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Pre and Post-Lockdown Cesarean Deliveries and Perinatal Quality Indicators During the COVID-19 Pandemic

Khaleel S. Hussaini, PhD;[1] Rui Li, PhD;[2] Jennifer Miles, BS;[3] Maridelle Dizon, BS;[4] Mathew K. Hoffman, MD, MPH, FACOG[5]

1. US Department of Health and Human Services, Centers for Disease Control and Prevention, Division of Reproductive Health, Field Support Branch, Atlanta, GA; Delaware Department of Health and Social Services, Division of Public Health

2. U.S. Department of Health and Human Services, Health Resources and Services Administration, Maternal and Child Health Bureau, Office of Epidemiology and Research, Division of Research

3. Delaware Department of Health and Social Services, Division of Public Health

4. Delaware Department of Health and Social Services, Division of Public Health

5. Marie E. Pinizzotto, M.D., Endowed Chair, Department of Obstetrics & Gynecology, Director, Center for Women & Children's Health Research, ChristianaCare

Abstract

We examined statewide perinatal quality indicators: nulliparous singleton term vertex cesarean births (NTSV) or low risk cesarean births, and non-medically indicated early term delivery (NMETD) rates during COVID-19 pandemic pre-lockdown (1/1/2019 to 3/23/2020) and post-lockdown (after 3/23/2020). Interrupted time-series analyses were used to examine the effects of the COVID-19 pandemic on these indicators. We observed a statistically significant increase in NTSV cesarean rates, 4.4% (95%CI: 1.3,7.4) immediately after lockdown, and a decrease in NMETD rate, 1.6% (95%CI: -2.5,-0.7). We observed an increase (0.3%; 95%CI: 0.0,0.6) in the slope (i.e., trend change) of NTSV rates post-lockdown and a decrease (-0.2%; 95%CI: -0.3,-0.1) in the slope of NMETD rates. Results suggest that the COVID-19 pandemic had an immediate effect on perinatal quality indicators in Delaware, with gradual return to pre-pandemic rates as the pandemic continued. In addition to emergency preparedness planning, hospital monitoring of perinatal quality indicators might improve obstetrical care during public health emergencies.

Introduction

The World Health Organization declared COVID-19 a public health emergency of international concern on January 30, 2020 and subsequently a global pandemic on March 11, 2020 leading to global lockdowns.[1] The COVID-19 pandemic has affected healthcare access, delivery, and utilization in the U.S.,[2] and pregnant women may face unique challenges,[3] which may manifest in perinatal quality indicators related to timing and mode of delivery.

One in three deliveries in the U.S. are by a cesarean delivery (CD),[4] and cesarean deliveries increase the risk of maternal morbidity when not clinically indicated.[5] Nulliparous term singleton vertex (NTSV) cesarean birth or "low-risk cesarean" is an endorsed perinatal quality indicator by the Joint Commission (TJC) and the National Quality Forum (NQF) and focuses on first-time,

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uncomplicated pregnancy and assesses the outcome of labor management.[6–8] In 2020, the U.S. NTSV rate of 25.9% was above the Healthy People 2030 benchmark rate of 23.6%,[4,9] One recent study found that there is considerable variation in NTSV rates among U.S. hospitals, suggesting differences in local policies, culture, and provider attitudes.[10] A second perinatal quality health indicator is non-medically indicated early term deliveries (NMETD) prior to 39 weeks gestation. NMETD are inductions of labor and cesarean deliveries that occur without indication in maternal or fetal medical conditions (e.g., preeclampsia, eclampsia, diabetes, congenital malformations, fetal distress, etcetera).[11–14] The American Congress of Obstetricians and Gynecologists (ACOG) have consistently advised against NMETD.[11–14] Although ACOG has provided labor and delivery guidance for hospital disaster preparedness including pandemics,[15,16] there is limited information on whether perinatal quality indicators (i.e., a measure of quality of care) vary during pandemics. Our primary goal was to assess statewide changes in NTSV and, NMETD rates comparing before and during the COVID-19 pandemic in Delaware.

Study Design and Methods

We used birth certificate data from January 2019 through December 2021 comprising 36 time points from Delaware for a total of 30,972 births; 2021 data were provisional. Provisional estimates of birth rates track closely with estimates based on final data.[17] We calculated monthly NTSV rates with NTSV births as the numerator (i.e., singleton, 37 weeks or greater gestation, with cephalic presentation to nulliparous women, with cesarean mode of delivery) and all hospital singleton term births to nulliparous women with cephalic presentation as the denominator. We calculated monthly NMETD rates with NMETD as the numerator (i.e., singleton, $37^{0/7}$ and $38^{6/7}$ weeks of gestation with cephalic presentation to nulliparous women) and excluded the following maternal conditions[11–14] available on Delaware's birth certificate: preeclampsia, eclampsia, chorioamnionitis, premature rupture of membranes, prolonged labor, pre-pregnancy diabetes, gestational diabetes, congenital anomalies, fetal distress, and history previous poor outcomes. All early term ($37^{0/7}$ and $38^{6/7}$ weeks of gestation) singleton hospital births formed the denominator.

Interrupted time-series (ITS) analyses were used to examine the effects of the COVID-19 pandemic on NTSV and NMETD rates using Delaware's Executive Order on Stay-At-Home (lockdown) as the point of interruption indicating the pre-lockdown (1/1/2019 to 3/23/2020; n = 13,034) and post-lockdown (after 3/23/2020 onward; n = 17,938) periods. The ITS is a quasi-experimental design to determine the influence of events at clearly defined time-points such as policies, interventions, or natural disasters.[18–23] Segmented regression models have two parameters of interest: 1) the intercept (i.e. level change); and 2) slope (trend change and/or month-to-month variation) and is expressed as follows:

$$Y_t = \beta_0 + \beta_1\text{*time} + \beta_2\text{*lockdown due to COVID19} + \beta_3\text{*time} + \varepsilon_t \text{ ----> (1)}$$

In this model, Y_t is the NTSV or NMETD monthly rate, β_1*time is the slope or overall secular trend for NTSV or NMETD expressed as a continuous variable beginning 1 in January of 2019 to 36 in December of 2021; β_2*lockdown due to COVID-19 is a dichotomous variable (0 = pre-lockdown or 1 = post-lockdown) and provides an immediate effect on the level of the outcome (i.e., an intercept or a level change); β_3*time is time after transition or the continuing effect of the lockdown due to COVID-19 (i.e., slope change) in successive time periods after a one month lag beginning 1 in May of 2020 to 20 in December of 2021 post-lockdown. The pre-lockdown

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months January of 2019 to March of 2020 are coded as 0 and finally ε_t is the random error term for each month.[18–23]

We used augmented Dickey-Fuller unit root test to assess seasonal fluctuations (stationarity) and Durbin-Watson statistic and test for autocorrelation. All parameters were modeled using autoregressive errors, as seasonality produces an autocorrelation at the seasonal lag. We used backward stepwise elimination specifying a lag of 13 for our monthly data, plotted our residuals and checked for normality using Anderson-Darling test. We estimated robust standard errors using Newey-West correction for any heteroscedasticity and autocorrelation. We conducted all analysis using SAS 9.4 and the significance level was set at alpha 0.05. Because we utilized aggregate data involving no human subjects, the study was exempt from review by Delaware Department of Health and Social Services review board.

Results

Figure 1 displays the time-series and Table 1 provides the ITS regression results. During pre-lockdown, baseline NTSV rates decreased by 0.3% (95%CI: -0.5, 0.0), and NMETD rates increased by 0.2% (95%CI: 0.0,0.3). Immediately after lockdown due to COVID-19 (i.e., level change) we observed a significant increase in NTSV rate of 4.4% (95%CI: 1.3,7.4), and a decrease in NMETD rate, of 1.6% (95%CI: -2.5,-0.7) respectively. A small increase (0.3%; 95%CI: 0.0,0.6) in the slope of NTSV rates and a small decrease (-0.2%; 95%CI: -0.3,-0.1) in the slope of NMETD rates (i.e., trend change) was observed post-lockdown. To test for potential bias from study population change, we tested for differences in the total number of deliveries pre-lockdown and post-lockdown and found no change.

Figure 1. Nulliparous Term Singleton Vertex Cesareans and Non-Medically Indicated Early Term Deliveries Before and During the COVID-19 Pandemic in Delaware, January 2019-December 2021

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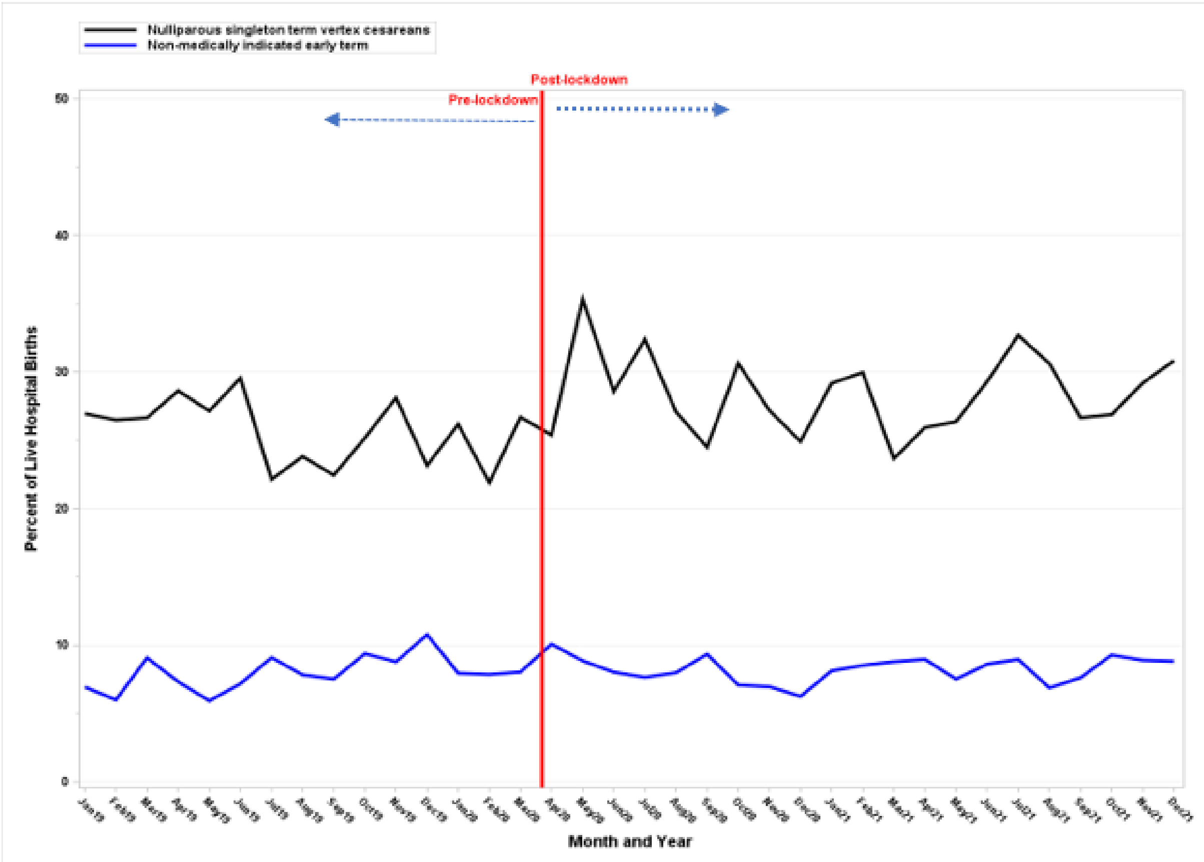

Notes: Delaware Department of Health and Social Services, Delaware Health Statistics Center, Monthly Vital Statistics data. The calendar year 2020 and 2021 data are provisional. COVID-19 Stay-At-Home Order began March 24, 2020 at 8:00 a.m. and Stay-At-Home ended on May 31, 2020 in Delaware.

*NTSV cesareans are singleton births, 37 weeks or greater gestation, with cephalic presentation to nulliparous women, with cesarean mode of delivery and all hospital singleton term births (>37 weeks or greater gestation) to nulliparous women with cephalic presentation serve as the denominator.

†NMETD is singleton births at 37 and 38 weeks of gestation with cephalic presentation to nulliparous women that exclude preterm births and conditions such as preeclampsia, eclampsia, chorioamnionitis, premature rupture of membranes, prolonged labor, pre-pregnancy diabetes, gestational diabetes, congenital anomalies, fetal distress, and history previous poor outcomes and all early term (37 and 38 weeks of gestation) singleton hospital births serve as the denominator.

Table 1. Interrupted Time-Series Regression Results for Cesarean Deliveries, Non-Medically Indicated Deliveries, Non-Medically Indicated Inductions, Non-Medically Indicated Cesareans, Before and During The COVID-19 Pandemic in Delaware, January 2019-March 2021

Outcomes	Mean (SD)	Parameters	Final Model	
			b (SE)	95% CI
Percent nulliparous term singleton vertex cesareans†	27.3 (±3.1)	Intercept	28.0 (1.0)***	26.1, 30.0

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		Baseline trend	-0.3 (0.1)**	-0.5, 0.0
		Level change	4.4 (1.5)**	1.3, 7.4
		Trend change	0.3 (0.1)**	0.0, 0.6
Percent non-medically indicated early term deliveries[‡]	8.1 (±1.1)	Intercept	6.4 (0.4)***	5.6, 7.3
		Baseline trend	0.2 (0.1)**	0.1, 0.3
		Level change	-1.6 (0.4)**	-2.5, -0.7
		Trend change	-0.2 (0.0)**	-0.3, -0.1

p-value ***<0.01 **<0.05

Notes: Delaware Department of Health and Social Services, Delaware Health Statistics Center, Monthly Vital Statistics data. The calendar year 2021 data are provisional. COVID-19 Stay-At-Home Order began March 24, 2020 at 8:00 a.m. and Stay-At-Home ended on May 31, 2020 in Delaware. The model of interruption was beginning of Stay-At-Home order on March 24, 2020. Denominator comprises of monthly hospital births. Stationarity was assessed using Augmented Dickey-Fuller test and Durbin-Watson statistic was used for autocorrelation. All parameters were modeled using autoregressive errors, as seasonality produces an autocorrelation at the seasonal lag. We used backward stepwise elimination specifying a lag of 13 for our monthly data, plotted our residuals and checked for normality using Anderson-Darling test. We estimated robust standard errors using Newey-West correction for any heteroscedasticity and autocorrelation.

[†]NTSV cesareans are singleton births, 37 weeks or greater gestation, with cephalic presentation to nulliparous women, with cesarean mode of delivery and all hospital singleton term births (>37 weeks or greater gestation) to nulliparous women with cephalic presentation serve as the denominator.

[‡]NMETD is singleton births at 37 and 38 weeks of gestation with cephalic presentation to nulliparous women that exclude preterm births and conditions such as preeclampsia, eclampsia, chorioamnionitis, premature rupture of membranes, prolonged labor, pre-pregnancy diabetes, gestational diabetes, congenital anomalies, fetal distress, and history previous poor outcomes and all early term (37 and 38 weeks of gestation) singleton hospital births serve as the denominator.

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Discussion

Although differences were small, NTSV rates decreased and NMETD rates increased during pre-lockdown period. When lockdown was announced in Delaware, the downward trend in NTSV rate was briefly interrupted with a four percentage-point increase while NMETD rates decreased by more than one percentage-point. During the post-lockdown period, NTSV rates continued to increase, while NMETD rates continued in a downward trend. These results suggest that the COVID-19 pandemic was associated with an immediate change in perinatal care in Delaware but appeared to gradually return to previous trends as the pandemic continued.

Reasons for the abrupt increase in NTSV and decrease in NMETD are unclear based on these data but may be due to delay or avoidance of care, limited resources, changes in labor and delivery unit practices or management.[2,10,15,16,24,25] These perinatal quality indicators are reported to the Joint Commission[26] and may be available to hospitals in their hospital electronic medical records in near real-time or monthly or quarterly basis. Further, perinatal quality collaboratives[26] can play an important role in monitoring these indicators[4,10,11,27] and may provide guidance in quality initiatives to improve triage, labor and delivery staffing during public health emergencies.

Strengths and Limitations

Strengths of this analysis include use of current statewide data available from birth certificates to assess two important perinatal quality indicators using a robust quasi-experiment design. As of this writing, we have identified two studies[28,29] specific to how these indicators are influenced during a pandemic. These studies were single hospital-based studies that compared data for a specific month as pre and post COVID-19 and found decreases in NTSV rates. However, such comparisons may not account for seasonal variations.[30] Our ITS study accounts for this potential issue using a large time-series that includes 36 months. Despite its strengths, the study is limited by the fact that birth certificate data are administrative data and the accuracy of certain conditions for medical indications may lack sensitivity and may be overestimated.[31] The aggregate nature of data also limited us from stratification of NTSV and NMETD rates by maternal age, race and ethnicity, and by hospitals that influence these indicators.[6,7]

Conclusion

Our study assessed statewide changes in NTSV, NMETD rates comparing before and during the COVID-19 pandemic lockdown in Delaware and found that there was an abrupt increase NTSV rates and decrease in NMETD rates post-lockdown impacting perinatal care. Future studies might explore occurrence of and reasons for changes in obstetrical care using multi-state or national initiatives such as the National Network of Perinatal Quality Collaboratives (NNPQC), Alliance for Innovation in Maternal Health (AIM) data, regional perinatal quality collaboratives chart-abstracted data and/or hospital network data that would provide more observations for further stratification. In addition to emergency preparedness planning, hospital monitoring and reporting of perinatal quality indicators to increase provider awareness of NTSV rates, reallocating and prioritizing clinical resources through surge capacity staffing in labor and delivery units might improve obstetrical care as measured by perinatal quality indicators during public health emergencies.

Dr. Hussaini may be contacted at khaleel.hussaini@delaware.gov.

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