

# Infant and Maternal Outcomes for Women Who Experience Imprisonment in Ontario, Canada: A Retrospective Cohort Study



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## Abstract

**Objective:** To describe the population-level risk of infant and maternal outcomes for women who experience imprisonment and compare outcomes with the general population.

**Methods:** We conducted a retrospective cohort study. We used linked correctional and health data for women released from provincial prisons in 2010. We defined three exposure groups for Ontario singleton deliveries from 2005–2015: deliveries to women who were in prison during pregnancy but not necessarily for delivery, *prison pregnancies*; deliveries to women who had been in prison but not while pregnant, *prison controls*; and *general population deliveries*. We compared groups using generalized estimating equations. Primary outcomes were preterm birth, low birth weight, and small for gestational age birth weight. Secondary outcomes included NICU admission, neonatal abstinence syndrome, placental abruption, and preterm prelabour rupture of membranes.

**Results:** In prison pregnancies (N = 544) and prison controls (N = 2156), respectively, preterm birth risk was 15.5% and 12.5%, low birth weight risk was 13.0% and 11.6%, and small for gestational age birth weight risk was 18.1% and 19.2%. Adjusted for

maternal age and parity and compared with general population deliveries (N = 1 284 949), odds ratios were increased for prison pregnancies and prison controls, respectively, at 2.7 (95% CI 2.2–3.4) and 2.1 (95% CI 1.9–2.4) for preterm birth, 3.1 (95% CI 2.4–3.9) and 2.7 (95% CI 2.3–3.1) for low birth weight, and 1.6 (95% CI 1.3–2.1) and 1.8 (95% CI 1.6–2.0) for small for gestational age birth weight.

**Conclusion:** There is an increased risk of adverse infant outcomes in women who experience imprisonment compared with the general population, whether they are in prison during pregnancy or not.

## Résumé

**Objectif :** Cette étude avait pour but de décrire les risques à l'échelle de la population relativement aux issues défavorables néonatales et maternelles chez les femmes qui vivent une incarcération en comparaison des issues dans la population générale.

**Méthodologie :** Nous avons réalisé une étude de cohorte rétrospective. Nous avons utilisé les données carcérales et sanitaires liées pour les femmes libérées d'un établissement carcéral provincial en 2010. Nous avons défini trois groupes d'exposition pour les accouchements de grossesses monofœtales de 2005 à 2015 : les accouchements de femmes incarcérées pendant la grossesse, mais pas nécessairement pour l'accouchement, les *grossesses en milieu carcéral*; les accouchements de femmes ayant déjà été incarcérées, mais pas pendant la grossesse, les *témoins carcéraux*; et les *accouchements dans la population générale*. Nous avons comparé les groupes au moyen d'équations d'estimation généralisées. Les critères de jugement principaux étaient la naissance avant terme, le faible poids à la naissance et le faible poids à la naissance pour l'âge gestationnel. Les critères de jugement secondaires comprenaient l'admission à l'USIN, le syndrome d'abstinence néonatale, le décollement placentaire et la rupture prématurée des membranes avant terme.

**Résultats :** Dans le cas des grossesses en milieu carcéral (N = 544) et les témoins carcéraux (N = 2 156), respectivement, les risques de naissance avant terme étaient de 15,5 % et de 12,5 %; les risques de faible poids à la naissance étaient de 13,0 % et de 11,6 %; et les

**Key Words:** prisoners, obstetrics, pregnancy complications

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Competing interests: See Acknowledgements.

Each author has indicated that they meet the journal's requirements for authorship.

Presented at the 75th Annual Clinical and Scientific Conference of the Society of Obstetricians and Gynaecologists of Canada, Jun 11–14, 2019; Halifax, NS, and published as an abstract in JOGC 2019;41:714.

Received on August 15, 2019

Accepted on November 18, 2019

risques de faible poids à la naissance pour l'âge gestationnel étaient de 18,1 % et de 19,2 %. Les rapports de cotes ajustés pour l'âge maternel et la parité et comparés aux accouchements dans la population générale (N = 1 284 949) étaient augmentés dans le cas des grossesses en milieu carcéral et des témoins carcéraux, respectivement, à 2,7 (IC de 95 % : 2,2–3,4) et à 2,1 (IC de 95 % : 1,9–2,4) pour la naissance avant terme; à 3,1 (IC de 95 % : 2,4–3,9) et à 2,7 (IC de 95 % : 2,3–3,1) pour le faible poids à la naissance; et à 1,6 (IC de 95 % : 1,3–2,1) et à 1,8 (IC de 95 % : 1,6–2,0) pour le faible poids à la naissance pour l'âge gestationnel.

**Conclusion :** On observe une augmentation des risques défavorables néonataux chez les femmes qui vivent une incarcération comparativement à la population générale, qu'elles aient été incarcérées ou non pendant la grossesse.

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J Obstet Gynaecol Can 2019;000(000):1–11

<https://doi.org/10.1016/j.jogc.2019.11.068>

## INTRODUCTION

In Canada, thousands of women experience imprisonment each year. Data on the number of women in prison per day and per year are not available for Canada,<sup>1</sup> nor are data on the proportion of women who experience imprisonment over their life course. We know, however, that there were 35 437 admissions to prison for women in 2017–2018, which represents a 38,6% increase from 2013–2014.<sup>2</sup> Furthermore, there is increasing overrepresentation of Indigenous women in female prison admissions—43% of female admissions in 2016–2017 compared with 28% in 2006–2007,<sup>3</sup> which is almost 10 times higher than the proportion of Indigenous women in the general population, at 4,9%.<sup>4</sup> In Canada, women who are admitted to prison without sentencing or who are sentenced to less than 2 years are imprisoned in the provincial or territorial system, and women who are sentenced to 2 years or longer are imprisoned in the federal system.<sup>5</sup> Health care in prisons may be administered by governmental authorities responsible for health or for corrections, which varies by jurisdiction.<sup>6</sup>

There are no population-based studies on pregnancy frequency or outcomes in women who experience imprisonment in Canada, and international data are limited. A 2016–2017 study revealed that in U.S. state and federal prisons, 3,8% of newly admitted women and 0,6% of all women were pregnant.<sup>7</sup> Data from the United States, Western Europe, and Australia indicate that women who experience imprisonment have increased risk of adverse perinatal outcomes, whether their pregnancies and

deliveries take place in prison or in the community. A 2005 meta-analysis specifically comparing women who experienced imprisonment while pregnant and women in the general population found 1.4 times greater odds of preterm delivery and 1.7 times greater odds of having a low birth weight baby.<sup>8</sup> A 2014 Australian study found that infants of mothers who had experienced imprisonment were more likely to have long neonatal intensive care unit (NICU) admissions and to require hospital re-admission.<sup>9</sup> Evidence regarding outcomes is limited, however, because many studies were conducted over 20 years ago, used small and select samples, presented data on few outcomes, and conflated descriptive and explanatory models of risk.<sup>10–16</sup>

Increased perinatal risk could be the result of overrepresentation of risk factors in this population,<sup>17–19</sup> including substance use, bloodborne and sexually transmitted infections,<sup>13,20</sup> inadequate antenatal care,<sup>9,10,15</sup> adolescent pregnancy,<sup>13</sup> high parity,<sup>13</sup> and mental illness. Furthermore, periods of imprisonment may be associated with acutely increased risk, which could reflect the causes of imprisonment, such as illicit drug use, or the consequences of imprisonment, such as abrupt cessation of substance use or inability to control access to health care in prison, including ambulatory physician care or emergency department care.

Understanding population-level infant and maternal risk is important to inform clinical and policy decision making. Quantifying risk with a representative, contemporary cohort could support health care that meets the needs of women who experience imprisonment. For example, these data may change the index of suspicion among front-line health care workers for risk factors and outcomes, which would affect history taking, investigation, and intervention. From a policy perspective, understanding the morbidity profile of women who experience imprisonment is necessary to develop services including primary and antenatal care in prison and after release and to support equitable resource allocation in the context of a universal health insurance system, in which providing “reasonable access to health services without financial or other barriers” is a primary objective of government health care policy.<sup>21</sup>

We aimed to describe the population-level risk of adverse infant and maternal outcomes of pregnancy among women who experience imprisonment in Ontario and to compare the outcomes in women in prison during pregnancy and pregnant women who experienced imprisonment at another time with outcomes in the general population.

## METHODS

### Study Design and Setting

We conducted a retrospective cohort study of in-hospital deliveries. We examined imprisonment status during pregnancy as the exposure and infant and maternal outcomes for each delivery.

In Ontario, provincial prisons are publicly funded and administered. For Ontario residents, hospitalizations and medically necessary physician services are paid for through public health insurance, including in provincial prison. This includes antenatal and postpartum care for women in provincial prison, which is provided through prison health care services or by referral to community-based care. Pregnant women who are in custody at the time of delivery are transferred to a hospital for intrapartum care.

### Data Linkage

For a separate study,<sup>22</sup> the Ontario Ministry of the Solicitor General (MSG) provided data on adults released in 2010 from provincial prison. The data included all time spent in provincial custody between 2005 and 2015. These data were transferred to ICES, a non-profit organization funded by the Ontario Ministry of Health, and linked to a unique encoded identification number in the Registered Persons Database (RPDB), which includes all people eligible for Ontario Health Insurance Plan (OHIP) coverage. The data were linked directly using OHIP number when available and valid or were deterministically or probabilistically linked using name, sex, and date of birth. We excluded incorrect linkages, as described elsewhere,<sup>22</sup> resulting in a linkage rate of 97.4%.

### Study Cohort

We identified Ontario in-hospital singleton deliveries for which the full pregnancy occurred between 2005 and 2015 (Figure 1). We selected this study period to align with the time window of the imprisonment data. We included deliveries at or after 20<sup>0</sup> because this is a common lower gestational age limit for defining outcomes of interest (e.g., stillbirth, preterm birth, and gestational hypertension).

Given our desire to understand and improve obstetrical outcomes in women while in prison or after release, we classified deliveries into three exposure groups (Table 1; Figure 1). We identified eligible deliveries in women in the MSG data set and used the imprisonment dates for all women released from provincial prison to stratify their deliveries by whether they spent any part of the pregnancy in prison. The first exposure group, *prison pregnancies*, included deliveries following a pregnancy during which the woman spent any time in provincial prison. We chose the

term *prison pregnancies* rather than *prison deliveries* to reflect that the delivery may have taken place while the woman was in custody or after release but that at least part of the pregnancy overlapped with imprisonment. The second exposure group, *prison controls*, included deliveries to women released from provincial prison who did not spend any of that pregnancy in prison. The role of the prison control group was to determine whether there was increased risk of perinatal outcomes for this population even for pregnancies that did not overlap with imprisonment. The third exposure group, *general population deliveries*, included all other deliveries, specifically those to women with no known history of imprisonment.

For women with multiple deliveries between 2005 and 2015, we included all eligible deliveries. Women released from prison could contribute deliveries to both the prison pregnancy and prison control groups.

### Variables

#### Sociodemographic information

We accessed MSG data on self-reported maternal race for prison pregnancy and prison control groups and used RPDB postal codes to derive neighbourhood income quintile and rurality for each woman during the first pregnancy between 2005 and 2015.

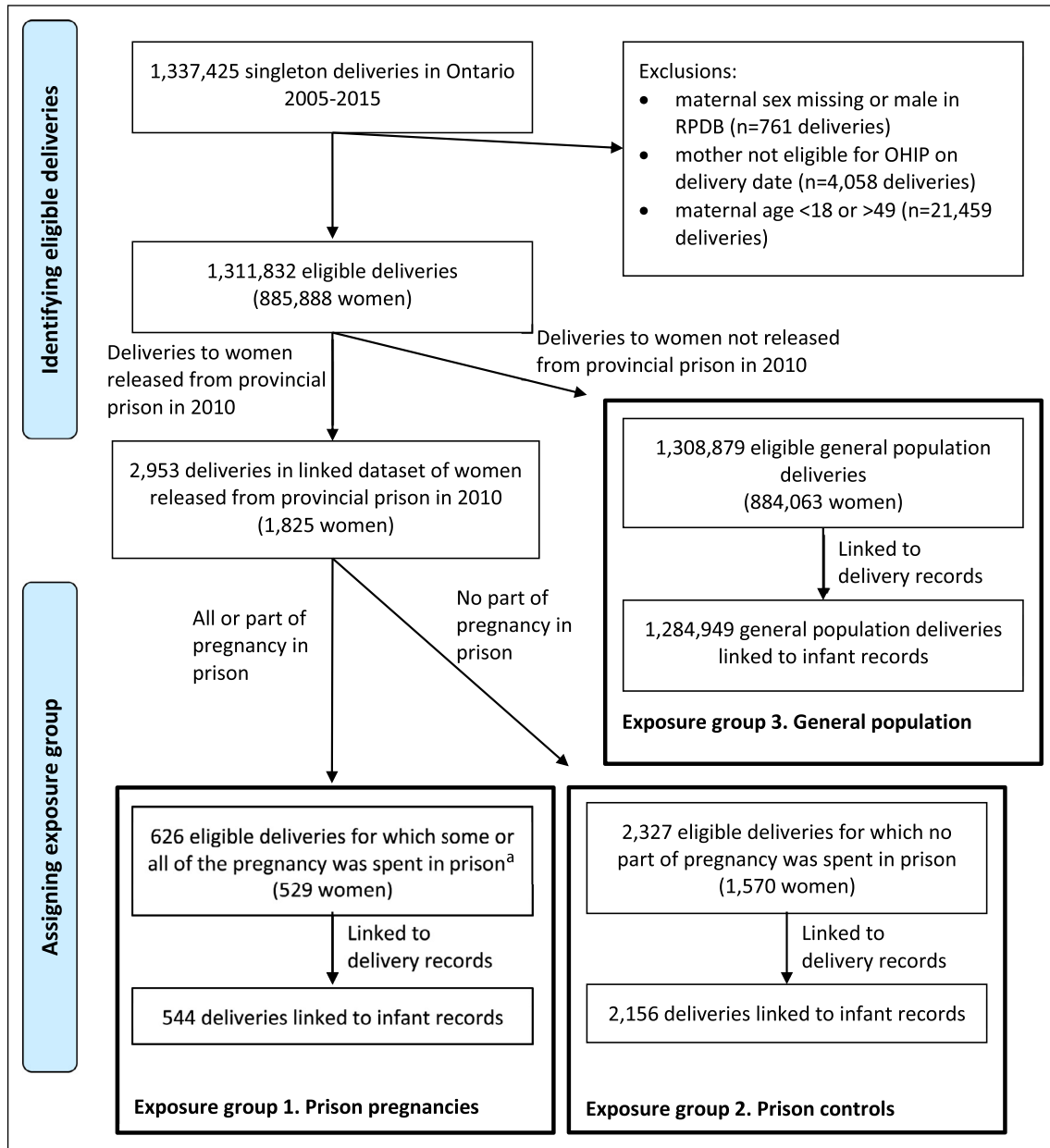
#### Maternal comorbidities

For each delivery, we determined maternal age from the RPDB and parity from MOMBABY, which is a database linking records of women and infants. We used validated algorithms to identify maternal hypertension,<sup>23</sup> pre-gestational diabetes (types 1 and 2),<sup>24</sup> and human immunodeficiency virus (HIV) infection,<sup>25</sup> and we identified viral hepatitis in the National Ambulatory Care Reporting System (NACRS) for emergency department visits and the Canadian Institute for Health Information (CIHI) Discharge Abstracts Database (DAD) for hospital admissions (Appendix Table 1). We applied definitions from the Ontario Mental Health and Addictions Scorecard and Evaluation Framework to identify persons with any mental health diagnosis (specifically, substance-related disorders, anxiety disorders, mood disorders, schizophrenia, or self-harm) in the past 2 years on the basis of physician billings in OHIP, NACRS, DAD, or the Ontario Mental Health Reporting System for hospital admissions (Appendix Table 1).<sup>26</sup>

### Outcomes

Our primary outcomes were preterm delivery at <37<sup>0</sup>, low birth weight <2500 g, and small for gestational age birth

Figure 1. Flow diagram for identification of eligible deliveries and assignment to exposure group.



OHIP: Ontario Health Insurance Plan; RPDB: Registered Persons Database.

<sup>a</sup>For prison pregnancies, the delivery may have occurred while the woman was in custody or after release.

weight (<10th percentile of the sex-specific birth weight distribution for gestational age),<sup>27,28</sup> which we accessed in MOMBABY. We chose these outcomes on the basis of clinical importance, data availability, expected incidence, and consistency with other studies.<sup>8-13</sup>

Secondary infant outcomes were preterm birth at <29<sup>0</sup>, preterm birth at <32<sup>0</sup>, very low birth weight <1500 g,

macrosomia >4000 g, NICU admission (level 2 or 3 unit), NICU stay length, neonatal abstinence syndrome, stillbirth, and infant death (birth to 1 year of age). Secondary maternal outcomes were hypertensive disorders of pregnancy, gestational diabetes, placental abruption, preterm prelabour rupture of membranes, and mode of delivery, which we accessed in MOMBABY, NACRS, DAD, and RPDB (Appendix Table 1).



**Table 1. Exposure group definitions for in-hospital singleton deliveries in Ontario, 2005 to 2015**

Population	Exposure group
Women released from provincial prison in 2010	<b>Prison pregnancies: Deliveries among women who spent any time during the pregnancy in provincial prison. Delivery may have occurred while in custody or after release.</b> <b>Prison controls: Deliveries among women who did not spend any of that pregnancy in prison</b>
Women in the general population	<b>General population deliveries: Deliveries to women in the general population</b>

### Sample Size Calculation

Using outcome rates for preterm birth and low birth weight for the Ontario general population<sup>17,27</sup> and incarcerated women in Australia,<sup>9</sup> we calculated a priori that we needed a sample size of 202 per group for power of 0.8 and a two-tailed alpha of 0.05 to compare outcomes in women who experience imprisonment and those in the general population.

### Statistical Analyses

We compared maternal characteristics among exposure groups at the first delivery during the follow-up period using standardized differences, which are less sensitive to sample size than traditional hypothesis tests; we considered a difference of 10% or greater as meaningful. We fit regression models to compare the odds of maternal and infant outcomes along with 95% confidence intervals. We used logistic regression with generalized estimating equations (GEE) to account for correlation across deliveries for each woman. We developed bivariate models to compare both prison groups with the general population and multivariable models adjusted for maternal age and parity, which we decided to control for a priori. We generated risk estimates from GEE post-estimation commands.

In exploratory analyses, we calculated the risk of the primary outcomes in prison pregnancies according to the length of stay in provincial prison during the pregnancy, given the potential value of interventions in prison.

The prison controls group did not exclude deliveries that occurred before first imprisonment between 2005 and 2015 because we were interested in risk in this population overall, not only after imprisonment. We may have included pregnancies for some women who had not yet been imprisoned at the time of that pregnancy. Given our interest in identifying people who experience imprisonment to tailor care

appropriately in clinical settings, and because care providers can determine a person's experience with imprisonment only after imprisonment, we conducted a sensitivity analysis that included only deliveries after prison release in 2010. In this analysis, we could be certain that the prison controls group only included deliveries following a period of imprisonment.

The study was approved by the Hamilton Integrated Research Ethics Board (#3120).

## RESULTS

### Cohort Creation

We identified 1 308 879 eligible deliveries to 884 063 women in the general population and 2953 eligible deliveries to 1825 women who were released from provincial prison in 2010 (Figure 1). Of the 2953 deliveries to women released from prison, there were 626 prison pregnancies, for which the woman was in provincial prison at some point during pregnancy, and 2327 prison controls, for which the woman was not in prison during pregnancy. Linkage rates to infant data were 86.9% for prison pregnancies, 92.7% for prison controls, and 98.2% for general population deliveries.

### Characteristics

Women's characteristics at their first delivery between 2005 and 2015 are shown in Table 2. Women in both prison groups were on average several years younger and more likely to live in a rural area and in a low-income quintile neighbourhood compared with the general population. In both prison groups, over half of women reported their race as White and over one fifth as Aboriginal.

Women in both prison groups had higher parity compared with those in the general population. They also had higher rates of HIV infection, viral hepatitis, and all mental health diagnoses examined. Specifically, almost half of women in the prison pregnancies group had any mental health diagnosis, and more than a third had a substance-related diagnosis.

The amount of time that women spent in prison during prison pregnancies (N = 544) was between 1 and 15 days for 46.5%, 16 and 30 days for 13.9%, 31 and 60 days for 18.8%, 61 and 90 days for 7.9%, 91 and 120 days for 3.9%, and over 120 days for 9.0% (Appendix Table 1).

### Infant Outcomes

For prison pregnancies and prison controls, the risks of primary outcomes were 15.5% and 12.5% for preterm birth <37<sup>0</sup>, 13.0% and 11.6% for low birth weight, and 18.1% and 19.2% for small for gestational age birth weight, respectively (Table 3).

**Table 2. Characteristics of women released from provincial prison and in the general population in Ontario during their first pregnancy between 2005 and 2015, by exposure group<sup>a</sup>**

Characteristic <sup>b</sup>	No (%) or mean $\pm$ SD, unless otherwise specified			Standardized difference	
	Prison pregnancies N = 372	Prison controls N = 1453	General population controls N = 884 063	Prison pregnancies vs. general population	Prison controls vs. general population
Age, years	26.07 $\pm$ 5.8	25.60 $\pm$ 5.6	29.90 $\pm$ 5.4	0.68	0.78
18–24	178 (47.8)	749 (51.5)	152 224 (17.2)	0.69	0.78
25–34	154 (41.4)	573 (39.4)	551 104 (62.3)	0.43	0.47
35–40	33 (8.9)	113 (7.8)	158 823 (18.0)	0.27	0.31
18–24	7 (1.9)	18 (1.2)	21 912 (2.5)	0.04	0.09
Race <sup>c</sup>					
Aboriginal	82 (22.0)	327 (22.5)	—	—	—
Black	37 (9.9)	111 (7.6)	—	—	—
White	203 (54.6)	751 (51.7)	—	—	—
Other	22 (5.9)	81 (5.6)	—	—	—
Missing	28 (7.5)	183 (12.6)	—	—	—
Rural residence					
No	316 (84.9)	1168 (80.4)	802 368 (90.8)	0.18	0.30
Yes	51 (13.7)	285 (19.6)	81 618 (9.2)	0.14	0.30
Missing	$\leq 5$ ( $\leq 1.3$ ) <sup>d</sup>	0 (0.0)	77 (0.0)	0.16	0.01
Neighbourhood income quintile					
1 (lowest)	161 (43.3)	627 (43.2)	200 686 (22.7)	0.45	0.45
2	82 (22.0)	292 (20.1)	181 215 (20.5)	0.04	0.01
3	46 (12.4)	218 (15.0)	179 562 (20.3)	0.22	0.14
4	40 (10.8)	146 (10.0)	180 256 (20.4)	0.27	0.29
5	28 (7.5)	120 (8.3)	138 456 (15.7)	0.26	0.23
Missing	15 (4.0)	50 (3.4)	3888 (0.4)	0.24	0.22
Parity	0.9 $\pm$ 1.1	0.9 $\pm$ 1.1	0.4 $\pm$ 0.7	0.57	0.51
Median (interquartile range)	1 (0–1)	1 (0–1)	0 (0–1)	0.59	0.53
Medical diagnosis					
Diabetes	6 (1.6)	30 (2.1)	16 448 (1.9)	0.02	0.01
Hypertension	$\leq 5$ ( $\leq 1.3$ ) <sup>d</sup>	12 (0.8)	21 566 (2.4)	0.16	0.13
Viral hepatitis	40 (10.8)	84 (5.8)	17 087 (1.9)	0.37	0.20
HIV infection	$\leq 5$ ( $\leq 1.3$ ) <sup>d</sup>	10 (0.7)	557 (0.1)	0.11	0.10
Mental disorder diagnosis					
Any	164 (44.1)	400 (27.5)	22 513 (2.5)	1.13	0.75
Substance-related disorders	131 (35.2)	277 (19.1)	5978 (0.7)	1.01	0.65
Anxiety disorders	57 (15.3)	156 (10.7)	13 847 (1.6)	0.51	0.39
Mood disorders	47 (12.6)	121 (8.3)	7048 (0.8)	0.49	0.37
Schizophrenia	23 (6.2)	40 (2.8)	911 (0.1)	0.35	0.22
Self-harm	42 (11.3)	72 (5.0)	3152 (0.4)	0.48	0.29

<sup>a</sup> Prison pregnancies are deliveries to women released from provincial prison from a pregnancy in which the woman spent time in prison; prison controls are deliveries to a woman released from provincial prison for which the woman was not in prison during the pregnancy.

<sup>b</sup> Characteristics at the time of the first pregnancy between 2005 and 2015.

<sup>c</sup> Data on race were available for prison pregnancies and prison controls only.

<sup>d</sup> The true value here is between 1 and 5, and was suppressed, according to ICES policy. We used the maximum value of 5 to calculate the prevalence.

HIV: human immunodeficiency virus.

**Table 3. Risk of infant and maternal outcomes in deliveries to women released from provincial prison in Ontario and in the general population, 2005 to 2015<sup>a</sup>**

Outcome	Prison pregnancies		Prison controls		General population	
	N <sup>b</sup>	% (95% CI <sup>c</sup> or median (IQR))	N <sup>b</sup>	% (95% CI <sup>c</sup> or median (IQR))	N <sup>b</sup>	% (95% CI <sup>c</sup> or median (IQR))
<b>Primary outcomes</b>						
Preterm birth <37 <sup>0</sup>	623	15.5 (12.9–18.6)	2293	12.5 (11.1–14.0)	1 302 063	6.4 (6.3–6.4)
Low birth weight <2500 g	544	13.0 (10.5–16.0)	2156	11.6 (10.3–13.1)	1 284 797	4.8 (4.7–4.8)
Small for gestational age birth weight	544	18.1 (15.0–21.5)	2156	19.2 (17.5–21.0)	1 284 797	12.5 (12.5–12.6)
<b>Secondary infant outcomes</b>						
Preterm birth <32 <sup>0</sup>	623	3.2 (2.0–5.0)	2293	2.1 (1.6–2.8)	1 302 063	0.9 (0.9–0.9)
Preterm birth <29 <sup>0</sup>	623	1.2 (0.6–2.4)	2293	1.1 (0.8–1.7)	1 302 063	0.5 (0.4–0.5)
Very low birth weight <1500 g	544	1.9 (1.0–3.4)	2156	1.3 (0.9–1.9)	1 284 797	0.7 (0.7–0.7)
Macrosomia >4000 g	544	6.5 (4.8–8.9)	2156	8.2 (7.0–9.5)	1 284 797	11.0 (10.9–11.0)
NICU admission	544	16.6 (13.6–20.1)	2156	11.8 (10.5–13.3)	1 284 797	5.3 (5.2–5.3)
NICU length of stay (days)	544	6 (3–17)	2156	9 (3–18)	1 284 797	3 (1–10)
Neonatal abstinence syndrome	544	20.5 (17.3–24.1)	2156	13.5 (12.0–15.1)	1 284 797	0.4 (0.4–0.4)
Stillbirth	626	— <sup>d</sup>	2327	1.5 (1.0–2.0)	1 308 879	0.5 (0.5–0.5)
Infant death (birth to 1 year)	544	— <sup>d</sup>	2156	1.2 (0.8–1.8)	1 284 797	0.3 (0.3–0.3)
<b>Secondary maternal outcomes</b>						
Hypertensive disorders of pregnancy	626	3.1 (2.0–4.9)	2327	4.7 (3.9–5.8)	1 308 879	6.2 (6.1–6.2)
Gestational diabetes	626	1.6 (0.9–2.9)	2327	3.9 (3.1–4.9)	1 308 879	6.1 (6.0–6.1)
Placental abruption	626	2.5 (1.5–4.2)	2327	2.0 (1.5–2.7)	1 308 879	0.9 (0.9–0.9)
Preterm prelabour rupture of membranes	626	3.7 (2.5–5.5)	2327	4.0 (3.2–4.9)	1 308 879	2.3 (2.3–2.3)
cesarean section	626	23.3 (20.5–26.3)	2327	24.3 (22.4–26.3)	1 308 879	28.8 (28.7–28.9)

<sup>a</sup> Prison pregnancies are deliveries to women released from provincial prison from a pregnancy in which the woman spent time in prison, and prison controls are deliveries to a woman released from provincial prison for which the woman was not in prison during the pregnancy.

<sup>b</sup> N varies depending on outcome; we included all deliveries for stillbirth and maternal outcomes, all live births for preterm birth, and all live births with linked infants for other infant outcomes.

<sup>c</sup> Generated with post-estimation commands to account for correlation between multiple pregnancies.

<sup>d</sup> Data suppressed for n≤5 because of risk of re-identification, according to ICES policy.

IQR: interquartile range; NICU: neonatal intensive care unit.

Unadjusted and adjusted odds ratios were significantly increased for primary outcomes in prison pregnancies and prison controls compared with general population deliveries (Figure 2, Table 4).

Compared with general population deliveries, deliveries in both prison groups had at least twice the odds of preterm birth <32<sup>0</sup> and <29<sup>0</sup>, very low birth weight, and NICU admission (Figure 2, Table 4), whereas the odds of neonatal abstinence syndrome was over 20 times higher. The odds of macrosomia was lower for deliveries in both prison groups compared with general population deliveries. The median length of NICU stay for infants in the prison pregnancy and prison control groups was over twice as long as that for general population deliveries.

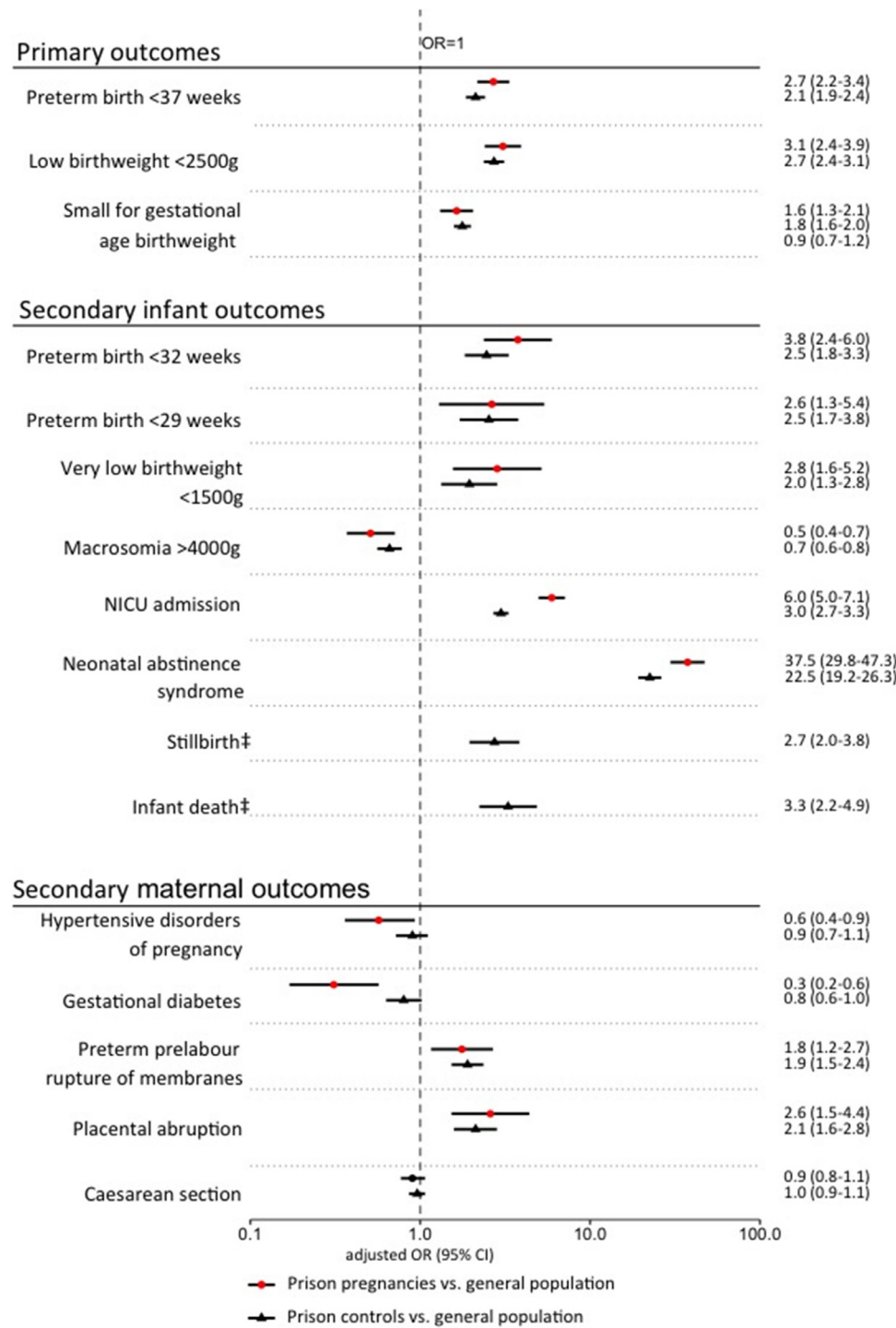
For stillbirth and infant death, odds ratios were significantly increased for the prison control group compared with general population deliveries (Figure 2, Table 4), but there was no difference between prison pregnancies and general population deliveries (not shown because of small cell counts).

For prison pregnancies, there was no significant difference in the risk of primary outcomes according to length of time in provincial prison during pregnancy (Appendix Table 1).

## Maternal Outcomes

The unadjusted and adjusted odds of hypertensive disorders of pregnancy and gestational diabetes were lower in prison

Figure 2. Odds ratios (OR)<sup>a</sup> and 95% confidence intervals (CI) for maternal and infant outcomes in singleton deliveries to women released from provincial prison in Ontario<sup>b</sup> and the general population in Ontario, 2005 to 2015.



NICU: neonatal intensive care unit. <sup>a</sup>Adjusted for maternal age and parity. <sup>b</sup>Prison pregnancies are deliveries to women released from provincial prison from a pregnancy in which the woman spent time in prison and prison controls are deliveries to a woman released from provincial prison for which the woman was not in prison during the pregnancy. <sup>c</sup>We suppressed data for prison pregnancies for stillbirth and infant death to prevent re-identification because n ≤ 5.

pregnancies than in general population deliveries. The difference between the prison control group and the general population for these two outcomes was not significant after adjusting for maternal age and parity (Figure 2, Table 4). Compared with the general population, both prison groups had higher odds of preterm prelabour rupture of



**Table 4. Odds ratios (95% CI) for infant and maternal outcomes in deliveries to women released from provincial prison in Ontario compared with the general population, 2005 to 2015<sup>a</sup>**

Outcome	Prison pregnancies compared with general population		Prison controls compared with general population	
	Unadjusted	Adjusted for maternal age and parity	Unadjusted	Adjusted for maternal age and parity
<b>Primary outcomes</b>				
Preterm birth <37 <sup>0</sup>	2.7 (2.2–3.4)	2.7 (2.2–3.4)	2.1 (1.4–2.4)	2.1 (1.9–2.4)
Low birth weight <2500 g	3.0 (2.4–3.8)	3.1 (2.4–3.9)	2.6 (2.3–3.0)	2.7 (2.4–3.1)
Small for gestational age birth weight	1.5 (1.2–1.9)	1.6 (1.3–2.1)	1.7 (1.5–1.9)	1.8 (1.6–2.0)
<b>Secondary infant outcomes</b>				
Preterm birth <32 <sup>0</sup>	3.7 (2.4–5.9)	3.8 (2.4–6.0)	2.4 (1.8–3.3)	2.5 (1.8–3.3)
Preterm birth <29 <sup>0</sup>	2.6 (1.3–5.3)	2.6 (1.3–5.4)	2.5 (1.7–3.7)	2.5 (1.7–3.8)
Very low birth weight <1500 g	2.7 (1.5–4.8)	2.8 (1.6–5.2)	1.8 (1.2–2.6)	2.0 (1.3–2.8)
Macrosomia >4000 g	0.6 (0.4–0.8)	0.5 (0.4–0.7)	0.7 (0.6–0.9)	0.7 (0.6–0.8)
NICU admission	3.6 (2.8–4.5)	3.7 (2.9–4.7)	2.4 (2.1–2.8)	2.5 (2.2–2.9)
Neonatal abstinence syndrome	70.4 (57.0–87.0)	37.5 (29.8–47.3)	42.8 (37.3–49.0)	22.5 (19.2–26.3)
Stillbirth	— <sup>b</sup>	— <sup>b</sup>	2.9 (2.0–4.0)	2.7 (2.0–3.8)
Infant death (birth to 1 year)	— <sup>b</sup>	— <sup>b</sup>	4.2 (2.9–6.2)	3.3 (2.2–4.9)
<b>Secondary maternal outcomes</b>				
Hypertensive disorders of pregnancy	0.5 (0.3–0.8)	0.6 (0.4–0.9)	0.8 (0.6–0.9)	0.9 (0.7–1.1)
Gestational diabetes	0.3 (0.1–0.5)	0.3 (0.2–0.6)	0.6 (0.5–0.8)	0.8 (0.6–1.0)
Placental abruption	2.9 (1.7–4.9)	2.6 (1.5–4.4)	2.3 (1.7–3.1)	2.1 (1.6–2.8)
Preterm prelabour rupture of membranes	1.6 (1.1–2.4)	1.8 (1.2–2.7)	1.7 (1.4–2.2)	1.9 (1.5–2.4)
cesarean section	0.8 (0.6–0.9)	0.9 (0.8–1.1)	0.8 (0.7–0.9)	1.0 (0.9–1.1)

<sup>a</sup> Prison pregnancies are deliveries to women released from provincial prison from a pregnancy in which the woman spent time in prison, and prison controls are deliveries to a woman released from provincial prison for which the woman was not in prison during the pregnancy.

<sup>b</sup> Data suppressed for n ≤5 because of risk of re-identification, according to ICES policy.

membranes and placental abruption. There was no significant difference in the risk of cesarean section for delivery in either prison group compared with general population after controlling for maternal age and parity.

## Sensitivity Analysis

When we limited deliveries in the prison controls group to those after imprisonment in 2010, there was no change in the direction of the association or the statistical significance of the association for any primary or secondary outcome (Appendix Table 1).

## DISCUSSION

In this population-based study, we found that the odds of preterm birth, low birth weight, and small for gestational age birth weight were substantially higher for women who experienced imprisonment compared with the general population, whether women were in prison during pregnancy or

not. The risk was also higher for many secondary outcomes in both prison groups compared with the general population, including extreme prematurity, very low birth weight, NICU admission, neonatal abstinence syndrome, placental abruption, and preterm prelabour rupture of membranes. The prevalence of mental health diagnoses, including substance-related disorders, was significantly higher in both prison groups than in the general population group.

This study has several potential limitations. This study does not represent all deliveries to women who experienced imprisonment between 2005 and 2015, but rather a subset of those deliveries (i.e., deliveries in women released from provincial prison in 2010). Linkage rates between deliveries and infants were lower for prison groups than for the general population, which may reflect less frequent health card activation for infants in prison groups. Our definition of prison pregnancies did not distinguish between deliveries that occurred while a woman was in custody or after release, and

outcomes may vary by imprisonment status on delivery; further research is warranted to explore this issue. Following from our objectives, we developed descriptive models to understand population-level risks rather than explanatory models to explore a causal association between imprisonment and adverse perinatal outcomes (i.e., we did not control for all confounders to look for an independent association). Therefore, the increased risks may reflect the overrepresentation of risk factors in this population, rather than identifying imprisonment as an independent cause of adverse outcomes.

This study has numerous strengths. As a population-based study using comprehensive health care databases, it encompasses a large representative sample of deliveries to women who experience imprisonment. Our research provides the first published data for this population in Canada, and it includes less frequently reported outcomes such as hypertensive disorders, placental abruption, and neonatal abstinence syndrome. Including the prison control group demonstrates that the risk of adverse pregnancy outcomes remains high for this population even when pregnancy occurs outside of the time spent in prison.

Our findings are consistent with research showing that women who experience imprisonment are at increased risk of delivering premature and low birth weight babies.<sup>8–11,16,29</sup> We identified risks similar to those reported in U.S. and Australian studies,<sup>9–11</sup> although there were small between-study differences for some outcomes, which could reflect the varying distribution of risk factors for adverse outcomes across populations. Our findings also agree with research showing higher NICU admission rates and longer admissions for infants in the prison groups,<sup>9</sup> and this may be a consequence of prematurity, low birth weight, and neonatal abstinence syndrome.

## CONCLUSIONS

Recognizing that this population is at higher risk of adverse perinatal outcomes suggests a clinical and policy imperative to improve care and services before and during pregnancy and both in prison and in the community. Existing guidance on the care of pregnant women in prison notes the importance of testing for pregnancy<sup>30</sup> and providing timely perinatal care and abortion services.<sup>31</sup> Women in prison should have access to scheduled obstetrical care that follows guidelines for women in the community,<sup>31</sup> including ultrasound and emergency care.<sup>30</sup> They should be screened for infectious diseases and mental health and substance-related disorders,<sup>30</sup> with access to indicated interventions. At the time of prison release, they should be connected

with community-based services for ongoing care. Furthermore, efforts should be made to increase awareness of risks among patients, correctional officers, and care providers.

This study has clinical implications for care of women who experience imprisonment. Clinicians should consider potential increased risks of adverse outcomes in this population. Institutional and community supports should facilitate access to high-quality antenatal care and comprehensive health care to promote health and address perinatal risk factors. Because women who experience imprisonment are also at increased risk of adverse perinatal outcomes outside of the time in prison, improving care is a responsibility to be shared between decision makers and health care providers in prisons and in the community. Future collaborative research should develop and evaluate clinical care models to support infant and maternal health in this population.

## SUPPLEMENTARY DATA

Supplementary data related to this article can be found at <https://10.1016/j.jogc.2019.11.068>.

## Acknowledgements

This study was supported by ICES, which is funded by an annual grant from the Ontario Ministry of Health. The authors acknowledge the Ontario Ministry of the Solicitor General, which provided data for the study. This work was funded by a Regional Medical Associates of Hamilton Research Scholarship. Parts of this material are based on data and/or information compiled and provided by the CIHI. However, the analyses, conclusions, opinions, and statements expressed in the material are those of the authors and not necessarily those of CIHI. The analyses, opinions, results, and conclusions reported in this paper are also independent from the other sources that provided data and funding. No endorsement by ICES, the Ministry of Health, or the Ministry of the Solicitor General is intended or should be inferred. The authors thank Ri Wang in the Centre for Urban Health Solutions at St. Michael's Hospital for assistance with preparing Figure 2 and Susan J. Bondy at the Dalla Lana School of Public Health at the University of Toronto for providing comments on a draft of the manuscript.

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**Appendix Table 1. Codes used in health administrative data to define specific maternal conditions and infant and maternal outcomes**

Variable	Codes/Source	Time window
Viral hepatitis	ICD-9: 070, ICD-10: B15-B19	Past 5 years
Mental illness	<p><i>Any</i>  ICD-10-CA: F04 to F99  OHIP: 291-292, 295-298, 300-306, 309, 311</p> <p><i>Substance-related disorders</i>  ICD-10-CA: F55, F10 to F19;  DSM-IV: 291.x (excluding 291.82), 292.x (excluding 292.85), 303.x, 304.x, 305.x; PROVDX1–PROVDX3: 4  OHIP: 291, 292, 303, 304, 305</p> <p><i>Anxiety disorders</i>  ICD-10-CA: F40, F41, F42, F43, F48.8, F48.9;  DSM-IV: 300, 300.0x, 300.2x, 300.3x, 308.3x, 309.0x, 309.24, 309.28, 309.3x, 309.4x, 309.8x, 309.9x;  PROVDX1–PROVDX3: 7, 15  OHIP: 300, 309</p> <p><i>Mood disorders</i>  ICD-10-CA: F30, F31, F32, F33, F34, F38, F39, F53.0;  DSM-IV: 296.x, 300.4x, 301.13, 311; PROVDX1: 6  OHIP: 296, 311</p> <p><i>Schizophrenia</i>  ICD-10-CA: F20 (excluding F20.4), F22, F23, F24, F25, F28, F29, F53.1;  DSM-IV: 295.x, 297.x, 298.x; PROVDX1: 5  OHIP: 295, 297, 298</p> <p><i>Self-harm</i>  ICD-10-CA: Dx10Code2 to Dx10Code10 = X60-X84, Y10-Y19, Y28</p>	Past 2 years
Neonatal abstinence syndrome	ICD10: P96.1	
Hypertensive disorders of pregnancy	O10-O16	Conception to 28 days after delivery
Gestational diabetes	O24	Conception to 28 days after delivery
Preterm prelabour rupture of membranes	O42.01, 42.11, O42.91	
Placental abruption	O45	Delivery admission
cesarean section	ICD-10: O82 P03.4, CCI: 5.MD.60	Delivery admission

DSM-IV: *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition; ICD-9: International Statistical Classification of Diseases and Related Health Problems, ninth revision; ICD-10-CA: International Statistical Classification of Diseases and Related Health Problems, tenth revision, Canada; OHIP: Ontario Health Insurance Plan; PROVDX: provisional diagnosis.

**Appendix Table 2. Prevalence of preterm birth, low birth weight, and small for gestational age birth weight in prison pregnancies<sup>a</sup> by length of time in provincial prison during pregnancy**

Days in provincial prison	N	Preterm birth			Low birth weight			Small for gestational age birth weight		
		n	%	P value	n	%	P value	n	%	P value
1–15	290	43	14.8	0.2	37	14.1	0.4	50	19.1	0.6
16–30	87	18	20.7		13	18.1		17	23.6	
31–60	117	20	17.1		12	11.5		14	13.5	
61–90	49	9	18.4		<sup>b</sup>	<sup>b</sup>		7	18.9	
91–120	24	<sup>b</sup>	<sup>b</sup>		<sup>b</sup>	<sup>b</sup>		<sup>b</sup>	<sup>b</sup>	
>120	56	<sup>b</sup>	<sup>b</sup>		<sup>b</sup>	<sup>b</sup>		9	17.3	

<sup>a</sup> Prison pregnancies are deliveries among women released from provincial prison in 2010 from a pregnancy in which the woman spent time in prison. Prison controls are deliveries among women released from provincial prison in 2010 for which the woman was not in prison during the pregnancy.

<sup>b</sup> Suppressed data because  $n \leq 5$ , according to ICES policy.

**Appendix Table 3. Odds ratios (95% CI) for deliveries to women released from prison in 2010 who were not pregnant while in provincial prison compared with general population**

Outcome	All deliveries 2005-2015		Only deliveries after imprisonment (2010-2015)	
	Unadjusted	Adjusted for maternal age and parity	Unadjusted	Adjusted for maternal age and parity
<b>Primary outcomes</b>				
Preterm birth <37 <sup>0a</sup>	2.09 (1.84–2.39)	2.12 (1.86–2.41)	2.16 (1.81–2.58)	2.15 (1.80–2.58)
Low birth weight <2500 g <sup>b</sup>	2.62 (2.29–3.01)	2.72 (2.37–3.12)	3.00 (2.50–3.60)	3.12 (2.59–3.75)
Small for gestational age birth weight <sup>b</sup>	1.66 (1.48–1.86)	1.77 (1.58–1.99)	1.78 (1.52–2.07)	1.94 (1.66–2.27)
<b>Secondary infant outcomes</b>				
Preterm birth <32 <sup>0</sup> weeks <sup>a</sup>	2.41 (1.79–3.25)	2.46 (1.83–3.32)	2.39 (1.56–3.64)	2.40 (1.57–3.66)
Preterm birth <29 <sup>0</sup> weeks <sup>a</sup>	2.50 (1.69–3.69)	2.54 (1.71–3.78)	2.24 (1.24–4.04)	2.27 (1.26–4.11)
Very low birth weight <1500 g <sup>b</sup>	1.80 (1.23–2.63)	1.95 (1.33–2.84)	1.48 (0.82–2.67)	1.59 (0.88–2.87)
Macrosomia >4 kg <sup>b</sup>	0.72 (0.61–0.85)	0.66 (0.56–0.78)	0.73 (0.59–0.92)	0.66 (0.52–0.83)
NICU admission <sup>b</sup>	2.41 (2.11–2.76)	2.99 (2.70–3.31)	4.66 (4.02–5.41)	4.75 (4.08–5.52)
Neonatal abstinence syndrome <sup>b</sup>	42.78 (37.33–49.03)	22.47 (19.23–26.25)	57.71 (48.67–68.43)	30.90 (25.35–37.66)
Stillbirth <sup>b</sup>	2.85 (2.03–3.99)	2.74 (1.95–3.84)	2.70 (1.65–4.42)	2.54 (1.56–4.16)
Infant death <sup>b</sup>	4.21 (2.86–6.20)	3.29 (2.23–4.87)	3.54 (1.95–6.43)	2.80 (1.53–5.09)
<b>Secondary maternal outcomes<sup>c</sup></b>				
Hypertensive disorders of pregnancy	0.75 (0.61–0.93)	0.90 (0.72–1.11)	0.80 (0.60–1.06)	0.94 (0.71–1.25)
Gestational diabetes	0.62 (0.49–0.79)	0.80 (0.63–1.02)	0.70 (0.52–0.95)	0.82 (0.60–1.11)
Preterm prelabour rupture of membranes	1.74 (1.40–2.16)	1.90 (1.53–2.36)	1.74 (1.28–2.37)	1.88 (1.37–2.56)
Placental abruption	2.31 (1.73–3.08)	2.12 (1.58–2.83)	2.48 (1.67–3.68)	2.23 (1.50–3.32)
cesarean section	0.79 (0.71–0.88)	0.96 (0.86–1.07)	0.85 (0.74–0.97)	0.99 (0.86–1.14)

<sup>a</sup> Adjusted for maternal age and parity. N = 2293 deliveries for pregnancies in 2005-2015 and 1127 for pregnancies in 2010-2015.

<sup>b</sup> N = 2156 deliveries for pregnancies in 2005-2015 and 1070 for pregnancies in 2010-2015.

<sup>c</sup> N = 2327 deliveries for stillbirths and maternal outcomes for pregnancies in 2005-2015 and 1143 for pregnancies in 2010-2015.

NICU: neonatal intensive care unit.