



Comparison of maternal mortality and morbidity between trial of labor and elective cesarean section among women with previous cesarean delivery

Shi Wu Wen, MB, PhD,^{a,b,*} I. D. Rusen, MD, MSc,^a Mark Walker, MD,^b Robert Liston, MB,^c Michael S. Kramer, MD,^d Tom Baskett, MB,^e Maureen Heaman, RN, PhD,^f Shiliang Liu, MB, PhD,^a for the Maternal Health Study Group,** Canadian Perinatal Surveillance System

Division of Health Surveillance and Epidemiology, Centre for Healthy Human Development, Health Canada, Ottawa, Ontario, Canada,^a Department of Obstetrics and Gynaecology and Clinical Epidemiology Program, University of Ottawa, Ottawa, Ontario, Canada,^b Department of Obstetrics and Gynaecology, University of British Columbia, Vancouver, British Columbia, Canada,^c Departments of Pediatrics and of Epidemiology and Biostatistics, McGill University Faculty of Medicine, Montreal, Quebec, Canada,^d Department of Obstetrics and Gynaecology, Dalhousie University, Halifax, Nova Scotia,^e and Faculty of Nursing, University of Manitoba, Winnipeg, Manitoba, Canada^f

Received for publication October 23, 2003; revised March 3, 2004; accepted March 9, 2004

KEY WORDS

Trial of labor
Vaginal birth after cesarean section
Elective cesarean delivery
Maternal mortality
Uterine rupture
Hysterectomy
Obstetric volume

Objective: This study was undertaken to assess the safety of trial of labor after previous cesarean delivery.

Study design: Retrospective cohort study of 308,755 Canadian women with previous cesarean delivery between 1988 and 2000. Occurrences of in-hospital maternal death, uterine rupture, and other severe maternal morbidity were compared between women with a trial of labor and those with an elective cesarean section.

Results: Rates of uterine rupture (0.65%), transfusion (0.19%), and hysterectomy (0.10%) were significantly higher in the trial-of-labor group. Maternal in-hospital death rate, however, was lower in the trial-of-labor group (1.6 per 100,000) than in the elective cesarean section group (5.6 per 100,000). The association between trial of labor and uterine rupture was stronger in low volume (<500) than in high volume (≥ 500 births per year) obstetric units.

Conclusion: Trial of labor is associated with increased risk of uterine rupture, but elective cesarean section may increase the risk of maternal death.

© 2004 Elsevier Inc. All rights reserved.

* Reprint requests: Shi Wu Wen, MB, PhD, 501 Smyth Rd, Box 241, Ottawa, Ontario K1H 8L6, Canada.

E-mail: swwen@ohri.ca

** Contributing members: Robert Kinch (McGill University), Reg Sauve (University of Calgary).

Several previous studies have assessed the safety of trial of labor among women with 1 or more previous cesarean deliveries. All these studies were based on observational designs and found that the risk of uterine rupture was increased among women who underwent a trial of labor.¹⁻⁶ A recent survey in industrialized countries found a more cautious approach to trial of labor, as shown by declining vaginal birth after cesarean delivery (VBAC) rates, probably because of concerns about uterine rupture.⁷

On the other hand, observational studies have consistently found that maternal mortality rates in women with cesarean delivery are 2 to 8 times those in women with vaginal delivery.⁸⁻¹⁵ Underlying diseases requiring cesarean delivery do not explain all of the increased risk of maternal mortality related to cesarean section, because the cesarean section–related risk appears to remain after various exclusions/adjustments.^{8,9} Moreover, a recent meta-analysis summarizing all randomized trials comparing outcomes between elective cesarean section and trial of labor in women with breech presentation also found an increased risk of maternal death and severe early morbidity in the elective cesarean section group, although perinatal mortality and morbidity were substantially higher in the trial-of-labor arm.¹⁶ Because of limited sample size, however, previous studies of trial of labor among women with a previous cesarean delivery have not had sufficient statistical power to detect an association between maternal death and trial of labor.

The primary objective of our study was to examine severe morbidity and mortality in a large population sample of women with previous cesarean delivery and compared those who underwent a trial of labor with those who had an elective cesarean section. Second, because previous studies have suggested that the outcomes of trial of labor in small community hospitals may be poorer,^{1,5} we examined this hypothesis.

Material and methods

We used hospital admission and separation records collected by the Canadian Institute for Health Information (CIHI) for 13 years from 1988 to 2000. Data for women admitted to hospital for obstetric delivery were abstracted by a combination of case-mix group, diagnostic, and procedure codes defining their deliveries.¹⁷ During the study period, CIHI-coded diagnoses according to the International Classification of Diseases, Ninth Revision (ICD-9),¹⁸ and coded procedures according to the Canadian Classification of Diagnostic, Therapeutic, and Surgical Procedures (CCP).¹⁹ About 70% of all obstetric deliveries in Canada were recorded by CIHI. Most of the obstetric deliveries in the province of Quebec and parts of Manitoba and Nova Scotia were not

included in CIHI. In a previous study, we demonstrated that obstetric deliveries recorded by CIHI form a reasonably representative sample of all births in Canada.²⁰

From the abstracted obstetric deliveries, mothers with an ICD-9 code of 6542 (previous cesarean delivery) in any of the 16 diagnosis fields were selected. Women with a diagnosis of multifetal pregnancy (ICD-9 651), preeclampsia/eclampsia (ICD-9 6424, 6425, 6426, 6427), breech or transverse or oblique presentation (ICD-9 6522, 6523, 6696), preterm labor (ICD-9 6441), placenta previa (ICD-9 6410, 6411), placental abruption (ICD-9 6412), herpes simplex (ICD-9 0549), or age younger than 14 years were excluded. These conditions are likely to affect the women's chance to undergo a trial of labor, and at the same time may be associated with the study outcomes and therefore may confound the associations under study.

The main analyses were carried out in 2 groups of women: those with versus those without a trial of labor. We used a combination of diagnosis and procedure codes to define trial of labor: woman with one or more previous cesarean section(s) who either: (1) gave birth vaginally in the index pregnancy; or (2) delivered by cesarean section (CCP 86) with indication of labor (CCP 850, 851, 855 or ICD-9 660-662). Adverse outcomes (dependent variables of interest) examined in this study included in-hospital maternal death, uterine rupture (ICD-9 6650, 6651), thrombotic disorders (ICD-9 6712, 6714, 6715, 6719, 6723, 6740, 6748), major puerperal infection ((ICD-9 670), transfusion (CCP 130), and hysterectomy (CCP 802-806).

We first calculated the yearly rates of trial of labor, successful VBAC, and uterine rupture and examined the determinants of trial of labor. We then compared rates and 95% CIs for in-hospital maternal deaths under various scenarios. Next, we compared rates of in-hospital maternal death, uterine rupture, and other severe morbidity outcomes between women with versus without a trial of labor. Both crude and adjusted (for year of birth, obstetric volume, and maternal age) odds ratios were estimated. Because emergency cesarean section is considered the most dangerous form of delivery, to assess the extent to which the trial of labor-related risk is attributable to a failed trial of labor (ending with emergency cesarean delivery), we compared maternal in-hospital death, uterine rupture, and other severe morbidity in women who had a failed trial of labor versus those who had a successful trial of labor. To assess the potential adverse effect of labor induction among women who underwent a trial of labor, we compared maternal death, uterine rupture, and other severe morbidity in women who had induction of labor versus those who had spontaneous onset of labor. Finally, we analyzed maternal death, uterine rupture, and other severe morbidity rates for women with and without a trial of labor after stratifying the study sample into 4 groups

according to the volume of the obstetric unit (number of births per year) where they gave birth: less than 500, 500 to 999, 1000 to 1999, and 2000 or more births per year. Because initial analysis found almost identical results for the three categories of women who gave birth in obstetric units 500 or more births per year, we combined these categories in the final analysis. We also conducted sensitivity analyses by varying the cutoff to categorize obstetric volume. All analyses were carried out with the use of SAS PC statistical software version 8 (SAS Inc, Cary, NC).

Results

During the 13-year study period, a total of 3,576,980 obstetric deliveries were recorded by CIHI. Of these, 352,215 had a history of at least 1 previous cesarean delivery, from which the following were excluded: multifetal pregnancy (3,569), preeclampsia/eclampsia (7,694), breech or transverse or oblique presentation (18,600), preterm labor (15,419), placenta previa (2,756), placental abruption (4,218), herpes simplex (293), and maternal age less than 14 years.⁵ This left 308,755 eligible deliveries for analysis (some subjects had more than 1 exclusion condition).

The rate of trial of labor rose from 21.5% in 1988 to 49.2% in 1998 and then declined to 42.9% in 2000 (Figure). The rates of VBAC and uterine rupture showed similar sharp increases until 1998 and a slight decrease thereafter (Figure). The use of trial of labor fell with advancing maternal age but increased with higher obstetric volume (Table I).

Twelve in-hospital maternal deaths occurred in the 13 years of the study: 10 in the elective cesarean section group and 2 in the trial-of-labor group. In the overall population and most subpopulation comparisons, the in-hospital maternal death rate was higher among women who were delivered by cesarean section than among women who were delivered vaginally (Table II).

The rate of uterine rupture observed in the trial-of-labor group was twice that of the elective cesarean group (Table III). On the other hand, the rates of puerperal infection and in-hospital maternal death were higher in the elective cesarean section group, although the CI for in-hospital maternal death included 1 (Table III).

The majority of cases of uterine rupture among women who underwent a trial of labor occurred in those who failed trial of labor (ie, ending with emergency cesarean deliveries). The maternal in-hospital death rate was also higher in the failed trial of labor group (Table IV).

For women who underwent a trial of labor, approximately half had labor induced. The risk of uterine rupture was significantly increased in women who had labor

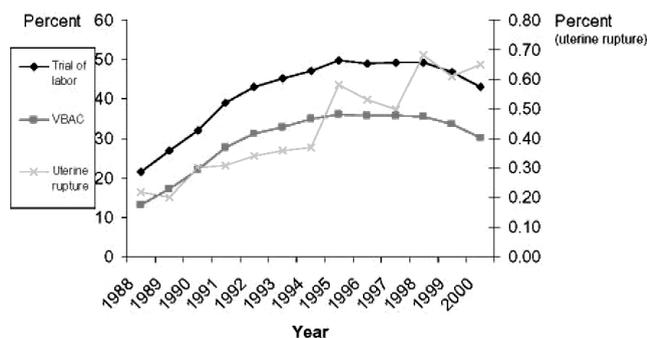


Figure Temporal trends in trial of labor, success VBAC, and uterine rupture in Canada, 1988 to 2000.

induced versus women who had spontaneous onset of labor (Table V).

The association between trial of labor and adverse outcomes was stronger in small-volume obstetric units (<500 births per year) than in large-volume units (≥ 500 births per year) (Table VI). For example, the adjusted odds ratios (relative to elective cesarean delivery) for uterine rupture were 4.02 (95% CI 2.48-6.51) and 2.30 (95% CI 2.04-2.59), and the odds ratios for in-hospital maternal death were 2.68 (95% CI 0.16-45.51) and 0.16 (95% CI 0.02-1.29), respectively, for women who gave birth in obstetric units with less than 500 births versus 500 or more births per year. Sensitivity analyses using different groupings for volume produced similar results, with increased risks observed only in units with less than 500 births per year (data not shown).

Comment

Trial of labor for women with “1 previous low transverse cesarean section, a singleton vertex presentation, and no absolute indication for cesarean section (such as placenta previa)” was recommended in Canada in 1985.²¹ We found that the rates of trial of labor and VBAC in Canada doubled from 1988 to 1998. The rate of trial of labor among women with previous cesarean section decreased slightly in more recent years, suggesting a more cautious approach in recent years, similar to the trends seen elsewhere.⁷

The use of trial of labor in this Canadian population was affected by maternal age and hospital size, with decreased use in older women but increased use among larger hospitals. These findings are consistent with the literature.^{1,5}

An important safety issue is whether a trial of labor will lead to catastrophic uterine rupture and consequent serious morbidity or death. The overall rate of uterine rupture tripled over the 13 years of study (Figure), probably owing to the increase in trial of labor rates. We found that the rate of uterine rupture in the

Table I Determinants of trial of labor in Canada, 1988 to 2000

Determinants	No. of births (n = 308,755)	No. (%) with trial of labor (n = 128,960)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)
Maternal age				
<20 y	3,589	1,692 (47.1)	1.23 (1.15-1.31)	1.27 (1.18-1.35)
20-29 y	130,217	54,758 (42.1)	Reference	Reference
30-34 y	114,538	48,876 (42.7)	1.03 (1.01-1.04)	1.00 (0.98-1.01)
35-39 y	52,189	20,799 (40.0)	0.91 (0.89-0.93)	0.87 (0.86-0.89)
≥40 y	8,219	2,834 (34.5)	0.73 (0.69-0.76)	0.69 (0.66-0.72)
Hospital size				
<500	30,668	8,516 (27.8)	0.50 (0.49-0.52)	0.49 (0.48-0.51)
≥500	278,087	120,444 (43.3)	Reference	Reference

Table II In-hospital maternal death rates (95% CIs) in various subgroups in Canada, 1988 to 2000

Subgroup	Number of deliveries	Number of deaths	Death rate (per 100,000)	Risk ratio (95% CI)
Women with a cesarean delivery	685,856	119	17.3	9.11 (6.62-12.53)
Women with a vaginal delivery	2,891,124	55	1.9	Reference
Women with an elective repeat cesarean delivery	209,007	23	11.0	5.25 (1.58-17.49)
Women with a trial of labor	143,208	3	2.1	Reference
Eligible women with an elective repeat cesarean delivery*	179,795	10	5.6	3.59 (0.79-16.37)
Eligible women with a trial of labor*	128,960	2	1.6	Reference

* After excluding women with a multifetal pregnancy, or preeclampsia/eclampsia, or breech or transverse or oblique presentation, or preterm labor, or placenta previa, or placental abruption, or herpes simplex, or age younger than 14 years.

trial-of-labor group was 0.65%, more than 2 times the rate in the elective cesarean section group. From the CIHI data source, we were not able to differentiate complete rupture from dehiscence. Kieser and Baskett²² reviewed 10-year cases (1988 to 1997) of uterine rupture in the Canadian province of Nova Scotia, based on a data set with clinical details that allowed a distinction between complete uterine rupture from dehiscence. They found a rate of complete uterine rupture of 0.13% and a rate of total (including both complete and dehiscence) uterine rupture of 0.31% among women with a previous cesarean delivery.²² The rate of uterine rupture in the overall sample (women with a previous cesarean delivery) in our study was 0.42%, which is slightly higher to the rate of total uterine rupture in Nova Scotia observed by Kieser and Baskett,²² suggesting that our data include both complete rupture and dehiscence.

Previous studies on the safety of trial of labor among women with a previous cesarean delivery have not observed any maternal deaths in either the elective cesarean section or trial-of-labor groups,^{1,3,4} probably

owing to their small sample sizes. In our large population-based study, however, we found the in-hospital maternal death rate among women with cesarean delivery to be substantially higher than among women with vaginal delivery (Table II). This could be explained by confounding by indication (ie, severe underlying maternal diseases requiring cesarean section). However, because the maternal in-hospital death rate remained substantially higher after extensive exclusion of women with various complications, we do not believe that this is the case (Table II). Surgical complications during cesarean section are probable causes of some of these deaths.

We have reviewed the clinical information of the 12 deaths and have conducted chart reviews for some of these deaths, although concerns about identifying individual cases prevent us from presenting the details here. Maternal age was similar (34.4 years in the 10 elective cesarean delivery cases vs 32.5 years in the 2 trial-of-labor cases). Among the 12 maternal deaths, only 4 had diagnosis codes suggesting underlying diseases, whereas embolic conditions and surgical complications were

Table III Comparison of mortality and morbidity among women with and without trial of labor in Canada, 1988 to 2000

Outcome	Number (%) with trial of labor (n = 128,960)	Number (%) with no trial of labor (n = 179,795)	Crude odds ratio (95% CI)	Adjusted* odds ratio (95% CI)
In-hospital maternal death	2 (1.6/100,000)	10 (5.6/100,000)	0.28 (0.04-1.35)	0.32 (0.07-1.47)
Uterine rupture	843 (0.65)	453 (0.25)	2.60 (2.32-2.93)	2.38 (2.12-2.67)
Thrombotic disorders	746 (0.58)	838 (0.47)	1.24 (1.12-1.37)	1.18 (1.07-1.31)
Postpartum infection	487 (0.38)	837 (0.47)	0.81 (0.72-0.91)	0.86 (0.77-0.97)
Transfusion	245 (0.19)	268 (0.15)	1.28 (1.07-1.52)	1.67 (1.39-2.00)
Hysterectomy	127 (0.10)	140 (0.08)	1.26 (0.99-1.62)	1.26 (0.99-1.61)

* Adjusted for year of birth, hospital volume, and maternal age; because of small number of deaths, maximum likelihood estimate for in-hospital maternal death may not exist.

Table IV Mortality and morbidity among women whose trial of labor succeeded (ending with vaginal delivery) versus failed (ending with emergent cesarean delivery), Canada, 1988 to 2000

	Failed trial of labor (n = 36,505)	Successful trial of labor (n = 92,455)	P value
In-hospital death	1 (2.7/100,000)	1 (1.1/100,000)	.496
Uterine rupture	714 (1.96%)	129 (0.14%)	< .001
Thrombotic disorders	207 (0.57%)	539 (0.58%)	.734
Postpartum infection	310 (0.85%)	177 (0.19%)	< .001
Transfusion	74 (0.20%)	171 (0.18%)	.509
Hysterectomy	63 (0.17%)	64 (0.07%)	< .001

Table V Morbidity among women with trial of labor by induction versus those who had spontaneous labor, Canada, 1988 to 2000

	Labor induction (n = 64,280)	Spontaneous labor (n = 64,680)	P value
In-hospital death	1 (1.6/100,000)	1 (1.5/100,000)	.99
Uterine rupture	524 (0.82%)	319 (0.49)	< .001
Thrombotic disorders	395 (0.61%)	351 (0.54%)	.09
Postpartum infection	254 (0.40%)	233 (0.36%)	.31
Transfusion	124 (0.19%)	121 (0.19%)	.81
Hysterectomy	61 (0.09%)	66 (0.10%)	.68

coded in 10. Our finding that maternal mortality tended to be higher among women with cesarean delivery than among those with vaginal delivery echoes the findings from previous studies, including randomized trials.⁸⁻¹⁶ Randomized trials comparing outcomes between elective cesarean section and trial of labor in women with breech presentation found an increased risk of a composite outcome of maternal death or severe early morbidity in the elective cesarean section group (relative risk 1.29, 95% CI 1.03-1.61), despite a high emergency cesarean section rate of 45% in the labor arm.¹⁶

Our comparison of maternal mortality was made between trial of labor (which might end in an emergent cesarean section) and elective cesarean section, which adequately reflects the decision-making process in the practice of obstetrics. In our data, most of the uterine rupture cases in women having a trial of labor occurred in the failed ones (ie, ending with emergent cesarean deliveries). On the other hand, only 1 maternal death occurred in 37,979 women with a failed and only 1 in 95,000 with a successful trial of labor (Table IV). These findings further support the argument that trial of labor is associated with increased risk of uterine rupture, but

elective cesarean section may increase the risk of maternal death.

Cesarean section is a major surgical procedure and carries a consistent increased risk of maternal death compared with vaginal birth.⁸⁻¹⁶ Such a risk should be considered by all concerned, including the pregnant woman. On the other hand, for the 2 maternal deaths in the trial-of-labor group, both had attempts at assisted vaginal delivery, successful in 1. One case had uterine rupture after induction of labor and was managed in a low-volume obstetric unit. The other case arrested in the second stage of labor with failed forceps, followed by cesarean section and postcesarean section bleeding.

Our results also suggest that inducing labor in women with a previous cesarean section significantly increases the likelihood of uterine rupture. This is consistent with recently published findings.⁶ Canadian guidelines on the practice of induction with the use of oxytocin in women with a previous cesarean section state that oxytocin should be used only after careful consideration of all other obstetrical factors.²³ In our study population, surprisingly, approximately half of all trials of labor were induced. Furthermore, during the study period, the

Table VI Comparison of occurrence of adverse outcomes among women with vs without trial of labor, stratified by obstetric volume (number of births per year), Canada, 1988 to 2000

Outcome	Number (%) with trial of labor	Number (%) with repeat cesarean section	Crude odds ratio (95% CI)	Adjusted* odds ratio (95% CI)
500 births per year (n = 30,668)				
In-hospital maternal death	1 (11.7/100,000)	1 (4.5/100,000)	2.60 (0.00-94.9)	2.68 (0.16-45.5)
Uterine rupture	45 (0.53)	28 (0.13)	4.20 (2.56-6.91)	4.02 (2.48-6.51)
Thrombotic disorders	28 (0.33)	71 (0.32)	1.03 (0.65-1.62)	1.05 (0.67-1.64)
Postpartum infection	26 (0.31)	61 (0.28)	1.11 (0.68-1.79)	1.17 (0.73-1.87)
Transfusion	68 (0.80)	128 (0.58)	1.39 (1.02-1.88)	1.56 (1.15-2.11)
Hysterectomy	7 (0.08)	11 (0.05)	1.66 (0.58-4.60)	1.69 (0.64-4.45)
≥500 births per year (n = 278,864)				
In-hospital maternal death	1 (0.8/100,000)	9 (5.7/100,000)	0.15 (0.01-1.11)	0.16 (0.02-1.29)
Uterine rupture	798 (0.66)	425 (0.27)	2.47 (2.19-2.78)	2.30 (2.04-2.59)
Thrombotic disorders	718 (0.60)	767 (0.49)	1.23 (1.11-1.36)	1.19 (1.08-1.32)
Postpartum infection	461 (0.38)	776 (0.49)	0.78 (0.69-0.87)	0.85 (0.75-0.95)
Transfusion	177 (0.15)	140 (0.09)	1.66 (1.32-2.08)	1.73 (1.39-2.17)
Hysterectomy	120 (0.10)	129 (0.08)	1.22 (0.94-1.57)	1.24 (0.96-1.59)

* Adjusted for year of birth and maternal age; because of small number of deaths, maximum likelihood estimate for in-hospital maternal death may not exist.

proportion of trials of labor that were induced increased from 43% to 52% (data not shown but available on request), suggesting a trend toward more liberal use of induction in this population, despite the increased risk. Recent research has reported that inducing labor with a vaginal prostaglandin among women with a previous cesarean section confers the highest risk for uterine rupture.⁶ Our data source do not allow consideration of the specific method of induction.

We found a higher risk of adverse outcomes associated with trial of labor in low-volume obstetric units (<500 births per year) than in high-volume units (≥500 births per year). For example, the adjusted odds ratios for uterine rupture were 4.02 (95% CI 2.48-6.51) and 2.30 (95% CI 2.04-2.59), respectively, for women who delivered in units with less than 500 versus those with 500 or more births per year (Table VI). For in-hospital maternal death, odds ratios relative to elective cesarean delivery (95% CIs) were 2.68 (0.16-45.50) and 0.16 (0.02-1.29), respectively, for low- (<500) and high- (≥500) volume obstetric units. Absolute risk is higher in high-volume units because women who were delivered there had more complications than those who were delivered in low-volume units. The fact that the relative risk of uterine rupture was higher in low-volume units, despite their overall lower-risk obstetric population supports the argument that the trial-of-labor-related risk of uterine rupture is higher in low-volume units. Other studies have found an increased risk of maternal complications in trial of labor conducted in small community hospitals.^{1,5} Similar phenomena have been observed in the care of surgical patients.²⁴ In our data, an average of only about 10 cases of trial of labor per year are per-

formed in typical low-volume obstetric units, which may not provide the number for physicians and nurses affiliated the opportunity to hone the skills required to manage complications.

Several limitations to our data require discussion. As in any observational study, possible imbalance among study groups cannot be entirely eliminated. To reduce the risk of imbalance between comparison groups, we used an extensive exclusion strategy and further adjusted for several potential confounding factors. However, these exclusions and adjustments may be insufficient, and residual confounding may still have occurred. Our study is based on administrative data, which lack clinical details.²⁵ For example, no information on the number of previous cesarean deliveries is available in our data. As a result, we could not separately assess the effects of trial of labor among women with 1 previous cesarean delivery from those with more than 1 previous cesarean deliveries. The lack of detailed clinical information also prevented us from exploring the reasons why there was a significant increase in thrombotic disorders and transfusions after trial of labor. Administrative data are also prone to a certain degree of coding errors.²⁵ However, in general, coding errors are likely to have occurred in a random fashion, which would tend to attenuate the observed effects.²⁶ On the basis of linked mother and infant records acquired from Med-Echo (a similar hospital discharge database from the Canadian province of Quebec), using preterm birth defined by gestational age less than 37 completed weeks as the “gold standard,” we found a concordance of 93% for the ICD-9 code-based diagnosis of preterm labor (data available on request). Although this result may not nec-

essarily be applicable to other diagnostic codes or other provinces, such high agreement suggests an acceptable quality of coding. On the other hand, coding errors may occur nonrandomly according to facility size. Larger units usually have designated personnel to only do obstetric coding versus multiple services. However, the nonrandom coding error should occur only in complicated diagnoses, and will not affect the straightforward diagnoses such as in-hospital death.

Observational studies remain the only source of current information for clinical and public health decision making for trial of labor. Our study compares favorably with previous clinical and epidemiologic studies in terms of sample size and population coverage. The consistent findings from many observational studies, including ours, suggest that uterine rupture constitutes the major risk associated with trial of labor. Our results also suggest, however, that more liberal use of elective cesarean section may increase the risk of maternal death.

Acknowledgments

We thank CIHI who gave us access to their data files, and Ling Huang for assistance in computer programming. This study was conducted under the auspices of the Canadian Perinatal Surveillance System. Drs Wen, Heaman, and Kramer are recipients of career investigator awards from the Canadian Institutes of Health Research, and Dr Walker is a career scientist of the Ontario Ministry of Health and Long-term Care.

References

- McMahon MJ, Luther ER, Bowes WA Jr, Olshan AF. Comparison of a trial of labor with an elective second cesarean section. *N Engl J Med* 1996;335:689-95.
- Miller DA, Diaz FG, Paul RH. Vaginal birth after cesarean: a 10 year experience. *Obstet Gynecol* 1994;84:255-8.
- Flamm BL, Goings JR, Liu Y, Wolde-Tsadik G. Elective repeat cesarean delivery versus trial of labor: a prospective multicenter study. *Obstet Gynecol* 1994;83:927-32.
- Rosen MG, Dickson JC, Westhoff CL. Vaginal birth after cesarean: a meta-analysis of morbidity and mortality. *Obstet Gynecol* 1991;77:465-70.
- Stone C, Halliday J, Lumley J, Brennecke S. Vaginal births after cesarean (VBAC): a population study. *Paediatr Perinat Epidemiol* 2000;14:340-8.
- Lydon-Rochelle M, Holt V, Easterling TR, Martin DP. Risk of uterine rupture during labor among women with a prior cesarean delivery. *N Engl J Med* 2001;345:3-8.
- Flamm BL. Vaginal birth after cesarean: what's new in the new millennium? *Curr Opin Obstet Gynecol* 2002;14:595-9.
- Bewley S, Cockburn J. The unfacts of 'request' cesarean section. *BJOG* 2002;109:597-605.
- Lilford RJ, van Coeverden de Groot HA, Moore P, Bingham P. The relative risks of cesarean section (intrapartum and elective) and vaginal delivery: a detailed analysis to exclude the effects of medical disorders and other acute pre-existing physiological disturbances. *BJOG* 1990;97:883-92.
- Schuitemaker N, van Roosmalen J, van Dongen P, van Geijin H, Gravenhorst JB. Maternal mortality after cesarean section in the Netherlands. *Acta Obstet Gynecol Scand* 1997;76:332-4.
- Hall MH, Bewley S. Maternal mortality and mode of delivery. *Lancet* 1999;354:776.
- Frigoleto FD, Ryan FJ, Phillippe M. Maternal mortality associated with cesarean section: an appraisal. *Am J Obstet Gynecol* 1980;136:969-70.
- Pettitti DB, Cefalo RC, Shapiro S, Whally P. In hospital maternal mortality in the United States: time trends and relation to method of delivery. *Obstet Gynecol* 1992;59:6-12.
- Moldin P, Hokegard K, Nielson TF. Cesarean section and maternal mortality in Sweden 1973-1979. *Acta Obstet Gynecol Scand* 1984;63:7-11.
- Rouse DJ, Owen J, Goldenberg RL, Cliver SP. The effectiveness and costs of elective cesarean delivery for fetal macrosomia diagnosed by ultrasound. *JAMA* 1996;276:1480-6.
- Hofmeyr GJ, Hannah ME. Planned cesarean section for term breech delivery. *Cochrane Database Syst Rev* 2001;1:CD000166.
- Health Canada. Canadian Perinatal Health Report, 2003. Ottawa: Minister of Public Works and Government Services Canada, 2003.
- Commission on Professional and Hospital Activities. International classification of disease, 9th rev. Clinical modification. Ann Arbor: The Commission; 1992.
- Canadian classification of diagnostic, therapeutic, and surgical procedures. Ottawa: Statistics Canada; 1986.
- Wen SW, Liu S, Marcoux S, Fowler D. Uses and limitations of routine hospital admission/separation records for perinatal surveillance. *Chronic Dis Can* 1997;18:113-9.
- Indications for cesarean section: final statement of the panel of the National Consensus Conference on Aspects of Cesarean Birth. *CMAJ* 1986;134:1348-52.
- Kieser KE, Baskett TF. A ten-year population-based study of uterine rupture. *Obstet Gynecol* 2002;100:633-7.
- Society of Obstetricians and Gynaecologists of Canada. Vaginal birth after caesarean birth. SOGC Clinical Practice Guidelines 1997;68.
- Wen SW, Simunovic M, Williams JI, Johnston KW, Naylor CD. Hospital volume, calendar age, and short term outcomes in patients undergoing repair of abdominal aortic aneurysms: the Ontario experience, 1988-1992. *J Epidemiol Commun Health* 1996; 50:207-13.
- Huston P, Naylor CD. Health services research: reporting on studies using secondary data sources. *CMAJ* 1996;155:1697-702.
- Rothman KJ, Greenland S. *Modern epidemiology*. 2nd ed. Philadelphia: Lippincott Raven Publishers; 1998.