	8697	47 132	12 007
Labor, delivery, and postpartum care practices				
Labor				
Labor induction[a]	11 359 (39.7)	3611 (46.2)	11 881 (34.1)	3697 (41.5)
Elective labor induction[a]	776 (2.7)	431 (5.5)	3031 (8.7)	1079 (12.1)
Epidural[a,b]	20 897 (83)	5691 (83.2)	19 538 (65.5)	5137 (67.6)
Oxytocin augmentation of spontaneous labor[b,c]	7799 (52.3)	2037 (55.5)	5545 (28.8)	1376 (31.5)
Delivery mode				
Cesarean birth	9828 (31.1)	2709 (31.1)	14 527 (30.8)	3688 (30.7)
Operative vaginal birth	2354 (7.5)	668 (7.7)	1063 (2.3)	241 (2)
Postpartum hospital length of stay[d]				
Early discharge, cesarean birth	1738 (17.7)	650 (24)	2766 (19)	1059 (28.7)
Early discharge, vaginal birth	1331 (6.1)	465 (7.8)	4235 (13)	1383 (16.6)
Maternal and newborn outcomes				
Pregnancy complications				
Preterm birth <37 wk gestation	2667 (8.4)	730 (8.4)	3919 (8.3)	959 (8)
Maternal complications				
Severe maternal morbidity	511 (1.6)	164 (1.9)	566 (1.2)	153 (1.3)
Newborn outcomes				
Low 5-min Apgar score (<7)	1002 (3.2)	290 (3.3)	932 (2)	214 (1.8)
NICU admissions, term	2531 (8.8)	618 (7.8)	2487 (5.8)	570 (5.2)
NICU admissions, preterm	1605 (60.2)	389 (53.3)	2230 (56.9)	521 (54.3)
Readmission				
Maternal	545 (1.7)	163 (1.9)	633 (1.3)	191 (1.6)
Newborn	631 (2)	197 (2.3)	710 (1.5)	231 (1.9)

[a]Denominator excludes no-labor cesareans (nulliparous: n = 2995 prepandemic, n = 877 pandemic; multiparas: n = 12 289 prepandemic, n = 3091 pandemic).

[b]Two hospitals (n = 13 121) with incomplete recording of oxytocin and epidural use were excluded for these outcomes.

[c]Denominator excludes no-labor cesareans and induced labors.

[d]Early discharge defined as postpartum stay <48 h after cesarean and <24 h after vaginal birth.

Missing: 1 nulliparas and 4 multiparas missing in prepandemic period for labor induction and elective labor induction. 22 prepandemic and 5 pandemic nulliparas and 33 prepandemic and 6 pandemic multiparas missing for epidural. 100 prepandemic and 30 pandemic nulliparas and 143 prepandemic and 33 pandemic multiparas missing for early discharge after cesarean. 80 prepandemic and 14 pandemic nulliparas and 132 prepandemic and 17 pandemic multiparas missing for early discharge after vaginal birth. 242 prepandemic and 64 pandemic nulliparas and 452 prepandemic and 87 pandemic multiparas missing for Apgar scores.

interest over time, thus allowing for the examination of level shifts in outcomes associated with pandemic-related hospital policy changes.[14,17] Our ITS found that only nulliparas had an increase in newborn readmission rates and that multiparas had no change in readmissions and experienced lower rates of term NICU admission. One possible explanation for these favorable outcomes among multiparas is that some COVID-19 restrictions, such as limiting the number of postpartum visitors, may have provided opportunities for birthing people to rest, bond, and establish breastfeeding, which may benefit multiparas with prior postpartum experience and skills.[30] For nulliparas, we found a 49% increase in newborn readmission rates, which is worrisome considering the associated medical, psychological, and financial costs of readmissions.[31] Other studies during the pandemic have found people giving birth for the first time felt isolated and had a lack of support postpartum[32] as

TABLE 3 Interrupted time series analyses of perinatal care practices and outcomes before and during the COVID-19 pandemic

	Nulliparous		Multiparous	
	Level shift (aRR) 95% CI[a]	P-value	Level shift (aRR) 95% CI[a]	P-value
Labor, delivery, and postpartum care practices				
Labor				
Labor induction	1.00 (0.95-1.05)	0.95	1.02 (0.99-1.05)	0.56
Elective labor induction	0.97 (0.88-1.07)	0.73	1.06 (0.98-1.15)	0.25
Epidural	0.99 (0.97-1.02)	0.81	1.01 (0.99-1.03)	0.74
Oxytocin augmentation of spontaneous labor	1.06 (1.00-1.10)	0.13	1.04 (0.96-1.14)	0.32
Delivery mode				
Cesarean birth	1.05 (1.00-1.09)	0.11	0.99 (0.96-1.01)	0.59
Operative vaginal birth	1.12 (1.00-1.26)	0.07	0.92 (0.79-1.08)	0.43
Postpartum hospital length of stay[b]				
Early discharge, cesarean birth	**1.36 (1.20-1.55)**	**<0.001**	**1.41 (1.31-1.51)**	**<0.001**
Early discharge, vaginal birth	**1.44 (1.20-1.73)**	**<0.001**	**1.31 (1.16-1.48)**	**<0.001**
Maternal and newborn outcomes				
Pregnancy complications				
Preterm birth <37 wk gestation	0.99 (0.93-1.04)	0.83	**0.90 (0.84-0.96)**	**0.04**
Maternal complications				
Severe maternal morbidity	1.06 (0.88-1.28)	0.64	1.02 (0.76-1.37)	0.89
Newborn outcomes				
Low 5-min Apgar score (<7)	1.04 (0.89-1.22)	0.69	**0.75 (0.68-0.81)**	**0.01**
NICU admissions, term	0.98 (0.91-1.05)	0.72	**0.85 (0.80-0.91)**	**0.01**
NICU admissions, preterm	0.97 (0.91-1.04)	0.74	0.97 (0.90-1.05)	0.70
Readmission				
Maternal	0.88 (0.75-1.04)	0.34	0.90 (0.70-1.16)	0.37
Newborn	**1.49 (1.17-1.91)**	**<0.001**	1.04 (0.83-1.31)	0.72

Note: Bolding indicates the 95% confidence interval does not include 1.

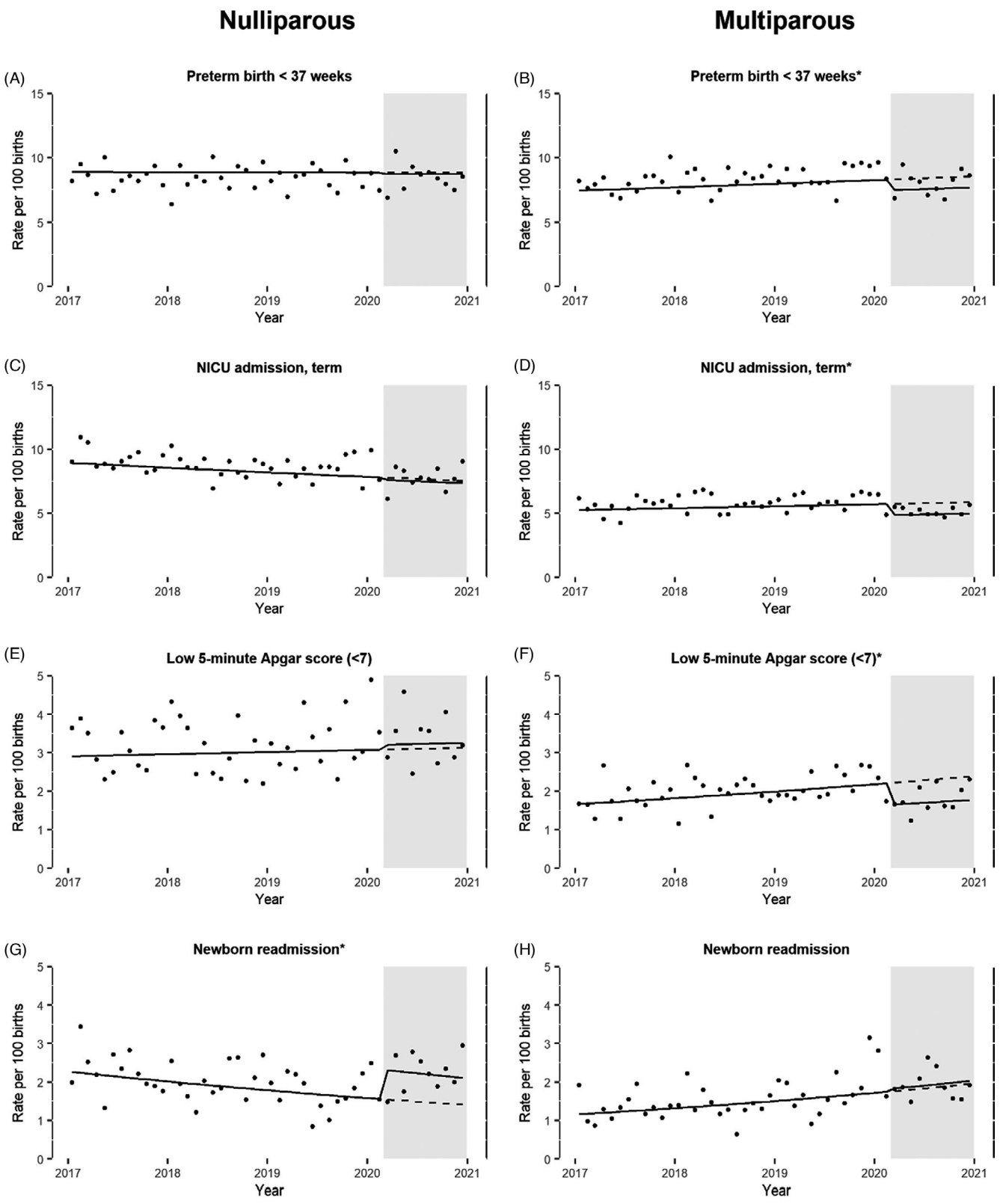
Abbreviations: aRR, adjusted rate ratio; CI, confidence interval.

[a]All models adjusted for seasonality. Autocorrelation addressed using Newey-West standard errors to calculate CIs.

[b]Early discharge defined as postpartum stay <48 h after cesarean and <24 h after vaginal birth.

well as had higher stress levels around feeling unprepared for birth or the postpartum period compared with people who had given birth before.[33] Along with qualitative findings that pandemic-related hospital policy changes in Washington state did not meet birthing people's needs,[34] these findings together suggest that more postpartum support is needed particularly for people giving birth for the first time.

The significant decline in preterm birth rates among multiparas in this study adds to the body of evidence suggesting pandemic-related declines in preterm birth. Globally, studies have shown reductions in preterm birth rates in high-income countries.[11,35-38] Findings from the US are mixed: three reported a decrease in preterm birth rates,[39-41] whereas four reported no change.[26,42-44] None considered parity as an effect modifier, which could have resulted in these mixed findings. The factors behind these reductions in preterm birth are likely multifaceted and affected by behavioral, medical, sociodemographic, and structural factors. Studies have hypothesized that lockdown measures could have contributed to these decreases through reductions in exposure to other infections and air pollution, increased hygienic practices, or decreased stress of not commuting or going into the workplace for those who were able to work from home.[35,40,41] It is also hypothesized that these reductions could be primarily among socially and economically advantaged birthing people who were able to work from home and had support systems.[40] We did not have data on employment or residence to better understand why



Solid line = modelled trend line.
Dotted line = predicted trend of outcome if the COVID-19 pandemic did not occur (i.e. the counterfactual).
Shaded area = COVID-19 period (March 1, 2020- December 31, 2020).
Asterik indicates relative risk for level shift is significant at p<0.05.

FIGURE 1 Interrupted time series analysis for maternal and newborn outcomes before and during the COVID-19 pandemic, by parity

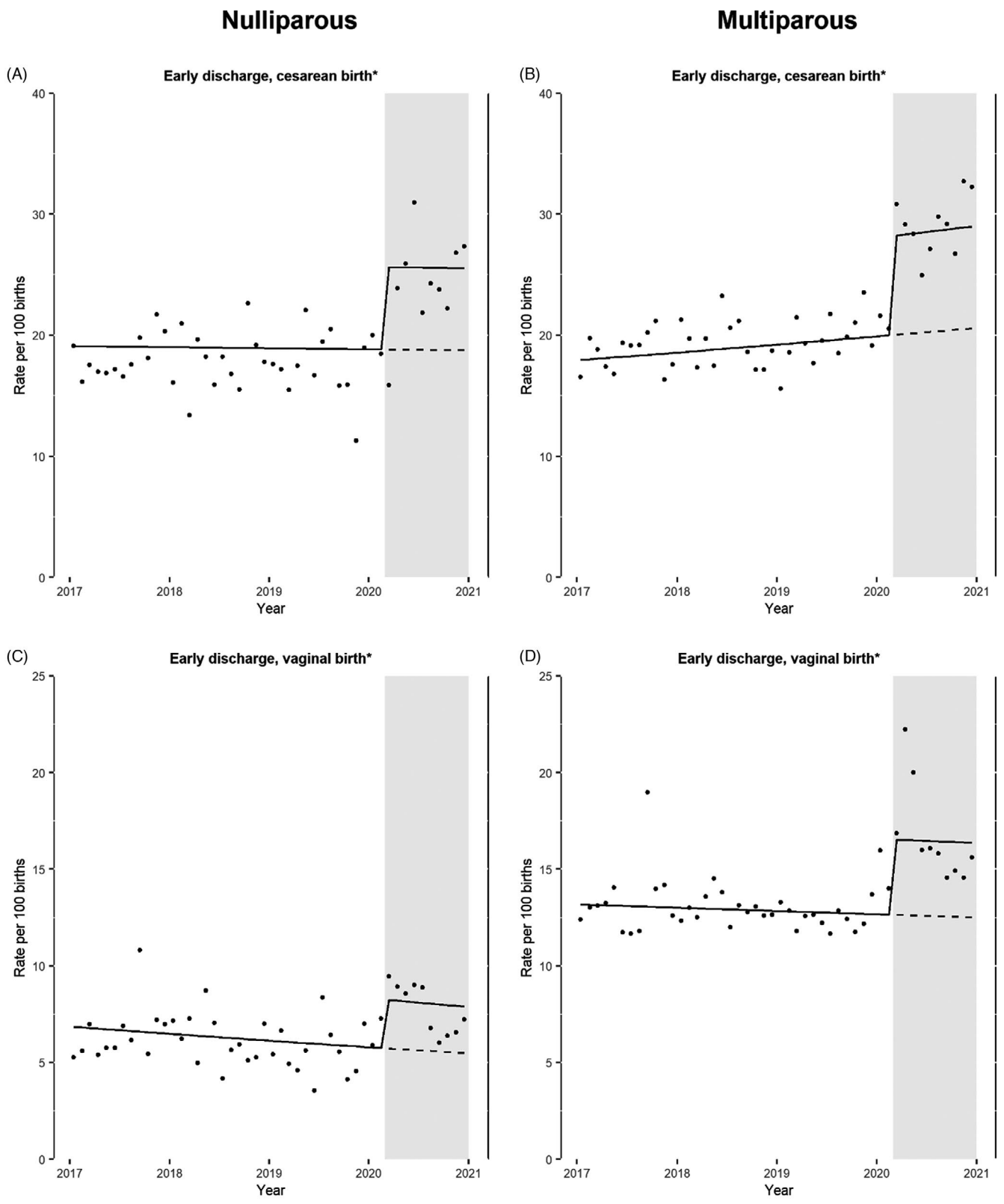


FIGURE 2 Interrupted time series analysis for early discharge before and during the COVID-19 pandemic, by parity

lower preterm birth rates were limited to multiparas in our study, but there are likely many contributing factors that require further research.

Our findings of no major changes in obstetric interventions and delivery outcomes during the pandemic generally align with studies in other settings. Three previous US studies similarly reported no change in cesarean birth rates during the pandemic,[26,27,39] although one multicenter study from the United Kingdom (UK) did report a minimal increase.[45] A meta-analysis of the effects of the COVID-19 pandemic on perinatal outcomes found no significant changes in cesarean birth, labor induction, or instrumental delivery in high-income settings, which aligns with our findings.[11] However, the evidence for NICU admissions is mixed. Two other studies, one from Japan and the other from the US, reported a significant decline in NICU admissions during the pandemic compared with a prepandemic period,[46,47] but other studies found no changes.[26,48,49] Although there were documented changes in NICU entry and staffing policies that could affect admissions,[50] given the decrease in low Apgar scores among multiparas in our study, it is conceivable that the decline in term NICU admissions could be related to lower newborn complication rates. More research is needed to understand why these improved neonatal outcomes occurred only among multiparas.

As hospitals work to protect patients and providers and prepare recommendations for future outbreaks, it is essential to consider how changes affect birthing peoples' experiences with care. Several studies have documented the increased stress among pregnant people because of changes in perinatal care and pandemic-related stressors as well as their negative experiences with adaptations to care, particularly among women of color.[2,34,51-54] Given the disparate impact of the pandemic on communities of color, compounded with pre-existing health disparities in perinatal outcomes,[4] future research should investigate the differential impact that hospital policy modifications have on such populations.

There were several limitations to this study. Generalizability is limited because hospitals included in OB COAP are not representative of all hospitals in the Pacific Northwest. Even though ITS studies are only vulnerable to time-varying confounders and there were likely no competing interventions at the pandemic onset, there is still the possibility of residual unmeasured confounding. There was no appropriate control group for comparison because the pandemic affected health care provision simultaneously across the country. We were unable to identify all SARS-CoV-2 patients because of differential hospital testing and could not remove positive patients from the database to capture secondary impacts, but universal testing at tertiary referral hospitals in this region estimated a low prevalence (2.7%) among pregnant patients.[55] Multiple comparisons of outcomes could lead to type I error; however, adjusting for these could increase type II error and is not recommended.[56] Readmissions were limited to those occurring at the birth hospital and thus may be an underestimate of hospital readmission. We did not have access to data related to indications for NICU admissions or hospital readmissions to better understand the mechanisms behind these changes. Finally, these findings do not reflect the lived experiences of individuals giving birth, which is an essential perspective to consider when assessing the impact of these practice modifications.

Despite these limitations, this study used ITS, one of the strongest quasi-experimental designs,[14,17,18] to provide robust estimates on changes in perinatal care and outcomes during the pandemic controlling for underlying trends and seasonality. These findings have clinical implications and can be used to inform adaptations to perinatal care during the continued pandemic and future outbreaks. Specifically, the combination of a large increase in early discharge and increased newborn readmissions among nulliparas is worrisome and suggests more postpartum support is needed for people giving birth for the first time. Improved newborn outcomes among multiparas, including preterm birth reductions, require further investigation, and future studies examining pandemic-related effects on perinatal care should consider differences by parity.

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CONFLICTS OF INTEREST

Vivienne Souter is the Medical Director for OB COAP and a Medical Director for Natera. The other authors report no conflict of interest.

DATA AVAILABILITY STATEMENT

Data are collected as part of a coordinated quality improvement program and are not publicly available.

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APPENDIX 1

Flow diagram of exclusions and final analytic