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Changes in preterm birth and caesarean deliveries in the United States during the SARS-CoV-2 pandemic

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Abstract

Background: Preliminary studies suggest that the SARS-CoV-2 pandemic and associated social, economic and clinical disruptions have affected pregnancy decision-making and outcomes. Whilst a few US-based studies have examined regional changes in birth outcomes during the pandemic's first months, much remains unknown of how the pandemic impacted perinatal health indicators at the national-level throughout 2020, including during the 'second wave' of infections that occurred later in the year.

Objectives: To describe changes in monthly rates of perinatal health indicators during the 2020 pandemic for the entire US.

Methods: For the years 2015 to 2020, we obtained national monthly rates (per 100 births) for four perinatal indicators: preterm (<37 weeks' gestation), early preterm (<34 weeks' gestation), late preterm (34–36 weeks' gestation) and caesarean delivery. We used an interrupted time-series approach to compare the outcomes observed after the pandemic began (March 2020) to those expected had the pandemic not occurred for March through December of 2020.

Results: Observed rates of preterm birth fell below expectation across several months of the 2020 pandemic. These declines were largest in magnitude in early and late 2020, with a 5%–6% relative difference between observed and expected occurring in March and November. For example, in March 2020, the observed preterm birth rate of 9.8 per 100 live births fell below the 95% prediction interval (PI) of the rate predicted from history, which was 10.5 preterm births per 100 live births (95% PI 10.2, 10.7). We detected no changes from expectation in the rate of caesarean deliveries.

Conclusions: Our findings provide nationwide evidence of unexpected reductions in preterm delivery during the 2020 SARS-CoV-2 pandemic in the US. Observed declines below expectation were differed by both timing of delivery and birth month, suggesting that several mechanisms, which require further study, may explain these patterns.

KEYWORDS
caesarean delivery, perinatal health, preterm birth, SARS-CoV-2 pandemic, United States

1 | BACKGROUND

The SARS-CoV-2 pandemic and associated social, economic and clinical disruption are widely speculated to have affected pregnancy decision-making and outcomes. Measures taken to prevent the spread of infection, including widespread lockdowns, have been linked with reductions in preterm birth (<37 weeks) and other adverse perinatal outcomes across several contexts, but this reduction was not universal.[1,2]

It remains unclear how the pandemic affected perinatal health in the United States, although some evidence suggests that preterm birth rates declined due to the pandemic. A recent National Center for Health Statistics (NCHS) report found that between 2019 and 2020, the late preterm birth rate declined by 1% and the early preterm birth rate declined by 3%.[3] However, NCHS reported only annual changes in preterm birth rates, making it difficult to assess potential pandemic-related temporal effects.

By contrast, most studies that examine monthly data from selected US geographies found no change in adverse perinatal outcomes, at least during the first stage of the pandemic. Provisional monthly data from California from April to July 2020, found no reduction in the overall rate of preterm births by payer, region or race/ethnicity; the study did, however, find a slight increase in births occurring between 28 to 32 weeks' gestation.[4] In a study of neonatal outcomes from a large hospital in New York City—one of the hardest hit areas at the onset of the pandemic—there was no evidence of changes in preterm birth in the first months of the pandemic.[5] Similarly, there were no significant changes in preterm birth or stillbirth rates in a racially diverse urban cohort from two Philadelphia hospitals between March and June 2020.[6] However, a study that used vital statistics data from Tennessee noted a decline in preterm birth during the Tennessee stay-at-home order in March and April 2020—a reduction that concentrated amongst late preterm births (35 to 36 weeks' gestation).[7]

Synopsis

Study question

Is the SARS-CoV-2 pandemic associated with changes in perinatal outcomes in the US?

What is already known?

Studies from outside the US show declines in adverse outcomes at the onset of the pandemic. Regional studies in the US are mixed, with most finding no changes in outcomes.

What this study adds?

We find that rates of preterm birth at the national-level in the US fell below expectation in the initial months of the pandemic, as well as later in 2020. Declines below expectation were differed by both indicator and birth month, suggesting that several mechanisms, which require further study, may explain these patterns.

No national-level studies, to date, investigate potential changes in monthly perinatal indicators in the initial stages of the pandemic, as well as over the course of 2020. This latter issue is especially important since the second wave of the pandemic accelerated sharply in November and December 2020, when the number of infections surpassed 200,000 per day.[8] Here, we use national-level data to address these evidence gaps. Notably, we—unlike most prior studies—use time-series methods to account for strong temporal patterning (e.g., seasonality, trend and other forms of autocorrelation) that could otherwise lead to spurious findings.

TABLE 1 Monthly observed and expected values, 95% prediction intervals (PI) for expected values, and per cent difference between observed and expected values for four perinatal indicators (rates per 100 live births), March through December, 2020

		Preterm delivery (<37 weeks) (%)				Early preterm delivery (<34 weeks) (%)		
	Live births	Observed	Expected	95% PI	Per cent difference	Observed	Expected	95% PI
March	301,457	9.8	10.5	(10.2, 10.7)	−6.1	2.6	2.8	(2.7, 2.9)
April	290,252	9.8	10.3	(10.0, 10.5)	−5.1	2.7	2.8	(2.7, 2.9)
May	301,313	10.1	10.4	(10.1, 10.6)	−3.2	2.8	2.8	(2.7, 2.9)
June	301,931	10.2	10.6	(10.4, 10.8)	−4.3	2.8	2.9	(2.8, 3.0)
July	321,253	10.2	10.4	(10.2, 10.7)	−2.8	2.7	2.8	(2.7, 2.9)
August	319,313	10.0	10.2	(9.9, 10.4)	−1.6	2.6	2.7	(2.6, 2.8)
September	311,224	9.6	9.8	(9.6, 10.1)	−2.3	2.6	2.7	(2.6, 2.8)
October	304,460	10.2	10.3	(10.0, 10.5)	−1.2	2.7	2.7	(2.6, 2.8)
November	281,576	10.0	10.6	(10.3, 10.8)	−5.7	2.6	2.8	(2.7, 2.9)
December	285,138	10.2	10.6	(10.3, 10.8)	−3.8	2.7	2.8	(2.7, 2.9)

2 | METHODS

We obtained national monthly rates (per 100 births) for four perinatal indicators: preterm delivery (<37 weeks' gestation), early preterm delivery (<34 weeks' gestation), late preterm delivery (34–36 weeks' gestation) and caesarean delivery from 2015 to 2020. We selected these indicators based on their inclusion in the NCHS's provisional estimates for 2020, released in March 2021 on NCHS's website.[9] At the time of data release, information on small-for-gestational-age births and stillbirths were not available. As of 8 March 2021, when the website was last updated, estimates for 2020 were based on 99.9% of births to US residents within the 50 states and the District of Columbia; disaggregated estimates were not available. We appended provisional data from 2020 with final birth data from 2015 to 2019 from the Centers for Disease Control and Prevention Wonder database, which only included information up to 2019.[10]

2.1 | Statistical analysis

We used an interrupted time-series quasi-experimental design.[11] We examined whether the observed incidence of the four perinatal indicators differed from expected values during the SARS-CoV-2 pandemic beginning March 2020. Perinatal outcome rates show well-documented patterns such as seasonality, trend and the tendency for high or low values to be 'remembered' into subsequent months, which violate the assumption of tests of association because the expected value of a patterned series is not its mean.[12] To address this issue, we used the routines devised by Box and Jenkins to identify and remove patterns in the outcome variable.[13] These routines express autocorrelation as a product of 'autoregressive' (AR), 'integrated' (I) and 'moving average' (MA) parameters, collectively referred to as ARIMA models. The residuals of ARIMA models meet the assumptions of correlational tests in that the expected value is zero and monthly observations are statistically independent of one another.

For each outcome, we used software from Scientific Computing Associates[14] to identify and model autocorrelation in 62 pre-pandemic months beginning January 2015 and ending February 2020. We then added a binary 'pandemic onset' variable scored 1 for March 2020 and 0 otherwise as a predictor to the best-fitting Box-Jenkins models of each outcome and re-estimated the equations (with ARIMA coefficients fixed to those estimated for the 62 pre-pandemic months) for all 72 months from January 2015 to December 2020. We specified the pandemic onset variable to estimate monthly differences between expected and observed outcomes from March through December 2020. We defined an 'unexpected' outcome as an observed value outside the expected 95% prediction interval (PI).

2.2 | Ethics approval

Institutional review board approval and informed consent were not required because NCHS provides publicly available de-identified data.

3 | RESULTS

Table 1 shows observed and expected rates for each of the four perinatal indicators, as well as the 95% PI for expected rates and the per cent difference between observed and expected rates, for March through December 2020. Figures 1 and 2 plot monthly trends in expected and observed rates of preterm and caesarean delivery, respectively, from 2015 to 2020.

Observed values of the preterm birth rate fell outside of the 95% PI across several months of the 2020 pandemic. Declines in preterm birth were the largest in magnitude in both early and later stages of the pandemic. For example, in March 2020, the expected rate predicted from history was 10.5 preterm births per

| Per cent difference	Late preterm delivery (34–36 weeks) (%)				Caesarean delivery (%)			
	Observed	Expected	95% PI	Per cent difference	Observed	Expected	95% PI	Per cent difference
−6.3	7.2	7.6	(7.5, 7.8)	−5.7	31.6	31.7	(31.1, 32.2)	0.2
−2.1	7.1	7.5	(7.3, 7.7)	−5.4	31.8	31.8	(31.2, 32.3)	−0.1
−2.0	7.3	7.6	(7.4, 7.8)	−3.1	31.6	31.6	(31.1, 32.1)	0.1
−4.1	7.4	7.7	(7.5, 7.9)	−3.3	32.0	31.6	(31.1, 32.2)	−1.2
−2.8	7.5	7.6	(7.4, 7.8)	−2.1	32.1	31.8	(31.3, 32.4)	−0.9
−3.4	7.5	7.5	(7.3, 7.7)	−1.0	31.6	31.6	(31.1, 32.1)	0.0
−3.4	7.0	7.2	(7.0, 7.4)	−2.0	31.8	31.5	(31.0, 32.1)	−0.9
−2.2	7.5	7.5	(7.3, 7.8)	−0.8	32.1	31.8	(31.2, 32.3)	−1.0
−9.1	7.4	7.7	(7.5, 7.9)	−3.9	31.9	31.7	(31.2, 32.3)	−0.6
−1.9	7.5	7.8	(7.6, 8.0)	−4.1	32.0	31.9	(31.4, 32.5)	−0.2
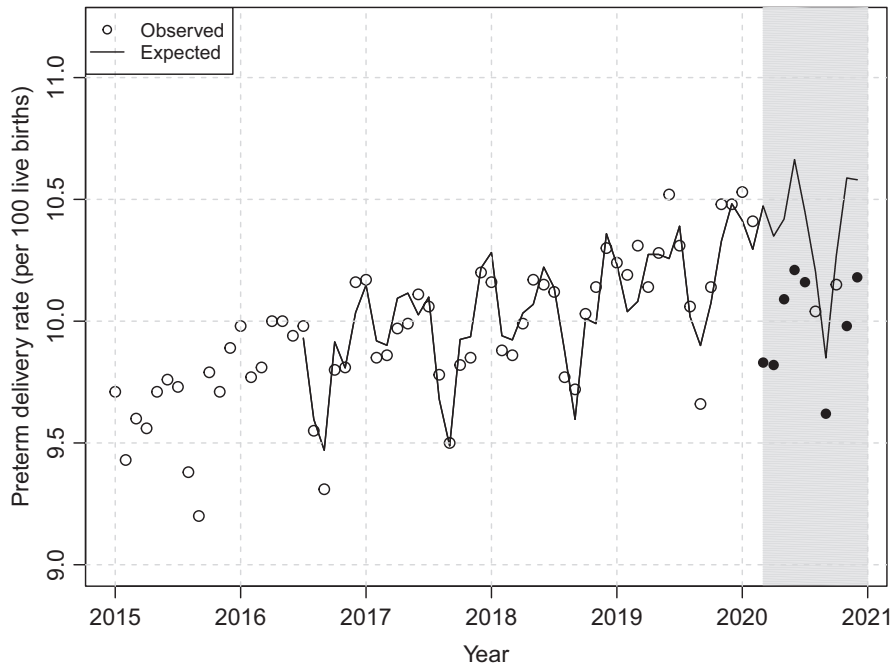
FIGURE 1 Observed and expected monthly trend of the preterm delivery rate (per 100 live births), 2015–2020. Shaded area represents pandemic months (March through December 2020). Observed points marked by a filled circle show observed values that fell outside of the 95% prediction interval of expected values during the pandemic period. Note: Includes 72 months beginning January 2015 and ending December 2020. Expected values were generated from a time-series model using observed rates from January 2015 through February 2020. The first 18 months were lost to modelling
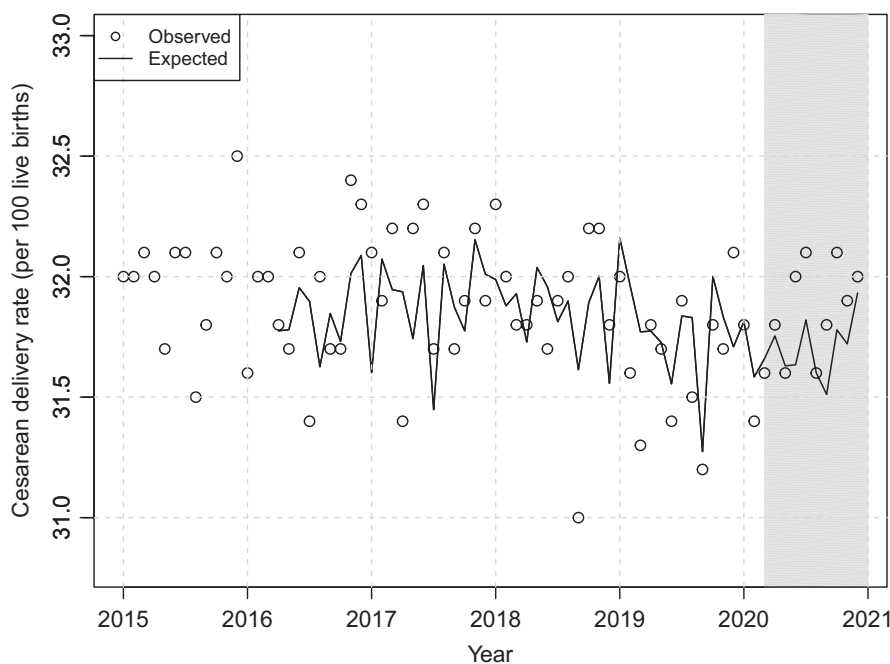

FIGURE 2 Observed and expected monthly trend of the caesarean delivery rate (per 100 live births), 2015–2020. Shaded area represents pandemic months (March through December 2020). Note: Includes 72 months beginning January 2015 and ending December 2020. Expected values were generated from a time-series model using observed rates from January 2015 through February 2020. The first 15 months were lost to modelling

100 live births (95% PI 10.2, 10.7). The observed rate, however, was 9.8 per 100, which fell outside the 95% PI of expectation, corresponding to a roughly 6% decline in the preterm birth rate for that month. Likewise, the difference between observed and expected preterm birth rates for the month of November was 6%, with the observed rate (10.0 per 100) falling below expectation (95% PI 10.3, 10.8).

Patterns for late preterm birth and early preterm differed somewhat, although for both indicators, declines occurred in the first few months of the pandemic and towards the end of the year. Declines for early preterm birth were largest in November 2020, when the

observed value of 2.6 per 100 was 9% lower than the expected value of 2.8 (95% PI 2.7, 2.9). We detected no changes from expectation in the rate of caesarean deliveries, as all observed values fell within the 95% PI of expected values.

4 | COMMENT

Our findings provide evidence of reductions below expectation in preterm delivery nationwide during the SARS-CoV-2 pandemic. These declines differed by both timing of delivery and birth month,

suggesting that several mechanisms, which require further study, may explain these patterns. By contrast, caesarean delivery rates appeared unaffected.

Our findings differ somewhat from a recently released NCHS report, which noted a 1% decline in the preterm delivery rate in 2020 relative to 2019.[3] Our approach likely detected larger declines both because we focus on monthly changes, which are more sensitive to acute shocks, and because we compare observed values to counterfactuals derived from 62 pre-pandemic months.

To date, perinatal epidemiology studies in the United States have primarily focussed on the initial stage of the pandemic, when most populous states mandated strict sheltering in place.[4–7] We document that the effects of the pandemic on perinatal health likely persisted through 2020.

Mechanisms linking the pandemic with changes in the rate of preterm birth remain unclear. Perinatal health might have improved, particularly early in the pandemic, due to lockdown measures that reduced deleterious exposures, including via reduced in-person work hours. Changes to clinical practice around labour and delivery interventions may also play a role. Other explanations may involve compositional changes in gestations that survive to live birth resulting from potential increases in rates of foetal loss and stillbirth,[15] which we could not directly estimate. Our results are also mediated through the impact of COVID-19 infection itself, which appears to increase preterm birth.[16]

Our approach is strengthened by methods that rule out autocorrelation and seasonal confounding as sources of spurious association and inefficient estimation. Provisional data for 2020 did not, however, allow us to examine other outcomes, vulnerable subgroups or severely affected geographies, limiting our inferences to the highest level of aggregation.

5 | CONCLUSIONS

The estimated declines in preterm delivery during the 2020 pandemic interrupt years of worsening rates in the United States.[3] Indeed, the improvement in some months is roughly the same magnitude as the 7% increase in the overall preterm birth rate between 2014 and 2019 in the US. As suggested by others,[17,18] the pandemic may, therefore, provide a unique opportunity to advance understanding of the processes that shape perinatal health. More detailed natality data expected later in 2021, will allow researchers to assess whether these patterns persist, as well as test whether proposed mechanisms (e.g., reduced exposure to occupational and environmental stressors, elevated selection in utero, and changes in healthcare seeking and clinical practice) may have caused these changes.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available at the National Center for Health Statistics website at https://www.cdc.gov/nchs/covid19/technical-notes-outcomes.htm and the Centers for Disease Control and Prevention Wonder database at https://wonder.cdc.gov/natality.html.

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