

BRITISH COLUMBIA PERINATAL HEALTH PROGRAM

Optimizing Neonatal, Maternal and Fetal Health



Maternal Mortality in British Columbia

**British Columbia Perinatal Health Program
Special Report / September 2008**

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Maternal Mortality in British Columbia is a Special Report developed through the British Columbia Perinatal Health Program's Perinatal Mortality Review Committee in collaboration with British Columbia Vital Statistics Agency. The goal of this publication is to provide information regarding maternal mortality in BC in response to the Special Report on Maternal Mortality and Severe Morbidity in Canada published by Health Canada in 2004 [1].

About the British Columbia Perinatal Health Program

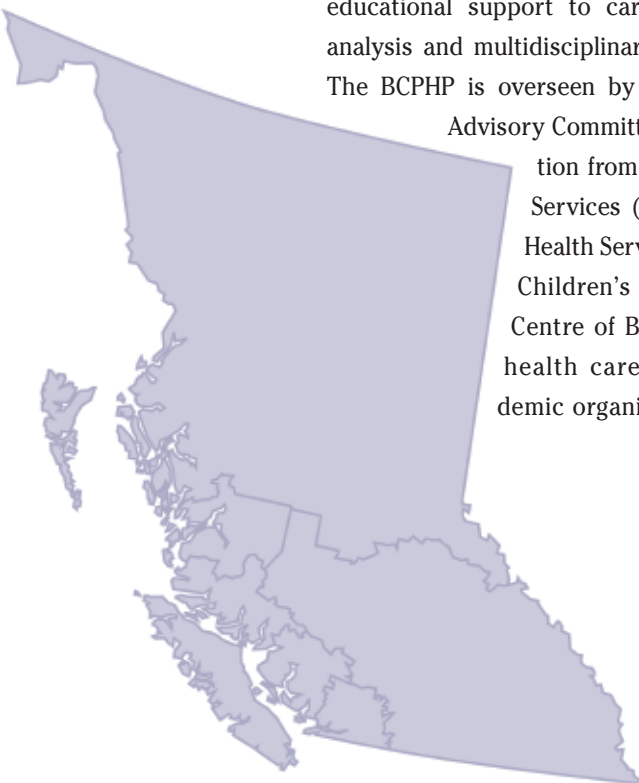
The Ministry of Health and the British Columbia Medical Association (BCMA) initiated the British Columbia Reproductive Care Program (BCRCP) in June 1988. The BCRCP became part of the Provincial Health Services Authority (PHSA) in 2001 when the government of British Columbia introduced five geographically based health authorities and one provincial health service authority. In 2007, a new organizational structure – the BC Perinatal Health Program (BCPHP) – was created to coordinate both the BCRCP and the Provincial Specialized Perinatal Services (PSPS). The BCPHP continues to work towards optimizing neonatal, maternal and fetal health in the province through educational support to care providers, outcome analysis and multidisciplinary perinatal guidelines. The BCPHP is overseen by a Provincial Perinatal

Advisory Committee and has representation from the Ministry of Health Services (MOHS), the Provincial Health Services Authority (PHSA), Children's and Women's Health Centre of BC, Health Authorities, health care providers, and academic organizations.

One of the mandates of the BCRCP is “the collection and analysis of data to evaluate perinatal outcomes, care processes and resources via a province-wide computerized database”. This mandate led to the development of the British Columbia Perinatal Database Registry (BCPDR), with its stated mission to collect, maintain, analyze and disseminate comprehensive, province-wide perinatal data for the purposes of monitoring and improving perinatal care. Rollout of the Registry began in 1994, with collection of data from a small number of hospital sites. Participation increased every year, resulting in full provincial data collection commencing April 1, 2000. The BCPDR is a relational database containing over 300 fields, and with complete provincial data, is a valuable source of perinatal information.

The BCPDR currently maintains records for more than 400,000 births that have been collected from obstetrical facilities throughout the province as well as births occurring at home attended by BC Registered Midwives. BC women who deliver out of province are not captured in the BC Perinatal Database Registry.

Data from the Canadian Institute for Health Information (CIHI) and matched files from the British Columbia Vital Statistics Agency complement the data elements.



On January 27, 1998, an Order in Council was signed by the Attorney General of British Columbia providing the Perinatal Mortality Review Committee of the British Columbia Reproductive Care Program with the designation of a Quality Review Committee under Regulation 363/95, paragraph (c) of 51(2) of the Evidence Act. The objective of the Perinatal Mortality Review Committee (PMR) is to review and report on maternal and perinatal mortality and morbidity to identify provincial concerns and recommend strategies to address these concerns. The PMR Committee is committed to a provincial approach to support quality in maternity care services and, as such, multidisciplinary representation from each Health Authority, College of Midwives and Aboriginal Health has been undertaken. Clinical representation includes obstetricians, neonatologists, pediatricians, nurses, anesthetists and midwives.

In addition, commitment to review findings, make recommendations and formulate subsequent reports with the Vital Statistics Agency of British Columbia, Coroners Service of British Columbia and Health Care Protection Program (HCPP) has been established.

The BC Perinatal Mortality Review Committee had been inactive for a number of years following the Order in Council in 1998. Subsequent to the Special Report on Maternal Mortality and Severe Morbidity in Canada published by Health Canada in 2004, the importance of this committee became evident and a revised membership list was submitted to amend the Order in Council on July 21, 2006. (Appendix A).

The mandate of the BC Perinatal Mortality Review Committee is to:

1. Collect accurate data on maternal mortality in British Columbia through liaison with the BC Perinatal Database Registry, the Office of the Chief Coroner in BC, and BC Vital Statistics.
2. Establish a data collection tool to facilitate review of maternal mortality and severe maternal morbidity.
3. Assist local Perinatal Mortality Committees in conducting appropriate review of maternal deaths.
4. Establish a process for the collection of British Columbia Perinatal Mortality data and review causes of potentially preventable stillbirths and early neonatal deaths.
5. Produce reports analyzing potentially preventable causes of direct and indirect maternal deaths.

In accordance with the mandate of the Perinatal Mortality Review Committee, a series of activities were completed. A maternal mortality collection tool (Maternal Mortality Review Form) was designed to facilitate data collection as part of the chart review of identified maternal mortality cases. A maternal morbidity adverse outcome index (Harvard Adverse Outcome Index) was also explored. The Harvard Adverse Outcome Index uses three indicators to describe the frequency and severity of adverse events occurring during labour and delivery, which include maternal death and severe maternal morbidity [2]. Subsequent to applying this index to a subset of BC data, differences in rates and severity of adverse events were noted between Health Authorities and hospitals. The BC Perinatal Mortality Review Committee recommended adopting the Harvard Adverse Outcome Index as a method for ongoing surveillance of maternal mortality and morbidity in BC. Finally, a maternal mortality and morbidity survey was conducted in order to determine the status of local hospital and regional perinatal mortality and morbidity review processes and to identify consistencies in reporting of maternal death. The findings of this survey showed significant hospital and regional disparities in review structures.

This Special Report describes the results compiled from a review conducted of the maternal deaths in British Columbia from 2000 to 2006 with the collaboration of the Vital Statistics Agency of BC and the Coroners Service of BC.

Health Canada's Special Report on Maternal Mortality and Severe Morbidity in Canada published in 2004 conveyed the importance of enhanced maternal death surveillance systems in order to increase awareness of the occurrence and ultimate prevention of maternal deaths [1]. At the time of publication of the Health Canada report, only three provinces and one territory in Canada were noted to have established maternal death review committees. Although an Order in Council had been signed in 1998 by the Attorney General of British Columbia providing the Perinatal Mortality Review Committee of the British Columbia Reproductive Care Program with the designation of a Quality Review Committee under Regulation 363/95, paragraph (c) of 51(2) of the Evidence Act, this committee had been inactive for a number of years. The importance of this deficiency was identified as a priority and a process was undertaken to re-activate the Perinatal Mortality Review Committee of British Columbia.

This Special Report describes some of the causes of maternal mortality in British Columbia over a seven-year period and uses information from the recent scientific literature to provide an informed perspective on the issue.

Maternal mortality is an important indicator of the risks of pregnancy and childbirth, a woman's status, a woman's access to healthcare and the ability of the healthcare system to provide appropriate and effective care to the woman [3]. Maternal mortality has nevertheless decreased considerably during the twentieth century, especially in developed countries [4] with Canada's maternal mortality rate one of the lowest in the world [1]. In 2005, in Canada, the maternal mortality rate was estimated as 7 per 100,000 live births [5]. However, with over 536,000 maternal deaths occurring worldwide in 2005 [5], the importance of accurately identifying, quantifying and classifying maternal mortality is critical in improving quality of care and reducing maternal death in British Columbia and throughout the world [1].

The data used for this analysis were obtained from the British Columbia Perinatal Database Registry (BCPDR) as well as the Vital Statistics Agency of British Columbia and Coroners Service of British Columbia.

The BCPDR is a comprehensive, province-wide perinatal database, which contains information on perinatal events, outcomes and care processes at a hospital, regional and provincial level. Data from January 1, 2000 to December 31, 2006 were used for the purposes of this report.

The Vital Statistics Agency of British Columbia (VSA) is responsible for the ascertainment, registration and certification of vital events under the Vital Statistics Act, Marriage Act and Name Act [6]. Information provided through the VSA is obtained from the Medical Certification of Death completed by the physician or coroner and the Registration of Death completed by the informant with assistance from the funeral home [6].

The Coroners Service of British Columbia is responsible for the investigation of all unnatural, sudden and unexpected, unexplained or unattended deaths [7]. The Coroners Service is a fact-finding agency that provides independent service to the family, community, government agencies and other organizations [7]. The information provided through the Coroners Service was classified as “coroner cases” only.

For the purposes of this study, identification of maternal deaths was based on indication in the medical certification of death that the woman was in a pregnant state at death or if death occurred within one year of her delivery date based on Vital Statistics data. The underlying cause of death was assigned a code from Chapter XV (Pregnancy, childbirth and

the puerperium) of the 10th Revision of the International Classification of Diseases and Related Health Problems (ICD-10) [8]. The underlying cause of death information was provided by the Vital Statistics Agency of BC. Expert chart review was carried out for 20 cases by the BCPHP to facilitate completion of the Maternal Mortality Review Form. Classification of maternal death was carried out using the ICD-10 definitions as determined by the World Health Organization (WHO) [8]. (Appendix B).

Maternal deaths were categorized as [8]:

- **Direct** if death occurred as a result of an obstetrical complication of the pregnant state (pregnancy, delivery and postpartum), from interventions, omissions, or incorrect treatment or from a chain of events involving any of the former,
- **Indirect** if the obstetrical complication resulted from a previous existing disease or disease that developed during pregnancy, which was not due to direct obstetric causes but which was aggravated by the physiological effects of pregnancy,
- **Incidental** if the conditions occurred during pregnancy but the pregnant state unlikely contributed significantly to the death and
- **Late** if the death occurred more than 42 days, but less than one year postpartum including direct and indirect obstetric causes.

Maternal mortality ratio (MMR) was calculated using international standards as the combined number of direct and indirect maternal deaths per 100,000 live births [8]. Direct, indirect and overall MMRs were calculated. Age-specific MMRs were calculated using a 95% confidence interval. Rates based on few cases should be interpreted with caution.

Maternal Deaths in British Columbia, 2000 to 2006

Review of data afforded through the VSA and the Coroners Service of BC demonstrated that there were 85 maternal deaths in British Columbia (BC) between 2000 and 2006 (Table 1). Of the 85 maternal deaths, 12 (14.1%) deaths were due to direct obstetric causes, while 10 (11.8%) were related to indirect obstetric causes. Incidental maternal deaths (deaths not related to pregnancy) accounted for 16 (18.8%)

of the maternal deaths in BC. Another category, other/pending, was created to represent maternal deaths that could not be categorized to the major groupings of direct, indirect, incidental or late maternal deaths based on the current definitions. This category outnumbered both direct and indirect obstetric deaths by 2:1 for a total 47 maternal deaths. The other/pending cases were mainly incidental deaths occurring during the postpartum period greater than 42 days.

Table 1
Categorization of maternal deaths in British Columbia, 2000 to 2006

Type of Maternal Death	Total Maternal Deaths	
	#	%
Direct Obstetric	12	14.1
Indirect Obstetric	10	11.8
Incidental Obstetric Deaths	16	18.8
Other/Pending Obstetric Deaths	47	55.3
Total	85	100.0

Source: BC Perinatal Database Registry, BC Vital Statistics Agency, BC Coroners Service

Table 2
Type of maternal death and maternal mortality ratio (MMR) per 100,000 live births in British Columbia, 2000 to 2006

Type of Maternal Death	Total Deaths	Maternal Mortality Ratio (MMR)
	#	%
Direct Obstetric	12	4.2
Indirect Obstetric	10	3.5
Total	22	7.8

Source: BC Perinatal Database Registry, BC Vital Statistics Agency, BC Coroners Service

Table 3
Direct maternal death by underlying cause of death and obstetric period, British Columbia, 2000 to 2006

Underlying Cause of Death	Obstetric Period			Total
	Pregnant	During Delivery	Postpartum <42 Days	
Thromboembolism	2	2	2	6
Pulmonary edema			1	1
Thrombosis, cardiac arrest			2	2
Rupture of spleen	1			1
Postpartum hemorrhage		1		1
Infection			1	1
Total	3	3	6	12

Source: BC Perinatal Database Registry, BC Vital Statistics Agency, BC Coroners Service
*Underlying cause of death diagnosis provided by BC Vital Statistics Agency

The maternal mortality ratio (MMR) was calculated as the number of direct maternal deaths and indirect maternal deaths per 100,000 live births. The total maternal mortality ratio (MMR) for British Columbia from 2000 to 2006 was 7.8 with a direct MMR of 4.2 and an indirect MMR of 3.5 per 100,000 live births (Table 2).

Chart Review

A chart review was completed for 20 out of the 85 cases. The chart review provided the information required to complete the Maternal Mortality Review Form for each of the 20 cases and facilitated in classifying the type of maternal death for each case. All of the direct causes of death cases (12) were reviewed and half of the indirect causes of death cases were reviewed (5). One incidental obstetric case and two cases of pending/other obstetric death were also reviewed.

Table 3 illustrates the etiology and obstetric period during which direct maternal death occurred. Thromboembolism including amniotic fluid embolism was the leading cause of direct maternal death, accounting for 50% or six of the direct maternal deaths and 7.1% of all maternal deaths. All but one of these maternal deaths was associated with or immediately following caesarean section. Two maternal deaths resulted from thrombosis with subsequent cardiac arrest and one each from pulmonary edema, postpartum hemorrhage, infection and ruptured spleen.

Of the ten indirect maternal deaths (Table 4), five were due to diseases of the circulatory system (e.g. intracerebral hemorrhage, subarachnoid hemorrhage, aortic dissection, arteriovenous malformation

of the cerebral vessels), two were due to malignant neoplasm, and one each due to septic shock with subsequent cardiopulmonary arrest and asphyxiation.

Table 4
Indirect maternal death by underlying cause of death and obstetric period, British Columbia, 2000 to 2006

Underlying Cause of Death	Obstetric Period			
	Pregnant	During Delivery	Postpartum <42 Days	Total
Epilepsy , unspecified	1			1
Diseases of the circulatory system (intracerebral hemorrhage, subarachnoid hemorrhage, aortic dissection, arteriovenous malformation of cerebral vessels)	2		3	5
Malignant neoplasm			2	2
Septic shock, cardiopulmonary arrest			1	1
Other specified threats to breathing, with asphyxiation	1			1
Total	4	0	6	10

Source: BC Perinatal Database Registry, BC Vital Statistics Agency, BC Coroners Service
 *Underlying cause of death diagnosis provided by BC Vital Statistics Agency

A significant portion of incidental maternal deaths was related to motor vehicle accidents (Table 5). Of the 16 incidental maternal deaths, 10 or 62.5% resulted from a motor vehicle accident. Three of the

incidental maternal deaths resulted from suicide and one each from accidental overdose, epilepsy, drowning and acute cocaine intoxication.

Table 5
Incidental maternal death by underlying cause of death and obstetric period, British Columbia, 2000 to 2006

Underlying Cause of Death	Obstetric Period				
	Pregnant	During Delivery	Postpartum <42 Days	Postpartum >42 Days	Total
Accidental overdose	1				1
Acute cocaine intoxication	1				1
Epilepsy, unspecified	1				1
Motor vehicle accident	9		1		10
Suicide	3				3
Total	15	0	1	0	16

Source: BC Perinatal Database Registry, BC Vital Statistics Agency, BC Coroners Service
 *Underlying cause of death diagnosis provided by BC Vital Statistics Agency

Of note are the high numbers of maternal deaths in the other/pending category (Table 6), suggesting that although the mortality rates are low at 7.8 per 100,000 live births in BC (Table 2) based on deaths due to

classic obstetric indicators and definitions, given that complications and adverse outcomes of pregnancy can extend beyond 42 days postpartum, a wider scope of maternal deaths should be examined [5, 9].

Table 6
Other/Pending maternal death by underlying cause of death and obstetric period, British Columbia, 2000 to 2006

Underlying Cause of Death	Obstetric Period					Total
	Pregnant	During Delivery	Postpartum <42 Days	Postpartum >42 Days	Unknown	
Atherosclerotic heart disease				1		1
Bronchopneumonia				2		2
Cardiomegaly				1		1
Cholelithiasis				1		1
Congenital cerebral cysts				1		1
Intracerebral hemorrhage, unspecified				1		1
Malignant neoplasm				7		7
Myocarditis				1		1
Non-Hodgkin's Lymphoma				1		1
Other convulsions				1		1
Other secondary pulmonary hypertension				1		1
Systemic lupus erythematosus				1		1
Unspecified cardiac arrhythmia				1		1
Unspecified viral intestinal infection				1		1
Aneurysm of iliac artery (pending)			1			1
Death due to external causes**			3	18	1	22
Final cause of death pending or unknown***	1			2		3
Total	1	0	4	41	1	47

Source: BC Perinatal Database Registry, BC Vital Statistics Agency, BC Coroners Service

*Underlying cause of death diagnosis provided by BC Vital Statistics Agency

**Includes drowning, homicide, motor vehicle accident, suicide, unintentional overdose, avalanche, unspecified injury of undetermined intent, sequelae of other unintentional injury

***Includes pending coroner's investigation – probably motor vehicle accident, and unknown cause of death

Table 7
Maternal Mortality ratio (MMR) per 100,000 live births by maternal age, British Columbia, 2000 to 2006

Maternal Age	Deaths	Livebirths	MMR (95% CI)
<20 years	0	10,992	
20 – 24 years	3	43,225	6.94 (1.43-20.28)
25 – 29 years	6	79,607	7.54 (2.76-16.39)
30 – 34 years	6	91,080	6.59 (2.44-14.32)
35 – 39 years	4	48,334	8.28 (2.25-21.17)
40 years and older	3	10,097	29.71 (6.13-86.94)
Total	22	283,335	7.77 (4.86-11.75)

Source: BC Perinatal Database Registry, BC Vital Statistics Agency, BC Coroners Service

Note: Late terminations are included.

Maternal Age

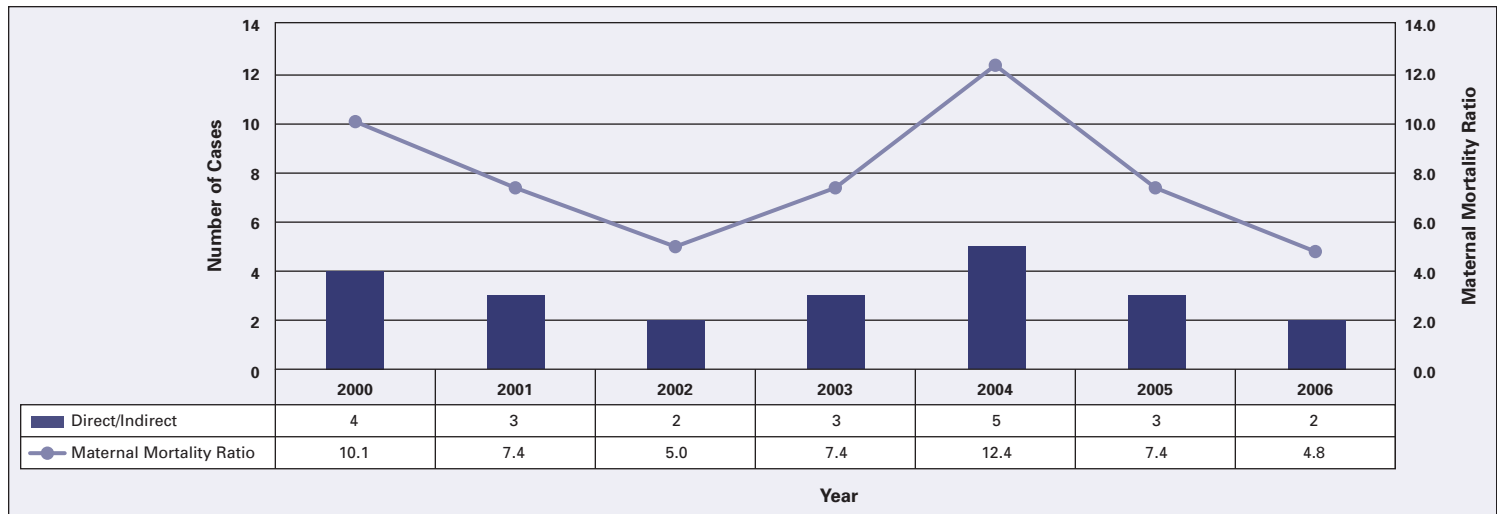
The maternal mortality ratio (MMR) shows a higher MMR with increasing maternal age for women 20 years and older (Table 7). Nevertheless, the number of deaths in several of the age categories is small in relation to the number of live births with resultant wide confidence levels and should be examined with caution. The maternal age for women over the age of 35 has steadily increased in British Columbia from 8.1% in 1986 to 22.3% in 2006 [6]. With women of increased maternal age at increased risk for pregnancy-related death [10,11] as well as increased adverse pregnancy outcomes [12,13], the surveillance of maternal mortality in high-risk groups is critical in reducing maternal mortality.

Maternal Mortality Trends

Trends in maternal deaths in British Columbia were further explored by analyzing yearly data from 2000 to 2006. Due to the small number of cases, a clear trend in maternal mortality ratio over time could not be identified (Figure 1). Moreover, regional stratification not only failed to identify a pattern across the seven-year period, but also effected a high risk of a

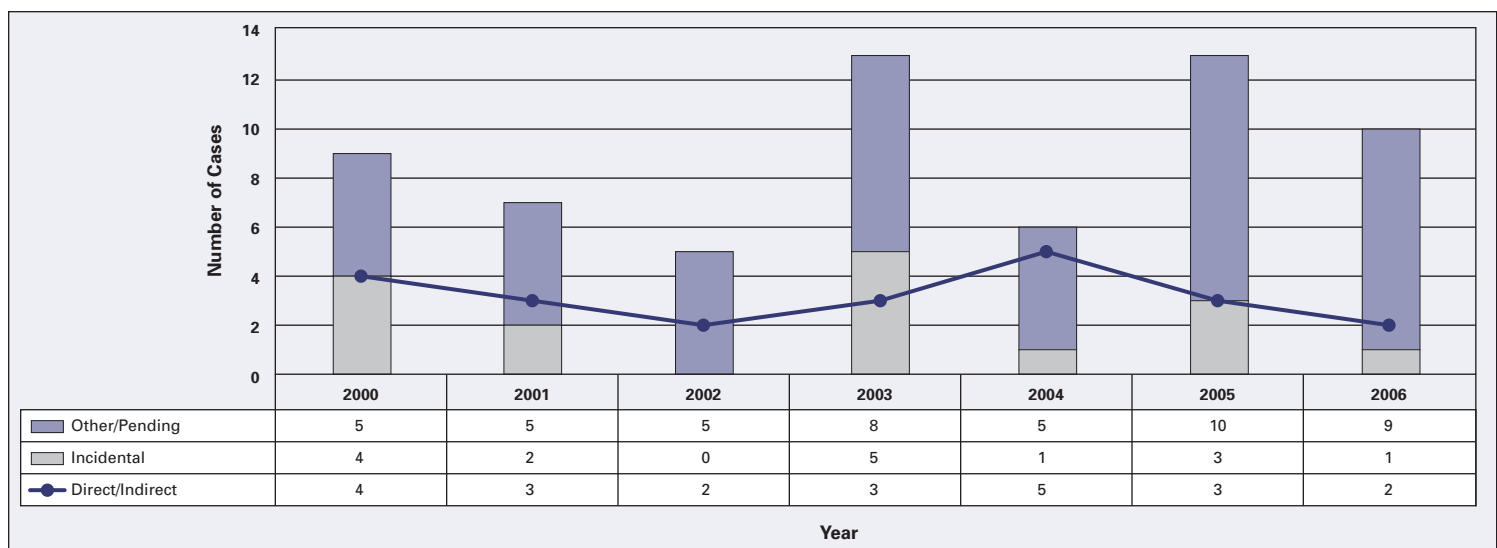
breach of confidentiality due to the small number of cases. The total number of incidental and other/pending cases were consistently greater than the direct and indirect maternal deaths (Figure 2) over time, with the other/pending deaths exceeding the number of incidental deaths.

Figure 1
Number of direct and indirect cases of maternal death and maternal mortality ratio per 100,000 live births, British Columbia, 2000 to 2006



Source: BC Perinatal Database Registry, BC Vital Statistics Agency, BC Coroners Service

Figure 2
Comparison of indirect/direct and incidental/other/pending maternal deaths in British Columbia, 2000 to 2006



Source: BC Perinatal Database Registry, BC Vital Statistics Agency, BC Coroners Service

This analysis shows that the maternal mortality in British Columbia between 2000 and 2006 was 7.8 per 100,000 live births, consistent with Canada's estimated maternal mortality of 7 per 100,000 live births. Thromboembolism including amniotic fluid embolism accounted for 50% of the direct maternal deaths while motor vehicle accidents accounted for 60% of the incidental maternal deaths in BC. Of the proportion of all maternal deaths, six out of 85 (7.1%) were due to thromboembolism, while 16 out of 85 (18.8%) were a result of motor vehicle accidents.

Thromboembolism

In well-developed countries, the incidence of maternal mortality from hemorrhage, infection, and preeclampsia has been reduced significantly in the last 30 years [14]. Thromboembolism is now the leading cause of maternal mortality in well-developed countries [1,14,15] and accounted for half of the direct maternal deaths in British Columbia from 2000 to 2006. It is worthwhile, therefore, to discuss current evidence regarding strategies to prevent thromboembolic disease in pregnancy, not only because of its association with caesarean section but also due to the rising caesarean section rates [14,16].

Physiologically, pregnancy itself is a hypercoagulable state. The classic triad of Virchow predicting the likelihood of venous thrombosis include stasis, hypercoagulable state, and trauma. Pregnancy is a condition where coagulation factors increase by as much as 50% of their prepregnancy values [17]. Lower limb stasis is always present because of the compression of the vena cava with the presence of the expanding uterus. It is recognized that 90% of deep venous thrombosis occur in the left leg as a result of this compression [18]. Finally, trauma with release of thromboplastin such as seen at caesarean section or

operative vaginal delivery increases the postpartum risk of thrombosis four fold [19]. The overall risk of thrombosis related to pregnancy is ten times higher than in the non-pregnant state [20,21,22].

Evidence in the form of randomized controlled trials regarding various prophylactic methods to reduce thromboembolism risk is relatively lacking in the literature, primarily because the prevalence of fatal and even seriously morbid thromboembolism in pregnancy is still very low. A Cochrane review in 2002 reports that there is at present insufficient data from randomized controlled trials to suggest one form of prophylaxis over another [23]. Perhaps the best retrospective cohort data comes from the Confidential Enquiries into Maternal Deaths in the United Kingdom [14]. In an attempt to stem the tide of deaths from venous thromboembolism (VTE) following caesarean section, the Royal College of Obstetricians and Gynaecologists (RCOG) in Britain recommended thromboprophylaxis using heparin in patients undergoing caesarean section [24]. Low risk women with no antecedent risk factors for VTE undergoing elective caesarean section only require early mobilization and rehydration [24].

Women at moderately increased risk included the following [24]:

1. patients >35 years of age
2. obesity with BMI >30
3. concurrent infection
4. preeclampsia
5. prolonged bed rest or physical immobility
6. shock/dehydration
7. nephrotic syndrome
8. sickle cell disease
9. parity IV or greater
10. all patients undergoing emergency caesarean section in labour.

Furthermore, the RCOG classified patients at high risk as having three or more risk factors as outlined above as well as extended surgery such as caesarean hysterectomy, personal or family history of deep venous thrombosis, pulmonary embolism or thrombophilia, and paralysis in the lower limbs and antiphospholipid antibody syndrome [24]. For high-risk patients, both heparin prophylaxis and venous compression stockings (TEDS) were recommended [24].

Current literature favours the use of low molecular weight heparin over traditional unfractionated heparin because of the reduced incidence of heparin-induced thrombocytopenia, allergic reactions, and osteopenia [25,26,27].

The Society of Obstetricians and Gynaecologists of Canada (SOGC) produced guidelines written by Dr. Nancy Kent and the Maternal Fetal Medicine Committee in 2000 [28]. These guidelines quoted the RCOG guidelines from Great Britain but stopped short of recommending heparin prophylaxis for all emergency caesarean sections. They concluded that no prospective studies exist to evaluate the effectiveness of thromboprophylaxis following a caesarean section to prevent VTE [28]. The RCOG in Britain has issued a report recommending the use of postpartum thromboprophylaxis (within 4 hours) in women who have moderate to high risk for VTE [21].

Prophylaxis needs to be considered in the presence of risk factors such as previous VTE, a known thrombophilia (IIB), a history of prolonged immobility or obesity (IIIC) [29]. It is recommended to start treatment following delivery of the neonate at the time of caesarean section using the following [21]:

1. Unfractionated heparin 5000 units subcutaneously every 12 hours until fully mobile, or
2. Low molecular weight heparin, such as Enoxaparin 20mg or Dalteparin 5000 units, subcutaneously once a day for 5 days.

Following publication of the aforementioned guidelines, the Confidential Enquiries into Maternal Deaths in the United Kingdom reported substantial decrease in the risk of VTE associated with caesarean section [30]. Unfortunately, in the same document, a slight increase in death from thromboembolism not associated with caesarean section was noted primarily because of failure to recognize risk factors such as obesity, diabetes, and operative vaginal delivery [30]. There is also evidence from the UK that, despite published guidelines recommending thromboprophylaxis at caesarean section, only 17% of eligible patients receive same at the time of emergency caesarean section [31]. This clearly points to the need for both public and practitioner education regarding thromboprophylaxis in pregnancy.

Motor Vehicle Safety in Pregnancy

In the Health Canada Special Report on Maternal Mortality and Severe Morbidity in Canada only 30 incidental deaths were noted in the period 1997 – 2000. Of the 30 incidental deaths, 15 or 50% occurred in association with motor vehicle trauma. Clearly, the impact of incidental deaths in the Health Canada report was significantly underreported. Data limitation regarding incidental deaths is noted by Health Canada [1]. Reporting of incidental deaths is the most common reason for underreporting of associated pregnancy in CIHI data, especially when the pregnancy is remote to the timing of the motor vehicle accident in the late postpartum period. The epoch of 2000 – 2006 in British Columbia demonstrated 16 of the 85 maternal deaths reported to be incidental and a substantial percentage of these were associated with motor vehicle trauma.

Once again, the pregnant patient is particularly at high risk, as is the fetus, when exposed to motor vehicle trauma during pregnancy or the puerperium. Data abstracted from crash test dummy experiments using pregnancy models suggests several factors that predispose to injury; improper use of the lap belt, allowing it to ride up higher than the bony pelvis such that direct pressure is placed on the

uterus in the case of a sudden deceleration injury [32,33]. A significant amount of shearing force is directed across the uterus in such circumstances, often resulting in placental abruption and/or direct fetal trauma [33]. More importantly, the uterus in the second and third trimester is dangerously close to the steering column when the pregnant patient is the driver of the vehicle. This steering column proximity does not allow for proper deployment of the airbag in sufficient time to prevent significant abdominal trauma [33,34].

Similar to the situation with respect to venous thrombembolism, it is clear from survey data in published reports that physicians are either unaware of appropriate motor vehicle safety counselling for pregnant women or in many circumstances do not offer the appropriate counselling during the antenatal period. Public education regarding motor vehicle safety in pregnancy is also lacking and in need of significant enhancement. A clear recommendation from the generation of this Maternal Mortality Report will be to produce a guideline through the BCPHP guideline development process to enhance information regarding motor vehicle safety to both practitioners and the public.

Limitations

This report on maternal mortality in British Columbia was limited by several factors. Examination of data across a seven-year period provided a general summary of maternal mortality in British Columbia. Due to the small number of cases, a more extensive and comprehensive study on the trends in the causes and rates of maternal mortality over time could not be completed.

Underreporting of maternal death as documented in the literature [4,35] may be an inherent limitation in all studies reporting maternal mortality. Inaccurate completion of death certificates, [4], inadequate determination at the time of death that the woman was pregnant or that cause of death was attributed to a non-maternal cause [8] and errors in coding the underlying cause of death [4] are some of the reasons for the underestimation of maternal deaths.

Distinguishing between incidental maternal deaths and indirect causes of maternal death can be problematic [1,36] and may, in fact, contribute to the underreporting of maternal death and lead to a misconception as to the extent of the problem of maternal mortality [35].

This report demonstrated a number of maternal deaths that could not be categorized under the current maternal death definitions. Deaths occurring beyond 42 days postpartum are noted in this report, but not included in mortality rate calculations (maternal mortality rate is calculated as the combined number of direct and indirect maternal deaths per 100,000 live births). By extending the period of maternal surveillance past 42 days, more accurate reporting of maternal deaths would result.



Conclusion

Maternal mortality rates, although low in industrialized countries like Canada, remains a public health concern. Improved surveillance of maternal mortality and severe morbidity [1, 37], availability of appropriate and improved healthcare for pregnant women [1] as well as a healthy population [1] are important factors that aid in the reporting and reduction of maternal mortality. As suggested in the Special Report on Maternal Mortality and Severe Morbidity in Canada, review of all maternal deaths in Canada requires consistency in the identification of maternal deaths and comparability in defining pregnancy related deaths amongst review committees as well as between provinces. Standardized regional, provincial and national surveillance systems reporting on maternal mortality and severe maternal morbidity are essential in monitoring the quality of maternity care in the prevention of maternal mortality and severe maternal morbidity [1].

Although late maternal deaths and incidental maternal deaths are not included in the calculation of maternal mortality rates, the importance of reporting these deaths was visibly evidenced in the findings of this report.

With thromboembolism as the leading cause of direct maternal deaths in Canada and other developed

countries, health professionals must be cognizant of women at risk for thromboembolism early in the prenatal period. Pregnant women are ten times more at risk of developing venous thromboembolism than non-pregnant women [20]. Public information should therefore be made available such that women with body mass index >30, family or personal history of deep vein thrombosis or pulmonary embolism, history of preeclampsia or other risk factors associated with thromboembolism obtain guidance before pregnancy.

More than half of the incidental maternal deaths as reported in the Maternal Mortality in British Columbia report from 2000 to 2006 were associated with motor vehicle accidents. Public awareness as well as conscious effort by health care professionals is unquestionably required regarding motor vehicle safety during pregnancy.

Finally, the BCPHP Mortality Review Committee is committed to continue to review, monitor and report on maternal mortality for the province of British Columbia. Comprehensive identification of maternal death, classification of the causes of death and determination of groups at increased risk of death are all significant in reporting maternal mortality and morbidity and subsequently improving maternal and newborn outcomes.

Appendix A – Provincial Perinatal Mortality Review Committee Members

Dr. Duncan Farquharson – Chair, Medical Director, British Columbia Perinatal Health Program

Ms. Karen Vida – Program Director, British Columbia Perinatal Health Program

Ms. Sheryll Dale – Manager, British Columbia Perinatal Database Registry, British Columbia Perinatal Health Program

Dr. Robert Liston – Chair, Provincial Perinatal Surveillance Committee, Children’s and Women’s Health Centre of BC

Dr. Brian Lupton – Clinical Director, Special Care Nursery, Children’s and Women’s Health Centre of BC

Dr. Bob Fisk – Director, Epidemiology, Ministry of Health

Ms. Anna-Maria Laughlin – Medical Advisor, Knowledge Management and Technology Division, Vital Statistics Agency of BC

Dr. Jerome Dansereau – Acting Chief, Department of Obstetrics, Victoria General Hospital, Vancouver Island Health Authority

Dr. Peter Hill – VP, Academic Research and Clinical Systems Redesign, Fraser Health Authority

Dr. Trent Smith – Pediatrics, Interior Health Authority

Dr. Brenda Wagner – Obstetrician, Vancouver Coastal Health Authority

Dr. Roberto Leon – Obstetrics and Gynecology, Northern Health Authority

Dr. Wayne MacNicol – Head of Obstetrics, Whitehorse General Hospital, Yukon Territory

Dr. Duncan Etches – Family Practice Consultant, UBC Family Practice Centre

Ms. Sarah Hein – Aboriginal Health, Carrier Sekani Family Services, Prince George

Ms. Catherine West – Antepartum Home Care Nurse, College of Registered Nurses of British Columbia

Jacquelyn Cameron – Clinical Resource Nurse, College of Registered Nurses of British Columbia

Ms. Jane Wines – Midwife, College of Midwives of British Columbia

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Appendix B – Definitions of Maternal Death [7]

Maternal Deaths – Deaths of women while pregnant or within 42 days of termination of the pregnancy, irrespective of the site or duration of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes.

- **Direct Obstetric Deaths** – Maternal deaths resulting from obstetric complications of the pregnant state (pregnancy, labour, and puerperium), interventions, omissions, or incorrect treatment, or a chain of events resulting from any of the above.
- **Indirect Obstetric Deaths** – Maternal deaths resulting from previous existing disease or disease that developed during pregnancy, which was not due to direct obstetric causes but which was aggravated by the physiologic effects of pregnancy.

Incidental Deaths – Maternal deaths due to conditions occurring during pregnancy, where the pregnancy is unlikely to have contributed significantly to the death, although it is possible to postulate a distant association.

Late Maternal Deaths – Deaths in women from direct or indirect obstetric causes occurring between 42 days and one year after the end of the pregnancy.

Appendix C – Glossary

Harvard Adverse Outcome Index – The Harvard Adverse Outcome Index was developed in a large multicenter trial in the United States. This index uses three indicators: the adverse outcome index (AOI), the weighted adverse outcome score (WAOS) and the severity index (SI) to describe the frequency and severity of events occurring during labour and delivery, which includes maternal death and severe maternal morbidity. The Harvard Adverse Outcome Index was tested for applicability in the British Columbia population with a subset of BC data. Differences were noted in rates and severities of adverse events between Health Authorities and hospitals. The BC Perinatal Mortality Review Committee recommended adopting the Harvard Adverse Outcome Index as a method for ongoing surveillance of maternal mortality and morbidity in British Columbia.

Late terminations – The medical termination of a pregnancy beyond 20 weeks of gestation.

Maternal deaths – Deaths of women while pregnant or within 42 days of termination of the pregnancy, irrespective of the site or duration of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes.

MMR – Maternal Mortality Ratio – Number of direct and indirect maternal deaths per 100, 000 live births during a specified time period (World Health Organization).

Other – Maternal deaths due to incidental causes during the postpartum period greater than 42 days and up to one year after the end of the pregnancy.

Pending – Coroner’s case where underlying cause of death is yet to be finalized.

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