**The proportion of maternal/neonatal readmission attributed to length of stay for childbirth**

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**Abbreviations:**

DAD Discharge Abstract Database

ICD-10-CA International Classification of Disease, Version 10, Canadian Modification

LOS Length of stay

SOGC Society of Obstetricians and Gynecologists of Canada

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Amy Metcalfe: Participated in data analysis, interpreted the findings, drafted the initial manuscript, and approved the final manuscript as submitted.

Matthews Mathai: Conceptualized the study, interpreted the findings, critically reviewed the manuscript, and approved the final manuscript as submitted.

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**Abstract**

**Background:** Length of stay (LOS) for childbirth has been steadily decreasing in recent decades in Canada, because of efforts to decrease costs and demedicalize pregnancy. We attempted to determine the optimal LOS following birth by examining the incidence pattern of neonatal readmission for different LOS.

**Methods:** The study was carried outon all term, singleton live births without congenital anomalies in Canada (except Quebec) from 2003 to 2010. Temporal trends in neonatal readmission rates were quantified in relation to LOS and the Kitagawa decomposition analysis was used to determine the proportion of the temporal increase in readmission due to LOS vs day-specific readmission rates.

**Results:** 1,875,322 live births met eligibility criteria. Neonatal LOS peaked at day 1 (47.3%) after vaginal birth and day 3 (49.3%) following cesarean section; 4.2% of infants were readmitted following vaginal birth and 2.2% after cesarean section. In 2008-10, most readmissions occurred among infants discharged in the first 2 days (83.8%) following a vaginal birth and among infants discharged in the first 3 days (81.7%) following a cesarean birth.

Readmissions increased from 4.1% in 2003-2005 to 4.6% in 2008-2010 among vaginal births and from 2.0% to 2.4% among cesarean births and occurred mostly due to changes in the day-specific readmission rates and not due to reductions in LOS.

**Conclusions:** Patterns of readmission suggest that most readmissions can likely be prevented with a 2-3 day stay following a vaginal birth and a 3-4 day stay following a cesarean birth given out-patient support in the community.

**Introduction**

Hospitalization for childbirth is one of the most frequent categories of hospital admission in industrialized countries ([1](#_ENREF_1), [2](#_ENREF_2)). Numerous studies have reported that the length of stay (LOS) for childbirth has been steadily decreasing in recent decades, in an effort to decrease costs and demedicalize pregnancy ([1](#_ENREF_1), [3-5](#_ENREF_3)). The medical necessity of hospitalization for and after childbirth is influenced by a variety of factors such as the availability of follow-up services, the organization of maternity care, the medical and social needs of mother and infant, mode of delivery and parity ([2](#_ENREF_2), [5-9](#_ENREF_5)). Most of the literature on LOS for childbirth has evaluated the impact of ‘early discharge’ with conflicting results. Some studies have shown that early discharge does not impact infant readmission ([10-13](#_ENREF_10)), while others have demonstrated an increase in infant readmission after early discharge ([14](#_ENREF_14)). However, synthesis of this body of literature is complicated by differing definitions of ‘early’ discharge (<24 hours, <36 hours, <48 hours, <72 hours), differing time periods for readmission (7 days to 90 days), the availability of nonhospital-based support systems, and the generalizability to all pregnant women not just those meeting strictly defined criteria ([11](#_ENREF_11), [12](#_ENREF_12), [15](#_ENREF_15), [16](#_ENREF_16)). Additionally, while understanding the impact of early discharge on maternal and infant health is a valid concern, the focus needs to shift from evaluating the impact of ‘early discharge’ to determining the most appropriate duration of hospitalization following childbirth ([3](#_ENREF_3)).

Readmission is an important outcome for evaluating the optimal LOS following childbirth as it is a measure of severe morbidity. Readmission is also costly and can may be a direct consequence of a reduced LOS (due to insufficient time to observe the patient for latent signs of disease or insufficient instruction on proper newborn care ([17](#_ENREF_17))). It is estimated that approximately 3% of infants will be readmitted to hospital ([18](#_ENREF_18)). The most frequently reported causes of infant readmission are: dehydration, diarrhea, feeding problems, fever, infections, gastro-intestinal problems, jaundice, sepsis, and viral/respiratory issues ([4](#_ENREF_4), [10](#_ENREF_10), [12](#_ENREF_12), [13](#_ENREF_13), [16](#_ENREF_16), [19](#_ENREF_19)). This study aimed to determine what proportion of neonatal readmissions can be attributed to changing LOS for childbirth and to identify an optimal LOS for childbirth.

**Patients and Methods**

The study population included all singleton live births in Canada (excluding Quebec) from 2003 to 2010 with data obtained from the Discharge Abstract Database (DAD) of the Canadian Institute for Health Information. Live births were identified by the use of International Classification of Diseases (ICD-10-CA) code Z37.0 (singleton live birth). This study was limited to all hospital deliveries of live born infants between 2003 and 2010 where the mother and infant are both discharged from hospital on the same day. This study period was chosen as all records in the database during this period were coded with ICD-10-CA. Mother-infant dyads that included infants with congenital anomalies (ICD-10-CA Q00-Q99) identified at birth, multiple gestation pregnancies (O30.0, O30.1, O30.2, O30.8, O30.9, O84.0, O84.9), premature births (gestational age <37 weeks) and maternal deaths were excluded.

LOS was derived by subtracting the date of birth from the date of discharge and was used as a continuous variable. Transfers between hospitals or between units within a single hospital were counted as a single admission. Mode of delivery was classified as vaginal or cesarean (Canadian classification of health interventions code 5MD60). All-cause and cause-specific readmission for jaundice (ICD-10-CA P55-P59), infection (ICD-10-CA P35-P39), and dehydration (ICD-10-CA P74.1) were evaluated.

The Kitagawa decomposition was used to assess the impact of temporal changes in the LOS and temporal changes in the LOS-specific readmission rate on overall temporal changes in all-cause and cause-specific readmission rates. The Kitagawa decomposition formula is given below:

$$N1-N2= \sum\_{i=1}^{n}\frac{\left(R\_{1i}+ R\_{2i}\right)}{2} \left(F\_{1i }- F\_{2i}\right)+ \sum\_{i=1}^{n}\frac{(F\_{1i}+ F\_{2i})}{2}(R\_{1i}- R\_{2i})$$

N refers to the neonatal readmission rate in periods 1 (2003-2005) and 2 (2008-2010); R represents the neonatal readmission rate for a given LOS (*i*); while F indicates the proportion of infants with a given LOS (*i*). The first part of this equation quantifies the impact of temporal changes in LOS on temporal changes in neonatal readmission rates, while the second part of the equation quantifies the impact of temporal changes in LOS-specific neonatal rates on temporal changes in neonatal readmission rates. All analyses were conducted using SAS Version 9.2. Ethics approval for this study was obtained from the Ethics Review Board at the University of British Columbia.

**Results**

There were 490,125 singleton live births delivered vaginally in 2003-05, of which 19,547 were readmitted in the 7 days after birth, yielding a readmission rate of 3.99 per 100 live births. Among 160,038 singleton live births delivered by cesarean in 2003-05, there were 3,460 readmissions (readmission rate 2.16 per 100 live births). In 2008-10, there were 611,342 live births and 27,567 readmissions (readmission rate 4.51 per 100 live births) following vaginal birth and 221,642 live births and 5,700 readmissions (readmission rate 2.57 per 100 live births) following a cesarean birth. In 2008-10, most readmissions occurred among infants discharged in the first 2 days (83.8%) or the first 3 days (94.5%) following a vaginal birth and among infants discharged in the first 3 days (81.7%) or the first 4 days (93.3%) after a cesarean birth.

LOS for childbirth decreased while neonatal readmission rates increased between 2003-2005 and 2008-2010 for both vaginal and cesarean births (Figure 1). In 2003-2005, the majority of infants were discharged on day 1 (41.2%, 95% CI: 41.1-41.4), day 2 (40.8%, 95% CI: 40.7-41.0) or day 3 (11.9%, 95% CI: 11.8-12.0) following a vaginal birth. By 2008-2010, the timing of discharge had shifted with an increasing proportion of infants being discharged on day 1 (50.9%, 95% CI: 50.8-51.1), day 2 (35.8%, 95% CI: 35.7-35.9) and day 3 (8.7%, 95% CI: 8.6-8.7) following a vaginal birth. Overall readmission rates following a vaginal birth were 13% higher in 2008-2010 compared to 2003-2005 (Table 1).

 A similar pattern emerged for cesarean births. In 2003-2005, the majority of infants were discharged on day 2 (20.4%, 95% CI: 20.2-20.6), day 3 (52.7%, 95% CI: 52.4-52.9), or day 4 (16.6%, 95% CI: 16.4-16.8) following a cesarean birth. By 2008-2010, the timing of discharge had shifted with an increasing proportion of infants being discharged on day 2 (35.4%, 95% CI: 35.2-35.6), day 3 (45.8%, 95% CI: 45.6-46.0), or day 4 (10.0%, 95% CI: 9.9-10.1) following a cesarean birth. Overall readmission rates following a cesarean birth were 19% higher in 2008-2010 compared to 2003-2005 (Table 1).

 The majority of neonatal readmissions were for jaundice (49.9%), respiratory conditions (8.1%), feeding problems (5.2%), sepsis (4.0%), and dehydration (3.3%). No temporal trends were observed among readmissions for infections and dehydration; however, readmission rates for jaundice increased over time.

The Kitagawa decomposition for readmission rates following vaginal birth showed that most of the rate difference in readmission rates between 2003-05 and 2008-10 (0.52 readmissions per 100 live births) was due to changes in the day-specific readmission rates and not due to changes in LOS (Table 2). Of the total rate difference of 51.87 per 10,000 live births, -7,78 per 10,000 live births was due to changes in LOS and 59.65 per 10,000 live births was attributed to changes in day-specific readmission rates. Similarly, the Kitagawa decomposition attributed the rate difference in readmission rates following cesarean birth between 2003-05 and 2008-10 (0.41 per 100 live births) to changes in day-specific readmission rates (and not due to changes in LOS).

 Table 3 shows the results of the Kitagawa decomposition for readmissions due to jaundice. The rate difference in readmission rates for jaundice following vaginal birth between 2003-05 and 2008-10 was entirely due to changes in day-specific readmission rates (and not due to changes in LOS), while the rate difference in readmission rates following cesarean birth was mostly due to changes in day-specific readmission rates (86.1%) and partly due to changes in the LOS (13.9%).

**Discussion**

Our study shows that LOS following childbirth decreased while neonatal readmission rates increased between 2003-2005 and 2008-2010 for both vaginal and cesarean births. However, neonatal readmission rates remain low overall even though neonatal readmission rates have increased over time in Canada. The increase in readmission rates during this period was almost entirely due to changes in day-specific readmission rates and not due to changes in LOS. This was true for overall rates of readmission following childbirth and also for readmission for jaundice. In 2008-10, most readmissions occurred among infants discharged in the first 2 days (83.8%) following a vaginal birth and among infants discharged in the first 3 days (81.7%) after a cesarean birth.

There are advantages and disadvantages associated with a shorter LOS following childbirth. Advantages of a shorter LOS include decreased costs, improved attachment, and improved breastfeeding rates in a family setting ([10](#_ENREF_10), [14](#_ENREF_14)), while disadvantages include less time to observe the mother and the infant for latent medical problems, less time for education on infant care, and less time to initiate and establish breastfeeding ([10](#_ENREF_10)). Our study suggests that neonatal readmission rates during recent years are not increasing due to decreasing LOS, but instead due to changes in the day-specific readmission rates i.e. a lowering of the threshold for readmission. Based on the observed readmission patterns, the optimal time to discharge infants appears to be after 2-3 days of hospital stay following a vaginal birth and 3-4 days following a cesarean birth as this would avert the vast majority of readmission. However, the advantages of a shorter LOS may be realized given appropriate community support. While the Society of Obstetricians and Gynecologists of Canada (SOGC) has issued explicit criteria for postpartum discharge less than 48 hours after birth ([18](#_ENREF_18)), they have not articulated what they deem to be the optimal time for discharge following childbirth. Regardless of the LOS following childbirth, the third and fourth day post-birth have been deemed to be a critical period during which all mothers and infants should be evaluated by a health professional ([3](#_ENREF_3)).

A nine-country European study showed a substantial inter-country variation in maternal average LOS following normal delivery (defined as vaginal birth of a singleton infant at term with no complications) ranging from 0.84 days in the Netherlands to 4.9 days in France ([6](#_ENREF_6)). Both the LOS in hospital and the division of labor between nurses and physicians during delivery result in wide fluctuations in the cost of childbirth ([6](#_ENREF_6)). A Canadian study determined that in spite of only 4% of infants requiring readmission post-birth, this was the single greatest cost to the health care system in the first month after birth ([20](#_ENREF_20)). Many studies support the proposition that the timing of discharge can be individualized based on the health of the mother and infant and the resources available to them in their local community.

This study has several strengths and some limitations. Approximately 98-99% of births in Canada occur in a hospital setting ([21](#_ENREF_21), [22](#_ENREF_22)). As readmission post-birth is a relatively uncommon outcome, we had a sufficiently large sample size to achieve adequate statistical power ([12](#_ENREF_12), [16](#_ENREF_16), [17](#_ENREF_17)). Additionally, we examined data from the population of healthy term singleton infants (excluding those with congenital anomalies), not a restricted sub-set of the population that might be eligible for early discharge programs. Despite restricting our sample to apparently healthy singleton term infants, we cannot rule out the possibility of confounding by indication as the reason some infants have longer LOS, might be the same reason why they are readmitted. Additionally, we had no data on community resources and use of outpatient services after discharge. This is important as in some jurisdictions LOS for childbirth decreased in the late 1980s/early 1990s, concomitantly with reductions in post-partum home visits by public health nurses ([23](#_ENREF_23)). Such simultaneous decreases in LOS following childbirth and reductions in community support following hospital discharge contribute to increasing readmission rates of infants ([23](#_ENREF_23)). Finally, we were unable to differentiate between preventable readmissions and essential readmissions. A Canadian study from Alberta found that potentially preventable readmissions related to jaundice, dehydration, feeding problems, weight gain or social reasons occurred following 3.5% of deliveries and that over 80% of these occurred within the first week following discharge ([24](#_ENREF_24)).

**Conclusion**

Patterns of readmission suggest that most readmissions can likely be prevented with a 2-3 day stay following a vaginal birth and a 3-4 day stay following a cesarean birth given community-level supports are available, such as the case in Canada. However contextual factors need to be considered when determining the optimal LOS for a particular infant**.** The low readmission rates observed in Canada and the varying LOS for apparently healthy neonates indicate that health care providers do a good job of risk stratifying infants**.** Integration of inpatient and outpatient services is critical to ensure that neonates receive the appropriate follow-up care in the community. Future studies should examine geographic variability in community support for childbirth and childrearing and its relationship with readmission rates and child health.

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Figure 1 – Temporal changes in length of stay (panels A and C) and readmission rates (panels B and D) between 2003-2005 and 2008-2010 for vaginal (panels A and B) and cesarean births (panels C and D) for singleton live births in Canada (excluding Quebec).

Table 1 – Numbers, Proportions and Rates of Neonatal Readmission Rates, Rate Ratios and Rate Differences by Length of Stay Among Singleton Live Births in Canada (excluding Quebec) (2003-2005 vs. 2008-2010).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Mode of Delivery** | **Length of Stay (days)** | **2003-2005** | **2008-2010** | **Rate Difference** | **Rate Ratio (95% CI)** |
| **N (%)** | **Neonatal Readmission Rate per 100 Live Singleton Births** | **N (%)** | **Neonatal Readmission Rate per 100 Live Singleton Births** |
| Vaginal | 1 | 7,442 (38.1) | 3.68 | 12,831 (46.5) | 4.12 | 0.44 | 1.12 (1.09-1.15) |
| 2 | 8,119 (41.5) | 4.06 | 10,272 (37.3) | 4.69 | 0.63 | 1.16 (1.12-1.19) |
| 3 | 2,701 (13.8) | 4.62 | 2,960 (10.7) | 5.58 | 0.97 | 1.21 (1.15-1.27) |
| 4 | 813 (4.2) | 4.61 | 921 (3.3) | 5.55 | 0.95 | 1.21 (1.10-1.32) |
| 5 | 268 (1.4) | 3.90 | 339 (1.2) | 5.21 | 1.32 | 1.34 (1.14-1.57) |
| 6 | 130 (0.7) | 4.30 | 168 (0.6) | 5.55 | 1.25 | 1.29 (1.03-1.62) |
| 7 | 74 (0.4) | 3.76 | 76 (0.3) | 3.96 | 0.20 | 1.05 (0.76-1.45) |
| **Overall** | **19,547 (100.0)** | **3.99** | **27,567 (100.0)** | **4.51** | **0.52** | **1.13 (1.11-1.15)** |
|  |  |  |  |  |  |  |  |
| Cesarean | 1 | 227 (6.6) | 3.64 | 510 (8.9) | 5.23 | 1.59 | 1.44 (1.23-1.68) |
| 2 | 720 (20.8) | 2.21 | 2,006 (35.2) | 2.56 | 0.35 | 1.16 (1.07-1.26) |
| 3 | 1,566 (45.3) | 1.86 | 2,143 (37.6) | 2.11 | 0.25 | 1.14 (1.06-1.21) |
| 4 | 648 (18.7) | 2.44 | 659 (11.6) | 2.98 | 0.54 | 1.22 (1.10-1.36) |
| 5 | 184 (53) | 2.82 | 252 (4.4) | 4.21 | 1.40 | 1.50 (1.24-1.81) |
| 6 | 92 (2.7) | 3.79 | 80 (1.4) | 3.45 | -0.34 | 0.91 (0.67-1.23) |
| 7 | 23 (0.7) | 1.72 | 50 (0.9) | 3.39 | 1.67 | 1.97 (1.20-3.22) |
| **Overall** | **3,460 (100.0)** | **2.16** | **5,700 (100.0)** | **2.57** | **0.41** | **1.19 (1.14-1.24)** |

Table 2 - Relative Contribution of Changes in the Length of Stay Distribution and in Length-of-Stay-Specific Neonatal Readmission Rates to the Overall Temporal Changes in Neonatal Readmission Among Singleton Live Births in Canada (excluding Quebec) (2003-2005 vs. 2008-2010).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Mode of Delivery** | **Length of Stay (days)** | **Contribution of Changes in** | **Total Change** | **Relative Contribution of Changes in** |
| **Length of Stay** | **Length of Stay Specific Neonatal Readmission** | **Length of Stay (%)** | **Length of Stay Specific Neonatal Readmission (%)** |
| Vaginal | 1 | 37.83 | 20.28 | 58.11 | 65.10 | 34.90 |
| 2 | -21.88 | 24.14 | 2.26 | -968.14 | 1068.14 |
| 3 | -16.68 | 9.89 | -6.79 | 245.66 | -145.66 |
| 4 | -4.52 | 2.97 | -1.55 | 291.61 | -191.61 |
| 5 | -1.55 | 1.61 | 0.06 | -2583.33 | 2683.33 |
| 6 | -0.64 | 0.69 | 0.05 | -1280.00 | 1380.00 |
| 7 | -0.35 | 0.07 | -0.28 | 125.00 | -25.00 |
| **Total** | **-7.78** | **59.65** | **51.87** | **-15.00** | **115.00** |
|  |  |  |  |  |  |  |
|  Cesarean | 1 | 2.22 | 6.60 | 8.82 | 25.17 | 74.83 |
| 2 | 35.73 | 9.76 | 45.49 | 78.54 | 21.46 |
| 3 | -13.60 | 12.31 | -1.29 | 1054.26 | -954.26 |
| 4 | -18.46 | 7.12 | -11.34 | 162.79 | -62.79 |
| 5 | -4.85 | 4.71 | -0.14 | 3464.29 | -3364.29 |
| 6 | -1.70 | -0.44 | -2.14 | 79.44 | 20.56 |
| 7 | -0.41 | 1.25 | 0.84 | -48.81 | 148.81 |
| **Total** | **-1.07** | **41.32** | **40.25** | **-2.65** | **102.65** |

Table 3 - Relative Contribution of Changes in the Length of Stay Distribution and in Length-of-Stay-Specific Neonatal Readmission Rates for Jaundice to the Overall Temporal Changes in Neonatal Readmission Among Singleton Live Births in Canada (excluding Quebec) (2003-2005 vs. 2008-2010).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Mode of Delivery** | **Length of Stay (days)** | **Contribution of Changes in** | **Total Change** | **Relative Contribution of Changes in** |
| **Length of Stay** | **Length of Stay Specific Neonatal Readmission** | **Length of Stay (%)** | **Length of Stay Specific Neonatal Readmission (%)** |
| Vaginal | 1 | 20.37 | 16.59 | 36.96 | 55.11 | 44.89 |
| 2 | -10.95 | 18.39 | 7.44 | -147.18 | 247.18 |
| 3 | -6.70 | 5.36 | -1.34 | 500.00 | -400.00 |
| 4 | -1.94 | 2.46 | 0.52 | -373.08 | 473.08 |
| 5 | -0.68 | 0.81 | 0.13 | -523.08 | 623.08 |
| 6 | -0.23 | 0.20 | -0.03 | 766.67 | -666.67 |
| 7 | -0.10 | 0.12 | 0.02 | -500.00 | 600.00 |
| **Total** | **-0.23** | **43.93** | **43.70** | **-0.53** | **100.53** |
|  |  |  |  |  |  |  |
|  Cesarean | 1 | 1.01 | 1.95 | 2.96 | 34.12 | 65.88 |
| 2 | 15.35 | 3.63 | 18.98 | 80.87 | 19.13 |
| 3 | -5.00 | 6.90 | 1.90 | -263.16 | 363.16 |
| 4 | -6.03 | 4.35 | -1.68 | 358.93 | -258.93 |
| 5 | -1.54 | 2.61 | 1.07 | -143.93 | 243.93 |
| 6 | -0.46 | 0.93 | 0.47 | -97.87 | 197.87 |
| 7 | -0.08 | -0.20 | -0.28 | 28.57 | 71.43 |
| **Total** | **3.25** | **20.17** | **23.42** | **13.88** | **86.12** |