Severe maternal morbidity in Canada, 1991–2001

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A longer version of this article is available at www.cmaj.ca/cgi/content/full/173/7/759.

Abstract

Background: Although death rates are often used to monitor the quality of health care, in industrialized countries maternal deaths have become rare. Severe maternal morbidity has therefore been proposed as a supplementary indicator for surveillance of the quality of maternity care. Our purpose in this study was to describe severe maternal morbidity in Canada over a 10-year period, among women with or without major pre-existing conditions.

Methods: We carried out a retrospective cohort study of severe maternal morbidity involving 2 548 824 women who gave birth in Canadian hospitals between 1991 and 2000. Thirteen conditions that may threaten the life of the mother (e.g., eclampsia) and 11 major pre-existing chronic conditions (e.g., diabetes) that could be identified from diagnostic codes were noted.

Results: The overall rate of severe maternal morbidity was 4.38 per 1000 deliveries. The fatality rate among these women was 158 times that of the entire sample. Rates of venous thromboembolism, uterine rupture, adult respiratory distress syndrome, pulmonary edema, myocardial infarction, severe postpartum hemorrhage requiring hysterectomy, and assisted ventilation increased substantially from 1991 to 2000. The presence of major pre-existing conditions increased the risk of severe maternal morbidity to 6-fold.

Interpretation: Severe maternal morbidity occurs in about 1 of 250 deliveries in Canada, with marked recent increases in certain morbid conditions such as pulmonary edema, myocardial infarction, hemorrhage requiring hysterectomy, and the use of assisted ventilation.

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Maternal mortality is an important measure of quality in maternity care.[1–3] However, maternal death rates are now so low in industrialized countries that use of the measure could cause complacency. Conversely, unstable statistics based on small numbers and resultant misinterpretation could lead to recommendations based on unusual events of little relevance to the care of most pregnant women.[4] Severe maternal morbidity has therefore been proposed as a supplementary indicator for monitoring the quality of maternity care.[1,2,4,5]

Severe morbidity appears along a health continuum that extends from normal pregnancy and delivery to organ failure and maternal death. In maternity care, severe morbidity and death betoken and therefore measure similar medical problems, but the incidence of severe morbidity is much higher. Well-established indicators of maternal morbidity based on a large body of data could be used to portray the magnitude of problems in maternal care and to improve its quality; for example, an excessively high rate for an indicator in a particular jurisdiction may warrant a local audit and appraisal of standard care.

A few studies have examined specific severe maternal morbidities such as amniotic-fluid embolism,[6] adult respiratory distress syndrome,[7] anesthesia,[8] eclampsia[9] and uterine rupture.[10] Information in the literature on comprehensive measures of severe maternal morbidity generated from a large population is sparse. Our objective in this study was to describe the occurrence and temporal trends in Canada of severe maternal morbidity among women with or without major pre-existing conditions, using information on hospital discharges compiled by the Canadian Institute for Health Information (CIHI).

Methods

A full description of the methods is available at www.cmaj.ca/cgi/content/full/173/7/759.

We analyzed data for women admitted to hospital for obstetric delivery from a national database capturing more than 70% of such deliveries. Because data on deliveries occurring in the provinces of Quebec, Manitoba and Nova Scotia were incomplete, they were excluded.

Conditions that could be reliably identified from the CIHI hospital-discharge database were included if they had potential to cause maternal death. The severe maternal morbidities we assessed included venous thromboembolism, eclampsia, complications of anesthesia affecting the pulmonary, cardiac or central nervous system, cerebrovascular disorders in the puerperium (including intracranial venous sinus thrombosis), uterine rupture, adult respiratory distress syndrome, pulmonary edema, myocardial infarction, acute renal failure after delivery, cardiac arrest or failure or cerebral anoxia after obstetric surgery, severe postpartum hemorrhage requiring hysterectomy or transfusion, and the need for assisted ventilation.

We also looked at the effects on the occurrence and severity of

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maternal morbidity of major pre-existing chronic diseases, including systemic lupus erythematosus, cystic fibrosis, chronic renal disease, essential hypertension, diabetes mellitus without and with (renal and other) complications, primary or secondary pulmonary hypertension, and congenital, chronic rheumatic and ischemic heart disease.

Estimation of the overall burden included calculations of the incidence of each of the conditions. To measure the severity of the chosen indicators, we calculated in-hospital death rates among women with various severe maternal morbidities and compared them with the in-hospital death rate for all women who gave birth during the study period. To assess whether we missed any important severe maternal morbidities, we examined ICD-9 codes in cases of death for conditions not included in our list. To examine variations in incidence, we compared the rates of severe maternal morbidities in 1991–1993 with those in 1998–2000 (fiscal years); for selected indicators, we graphed the rates yearly as well. To assess the effect of demographic changes we conducted additional analyses of temporal trends, adjusting for maternal age, multifetal pregnancy and previous cesarean delivery. We calculated the rates of various pre-existing conditions in our maternity sample and analyzed their relations to severe morbidity and in-hospital death.

Results

The CIHI database had records for a total of 2 548 824 obstetric deliveries (a number that excludes deliveries in Quebec, Manitoba and Nova Scotia) during the 10-year period of this study. Among these, we identified 11 066 cases with at least 1 condition defined by us as a severe morbidity, yielding an overall rate of 4.38 severe maternal morbidities per 1000 deliveries (Table 1). The rate of in-hospital death ranged from 7.5% among women who required assisted ventilation to 0.16% among those with anesthesia complications. The rate was far higher among women with severe maternal morbidity than in the overall study sample.

Some of the women who died in hospital had conditions not included in our list of severe maternal morbidities (Table 2).[11] When the entire sample population was considered, cardiac arrest unrelated to obstetric surgery was the condition coded most frequently; but when data on women who died who had no study-defined morbidities were analyzed, the code most frequently seen was that which indicates injury or poisoning.

Ten-year trends for 6 of the severe maternal morbidities considered are shown in Fig. 1 (complete data can be found in the third table of the unabridged version of this article, available at www.cmaj.ca/cgi/content/full/173/7/759). Rates of venous thromboembolism, uterine rupture, adult respiratory distress syndrome, pulmonary edema, myocardial infarction, severe postpartum hemorrhage requiring hysterectomy, and need for assisted ventilation increased substantially (≥ 50% or more) over the 10-year period; that for cerebrovascular disorders in the puerperium increased

Table 1: Rates in Canada* of severe maternal morbidity and in-hospital maternal deaths among the women with these morbidities, 1991–2001

Maternal morbidity	No. of cases	Rate per 1000 deliveries (95% CI)	Deaths (% of cases)
Cardiac arrest or failure or cerebral anoxia after obstetric surgery	2 677	1.05 (1.01–1.09)	37 (1.4)
Postpartum hemorrhage requiring transfusion	2 317	0.91 (0.87–0.95)	7 (0.3)
Uterine rupture	1 898	0.74 (0.71–0.78)	4 (0.2)
Pulmonary, cardiac or central-nervous-system complications of anesthesia	1 246	0.49 (0.46–0.52)	2 (0.2)
Eclampsia	973	0.38 (0.36–0.41)	4 (0.4)
Postpartum hemorrhage requiring hysterectomy	892	0.35 (0.33–0.37)	14 (1.6)
Cerebrovascular disorders in the puerperium, including intracranial venous sinus thrombosis	412	0.16 (0.15–0.18)	19 (4.6)
Pulmonary edema	402	0.16 (0.14–0.17)	3 (0.7)
Need for assisted ventilation	387	0.15 (0.14–0.17)	29 (7.5)
Venous thromboembolism	334	0.13 (0.12–0.15)	14 (4.2)
Acute renal failure after delivery	219	0.09 (0.07–0.10)	5 (2.3)
Adult respiratory distress syndrome	205	0.08 (0.07–0.09)	11 (5.4)
Myocardial infarction	31	0.01 (0.01–0.02)	2 (6.5)
Summary of women with morbidities†			
1 morbid condition only	10 307	4.04 (3.96–4.12)	41 (0.4)
2 morbid conditions	621	0.25 (0.23–0.27)	26 (4.2)
3 or more morbidities	138	0.06 (0.05–0.07)	17 (12.3)
Totals, women with ≥ 1 morbidity	11 066	4.38 (4.30–4.46)	84 (0.8)

*Excluding Quebec, Manitoba and Nova Scotia.
†Severe maternal morbidity, as defined in this study.

moderately (< 50%); that for severe postpartum hemorrhage requiring transfusion declined (Fig. 1); and those for eclampsia, anesthesia complications, acute renal failure after delivery, cardiac arrest or failure or cerebral anoxia after obstetric surgery, and overall severe maternal morbidity showed no consistent trends. Adjustment for maternal age, multifetal pregnancy and previous cesarean delivery did not change the results (data available upon request).

The database included 9352 cases with 1 or more of the specified pre-existing chronic diseases, yielding a proportion in our study population of 3.67 per 1000 deliveries (see online Table 4, available at www.cmaj.ca/cgi/content/full/173/7/759). Their rate of in-hospital death was 0.14%, higher than that among women without pre-existing chronic diseases but substantially lower than that among those with severe maternal morbidity.

The risk of severe maternal morbidity among women with pre-existing chronic diseases was increased substantially to 5.8-fold the risk among those without pre-existing conditions (Table 3). Increases for individual comorbidities ranged from only about 1.5- to 2-fold (uterine rupture, adult respiratory distress syndrome and postpartum hemorrhage requiring hysterectomy or transfusion) up to 30-fold (pulmonary edema) and 50-fold (myocardial infarction). Excluding women with at least 1 pre-existing chronic condition reduced the risk of in-hospital death among women with severe maternal morbidity conditions only slightly (see online Table 6 at www.cmaj.ca/cgi/content/full/173/7/759).

Interpretation

Our study provides an estimate of the incidence of and temporal trends in severe maternal morbidity, based on an analysis of the hospital admission and separation records collected by CIHI. This analysis yielded a rate of 4.38 per 1000 deliveries for severe maternal morbidity in the general

Table 2: Conditions* of the women who died in hospital that were not defined in this study as severe maternal morbidities

Condition	No. (%) of women† ≥ 1 morbidity‡ *n = 84*	No. (%) of women† No morbidities‡ *n = 39*
Cardiac arrest unrelated to obstetric surgery	24 (29)	5 (13)
Injury or poisoning	23 (27)	26 (67)
Pre-eclampsia	20 (24)	4 (10)
Obstetric shock	18 (21)	0 –
Previous cesarean section	17 (20)	0 –
Anemia	17 (20)	0 –
Pre-existing cardiovascular disease complicating pregnancy	13 (15)	0 –
Breech presentation	11 (13)	0 –
Defibrination syndrome	10 (12)	0 –
Infection	5 (6)	0 –
Cancer	4 (5)	13 (33)

*Conditions were identified from patients' charts by ICD-9 codes.
†Because patients may have more than 1 diagnosis apiece, numbers do not add up.
‡Severe maternal morbidity as defined in this study, concurrent with the condition listed here.

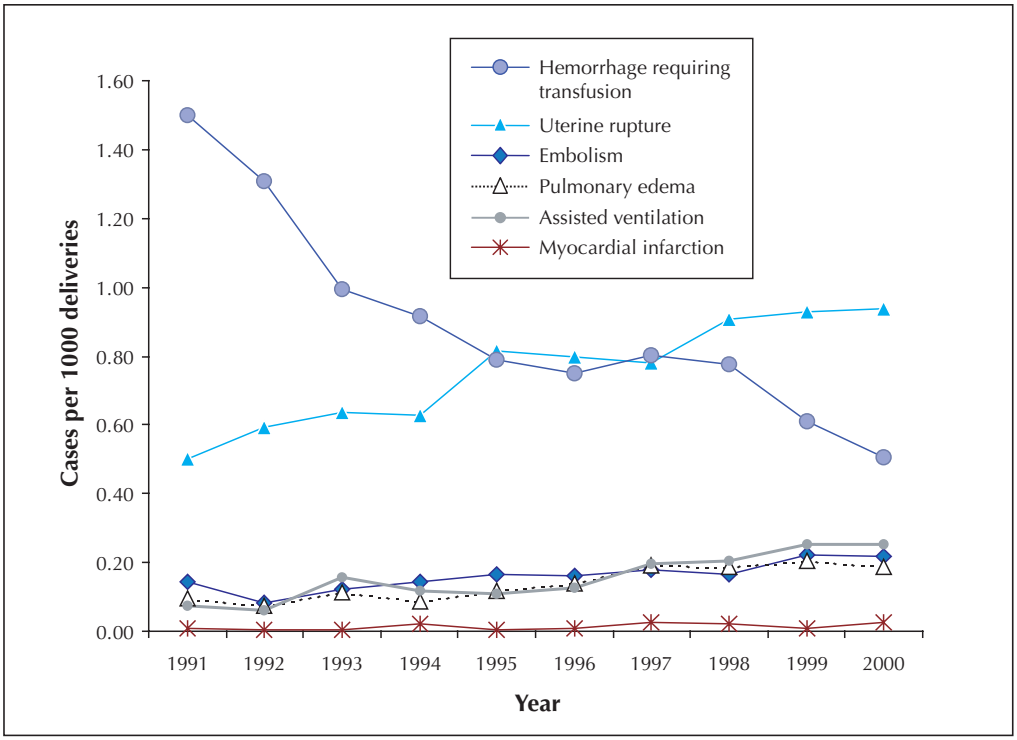

Fig. 1: Temporal trends in specific types of severe maternal morbidity in Canada, 1991–2001.

populace. We also observed large increases during the last decade in the rates of venous thromboembolism, uterine rupture, adult respiratory distress syndrome, pulmonary edema, myocardial infarction and severe postpartum hemorrhage requiring hysterectomy. The use of assisted ventilation increased as well. No change was observed in rates of eclampsia, anesthesia complications, acute renal failure after delivery, cardiac arrest or failure or cerebral anoxia after obstetric surgery, or overall severe maternal morbidity.

Our study also provides an estimate of the incidence of major pre-existing chronic diseases among pregnant women: 3.67 per 1000 deliveries. The presence of major pre-existing conditions predisposes pregnant women to an increased risk of severe maternal morbidity and mortality. (It should be recognized that it is sometimes difficult for one to separate chronic diseases from conditions that occur during pregnancy [e.g., thromboembolic disease] using ICD-9 codes.) Regardless of pre-existing chronic conditions, severe maternal morbidity occurs mostly among young and otherwise healthy women, because excluding women with pre-existing chronic diseases from our analysis reduced the overall risk of severe maternal morbidity only slightly.

Previous studies have estimated the incidence of individual causes of severe maternal morbidity.[7–10] Using medical charts for obstetric deliveries from the Medical Sciences Center of the University of Arkansas, Catanzarite and colleagues[7] estimated a rate of acute respiratory distress syndrome of 0.16 per 1000 deliveries. This rate is almost double that observed in our population (0.08 per 1000), probably owing to the high-risk obstetric population served at the US centre. Studies in Nova Scotia found that the rate of eclampsia was 0.27 per 1000 deliveries[9] and the rate of uterine rupture, 0.34 per 1000,[10] both lower than the rates observed in our study (0.38 per 1000 and 0.74 per 1000, respectively). The Nova Scotia data are more comprehensive and contain more clinical details, which may improve the accuracy of the diagnoses. Geographic variation in outcomes secondary to regional variations in practice is another possibility, one that should be explored in future studies.

Our study used administrative data, which are prone to a certain degree of coding error.[12] Particular attention should be paid to this when rare conditions (such as severe maternal morbidity) are involved, because the effect of coding errors is greater. In our preliminary analysis, for example, we found that the rate of myocardial infarction during pregnancy or delivery decreased markedly (from 0.26 per 1000 deliveries in 1991 to 0.03 per 1000 in 2000). This observation is counterintuitive and is not supported by changes in population demography (e.g., the increase in maternal age). Further exploration of this anomalous temporal pattern revealed that almost all of the myocardial infarction cases in 1991–1996 (342 cases of 353 in Canada) occurred in Saskatchewan, which accounts for only about 3% of the country's population. No myocardial infarction case was reported in that province after 1996. We therefore reclassified all myocardial infarction cases in Saskatchewan as non-cases, after which an increase to 3.5-fold in the rate of myocardial infarction in Canada during the 10 years of study was observed instead. Amniotic-fluid embolism is a severe maternal morbidity with a high case-fatality rate.[6] In the preliminary analysis we found that the incidence of amniotic-fluid embolism based on ICD-9 codes in CIHI data was about twice the rates seen in other clinical settings, whereas the case-fatality rate was only about half that reported in the literature.[6] These abnormalities cast doubt on the ICD-9 coding of this condition in CIHI data. Since we could not find the sources of coding errors and the means to correct them, we have not presented our study data on amniotic-fluid embolism.

In summary, we found that severe maternal morbidity occurs in about 1 of 250 deliveries in Canada. Considerable increases have occurred over the past decade in rates of venous thromboembolism, uterine rupture, adult respiratory distress syndrome, pulmonary edema, myocardial infarction, severe postpartum hemorrhage requiring hysterectomy, and the need for assisted ventilation. Because adjustment for maternal age, multifetal pregnancy and previous cesarean delivery did not change the overall results, these changes are unlikely to be caused by demographic trends; investigational attention should be paid to the reasons for these increases.

Table 3: Rates of severe maternal morbidity in Canada* among women with or without major pre-existing conditions, 1991–2001

Maternal morbidity	No. (%) of women (rate per 1000 deliveries)			
	≥ 1 pre-existing condition		No pre-existing conditions	
Venus thromboembolism	15	(1.60)	319	(0.13)
Eclampsia	17	(1.82)	956	(0.38)
Pulmonary, cardiac or CNS complications of anesthesia	20	(2.14)	1 226	(0.48)
Cerebrovascular disorders in the puerperium†	20	(2.14)	392	(0.15)
Uterine rupture	19	(2.03)	1 879	(0.74)
Adult respiratory distress syndrome	12	(1.28)	193	(0.08)
Pulmonary edema	46	(4.92)	356	(0.14)
Myocardial infarction	6	(0.64)	25	(0.01)
Acute renal failure after delivery	8	(0.84)	211	(0.08)
Cardiac arrest or failure or cerebral anoxia after obstetric surgery	68	(7.27)	2 609	(1.03)
Postpartum hemorrhage				
Requiring hysterectomy	8	(0.86)	884	(0.35)
Requiring transfusion	12	(1.28)	2 305	(0.91)
Need for assisted ventilation	20	(2.14)	367	(0.14)
Total, women with ≥ 1 morbidity	232	(24.34)	10 834	(4.27)

Note: CNS = central nervous system.
*Excluding Quebec, Manitoba and Nova Scotia.
†Including intracranial venous sinus thrombosis.

Severe maternal morbidity is associated with increased risk of maternal death and may result in substantial costs to the health care system and to society. Policy-makers and care providers should pay attention to this major public-health issue and devise interventions to prevent these "near miss" conditions or reduce their severity. We also found that the presence of major pre-existing chronic disease predisposes pregnant women to severe maternal morbidity. Finally, a large proportion of women who died in hospital, including those who had at least 1 condition meeting our criteria for severe maternal morbidity, had ICD-9 codes for conditions unrelated to pregnancy, such as injury or poisoning, cardiac arrest unrelated to obstetric surgery, and cancer, underlining the importance of injury prevention and appropriate treatment of pre-existing conditions in pregnant women.

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