

# Risks of stillbirth and early neonatal death by day of week

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## Abstract

**Background:** Higher risks of stillbirth or early neonatal death, or both, have been reported from several countries for births on weekend days. It is unclear whether such higher risks have persisted in recent years. We investigated weekend-associated risks of stillbirth and early neonatal death in most Canadian provinces.

**Methods:** We studied all 3 239 972 births recorded in Canada, excluding Ontario, between 1985 and 1998. The main outcome measures were the relative risks (RRs) of stillbirth and early neonatal death for infants born on weekends versus weekdays.

**Results:** The proportion of births on weekend days was 24% lower than the proportion on weekdays. Infants born on weekend days had slightly but significantly elevated risks of stillbirth (RR 1.06, 95% confidence interval [CI] 1.02–1.09) and early neonatal death (RR 1.11, 95% CI 1.07–1.16). However, the higher risks disappeared after adjustment for gestational age.

**Interpretation:** The crude risks of stillbirth and early neonatal death remained slightly higher for births on weekend days, but the excesses were much smaller than those reported from other countries.

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Births on different days of the week should have similar outcomes in the absence of preferential timing of high-risk deliveries and differences in the quality of perinatal care. Relatively few studies have examined the risk of perinatal death by day of the week. All previous studies have reported higher risks of stillbirth or early neonatal death, or both, among infants born on weekend days than among those born on weekdays,<sup>1-5</sup> but we are unaware of any recent investigations of this phenomenon. Weekend-associated excess risks are a potentially important public health issue, because even a modestly elevated risk, such as 10% to 30%, translates into many lives lost each year. We therefore investigated differentials in the risks of stillbirth and early neonatal death by day of week at birth in Canada, where a universal health insurance system has been in place for 30 years<sup>6</sup> and the infant mortality rate is among the lowest in the world.<sup>7,8</sup>

## Methods

We used the most updated linked data files for stillbirth, live birth and infant death from Statistics Canada. We studied all 3 239 972 births recorded in Canada between 1985 and 1998, after excluding Ontario data because of documented problems with data quality.<sup>9</sup> Day of week at birth was obtained from birth-registration records. Outcome measurements included the rates of stillbirth and early neonatal death (at 0–6 days) and the relative risks (RRs) (with 95% confidence intervals [CIs]) of those outcomes for infants born on weekends versus on weekdays. Rates of stillbirth and early neonatal death were examined by day of week at birth and by weekend births versus weekday births. We used  $\chi^2$  tests to test for differences in risks of stillbirth and early neonatal death by day of week at birth. The RRs of stillbirth and early neonatal death for infants born on weekends versus weekdays were assessed for the periods 1985–1989, 1990–1994 and 1995–1998 separately and for the overall period combined.

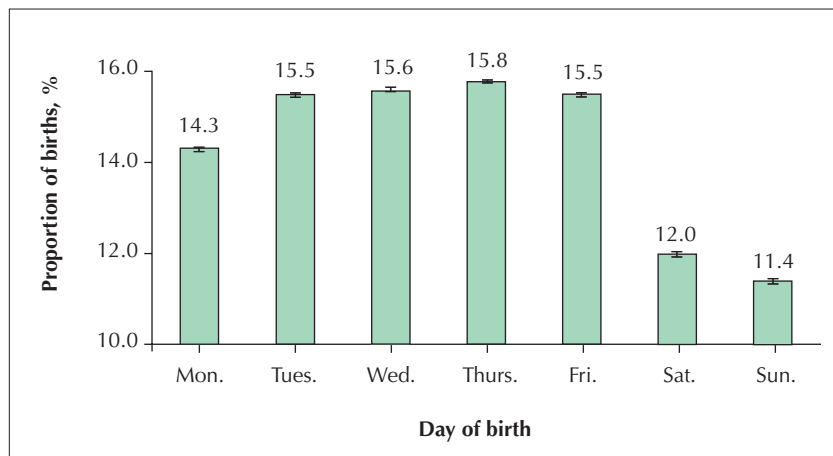
Stillbirths and early neonatal deaths were assessed separately rather than combined as perinatal deaths because they differ substantially with respect to etiology and appropriate denominators.<sup>10</sup> To understand whether weekend-associated excess risks are due to selective timing of elective deliveries or variations in quality of perinatal care, or both, we also assessed the risks for selected causes of death (asphyxia, congenital anomalies and immaturity-related conditions) using the classification of the International Collaborative Effort (ICE) on Perinatal and Infant Mortality,<sup>11</sup> which is based on the International Classification of Diseases, 9th Revision.<sup>12</sup>

To understand the occurrence of high-risk births on weekends compared with weekdays, we examined the rates of births classified as preterm (< 37 weeks' gestation),<sup>9</sup> low birth weight (< 2500 g) or small for gestational age (< 10th percentile of the recently published reference standard<sup>13</sup>). We examined the crude RRs and the adjusted odds ratios (ORs) of stillbirth and early neonatal death among infants born on weekends, controlling for gestational age in completed week by means of logistic regression analysis. RRs and ORs are virtually identical when the event of interest (e.g., stillbirth or early neonatal death) is rare. Likelihood-ratio statistics and Max-rescaled R<sup>2</sup> statistics were used to assess the significance of the overall regression models and goodness-of-fit. To assess the quality of care for preterm newborns, we compared gestational-age-specific risks of early neonatal death among such infants born on weekends versus weekdays.

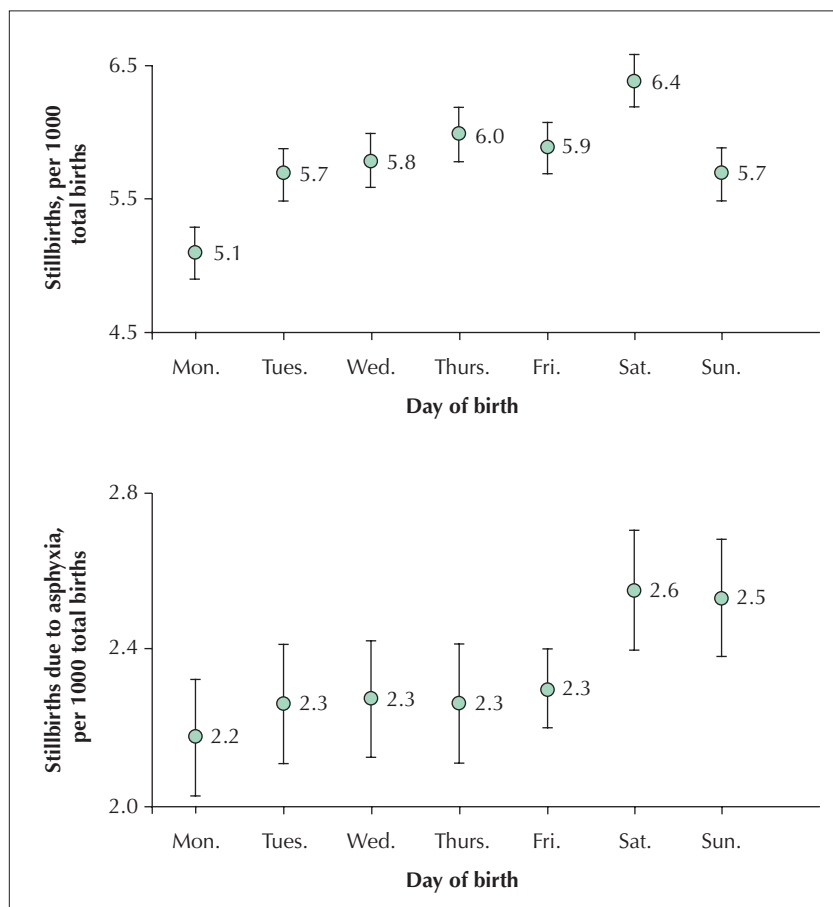
Ethics approval was not sought for this study because it was based on anonymous national birth-registration data from Statistics Canada. Statistics Canada has agreements with all Canadian provinces on the privacy and use of data.

## Results

The proportion of births was unevenly distributed by day of week, with a 24% lower frequency ( $p < 0.001$ ) on weekend days (Fig. 1). The average daily number of births



**Fig. 1: Proportion of births by day of week, Canada (Ontario excluded), 1985–1998. Error bars represent 95% confidence intervals (CIs).**



**Fig. 2: Stillbirth rates (overall and due to asphyxia) by day of week. Error bars represent 95% CIs.**

was 377 713 on weekend days and 496 909 on weekdays. The lowest proportion was on Sundays and the second-lowest on Saturdays. This pattern persisted over the 3 periods (1985–1989, 1990–1994 and 1995–1998; data not shown). Compared with infants born on weekdays, those born on weekends had a 14% higher preterm birth rate and a 7% higher low-birth-weight rate but the same small-for-gestational-age birth rate (11.3%). Despite these higher proportions, however, the average daily number of preterm births was lower on weekend days than on weekdays (29 080 v. 33 472).

There were 18 763 stillbirths (5.8 per 1000 total births) and 11 308 early neonatal deaths (3.5 per 1000 live births). As Fig. 2 shows, stillbirth rates were lowest on Mondays and highest on Saturdays ( $p < 0.001$ ); rates of stillbirth due to asphyxia were highest on Saturdays and Sundays ( $p < 0.001$ ). As Fig. 3 shows, early neonatal death rates were substantially higher among infants born on Saturdays and Sundays ( $p < 0.001$ ), particularly those dying of asphyxia ( $p < 0.001$ ). The patterns were similar for 1985–1989, 1990–1994 and 1995–1998 (data not shown).

Infants born on weekends had a 6% higher crude risk of stillbirth from all causes (mostly owing to the high stillbirth rate on Saturdays), but cause-specific excess risks varied from +13% for asphyxia to –20% for congenital anomalies (Table 1). The average daily number of stillbirths due to congenital anomalies was 237 on weekend days, much lower than the average on weekdays (385). For early neonatal death, infants born on weekends had an 11% excess crude risk overall, but cause-specific excess risks varied from +28% for asphyxia and immaturity to –3% for congenital anomalies. The slightly elevated crude risks of overall stillbirth and overall early neonatal death for infants born on weekends persisted through 1985–1989, 1990–1994 and 1995–1998 (results available upon request).

Low birth weight can be attributable to preterm birth or small-for-gestational-age, or both. Since the small-for-gestational-age rates were identical on weekend days and weekdays, we used logistic regression analysis to estimate the adjusted RRs of weekend-associated risks of stillbirth and early neonatal death after controlling for gestational age in completed weeks. The

excess risks of overall stillbirth and early neonatal death on weekends disappeared, and most cause-specific disparities diminished (Table 1). For instance, the weekend-associated adjusted RR of early neonatal death due to asphyxia for the overall period was 1.15 (95% CI 1.03–1.29) (crude RR 1.28). An even lower risk of stillbirth due to congenital anomalies was observed on weekend days after the adjustment. The adjusted RRs of outcomes were virtually identical when further controlled for other maternal characteristics, including age (results available upon request).

The gestational age-specific risks of overall early neonatal death were similar or slightly lower for infants born preterm on weekend days (Table 2) compared with those born preterm on weekdays. The early neonatal death rate was lower among infants born on weekends at 32–36 weeks, mainly owing to the lower rate of death due to congenital anomalies.

## Interpretation

We observed slightly higher crude risks of overall stillbirth and early neonatal death for infants born on weekends in Canada. More important, the excess risk appeared to be attributable to the higher proportion of preterm births on weekends, probably owing to the lower frequency of elective term delivery on weekends.

The uneven distribution of births by day of week followed a pattern similar to that reported from other countries.<sup>1–5</sup> However, the excess crude risks of stillbirth and early neonatal death in Canada — 6% and 11%, respectively — for infants born on weekends were much lower than those reported from other countries. For example, in Australia the weekend-associated risks were 17% higher for stillbirth and 29% higher for neonatal death.<sup>4</sup> In the United States a 27% higher risk of neonatal death was reported for infants born on Sundays.<sup>2</sup> It is unclear how the risks have changed over time in those countries, since no recent reports have been published. Although the previous studies of weekend-associated risks of perinatal death reported only crude RRs, we also assessed those risks after adjusting for gestational age. We found that the excess risks of overall stillbirth and early neonatal death for infants born on weekends became nonsignificant and even changed direction after adjustment for gestational age. This finding can probably be explained by the selective timing of low-risk elective deliver-

ies, most of which occur at term on weekdays. In fact, the average daily number of preterm births was lower on weekend days than on weekdays, but the even lower average number of term births on weekend days led to a higher weekend rate of preterm births as a proportion of all births. Previous studies have not reported weekend-associated risks after adjustment for gestational age.<sup>1–5</sup> Thus, the extent to which their reported disparities can be attributed to the differences in occurrence of preterm births is unclear.

The effect of selective timing of elective deliveries is speculative owing to the limitation of our data; we have no information on whether the deliveries were spontaneous or induced. In addition, the day of death in most stillbirths is usually before the day of birth.<sup>14</sup> Our data therefore do not allow a distinction between antepartum and intrapartum stillbirths; the latter are more likely related to the quality of care at delivery.<sup>15</sup> Moreover, because Ontario data were excluded from our analysis owing to documented problems with the quality of linked vital data, caution is advised in generalizing our findings to that province or to Canada as a whole.

Preferential timing of high- versus low-risk elective de-

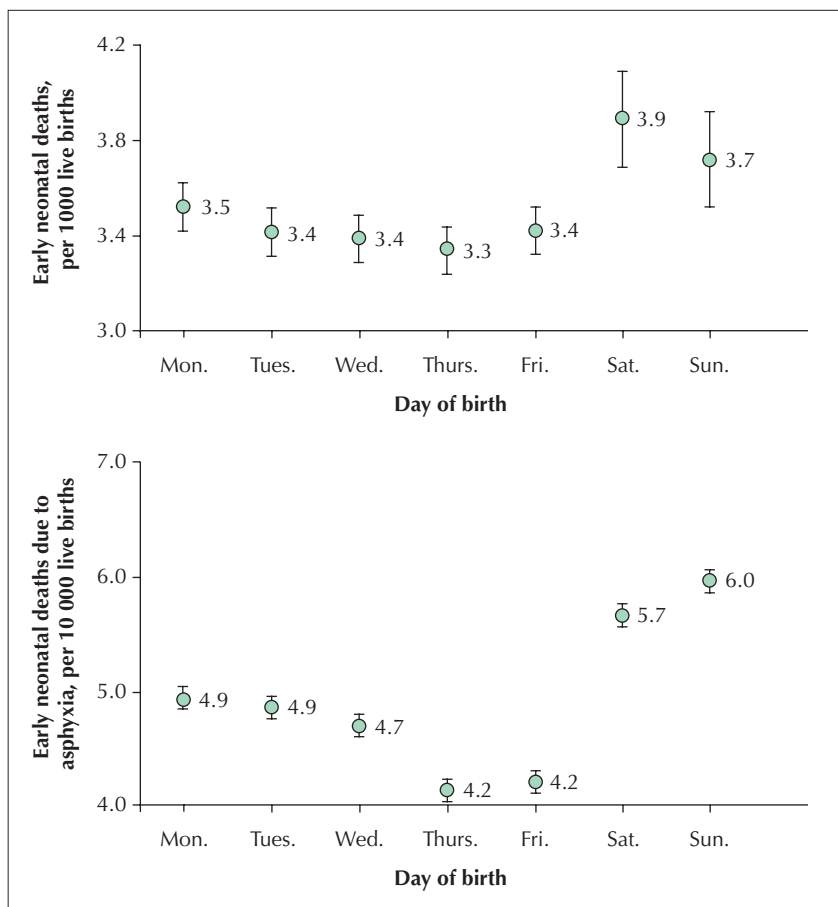


Fig. 3: Early neonatal death rates (overall and due to asphyxia) by day of week at birth. Error bars represent 95% CIs.

liveries is strongly suggested by the lower relative frequency of stillbirths due to congenital anomalies on weekend days. Most “unavoidable” deaths (e.g., those due to congenital anomalies) occurred on weekdays. Women bearing fetuses with known congenital anomalies are probably scheduled for weekday induction and delivery: elective deliveries are rarely scheduled on weekend days. Births on weekend days are therefore more frequently of an emergent nature. The fact that the lowest stillbirth rates were on Mondays may be explained by fewer instances of weekend induction of labour in high-risk cases with resultant birth on Mondays. The high stillbirth rates on Saturdays may be due to the cumulative effect of diagnosis and induction on successive weekdays. Overall, however, our results suggest that the accessibility and quality of obstetric and neonatal care in Canada are maintained on weekend days.

This article has been peer reviewed.

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Competing interests: None declared.

Contributors: All authors were involved in formulating the study framework and interpreting the results. Drs. Luo and Liu and Mr. Wilkins conducted the analyses. Dr. Luo was responsible for literature review and for writing the manuscript. Dr. Kramer was responsible for the overall theoretical framework and manuscript revision. Dr. Liu and Mr. Wilkins revised the article critically for important intellectual content. All authors approved the version to be published.

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**Table 1: Crude and adjusted relative risks (RRs) of stillbirth and early neonatal death for infants born on weekend days versus weekdays in Canada, excluding Ontario, 1985–1998**

Variable	Time of birth; no. (and rate)		RR (and 95% confidence interval [CI])	
	Weekend days	Weekdays	Crude	Adjusted*
Total births	755 425	2 484 547		
Live births	750 857	2 470 352		
Stillbirths (per 1000 total births)	4 568 (6.0)	14 195 (5.7)	1.06 (1.02–1.09)	0.96 (0.93–1.00)
Due to congenital anomaly (per 10 000)	473 (6.3)	1 927 (7.8)	0.81 (0.73–0.89)	0.71 (0.64–0.79)
Due to asphyxia (per 10 000)	1 921 (25.4)	5 608 (22.6)	1.13 (1.07–1.19)	1.06 (1.00–1.11)
Early neonatal deaths (per 1000 live births)	2 860 (3.8)	8 448 (3.4)	1.11 (1.07–1.16)	0.96 (0.91–1.01)
Due to congenital anomaly (per 10 000)	868 (11.6)	2 956 (12.0)	0.97 (0.90–1.04)	0.90 (0.83–0.97)
Due to asphyxia (per 10 000)	438 (5.8)	1 130 (4.6)	1.28 (1.14–1.42)	1.15 (1.03–1.29)
Due to immaturity (per 10 000)	1 034 (13.8)	2 663 (10.8)	1.28 (1.19–1.37)	1.10 (1.01–1.21)

\*Controlled for gestational age by logistic regression; likelihood-ratio test for global null hypothesis,  $p < 0.001$  for all models; rescaled  $R^2 = 0.33$  for stillbirth and  $= 0.44$  for early neonatal death. Odds ratios were actually calculated for the adjusted values; the RRs are virtually identical when the event of interest is rare.

**Table 2: Gestational-age-specific crude RRs of early neonatal death for infants born preterm on weekend days versus weekdays**

Gestational age; early neonatal deaths	Time of birth; no. of early neonatal deaths (and rate per 1000 live births) among preterm infants		RR (and 95% CI)
	Weekend days	Weekdays	
<b>22–27 wk</b>	<i>n</i> = 2 988	<i>n</i> = 8 001	
Total	1 217 (407.3)	3 311 (413.8)	0.98 (0.94–1.05)
Due to congenital anomaly	92 (30.8)	291 (36.4)	0.85 (0.67–1.07)
Due to asphyxia	174 (58.2)	399 (49.9)	1.17 (0.98–1.39)
<b>28–31 wk</b>	<i>n</i> = 5 258	<i>n</i> = 14 897	
Total	578 (109.4)	1 671 (112.2)	0.98 (0.89–1.07)
Due to congenital anomaly	130 (24.6)	433 (29.1)	0.85 (0.70–1.03)
Due to asphyxia	67 (12.7)	195 (13.1)	0.97 (0.74–1.28)
<b>32–36 wk</b>	<i>n</i> = 46 698	<i>n</i> = 134 685	
Total	389 (8.3)	1 305 (9.7)	0.86 (0.77–0.96)
Due to congenital anomaly	250 (5.4)	898 (6.7)	0.80 (0.70–0.92)
Due to asphyxia	43 (0.9)	98 (0.7)	1.27 (0.89–1.81)

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## CLINICAL PRACTICE GUIDELINES FOR THE CARE AND TREATMENT OF BREAST CANCER



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### REVISED:

- Guideline 3: Mastectomy or lumpectomy? The choice of operation for clinical stages I and II breast cancer [July 23, 2002]
- Guideline 5: The management of ductal carcinoma in situ [Oct. 2, 2001]
- Guideline 6: Breast radiotherapy after breast-conserving surgery [Feb. 18, 2003]
- Guideline 7: Adjuvant systemic therapy for women with node-negative breast cancer [Jan. 23, 2001]
- Guideline 8: Adjuvant systemic therapy for women with node-positive breast cancer [Mar. 6, 2001]
- Guideline 10: The management of chronic pain in patients with breast cancer [Oct. 30, 2001]

### NEW:

- Guideline 11: Lymphedema [Jan. 23, 2001]
- Guideline 12: Chemoprevention [June 12, 2001]
- Guideline 13: Sentinel node biopsy [July 24, 2001]
- Guideline 14: The role of hormone replacement therapy in women with a previous diagnosis of breast cancer [April 16, 2002]