Paediatrics & Child Health, 2023, **XX**, 1–8
https://doi.org/10.1093/pch/pxad063
Original Article

OXFORD

Original Article

The paradoxical influence of the COVID-19 lockdown period on different types of preterm births in Alberta: a provincial study

Aliyah Dosani PhD[1,2,3], Khokan C. Sikdar PhD[2,3,4], Mahalakshmi Kumaran MSc, PhD[4], Kumar Kumaran MD, MRCP[4,5], Abbas Hyderi MD, FRCPC[5], Amina Benlamri MD, FRCPC[6], Baldeep Rai BSc[2], Nalini Singhal MD, FRCPC[6,7], Abhay Lodha MSc, MD, DM, FRCPC, FAAP[2,6,7]

[1]Faculty of Health, Community and Education, School of Nursing and Midwifery, Mount Royal University, Calgary, Alberta, Canada;
[2]Department of Community Health Sciences, Cumming School of Medicine, University of Calgary, Calgary, Alberta, Canada;
[3]O'Brien Institute for Public Health, University of Calgary, Calgary, Alberta Canada;
[4]Surveillance and Reporting, Provincial Population and Public Health, Alberta Health Services, Calgary, Alberta, Canada;
[5]Department of Pediatrics, University of Alberta, Edmonton, Canada;
[6]Department of Pediatrics, University of Calgary, Calgary, Canada;
[7]Alberta Children's Hospital Research Institute, University of Calgary, Calgary, Canada

Correspondence: Abhay Lodha, Department of Pediatrics, Foothills Medical Centre, C211, 1403 29th Street NW, Calgary, T2N2T9, Alberta, Canada.
Telephone: 403-944-1087, fax: 403-944-4892, E-mail: aklodha@ucalgary.ca

ABSTRACT

Objectives: The objective of this study was to determine if the COVID-19 pandemic impacted different types of preterm birth rates in Alberta, Canada.

Methods: A population-based, retrospective, cohort study was conducted from March 15, 2015 to December 31, 2020 using provincial data. The primary exposure was the COVID-19 lockdown period, and the primary outcome was the incidence of preterm birth (<37 weeks gestational age). Multivariable analyses in the complete lockdown and overall lockdown (partial and complete lockdown) periods were performed to test the association between the year of birth and preterm birth status and were adjusted for various independent variables. Preterm birth status was adjusted for various confounding factors.

Results: Following the analysis of n = 41,187 mothers and their singleton infants, we found that the lockdown due to COVID-19 had no impact in reducing the overall preterm birth rate. However, a paradoxical influence was observed with an increase of extremely low preterm births in the overall lockdown period, and a decrease in moderate preterm births during the complete lockdown period.

Conclusions: The results of this study demonstrated that there was a decrease in moderate and increase in extremely low preterm birth rates as a result of the COVID-19 lockdown. However, the COVID-19 lockdown did not impact the very preterm and late preterm birth rate in Alberta.

Keywords: Alberta; Canada; COVID-19; Lockdown period; Preterm birth.

Each year, approximately 15 million infants (more than 1 in 10) are born prematurely (1–3). Preterm infants are born before 37 weeks of gestation and can be classified as extremely preterm gestational age (less than 28 weeks), very preterm (28 to less than 31 + 6 weeks), moderate preterm (32 + 0 to less than 33 + 6 weeks), and late preterm (34 + 0 to 36 + 6 weeks) (1). While 80% of preterm births occur in countries located in sub-Saharan Africa and South Asia, large variability within each country context is observed (4). Globally, experts in only 65 countries have been able to capture reliable data over the past 2 decades, with the data indicating an increase in preterm births overtime (1). Current rates of preterm birth globally range from 5% to 18% (1). The national preterm birth rate in Canada is 7.9% (5). In

Received: May 7, 2023; Accepted: August 19, 2023

2021, Alberta had the highest preterm birth rate (8.8%) of all provinces (6).

Premature birth and its complications have been a burden on families as well as on health care systems in all countries. This is associated with an increased risk of morbidity and mortality that varies within and between countries globally (3,4,7–13). Preterm birth is the leading cause of childhood mortality and in 2015 preterm birth was responsible for approximately 1 million infant deaths (14,15). A large portion of preterm births (up to 30%) are spontaneous and unexplained (3,16). As such, preterm birth is a significant public health issue globally and carries considerable weight in achieving United Nations Sustainable Development Goal 3.2.1, which is to end preventable deaths of newborns and under-5 children by 2030 (14). Therefore, it is important to understand epidemiological trends with respect to disparities in preterm birth rates around the world. This knowledge will be crucial for advocating for the appropriate level of resources for surveillance activities, prevention interventions, and care algorithms of preterm infants.

During the COVID-19 pandemic, various hypotheses emerged regarding how the pandemic would influence the rate of preterm birth. A decrease in preterm birth rates were predicted based on increased hygiene, diminished air pollution due to decreases in transportation, declines in employment-related stress, and reductions in the receipt of obstetric services, either due to anxiety around COVID-19 transmission, or reductions in health care services that were available (17,18). Globally, many researchers reported a decrease in preterm birth rates (19–23). In contrast, other studies did not find a significant difference in preterm birth rates before and during the pandemic (24–31). The literature from the Canadian context aligns with findings elsewhere in the world that show that the pandemic did not impact preterm birth rates and has very discrete data about the type of preterm birth rates during the COVID period (32–34). However, provincial research regarding the impact of the COVID-19 pandemic on different categories of preterm birth rates is not known. Given that Alberta has one of the highest rates of preterm birth in Canada, this study begins to bridge this gap.

The objective of this research was to evaluate whether the COVID-19 pandemic impacted the different categories of preterm birth rates in Alberta by comparing rates for the overall (partial and complete lockdown) and complete lockdown periods with the same time periods in the previous years to identify any variations.

MATERIALS AND METHODS

Study design, setting, and time period

A population-based, retrospective, cohort study was conducted from March 15, 2015, to December 31, 2020.

Study population and data source

Data were collected from the Alberta Perinatal Health Program (APHP). The APHP database is provincial clinical registry that collects information about maternal, obstetrics, and neonatal data for all deliveries in the province. In addition, we also accessed Vital Statistics stillbirth data, and Vital Statistics neonatal mortality up to 28 days of life. All datasets were linked by personal health number (PHN), which is also referred to as the unique lifetime identifier (ULI). In Alberta, every individual, including mother and infant, is assigned a PHN for healthcare covered with the Alberta Health Care Insurance Plan.

Variables

The primary exposure was the Overall lockdown period of the COVID-19 pandemic (March 15, 2020 to December 31, 2020). Subsequently, we narrowed it down to the complete lockdown period of the COVID-19 pandemic (March 15, 2020 to July 31, 2020). These dates were chosen based on the data we had available during our study.

Baseline maternal and neonatal characteristics are described in Table 1. The variables included are those which are critical for predicting preterm birth outcomes including antepartum risk score (35,36) calculated based on several factors including adverse maternal and neonatal outcomes [Apgar score < 7 at 5 min, NICU admission, serious resuscitation, low birth weight (<2.5 kg), preterm birth (<37 weeks)].

The Pampalon Material and Social Deprivation Index assesses socioeconomic status at the area level. It utilizes six census variables and calculates index values for dissemination areas (DAs), the smallest census units (37). The index assigns quintiles (Q1 to Q5) indicating the level of deprivation in each DA. Residential postal codes are linked to the index database to determine individual socioeconomic status. These values are specific to individuals residing in the identified DAs.

Outcomes

The primary outcome was incidence of preterm birth (<37 weeks gestational age). Secondary outcomes were preterm births in four gestational age categories: <28 weeks, 28 + 0 weeks to $31^{+6/7}$ weeks, 32^{+0} to $33^{+6/7}$weeks, and 34^{+0} to $36^{+6/7}$ weeks. Infants were excluded if they had moribund conditions, were born premature with major congenital anomalies, were born premature and transferred to Alberta from another province, were born premature due to various maternal conditions including uterine rupture, placental abruption, and antepartum haemorrhage.

Statistical analysis

Data were analyzed using SAS Version 8.3 statistical software. Descriptive analyses of categorical variables were completed and included determining frequencies and percentages of baseline maternal and neonatal characteristics. Continuous baseline characteristics were summarized as median and interquartile range (IQR) for overall and complete lockdown periods and corresponding comparators. The prevalence of singleton preterm and term births per 1000 were calculated for every year and the trend of changes in the prevalence of preterm or term births over the years was tested using the Cochran–Armitage trend test. The prevalence estimates by gestational age categories were determined and compared between the complete lockdown period and the same time period in 2019. The overall lockdown period was compared with the same time period in 2019 as well as the previous 5 years. Differences in prevalence or proportions among

Table 1. Baseline characteristics of the study cohort in 2020 compared with the same time period in 2019

Variables	Complete lockdown period compared with the same time period in 2019			Overall lockdown period compared with the same time period in 2019		
	Mar to Jul 2019 (n = 20,258)	Mar to Jul 2020 (n = 18,946)	P-value	Mar to Dec 2019 (n = 41,187)	Mar to Dec 2020 (n = 37,784)	P-value
Maternal age, median (IQR), years	31.0 (27.0 to 34.0)	31.0 (27 to 34)	0.49+	31.0 (27.0 to 34.0)	31.0 (27 to 34)	0.19+
Maternal age <20 years, n (%)	343 (1.69%)	323 (1.71%)	0.93	713 (1.7%)	665 (1.8%)	0.75
Maternal age ≥35 years, n (%)	4708 (23.24%)	4395 (23.20%)	0.93	9668 (23.5%)	8943 (23.7%)	0.49
Nulliparous, n (%)	7722 (38.20%)	7301 (38.68%)	0.33	15,904 (38.7%)	14,774 (39.2%)	0.13
Diabetes mellitus, n (%)	331 (1.64%)	312 (1.66%)	0.90	723 (1.8%)	678 (1.8%)	0.68
Pregnancy-induced hypertension, n (%)	1405 (6.97%)	1432 (7.60%)	0.016	2833 (6.9%)	2878 (7.7%)	<0.0001
Caesarean birth, n (%)	6164 (30.43%)	5722 (30.20%)	0.62	12,497 (30.3%)	116,110 (30.7%)	0.24
Multiple pregnancies, n (%)	354 (1.75%)	267 (1.41%)	0.007	693 (1.7%)	562 (1.5%)	0.03
Antenatal corticosteroids given, n (%)	489 (2.41%)	393 (2.07%)	0.024	972 (2.4%)	792 (2.1%)	0.012
Prolonged rupture of membranes, n (%)	696 (3.45%)	650 (3.45%)	0.99	1418 (3.5%)	1339 (3.5%)	0.44
Pampalon material deprivation						
Index, MDI, quintiles: n (%)						
Q1 (least deprived)	3478 (18.73%)	3193 (18.84%)		7111 (18.9%)	6275 (18.7%)	
Q2	4013 (21.61%)	3526 (20.81%)	0.47	7886 (21.0%)	7021 (20.9%)	0.69
Q3	3476 (18.72%)	3205 (18.91%)		7069 (18.8%)	6287 (18.7%)	
Q4	3324 (17.90%)	3083 (18.19%)		6770 (18.0%)	6152 (18.3%)	
Q5 (most deprived)	4279 (23.04%)	3938 (23.24%)		8704 (23.2%)	7885 (23.5%)	
Total Antepartum Risk Score, high range (>6), n (%)	1718 (8.53%)	1617 (8.60%)	0.83	3561 (8.7%)	3243 (8.6%)	0.65
Births						
Total births, n	20,625	19,210		41,900	38,343	
Live births, n (%)	20,607 (99.91%)	19,176 (99.82%)	<0.0001	41,844 (99.87%)	38,283 (99.84%)	<0.0001
Still births, n (%)	18 (0.09%)	34 (0.18%)	0.027	56 (0.13%)	60 (0.16%)	0.71
Birth weight, median (IQR), g	3320.0 (2990.0 to 3650.0)	3330.0 (3000.0 to 3660.0)	0.07+	3310.0 (2980.00 to 3645.00)	3325.0 (2990.0 to 3650.0)	0.03+
Gestational age, median (IQR), weeks	39.0 (38.0 to 40.0)	39.0 (38.0 to 40.0)	0.34+	39.0 (38.0 to 40.0)	39.0 (38.0 to 40.0)	0.32+
Gestational age category						
Term/post term ≥37 weeks, n (%)	18,793 (91.20%)	17,569 (91.62%)	0.13	38,174 (91.2%)	34,983 (91.2%)	0.45
Preterm < 37 weeks, n (%)	1814 (8.80%)	1607 (8.38%)		3670 (8.7%)	3300 (8.6%)	
Male, n (%)	10614 (51.51%)	9813 (51.17%)	0.79	21433 (51.2%)	19639 (51.3%)	0.97
NICU admission, n (%)	1778 (8.63%)	1567 (8.17%)	0.10	3683 (8.8%)	3333 (8.7%)	0.63
Small for gestational age, n (%)	2051 (9.95%)	1890 (9.86%)	0.75	4286 (10.2%)	3779 (9.9%)	0.08
Apgar score <7 at 5 min	660 (3.21 %)	563 (2.94%)	0.13	1323 (3.2%)	1172 (3.1%)	0.42
Neonatal mortality, n (rate per 1000 live births)	57 (2.8 birth per 1000 live births)	46 (2.4 birth per 1000 live births)	0.47	100 (2.4 birth per 1000 live births)	97 (2.5 birth per 1000 live births)	0.68

P-value estimate proportions are estimated using chi-square test.
+P-values for medians are estimated using Mann–Whitney U test

categorical variables were estimated using the chi-square test and those for medians were estimated using the Mann–Whitney test.

Univariate logistic regression analyses for all singleton live births were completed including a calculation of the odds of overall preterm birth (all preterm outcomes). These odds were compared to term and post term births in 2020 compared to the reference year 2019 or 2019 to 2015. Multivariable analyses in the complete lockdown period were performed to test the association between the year of birth (2020 compared with 2019) and preterm birth status and were adjusted for various independent variables. Multivariable analyses in the overall lockdown period were performed to test the association between the year of birth (2020 compared with 2019, and 2020 compared with 2015 to 2019) and preterm birth status and were adjusted for various confounding factors. A P-value of ≤ 0.05 was considered statistically significant.

Ethics approval was obtained from the Conjoint Health Research Ethics Board at the University of Calgary (Ethics ID: REB20-0808) and the Human Research Ethics Board at Mount Royal University (Ethics ID: 102283).

RESULTS

The prevalence of singleton preterm birth per 1000 by gestational age in Alberta from 2015 to 2022 are presented in Figure 1. The trend analysis indicates that the rate of preterm births has increased in Alberta over time.

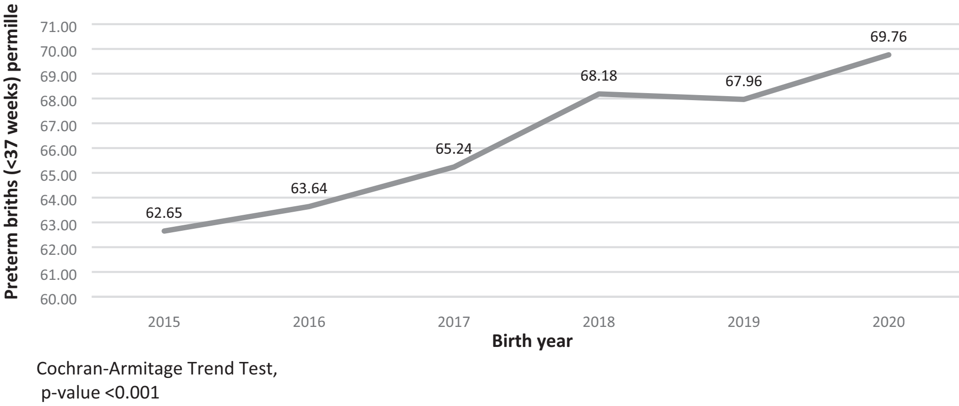

Figure 1. The prevalence of Singleton Live preterm births per 1000 births in Alberta, March 15th to Dec 31st 2015 to 2020. The prevalence of preterm (<37 weeks) in per mille of the singleton live births over the March to December between 2015 and 2020

Descriptive data

In Table 1, the baseline characteristics of the study population during overall lockdown and complete lockdown period were compared with the same time periods in previous year. Lockdown is a circuit-breaker approach and is a time-limited partial or complete lockdown intended to drop transmission of the virus quickly in the absence of a vaccine or period when the vaccine was being developed. In a complete lockdown, everyone is restricted to their homes, cannot have visitors, and has limited time to accomplish essential activities outside the home. In partial lockdown may restrict some activities by the type of activity, group size allowed, and time allowed for certain activities. With respect to maternal characteristics, we observed no difference in median maternal age. An increased risk of pregnancy-induced hypertension over both the complete (6.97% in 2019 versus 7.60% in 2020, P < 0.016) and overall lockdown (6.9% in 2019 versus 7.7% in 2020, P < 0.0001) periods were observed. On the contrary, we observed a decrease in the number of women who were given antenatal corticosteroids over both the complete (2.41% in 2019 versus 2.07% in 2020, P-value 0.024) and overall (2.4% in 2019 versus 2.1% in 2020, P < 0.012) lockdown periods. Similar trends were observed among women carrying multiple pregnancies. Statistically significant trend of decrease in live births was observed for the complete lockdown (99.82% in 2020) period when compared to the same time period in the previous year (99.91% in 2019) with a P < 0.0001. However, the rate of still births increased in 2020 compared to 2019 (0.18% versus 0.09%, P < 0.027). No differences in median gestational age were observed between either of the lockdown periods and the corresponding time periods in 2019.

Prevalence of preterm births

The prevalence of singleton live births per 1000 by gestational age categories are presented in Table 2. An increase in preterm birth rate in the overall lockdown period when compared to the same time period over the last 5 years was observed. A concurrent decrease in term and post term births were observed. An increase in extreme low gestational age preterm births was observed in the overall lockdown period when compared to the same time period in the last 5 years. However, a decrease in moderate preterm births was observed during the complete lockdown period when compared to the same time period in 2019.

Regression modelling results

The unadjusted univariate model presented in Table 3 shows that the odds of preterm birth were higher in overall lockdown period compared to the same time period in last 5 years. The multivariable logistic regression analyses are presented in Table 4. There is no association between the complete lockdown period and preterm birth when compared to the same time frame in 2019, after adjusting for other independent variables. However, maternal age, nulliparous, pregnancy-induced hypertension, the delivery method by c-section, and maternal steroid administrated, and material deprivation quintile 5 versus 1 showed an independent association with preterm births after adjusting for other variables. The odds ratios of these variables are associated with an increased risk of preterm births. Specifically, the odds of preterm birth in mothers who received maternal steroids were 57 times the odds of preterm births to mothers who did not receive steroids (OR 56.57, 95% CI 46.83, 68.32; p< 0.001).

Other Analyses

An association was found between the overall lockdown period and preterm birth when compared to the same time frame in 2019 (OR 1.08; 95% CI 1.01, 1.15; P 0.03) and from 2015 to 2019 (OR 1.11, 95% CI 1.05, 1.18; P < 0.001), after adjusting for other independent variables. For both time periods (overall lockdown period compared to the same time frame in 2019 and from 2015 to 2019) maternal age, pregnancy-induced hypertension, maternal steroid administration, mode of delivery, maternal deprivation quintile 4 versus 1 and maternal deprivation quintile 5 versus 1 showed an independent association with preterm births after adjusting for other variables, indicating the odds ratios of these variables are associated with an increased risk of preterm births. In routine practice, cases where there is a higher likelihood of preterm births, maternal steroids are administered (38). We observed a similar trend with higher risk of preterm births among mothers who received maternal steroids, both during complete (OR 58.75; 95% CI 54.73,

Table 2. Prevalence of Singleton Live Births per 1000 (per mille) by gestational age categories

Gestational age categories	Complete lockdown period compared with the same time period in 2019			Overall lockdown period compared with the same time period in 2019			Overall lockdown period compared with the same time period in the last 5 years		
	Prevalence (95% CI)		P-value	Prevalence (95% CI)		P-value	Prevalence (95% CI)		P-value
	Mar 15 to July 31, 2019	Mar 15 to July 31, 2020		Mar 15 to Dec 31, 2019	Mar 15 to Dec 31, 2020		March 15 to Dec 31, 2015 to 2019 (consolidated)	March 15 to Dec 31, 2020	
Term vs. preterm*									
Overall preterm (<37 weeks)	67.8 (64.2 to 71.5)	68.7 (64.9 to 72.5)	0.73	68.0 (65.5 to 70.5)	69.8 (67.1 to 72.5)	0.34	59.5 (58.5 to 60.5)	74.9 (67.1 to 72.5)	<0.05
Term and post term (≥37 weeks)	932.2 (918.8 to 945.7)	931.3 (917.5 to 945.3)	0.93	932.0 (922.7 to 941.5)	930.2 (920.5 to 940.1)	0.79	850.9 (847.2 to 854.7)	930.2 (920.5 to 940.1)	<0.05
Total births (n)	19888	18656		40448	37183		232010	37183	
Preterm categories**									
Extreme preterm (<28 weeks)	54.1 (42.4 to 68.0)	62.5 (49.5 to 77.7)	0.37	54.9 (46.52 to 64.42)	66.3 (56.77 to 76.9)	0.09	49.7 (46.06 to 53.56)	66.3 (56.77 to 76.99)	<0.05
Very preterm (28 to 31 weeks)	77.1 (62.9 to 93.4)	79.6 (64.9 to 96.6)	0.81	80.4 (70.14 to 91.72)	78.6 (68.22 to 90.2)	0.82	76.9 (72.35 to 81.67)	78.6 (68.22 to 0.2)	0.76
Moderate preterm (32 to 33 weeks)	116.4 (98.9 to 136.1)	87.4 (71.99 to 105.2)	0.02	109.9 (97.8 to 123)	95.2 (83.7 to 107.8)	0.09	105.4 (100.1 to 111)	95.2 (83.7 to 07.8)	0.14
Late preterm (34 to 36 weeks)	752.4 (706.8 to 800.2)	770.5 (723.2 to 820.1)	0.59	754.8 (722.7 to 788)	759.8 (726.7 to 794.1)	0.83	768.0 (753.4 to 782.7)	759.8 (726.7 to 4.1)	0.66
Total preterm births (n)	1349	1281		2749	2594		13,822	2594	

*Term vs. preterm – denominator for this analysis is total births; Numerator term + post births and preterm births.
**Preterm categories – denominator for this analysis is total preterm births; Numerator – each preterm categories by GA

Table 3. Univariate logistic regression model: association between the overall preterm births and COVID-19 lockdown period

Variable	Complete lockdown compared to the same time period in 2019[1]		Overall lockdown compared to the same time period in 2019[2]		Overall lockdown compared to the same time period in 2015 to 2019[3]	
Year of birth	OR (95% CI) (unadjusted)	P-value	OR (95% CI) (unadjusted)	P-value	OR (95% CI) (unadjusted)	P-value
Year of birth 2020	1.01 (0.94 to 1.10)	0.75	1.03 (0.97 to 1.09)	0.32	1.07 (1.03 to 1.12)	<0.001
Year of birth 2019	1.00 (reference)		1.00 (reference)			
Year of birth 2019 to 2015					1.00 (reference)	

Outcome variable – overall preterm (0/1)—1= any preterm, 0 = term, and post term. The event = 1 (= any preterm) and independent variable is year of birth.
[1]Complete lockdown vs. the same calendar period of the previous year = 15th March to 31st July 2020 vs. 15th March to 31st July 2019.
[2]Overall lockdown vs. the same calendar period of the previous year = 15th March to 31st December 2020 vs. 15th March to 31st December 2019.
[3]Overall lockdown vs. the same calendar period of the previous 5 years = 15th March to 31st December 2020 vs. 15th March to 31st December 2015 to 2019

63.01; P < 0.001) and overall lockdown periods (OR 67.47, 95% CI 58.56, 77.73; P < 0.001) compared to mothers who did not receive steroids.

DISCUSSION

During COVID period, our study showed that the COVID-19 lockdown period there was decreased in moderate and increase in extremly preterm birth rates. However, the very preterm and late preterm birth rates in Alberta remained unimpacted. Our results are similar to other studies around the world (23–31) and from the Canadian context (32–34). Various hypotheses have been proposed in the literature that could explain why some studies (19–23) found a decrease in preterm birth rates during the COVID-19 period.

These explanations could include better work-life balance, improved sleep quality and nutrition, decreased workload leading to reduced work-related physical and emotional stress, reduced physical activity, decreased air pollution due to less traffic, better hygiene, and lower incidence of infections in general (39–41). Certainly, Goldenberg and colleagues (42) explained how maternal infections, mainly ascending infections from the lower genital tract, can impact the pathophysiology of most spontaneous preterm birth cases.

Table 4. Multivariable logistic regression model: association between overall preterm births and COVID-19 lockdown (adjusted for mother's demographic and clinical characteristics)

Variables	Complete lockdown compared to the same time period in 2019[1]		Overall lockdown compared to the same time period in 2019[2]		Overall lockdown compared to the same time period in 2015 to 2019[3]	
	OR (95% CI) (adjusted)	P-value	OR (95% CI) (adjusted)	P-value	OR (95% CI) (adjusted)	P-value
Year of Birth 2020 vs. (ref = 2019 or 2019 to 2015)	1.07 (0.98, 1.18)	0.13	1.08 (1.01, 1.15)	0.03	1.11 (1.05, 1.18)	<0.001
Maternal age	1.01 (1.00, 1.02)	0.01	1.01 (1.00, 1.01)	0.03	1.01 (1.01, 1.01)	<0.001
Nulliparous (ref = 0)	1.15 (1.04, 1.27)	0.01	1.05 (0.97, 1.12)	0.22		Data not available
Pregnancy-induced hyper-tension (ref = 0)	2.84 (2.49, 3.23)	<0.001	2.72 (2.48, 2.99)	<0.001	2.94 (2.79, 3.10)	<0.001
Delivery method C-section (ref = false)	2.13 (1.75, 2.58)	<0.001	2.14 (1.86, 2.45)	<0.001		Data not available
Maternal steroids administered (ref = false)	56.57 (46.83, 68.32)	<0.001	67.47 (58.56, 77.73)	<0.001	58.75 (54.73, 63.06)	<0.001
Mode of delivery (ref = false)	1.44 (1.19, 1.75)	<0.001	1.37 (1.19, 1.57)	<0.001	0.73 (0.71, 0.76)	<0.001
Material deprivation quin-tile 2 vs. 1 (ref = 1, lease deprived)	0.93 (0.80, 1.08)	0.32	1.03 (0.92, 1.14)	0.65	1.03 (0.92, 1.14)	0.62
Material deprivation quin-tile 3 vs. 1 (ref = 1, lease deprived)	0.97 (0.83, 1.13)	0.67	1.05 (0.94, 1.17)	0.37	1.05 (0.94, 1.17)	0.41
Material deprivation quin-tile 4 vs. 1(ref = 1, lease deprived)	1.12 (0.96, 1.30)	0.14	1.18 (1.06, 1.31)	<0.001	1.19 (1.07, 1.32)	<0.001
Material deprivation quin-tile 5 vs. 1 (ref = 1, lease deprived)	1.16 (1.00, 1.34)	0.04	1.20 (1.08, 1.33)	<0.001	1.11 (1.02, 1.21)	0.02

This includes **for all live births and singleton births only**, outcome variable – overall preterm (0/1). 1= Any preterm, 0 = term, and post term. The event = 1 (= any preterm) and independent variable is year of birth, maternal age, nulliparous, pregnancy-induced hypertension, delivery method C-section, maternal steroids administered, mode of delivery, material deprivation (1 to 5, 1 = least deprived, 5-most deprived).

[1]Complete lockdown vs. the same calendar period of the previous year = 15th March to 31st July 2020 vs. 15th March to 31st July 2019.

[2]Overall lockdown vs. the same calendar period of the previous year = 15th March to 31st December 2020 vs. 15th March to 31st December 2019.

[3]Overall lockdown vs. the same calendar period of the previous 5 years = 15th March to 31st December 2020 vs. 15th March to 31st December 2015 to 2019

However, vaginal microbiome is complex, and it is highly unlikely that changes in lifestyle and increased hand hygiene could modify vaginal microbiome in a way that reduces the risk of ascending genital infections and spontaneous preterm birth (17). Reasons for some studies observing decreases in preterm birth rates could have been due to various service disruptions during the pandemic (18). This is because a large component of preterm births are medically indicated and with the onset of the pandemic, there may have been a reduction in medical interventions stemming from decreased antenatal surveillance as well as reluctance to seek hospital-based care (43).

This study found an increase in preterm birth rates in the overall lockdown period when compared to the same time frame in 2019. A similar association was found when comparing the overall lockdown period and the last 5 years. This finding as well as an increasing trend of preterm birth over the year in Alberta, indicates that lockdown due to COVID-19 had no impact in reducing the overall preterm birth rate in this study population. However, a breakdown analysis indicated a paradoxical influence that there was an increase in extremely low preterm births in the overall lockdown period, whereas a decrease in moderate preterm births during the complete lockdown period.

Two studies conducted in Nepal and Uruguay found an increase in preterm birth rates during COVID-19 (23,40). Differences may have been attributed to varying methods used to determine gestational age, heterogeneity in preterm birth rates between countries, as well as study methods used. Furthermore, the psychosocial stress of populations in Nepal and Uruguay are very different than those in Canada, where gender roles are concerned. Higher rates of gender inequality are often observed in low- and middle-income countries where women bear the majority of burden with respect to household work and having less access to transportation to access health services (21,44). Maternal-fetal medicine is often of decreased quality in low- and middle-income countries when compared to the Canadian context due to lack of available specialist and equipment (21,44). In addition, variations in complete and overall lockdown periods between and within countries make studies difficult to compare. Therefore, these results should be interpreted with caution.

A significant strength of our study was our large sample size. Second, we were able to access data from across the province of

Alberta. Third, we were able to access data from the past 5 years which allowed us the opportunity to compare trends of preterm birth over time. A fourth strength of this study was its sampling procedure. Data for this study were derived from the APHP database, which contains information on all births that took place in Alberta hospitals during the study time period. Consequently, all births were accounted for there was minimal risk of sampling bias. Fifth, numerous maternal and neonatal-health related variables were available, and all variables collected were measured and reported by clinicians and therefore contained very little missing data. Furthermore, data that were analyzed were objectively measured and recall bias was not a concern. Finally, the lack of available socioeconomic data included in the APHP database was overcome by performing data linkage to obtain Material Deprivation Index measures for our sample. The Institut National de Santé Publique du Québec (INSPQ) Deprivation Index is a validated and reliable measure of socioeconomic status (37), and its Material Deprivation Index scale accounts for education, employment, and income relative to the general Canadian population (45).

Limitations of our study included the relatively short lockdown period in Alberta. Therefore, we must interpret our results with caution. We may have had different results had the complete lock down period been longer. In addition, due to the heterogeneity of the lockdown periods of other studies, it was difficult to compare and contrast results from other studies. Moreover, our results must be interpreted with vigilance due to the heterogeneity of preterm birth rates in Alberta over time.

In summary, during COVID period, our provincial based study showed that the COVID-19 lockdown period there was decreased in moderate and increase in extremly preterm birth rates in Alberta. However, the rates of very preterm and late preterm birth rates remained unimpacted. More research is required to determine the causality of preterm birth to mobilize prevention efforts, outside of the context of the COVID-19 pandemic.

FUNDING

No funding to report.

POTENTIAL CONFLICT OF INTEREST

All authors: No reported conflicts of interest. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

DATA AVAILABILITY

Research data are not shared

REFERENCES

1. World Health Organization. Preterm Birth, 2018. Accessed August 25, 2023 from https://www.who.int/news-room/fact-sheets/detail/preterm-birth
2. Walani SR. Global burden of preterm birth. *Int J Gynaecol Obstet* 2020;150:31–3. doi:10.1002/ijgo.13195
3. Zierden HC, Shapiro RL, DeLong K, Carter DM, Ensign LM. Next generation strategies for preventing preterm birth. *Adv Drug Deliv Rev* 2021;174:190–209. doi:10.1016/j.addr.2021.04.021
4. Chawanpaiboon S, Vogel JP, Moller AB, et al. Global, regional, and national estimates of levels of preterm birth in 2014: A systematic review and modelling analysis. *Lancet Glob Health* 2019;7:e37–46. doi:10.1016/S2214-109X(18)30451-0
5. Live Births, by Weeks of Gestation. Table: 13-10-0425-01. Statistics Canada, 2022. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310042501&pickMembers%5B0%5D=4.2&cubeTimeFrame.startYear=2017&cubeTimeFrame.endYear=2021&referencePeriods=20170101%2C20210101
6. Canadian Institutes for Health Information. Hospitalization and Childbirth, 1995–1996 to 2020–2021-Supplementary Statistics. Canadian Institutes for Health Information, 2022. Acccessed August 25, 2023 from https://www.cihi.ca/en/search?query=preterm±birth
7. Acharya R, Panthee A, Basnet R, Adhikari S, Ghimire N. Preterm birth, exasperation to the South Asian countries. *Kathmandu Univ Med J* 2022;20:102–6.
8. Adu-Bonsaffoh K, Oppong SA, Dassah ET, Seffah JD. Challenges in preterm birth research: Ghanaian perspective. *Placenta* 2020;98:24–8. doi:10.1016/j.placenta.2020.04.016
9. Gurung A, Wrammert J, Sunny AK, et al. Incidence, risk factors and consequences of preterm birth—findings from a multi-centric observational study for 14 months in Nepal. *Arch Public Health* 2020;78:64. doi:10.1186/s13690-020-00446-7
10. Opondo C, Gray R, Hollowell J, Li Y, Kurinczuk JJ, Quigley MA. Joint contribution of socioeconomic circumstances and ethnic group to variations in preterm birth, neonatal mortality and infant mortality in England and Wales: A population-based retrospective cohort study using routine data from 2006 to 2012. *BMJ Open* 2019;9:e028227. doi:10.1136/bmjopen-2018-028227
11. Ream MA, Lehwald L. Neurologic consequences of preterm birth. *Curr Neurol Neurosci Rep* 2018;18:48. doi:10.1007/s11910-018-0862-2
12. Richter LL, Ting J, Muraca GM, et al. Temporal trends in preterm birth, neonatal mortality, and neonatal morbidity following spontaneous and clinician-initiated delivery in Canada, 2009–2016. *J Obstet Gynaecol Can* 2019;41:1742–1751.e6 e6. doi:10.1016/j.jogc.2019.02.151
13. Wu M, Wang L, Liu Y, et al. Association between early-term birth and delayed neurodevelopment at the age of 2 years: Results from a cohort study in China. *Eur J Pediatr* 2021;180:3509–17. doi:10.1007/s00431-021-04152-6
14. World Health Organization. Child Mortality (Under 5 Years), 2022. Accessed August 25, 2023 from https://www.who.int/news-room/fact-sheets/detail/levels-and-trends-in-child-under-5-mortality-in-2020
15. Liu L, Oza S, Hogan D, et al. Global, regional, and national causes of under-5 mortality in 2000–15: An updated systematic analysis with implications for the sustainable development goals. *Lancet* 2016;388:3027–35. doi:10.1016/S0140-6736(16)31593-8
16. Cunningham FG SK, Bloom SL, Dashe JS, Hoffman BL, Casey BM. *Williams Obstetrics*. New York, NY: Mcgraw-Hill, 2018.
17. Dehaene I, Van Holsbeke C, Roelens K, et al. Preterm birth during the COVID-19 pandemic: More, less, or just the same? *Acta Clin Belg* 2023;78:140–59. doi:10.1080/17843286.2022.2091321
18. Lisonkova S, Joseph KS. Why did preterm birth rates fall during the COVID-19 pandemic? *Paediatr Perinat Epidemiol* 2023;37:113–6. doi:10.1111/ppe.12916
19. 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;5:e604–11. doi:10.1016/S2468-2667(20)30223-1
20. De Curtis M, Villani L, Polo A. Increase of stillbirth and decrease of late preterm infants during the COVID-19 pandemic lockdown. *Arch Dis Child Fetal Neonatal Ed* 2021;106:456. doi:10.1136/archdischild-2020-320682
21. Ashish KC, Gurung R, Kinney MV, 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;8:e1273–81. doi:10.1016/S2214-109X(20)30345-4
22. Matheson A, McGannon CJ, Malhotra A, et al. Prematurity rates during the coronavirus disease 2019 (COVID-19) pandemic lockdown in Melbourne, Australia. *Obstet Gynecol* 2021;137:405–7. doi:10.1097/AOG.0000000000004236
23. McDonnell S, McNamee E, Lindow SW, O'Connell MP. The impact of the Covid-19 pandemic on maternity services: A review of maternal and neonatal outcomes before, during and after the pandemic. *Eur J Obstet Gynecol Reprod Biol* 2020;255:172–6. doi:10.1016/j.ejogrb.2020.10.023
24. Handley SC, Mullin AM, Elovitz MA, et al. Changes in preterm birth phenotypes and stillbirth at 2 Philadelphia hospitals during the SARS-CoV-2 pandemic, March–June 2020. *JAMA* 2021;325:87–9. doi:10.1001/jama.2020.20991
25. Hedermann G, Hedley PL, Baekvad-Hansen M, et al. Danish premature birth rates during the COVID-19 lockdown. *Arch Dis Child Fetal Neonatal Ed* 2021;106:93–5. doi:10.1136/archdischild-2020-319990
26. 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;324:705–6. doi:10.1001/jama.2020.12746
27. Li M, Yin H, Jin Z, et al. Impact of Wuhan lockdown on the indications of cesarean delivery and newborn weights during the epidemic period of COVID-19. *PLoS One* 2020;15:e0237420. doi:10.1371/journal.pone.0237420
28. Maslin K, McKeon-Carter R, Hosking J, et al. Preterm births in south–west England before and during the COVID-19 pandemic: An audit of retrospective data. *Eur J Pediatr* 2022;181:859–63. doi:10.1007/s00431-021-04265-y
29. Pasternak B, Neovius M, Soderling J, et al. Preterm birth and stillbirth during the COVID-19 pandemic in Sweden: A Nationwide Cohort Study. *Ann Intern Med* 2021;174:873–5. doi:10.7326/M20-6367
30. Rasmussen MI, Hansen ML, Pichler G, et al. Extremely preterm infant admissions within the SafeBoosC-III Consortium during the COVID-19 lockdown. *Front Pediatr* 2021;9:647880. doi:10.3389/fped.2021.647880
31. Wood R, Sinnott C, Goldfarb I, Clapp M, McElrath T, Little S. Preterm birth during the coronavirus disease 2019 (COVID-19) pandemic in a large hospital system in the United States. *Obstet Gynecol* 2021;137:403–4. doi:10.1097/AOG.0000000000004237
32. Liu S, Dzakpasu S, Nelson C, et al. Pregnancy outcomes during the COVID-19 pandemic in Canada, March to August 2020. *J Obstet Gynaecol Can* 2021;43:1406–15. doi:10.1016/j.jogc.2021.06.014
33. Shah PS, Ye XY, Yang J, Campitelli MA. Preterm birth and stillbirth rates during the COVID-19 pandemic: A population-based cohort study. *CMAJ* 2021;193:E1164–72. doi:10.1503/cmaj.210081
34. Simpson AN, Snelgrove JW, Sutradhar R, Everett K, Liu N, Baxter NN. Perinatal outcomes during the COVID-19 pandemic in Ontario, Canada. *JAMA Netw Open* 2021;4:e2110104. doi:10.1001/jamanetworkopen.2021.10104
35. Burstyn I. Antepartum risk score predicts adverse birth outcomes. *J Obstet Gynaecol Can* 2010;32:16–20. doi:10.1016/S1701-2163(16)34398-5
36. Coopland AT, Peddle LJ, Baskett TF, Rollwagen R, Simpson A, Parker E. A simplified antepartum high-risk pregnancy scoring form: Statistical analysis of 5459 cases. *Can Med Assoc J* 1977;116:999–1001.
37. Pampalon R, Hamel D, Gamache P, Raymond G. A deprivation index for health planning in Canada. *Chronic Dis Can* 2009;29:178–91.
38. Bonanno C, Wapner RJ. Antenatal corticosteroids in the management of preterm birth: Are we back where we started? *Obstet Gynecol Clin N Am* 2012;39:47–63. doi:10.1016/j.ogc.2011.12.006
39. Berghella V, Boelig R, Roman Aurd J, Anderson K. Decreased incidence of preterm birth during coronavirus disease 2019 pandemic. *Am J Obstet Gynecol MFM* 2020;2:100258. doi:10.1016/j.ajogmf.2020.100258
40. Einarsdottir K, Swift EM, Zoega H. Changes in obstetric interventions and preterm birth during COVID-19: A nationwide study from Iceland. *Acta Obstet Gynecol Scand* 2021;100:1924–30. doi:10.1111/aogs.14231
41. Gallo LA, Gallo TF, Borg DJ, Moritz KM, Clifton VL, Kumar S. A decline in planned, but not spontaneous, preterm birth rates in a large Australian tertiary maternity centre during COVID-19 mitigation measures. *Aust N Z J Obstet Gynaecol* 2022;62:62–70. doi:10.1111/ajo.13406
42. Goldenberg RL, McClure EM. Have coronavirus disease 2019 (COVID-19) community lockdowns reduced preterm birth rates? *Obstet Gynecol* 2021;137:399–402. doi:10.1097/AOG.0000000000004302
43. Yang J, D'Souza R, Kharrat A, et al. COVID-19 pandemic and population-level pregnancy and neonatal outcomes: A living systematic review and meta-analysis. *Acta Obstet Gynecol Scand* 2021;100:1756–70. doi:10.1111/aogs.14206
44. Briozzo L, Tomasso G, Viroga S, Nozar F, Bianchi A. Impact of mitigation measures against the COVID 19 pandemic on the perinatal results of the reference maternity hospital in Uruguay. *J Matern Fetal Neonatal Med* 2022;35:5060–2. doi:10.1080/14767058.2021.1874911
45. Pampalon R, Raymond G. A deprivation index for health and welfare planning in Quebec. *Chronic Dis Can* 2000;21:104–13.