ORIGINAL RESEARCH

Barbara S.E. Verstraeten, M.D.^{1,2},
Jane Mijovic-Kondejewski, Ph.D.¹
Jun Takeda, M.D.^{1,3}
Satomi Tanaka, M.D.^{1,3}
David M. Olson, Ph.D., FRCOG¹

¹Department of Obstetrics and Gynaecology,
Faculty of Medicine and Dentistry, University
of Alberta, Edmonton, Canada

²Department of Obstetrics and Gynecology,
Faculty of Medicine & Health Sciences, Ghent
University, Ghent, Belgium.

³Department of Obstetrics and Gynaecology,
Juntendo University Faculty of Medicine, To-
kyo, Japan

Canada's pregnancy-related mortality rates: doing well but room for improvement

Abstract

Purpose: Canada's perinatal, infant and maternal mortality rates were examined and compared with other Organization for Economic Cooperation and Development (OECD) countries. The type and the quality of the available data and best practices in several OECD countries were evaluated.

Source: A literature search was performed in PubMed and the Cochrane Library. Vital statistics data were obtained from the OECD Health Database and Statistics Canada and subjected to secondary analysis.

Principal findings: Overall, Canadian pregnancy mortality rates have fallen dramatically since the early 1960's. Perinatal and infant mortality rates remain low and stable, but the maternal mortality rate has increased slightly and both mortality rates have declined in their relative OECD rankings over the last 20 years. Data quality and coverage across Canada and internationally, especially for Indigenous peoples, is inconsistent and registration practices differ greatly, making comparisons difficult. Available data do show that Indigenous people's perinatal and infant mortality rates are nearly twice those of the general population. Best practices in other OECD countries include Australia's National Maternity Services plan to improve Aboriginal perinatal health, the Netherlands' midwifery services and National Perinatal Registry and Japan's national pregnancy registration and Maternal Handbook.

Conclusion: To diminish Canadian disparities in perinatal health rates and improve health outcomes we recommend a) uniform registration practices across Canada, b) better data quality and coverage especially among Indigenous communities, c) adoption of a national pregnancy registration and a maternal handbook along with d) improved midwifery and primary practice services to rural and remote communities. At a time when Canada is focusing upon improving pregnancy health in developing nations, it also needs to address its own challenges in improving pregnancy outcomes.

Manuscript submitted 1st August, 2014
Manuscript accepted 27th January, 2015

Clin Invest Med 2015; 38 (1): E15-E36.

Correspondence to:
David M. Olson, Ph.D., FRCOG
University of Alberta
220 HMRC, Edmonton, AB T6G 2S2, Canada
Email: david.olson@ualberta.ca

Canada has shown itself to be a world leader in the global effort to reduce maternal and child mortality by identifying Maternal, Newborn and Child Health (MNCH) as its top international development priority. In May 2014, Canada hosted the *Saving Every Woman, Every Child: Within Arm's Reach* summit, a high-level meeting to support MNCH, as a follow-up of the G-8 Muskoka Initiative of 2010, in which Canada spearheaded a global effort to save the lives of millions of mothers, newborns and children in developing countries [1, 2]. As a consequence of this initiative, plus related worldwide efforts, especially the World Health Organization's (WHO) Millennium Development Goals, maternal, neonatal and infant mortality rates have declined among the world's most vulnerable people by 45%, 28% and 34%, respectively, between 1990 and 2010 [3]. While the federal government is leading this international initiative and directly supporting efforts in ten of the world's neediest countries, it is timely to examine how well Canada is doing at home in dealing with its own perinatal mortality issues and benchmarking these against other countries. Reasonable comparisons of the data have been published by the Organization for Economic Co-operation and Development (OECD). The OECD, consisting of 34 nations from Europe, North- and South-America and the Asia-Pacific region, is dedicated to global development and the wellbeing of people around the world. As such, it is one of the world's most trustworthy sources of comparable health and other statistics. The purpose of writing this review is

- i) to examine perinatal health rates and trends within regions and provinces of Canada;
- ii) to examine perinatal health rates among the Canadian Indigenous peoples;
- iii) to assess where sufficient good quality data exist and where improvements in data collection are needed;
- iv) to benchmark Canadian perinatal health rates against other OECD countries;
- v) to identify specific examples that may help improve perinatal health outcomes in Canada;
- vi) to identify what Canadian health care does well and where improvements could be made; and,
- vii) to make recommendations based upon this examination.

Methods

Literature search

A literature search was performed using PubMed and the Cochrane Library with the terms *perinatal*, *neonatal*, *infant* and *maternal mortality*, including all acronyms and synonyms, as well as the search words *indigenous*, *developed countries*, *preg-*

nancy, *perinatal outcome and stillbirth*, *Canada*, *Japan*, *the Netherlands* and *Australia*. Articles were selected based on abstract content and date of publication between 2000 and 2014. Ancestor and descendant search strategies were used as well, including earlier publications if the article was highly applicable. Full text was obtained for the articles that were deemed relevant. The reasons for comparing Canadian rates with those of Japan, the Netherlands and Australia are found in the *Pregnancy-related mortality rates in other OECD countries* section.

Definitions (see Fig. 1)

Perinatal mortality rate

The OECD defines perinatal mortality rate as the ratio of deaths of infants within one week of birth (early neonatal deaths) combined with fetal deaths at a minimum gestation period of 28 weeks or a minimum fetal weight of 1,000 g, expressed per 1,000 total births (live and stillbirths)[4]. This is the same as the weight-specific definition ($\geq 1,000$ g) of the WHO. The non-weight specific definition for WHO includes fetuses weighing at least 500 g, when birth weight is unavailable after 22 completed weeks of gestation, or a crown-heel length of 25 cm or more occurs, plus the number of early neonatal deaths. Live births are defined by the WHO as the complete expulsion or extraction of a product of conception from its mother, irrespective of the duration of pregnancy, evidence of life, whether or not the umbilical cord has been cut or the placenta is attached [5]. Variations in the definition of perinatal mortality exist for some countries, especially regarding fetal deaths and, therefore, comparisons between countries should be made carefully.

Fetal mortality rate

Fetal mortality rate is most commonly defined in Canada as all fetal deaths with a gestational age at delivery of 20 weeks or more, or a birth weight of at least 500 g, per 1,000 total births. Quebec uses a slightly different definition by only using the birth weight criterion (≥ 500 g)[6]. For international comparisons, the WHO and OECD suggest using a different definition: the perinatal mortality rate in fetuses of gestational age at least 28 weeks or a birth weight of $\geq 1,000$ g [7], although this definition seems to be outdated for most of the OECD countries. Both these rates are reported by Statistics Canada [4, 8].

FIGURE 1. Visualization of the definitions of perinatal and infant mortality (Adapted with permission from [184]).

Neonatal mortality rate

Neonatal mortality is defined by the OECD as the number of deaths of children under 28 days of age in a given year, expressed per 1,000 live births in that same year [4]. Variations exist between countries regarding the registration practices for preterm born children. While most countries do not use gestational age or weight limits, some countries use a combination of gestational age, birth weight and/or survival to limit for mortality registration.

Infant mortality rate

The description of infant mortality rate as used by the OECD is based on the definition published by the United Nations (UN) in 1991 [9]. It outlines the infant mortality rate as the number of deaths under one year of age that occurred in a given year expressed per 1,000 live births occurring among the population of a given geographical area during the same year. Neonatal mortality registration for premature infants differs between countries, urging care to be exercised when comparing these rates. Infant mortality can be divided into three groups: early neonatal (0-6 days), late neonatal (7-28 days) and postneonatal mortality (28-364 days). Early neonatal mortality is also part of the definition of perinatal mortality. For postneonatal deaths, the denominator is the number of children surviving past 28 days [6, 10].

Maternal mortality rate

The OECD follows the recommendation of the tenth edition of the International Statistical Classification of Diseases and

Related Health Problems of the WHO (ICD-10) for defining maternal death. Death during pregnancy, childbirth and the puerperium is defined as the death of a woman during pregnancy or within 42 days of termination of the pregnancy, irrespective of the duration or the site of the pregnancy and irrespective of the cause of death [5]. The current version of the ICD was first published in 1992 by the WHO, as a revision of the ICD-9 [11], and was implemented by member states starting in 1999. An 11th revision of the ICD is currently being prepared [12].

The ICD-10 divides maternal deaths into two groups: direct and indirect obstetric deaths. Direct obstetric deaths are those resulting from obstetric complications of pregnancy, as well as from interventions, omissions, incorrect treatment, or from a chain of events resulting from any of the above. Indirect obstetric deaths arise from a previously existing disease or a disease that developed during pregnancy and that was not due to a direct obstetric cause but that was aggravated by the physiological effects of pregnancy. As of ICD-10, a new category of late maternal death was created, which is the death of a woman from either direct or indirect causes more than 42 days, but less than a year, after termination of the pregnancy [13].

The maternal mortality rate (MMR) is defined in accordance with the definition of the United Nations as the number of puerperal deaths from all causes, per 100,000 live births, as classified by the ICD-10 codes O00 to O99 (codes 630-676 under ICD-9) [9]. This definition, however, does not represent a true rate as the numerator has cases, such as maternal deaths after abortions or ectopic pregnancies, which are not repre-

sented in the denominator. Therefore it is a ratio, rather than a rate, although many sources refer to it as a rate [14].

Data collection

Vital statistics on perinatal, infant and maternal deaths for the years 1960-2011 were collected for all OECD countries using OECD, WHO and UN databases and were aggregated in an Excel file. The UN database, UNData, pools data from major UN databases as well as from several international databases (UNICEF, WHO, UN Population Division, World Bank and other sources) into one environment. The UN Interagency Group for Child Mortality Estimates, which has representatives from the previously mentioned institutions, formulates child mortality estimates based on the information available [15]. Missing rates were calculated based on the reported number of deaths of the group of interest and the number of total or live births as reported by the individual country-specific statistics agencies. Additional statistics for Canada were acquired from Statistics Canada.

Statistics

Secondary analysis of existing data obtained from the OECD Health database and Statistics Canada was performed. Mortality rates for OECD countries from 1960 to 2010 were ranked lowest (best) to highest (worst) to determine the rank of Canada, Australia, the Netherlands and Japan.

Results and Discussion

Provincial/territorial data accumulation within Canada

It is widely acknowledged that there are considerable issues with the quality of vital statistics data from Ontario [6, 10, 16]. Errors in birth weight as well as gestational age resulted in an apparent increase in low-birth weight infants and preterm birth rate [17]. The current data on birth weight and gestational age appear to be nearly error-free; however, there are still other concerns regarding the under-registration of live births, especially among vulnerable sub-populations [18]. Linking birth registrations to infant death registrations has consistently resulted in a considerable number of unlinked infant deaths; i.e., 40% of unlinked infant deaths in 2003 in Ontario compared with 1% in all other provinces and territories combined [17]. For these reasons, Ontario data remain excluded from the calculation of indicators. The maternal mortality ratio is the only indicator that is included [6, 10, 16-18].

Quebec does not contribute to the Canadian Institute of Health Information (CIHI)'s Discharge Abstract Database,

which collects information on hospital discharges, including deaths. Data from Quebec are directly submitted to CIHI by the Ministère de la Santé et des Services Sociaux du Québec [19]. Therefore, Quebec data are not included in all indicators.

Manitoba data have only been included since 2004/2005 because of incomplete data prior to that time [10]. Newfoundland on the other hand, had been excluded from calculations until 1991, as no data were forwarded to Statistics Canada prior to 1991 [20].

Data comparison between OECD countries

Several well-known institutions, such as the OECD, provide international rankings based on perinatal, infant and maternal mortality; however, the validity of these rankings is questionable because of wide variations in live birth and stillbirth registration practices [21-25]. Therefore, care must be taken when comparing perinatal health data between countries, since they use varying criteria to describe the same mortalities.

Large differences have been reported in infant mortality between and within both developed and developing countries. For industrialized countries, these differences are, at least in part, the result of vast differences in birth and death registration of infants near the borderline of viability; those with a birth weight of less than 500 g. Other potential sources of variation are the use of different cut-offs of gestational age and/or birth weight for reporting fetal deaths and live births, as well as the classification of deaths as neonatal *vs.* stillbirths [16, 23, 25]. For this reason, the WHO recommends the use of a cut-off of at least 1,000 g for live births when making international comparisons of infant mortality [5]. The Canadian Perinatal Surveillance System, therefore, reports information on IMR among live births ≥ 500 g as well as crude infant mortality rates [26, 27].

Countries also use different criteria for the classification of stillbirths. Most countries use the WHO definition of stillbirth, with a birth weight of 500 g and gestational age of 22 weeks, as cut-offs; however, some countries use different definitions based on birth weight and/or gestational age. Most provinces and territories in Canada use a lower limit of at least 20 weeks with a birth weight of ≥ 500 g for stillbirths. For other OECD countries, there is also considerable variation between nations: Hungary (24 weeks), Greece (28 weeks), Portugal (24 weeks) and Sweden (28 weeks until 2007, 22 weeks since 2008) all have higher cut-offs, leading to an underestimation of stillbirths in those countries [28], while Australia has a cut-off of 22 weeks or 400 g [29].

Disparities between provinces and territories in Canada can be explained, at least in part, by the use of prenatal diagno-

FIGURE 2. Perinatal (a), infant (b) and maternal mortality rates (c) in Canada according to OECD data, 1960-2011 [37]. Perinatal mortality is defined by the OECD as the ratio of deaths of children within one week of birth; i.e., early neonatal deaths, plus fetal deaths with a minimum gestation of 28 weeks or minimal fetal weight of 1000 g, expressed per 1000 total births. The infant mortality rate is the number of deaths under one year of age, expressed per 1000 live births, while maternal mortality is the death of a woman during pregnancy or within 42 days of termination of the pregnancy, irrespective of the duration or the site of the pregnancy, irrespective of the cause of death, expressed per 100,000 live births [4, 5].

FIGURE 3. Ranking of the perinatal (a), infant (b) and maternal mortality rate (c) among OECD countries for Canada, Australia, the Netherlands and Japan from 1960 to 2011. Australia's definition of perinatal mortality deviated from the OECD definition before 1979 (fetal deaths of 500 g at delivery or 22 weeks of gestation) and from 1999 onwards (fetal deaths of 400 g or 22 weeks of pregnancy at delivery). Furthermore, the data between 1978 and 1998 include live births under 1000 g. For Japan, live births are registered regardless of gestational age, so even very premature babies are registered as live births [4, 37].

TABLE 1. Perinatal mortality rates per 1,000 total births, infant mortality rates per 1,000 live births, and subdivisions, according to place of residence in Canada, its provinces and territories for 2011.¹

Jurisdiction	Perinatal mortality rates ²			Infant mortality rates		
	Overall	Late fetal ³	Early neonatal ³	Overall	Neonatal	Post-neonatal
Newfoundland and Labrador	8	3.1	4.9	6.3	5.1	1.1
Prince Edward Island	0 ⁶	0 ⁶	0 ⁶	4.2	2.1	2.1
Nova Scotia	5.5	2.6	2.9	4.9	3.7	1.1
New Brunswick	6.4	4.3	2.1	3.5	2.5	1
Quebec ⁴	5.5	2.8	2.7	4.3	3.3	1
Ontario ⁵	5.9	2.8	3.0	4.6	3.7	1
Manitoba	9.3	4.7	4.6	7.7	5.4	2.3
Saskatchewan	8.4	4.5	4.0	6.7	5.4	1.3
Alberta	6	2.6	3.4	5.3	4	1.2
British Columbia	4.7	2.5	2.2	3.8	2.4	1.4
Yukon	2.3	2.3	0.0	0 ⁷	0 ⁷	0 ⁷
Northwest Territories	5.8	2.9	2.9	7.2	2.9	4.3
Nunavut	23.6 ⁸	10.6 ⁸	12.9 ⁸	26.3	13.1	13.1
Canada	6	2.9	3.0	4.8	3.6	1.2

¹Data extracted from tables 102-0507 and 102-0508 from Statistics Canada [38, 55]. For definitions, see *Materials and methods, Definitions* as well as Figure 1.

²Perinatal deaths are defined as early neonatal deaths (0-6 days) or stillbirths ≥ 28 weeks of gestation.

³Ratios were calculated based on the number of deaths and total births provided by Statistics Canada [38, 185].

⁴Quebec uses a different definition for fetal deaths, registering only those weighing ≥ 500 g, regardless of gestational period [6].

⁵Because of considerable issues with vital statistics data quality in Ontario, Ontario data are not included in the calculation of these indicators [6, 10].

⁶In Prince Edward Island, considerable year-to-year differences exist, possibly because of the population size or reporting issues. For 2010, the total perinatal, late fetal and early neonatal rates were 7.1, 5.6 and 1.4 per 1,000 total births, respectively.

⁷Yukon infant mortality rates were 0 in 2011. In 2010 the total neonatal and post-neonatal mortality rates were 5.2, 2.6 and 2.6 per 1,000 live births, respectively.

⁸As for Prince Edward Island, Nunavut's perinatal mortality rates differ greatly per year. For 2010 the total, late fetal and early neonatal rates were 7.2, 4.7 and 2.3 per 1,000 total births, respectively.

sis and pregnancy termination for congenital anomalies. Although these are insured services within Canada, the availability and uptake of these services are variable and depend on local factors, with differences in access to these services among regions and between remote rural and urban areas. In places where an increase in prenatal diagnosis and pregnancy termination has occurred, there has been a decrease in overall infant mortality at the population level, because of a decline in late fetal and infant deaths due to birth defects [16].

Measurement, comparability and value of MMR data

The OECD data are based on vital statistics and although WHO regards the civil registration data for all OECD countries, except Turkey, as complete with good attribution of the cause of death, it is widely accepted that the Vital Statistics death registration system underestimates the number of maternal deaths when compared to other, more comprehensive methods [30-32]. This might be due to inconsistencies in death attribution, misclassification of ICD-10 coding or improper completion of the death certificate. Furthermore, within Can-

ada, and perhaps other countries as well, these data exclude people living in Canada, but with non-resident status, as well as late maternal deaths and pregnancy-related deaths [30, 33].

In order to achieve higher ascertainment, as well as to increase MMR comparability and allow evaluation of trends over time, enhanced surveillance mechanisms are necessary. Models of these surveillance mechanisms are available from several countries, including Australia and the United States [34, 35]; however, the UK's Confidential Enquiry into Maternal Deaths (CEMD) is widely regarded as the "gold standard" [36]. The CEMD, which is now part of the MBBRACE-UK (Mothers and Babies: Reducing Risks through Audits and Confidential Enquiries across the UK), was established in 1952. Its aim is to improve the safety of motherhood by reviewing maternal deaths on a timely and nationwide basis, publishing their findings and recommendations every three years. The national requirement to report all maternal deaths, to subject them to a confidential enquiry, as well as for all health professionals to provide the required information, is of critical importance. The most recent CEMD report described 60% more maternal deaths than those reported through the routine civil registration system [36].

Another element that could cause disparities is the coverage of data collection. Civil registration systems often have different inclusion criteria for non-residents and usually include only citizens and permanent residents. Health registration systems, on the other hand, generally include all patients, regardless of nationality or residence status [28]. This can lead to discrepancies, even for basic indicators.

Perinatal mortality

The perinatal mortality rate in Canada decreased from 10.9 per 1,000 births in 1980 to 7.7 in 1990 and 6.0 in 2011 (Fig. 2a) [37, 38]. This is comparable to the next lowest OECD rate; Iceland, at 1.1 per 1,000 births [37]. Between 2000 and 2011, the Canadian rate fluctuated between 6.0 and 6.3 per 1,000 births. Data from Ontario are excluded from these numbers because of concerns regarding data quality [10, 16-18]. The perinatal mortality rate, as well as the late fetal and early neonatal mortality rate, for Canada, the provinces and territories, can be found in Table 1. Among the OECD countries, Canada's rank dropped from 8th in 1990 to 21st in 2011 (Fig. 3a) [37]. Several OECD countries do not supply perinatal mortality rate numbers, or only periodically, including the United States and Belgium; therefore, interpretation of the ranking of Canada needs to be made with caution.

Causes of perinatal mortality

Stillbirth and early neonatal deaths have historically been combined to form the perinatal death rate in an effort to maximize international, regional and temporal comparisons, as well as to minimize variations of classifications of stillbirth *vs.* live births. This combination appeared justified in the past, since asphyxia was the main cause of both stillbirth and early neonatal death; however at the present time, stillbirth and early neonatal deaths vary considerably regarding their principal causes, with congenital anomalies now an important cause of early neonatal deaths, while asphyxia still accounts for almost half of the stillbirths [39]. Neonatal mortality will be discussed as a division of infant mortality, since limited data are available for early neonatal mortality.

In Canada, the overall fetal mortality rate increased between 2001 and 2010 from 5.9 to 6.7 per 1,000 total births [6]. This increase occurred predominantly in the last 5 years of the decade and seems to have been caused by an increase in late pregnancy terminations [40]. Between 2006 and 2010, the mortality rate for fetuses ≥ 500 g, which includes fetal deaths with a gestational age of at least 22 weeks when the birth weight is unknown, was highest in Nunavut and lowest in New Brunswick, at 10.3 and 3.9 fetal deaths per 1,000 total births, respectively. When excluding the terminations of pregnancy, the mortality among fetuses ≥ 500 g decreased in the time period between 2001 and 2010 [6].

Congenital anomalies [41], placental infarction and abruption [42], umbilical cord abnormalities and accidents [43, 44], infection [45] and maternal complications of pregnancy, such as hypertension and diabetes [46, 47], are important causes of stillbirth; however, more than one quarter of stillbirths remains unexplained [10, 42, 48, 49]. The causes of stillbirth in developed countries are considerably different than those in developing nations, because of differences in education, medical facilities, quality of life and economy [50].

The fetal mortality rates due to congenital anomalies, complications of placenta, cord and membranes, and intrauterine hypoxia and birth asphyxia declined by 14%, 17.5% and 51.5%, respectively, between 1995 and 2004. Between 2001 and 2010, no clear trend in cause-specific fetal mortality rates was observed other than an increase in the number of terminations of pregnancy [10, 51].

The main source of information regarding stillbirths comes from postmortem examinations, and, unfortunately, the number of autopsies performed has been falling. Autopsy findings may change the clinical diagnosis of the cause of death, as well as yield new information, in up to 75% of stillbirth cases [52]. The development of an accurate classification system for still-

births, based on the cause of death and other information, is crucial for the reduction of perinatal mortality. It also improves understanding of the etiology and patterns of causation of stillbirth, whereas suboptimal classification leads to a loss of information, as well as a high proportion of unexplained deaths. The ICD coding system is inadequate for the classification of stillbirths since there is no stillbirth specific category, with a consequent loss of information [50, 53].

Infant mortality

The infant mortality rate (IMR) is often considered as the most comprehensive measure of a society's health. Unfortunately, disparities exist in the risk of infant death across subpopulations in Canada. Differences in reporting deaths at the borderline of viability might be one cause of these geographical differences [10, 22].

The overall Canadian infant mortality rate decreased by more than 50% between 1979 and 2011, from 10.9 to 4.8 infant deaths per 1,000 live births, respectively. Between 2000 and 2011, the rate fluctuated between 4.8 and 5.4 per 1,000 live births (Fig. 2b)[27, 37, 54]. In 1979, boys had a higher rate of infant mortality, at 12.2 per 1,000 live births, compared with girls at 9.5 per 1,000 live births. The rates for both genders decreased to 5.3 and 4.3 per 1,000 live births, respectively, in 2011; therefore, the gap between boys and girls regarding infant mortality rates has gradually decreased from 3.1 per 1,000 in 1979 down to 1.0 in 2011 [27]. In spite of these decreases in absolute rates, Canada's OECD ranking position worsened from 5th place in 1990 to 27th in 2011 (Fig. 3b)[37], although Canada compares favorably overall when considering the international rate of infant mortality at 35 per 1,000 in 2010, with the lowest recorded OECD rate at 0.9 per 1,000 births (Iceland) in 2011 [3, 37].

Regarding geographical differences, the lowest infant mortality rates in 2004 at 4.3 per 1,000 live births occurred in Prince Edward Island, New Brunswick and Quebec, while the highest rate was reported in Nunavut at 16.1 per 1,000 live births [10]. This trend remained more or less the same over the 2005-2009 period, with Prince Edward Island having the lowest rate at 3.0 per 1,000 live births and Nunavut the highest at 14.0 per 1,000 live births [6], although the overall infant mortality rates decreased in each province. In 2011, New Brunswick, Quebec, British Columbia and Prince Edward Island all had rates below the national average. Yukon reported no infant

deaths for 2011 (Table 1) [27, 54, 55]. Again, Ontario was not included because of data quality concerns.

Neonatal and post-neonatal mortality

The overall Canadian neonatal mortality rate decreased between 1995 and 2004 from 4.2 to 3.71 deaths per 1,000 live births. Between 2000 and 2009, this rate fluctuated between 3.4 and 3.9 per 1,000 live births, with 3.6 per 1,000 live births in 2011. Yukon reported no infant deaths in 2011, while Nunavut showed the highest neonatal mortality rate at 13.1 per 1,000 live births. Prince Edward Island reported the lowest rate at 2.1/1,000 [6, 10, 55]. The crude post-neonatal mortality rate also decreased, from 2.1 per 1,000 neonatal survivors in 1998 to 1.3 in 2004. Between 2000 and 2009, the rate varied between 1.3 and 1.7 per 1,000 neonatal survivors. Nunavut reported the highest rate of post-neonatal mortality over the period 2005-2009, with Prince Edward Island and Quebec having the lowest rates (6.4, 0.6 and 1.0 per 1,000 neonatal survivors, respectively). This is a continuation of the trend seen in 2004 [6, 10]. The post-neonatal mortality rate per 1,000 live births was 1.2 in 2011, with New Brunswick and Quebec having the lowest rates at 1.0 per 1,000 live births, and Nunavut the highest rate at 13.1 per 1,000 live births (Table 1) [55]. The worldwide neonatal mortality rate was 21 per 1,000 live births in 2012 [56].

As mentioned earlier, some of the international variation in mortality rates is caused by variations in reporting extremely low birth weight and very preterm infants. The United States and Canada, for instance, register much higher fractions of infants weighing less than 500 g. Since these babies have low odds of survival, the reported infant mortality rates in these countries are relatively higher when compared with countries that do not register them as such. In Europe on the other hand, countries such as France and the Netherlands, use a minimum gestational age of at least 22 weeks and/or a birth weight of 500 g or more to be registered as live births [23, 28, 57].

Causes of infant mortality

Cause-specific infant mortality is commonly reported according to the modified International Collaborative Effort (ICE) on Perinatal and Infant Mortality groupings, which comprise eight categories: congenital anomalies, asphyxia, immaturity, infection, sudden infant death syndrome (SIDS), other sudden or unexplained infant death, external causes and other condi-

¹ These numbers are supplied by the Public Health Agency Canada in the Canadian Perinatal Health Report, 2008 Edition, and differ from those supplied by Statistics Canada.

tions [58]. The overall infant mortality rate has the same main causes as neonatal mortality. This comes as no surprise since the number of neonatal deaths is three times as high as the post-neonatal mortality.

Worldwide, the primary cause of infant deaths today is preterm birth, and it is also the primary cause of death in children under 5 [59, 60]. Up to 1999, congenital anomalies were the leading cause of Canadian infant mortality, but from 2000 – 2009, immaturity assumed first place. During this period overall infant mortality decreased due to improved prenatal diagnosis and pregnancy terminations [6, 10, 16]. In Canada in 2009, neonatal deaths accounted for 74% of infant deaths, which is comparable to other OECD countries [61]; however, this percentage in Canada seems to be slowly rising, as it increased from 64% in 1991 to 76% in 2010. Immaturity, congenital anomalies and asphyxia were the primary causes for neonatal deaths [6].

In 2000, 31% of infant deaths occurred in the post-neonatal period, compared with 24% in 2010. The leading causes for post-neonatal mortality in 2004 were congenital anomalies, infection and SIDS at 22.3%, 20.5% and 17.3%, respectively, while the leading causes over the period 2005-2009 were congenital anomalies and SIDS (21.9 and 21.3%, respectively) suggesting a decrease in the relative number of infection-associated deaths. However for 20.5% of all post-neonatal deaths, the causes remain unknown [6, 10]. Infant mortality due to congenital anomalies decreased from 1.4 per 1,000 live births in 1999 to 1.2 in 2004. Since then, the numbers have fluctuated between 1.1 and 1.4 per 1,000 live births. Between 1999 and 2011, the rate of SIDS decreased from 0.6 to 0.19 per 1,000 live births [6, 10, 62].

Immaturity

The preterm birth (PTB) rate represents the percentage of births with a gestational age of more than 20 but less than 37 completed weeks of pregnancy [6]. Preterm birth is a major health problem since it is the leading cause of perinatal morbidity and mortality. Worldwide, PTBs account for 5 to 18% of all live births but vary according to geographic region [63]. Each year 15 million babies are born preterm, and 1.1 million of these children die, with immaturity being the leading cause of both neonatal and infant mortality [59]. Additionally, PTB is the single greatest contributor to disability-adjusted life years [64] and it leads to the high cost of hospitalization and long-term disability since it is associated with high risks of cerebral palsy and other long-term sequelae, such as cognitive impairment, blindness, deafness, respiratory problems and complications of neonatal intensive care [65, 66]. In Canada, the na-

tional PTB rate fluctuated between 7.5% and 8.2% from 2001 to 2011, which is an evident increase from 7.0% in 1995 and 6% in the 1980s [70, 71]. The current rate has hardly changed over the past years despite the advancements in medicine and the growing knowledge about the causes of preterm delivery. Provincial and territorial PTB rates vary widely with a low of 7.4% for Saskatchewan to a high of 12.2% for Nunavut in 2004. This is comparable to the rates in the period 2006-2010, with Quebec and Saskatchewan having the lowest level at 7.4% and Nunavut again the highest rate at 12.8%. It disproportionately affects minority groups, since the prevalence of PTB in African-American women in the United States reaches up to 18% [67]. This number is comparable to that for the Inuit population in the Baffin region [68] and, in British Columbia, First Nations experience PTB at a 40 to 70% higher rate than the national level [69]. Boys are more likely to be born preterm: in 2005-2007 and 2008-2010, 8.2% of boys were born preterm, as compared with 7.4% of girls. Both percentages are significantly higher than in the previous reference period 2000-2002 [72, 73]. Worldwide, the PTB rates range from 5.5% (Finland) to 18% (Malawi) with an average of >10% and this rate is rising [63].

Several factors have contributed to the 30% increase in the number of PTBs over the last 30 years. Older maternal age, multiple births as a consequence of increased use of assisted reproductive technologies, as well as increases in obstetrical interventions have added substantially to this rise [70, 74, 75]. In 2006-2007, multiple births were the most important factor associated with PTB, followed by maternal hypertension and diabetes [76, 77]. Furthermore, mothers with a previous preterm delivery were more likely to deliver preterm again [78-80]. Additionally, maternal age (teenagers or older than 35 years)[81-85], parity (first-time moms and high-parity women)[86], the mode of delivery or complications necessitating these interventions (Caesarean section, induction)[87-89], the socio-economic status (low neighborhood income)[90] as well as the sex of the baby (boys)[73] were factors associated with preterm birth [71].

Congenital anomalies

Congenital anomalies or birth defects are abnormalities of structure or function present at birth. In Canada, between 3 and 5% of newborns and 8-10% of stillbirths are born with one or more birth defects, and considerable variation exists between the provinces and territories. These defects accounted for 23.2% of infant mortality between 2003 and 2007, including 23% of neonatal deaths. Furthermore, congenital anomalies are the second leading cause of infant deaths, with immaturity

being the first, amounting to an overall mortality rate of 5.0 per 1,000 live births in 2006-2007. Some of the most commonly recognized anomalies include Down syndrome, congenital heart disease, neural tube defects and orofacial clefts [6, 51].

The overall prevalence of birth defects in 2010 was 397 per 10,000 total births, which is a slight increase compared to 377 per 10,000 total births in 2007 [6]. Congenital heart defects are the most common congenital anomalies among neonates, at 85.1 per 10,000 total births in 2009 in Canada (excluding Quebec). While this is a 21% decrease compared to 1998, congenital heart defects remain one of the most important causes of infant morbidity and mortality [51].

Studies in Canada have shown that congenital anomaly-related fetal deaths have declined in late gestation, while they have increased early in pregnancy, and that congenital anomaly-related infant deaths have decreased in the past few decades [16, 20]. The reduced number of fetal deaths is likely the effect of increased availability of prenatal diagnosis and pregnancy termination. For infant deaths, on the other hand, this change most likely reflects a combined effect of prenatal diagnosis and termination of pregnancy, with enhancements in postnatal care. There is also evidence suggesting that prenatal screening and pregnancy termination have led to a reduction of up to 21% in the prevalence at birth of congenital heart disease [51, 91, 92].

Maternal mortality

Before 2000, all maternal deaths in Canada were classified according to the ICD-9. Implementation of the ICD-10, containing a more comprehensive definition of maternal mortality, was started in 2000 and finalized in 2005, with different execution times depending on province or territory [93]. Although several provinces and one territory have established maternal death review committees, on a national level there is no systematic system to synthesize and report on maternal mortality [33].

Between 1997 and 2000, pulmonary embolism and hypertensive disorders of pregnancy were the leading direct causes of maternal death in Canada, excluding Quebec. Amniotic fluid embolism and intracranial hemorrhage came next, each accounting for 16%. Cardiovascular diseases were the most common causes of indirect death. Remarkably, no deaths were attributed to primary postpartum hemorrhage during that time period [33]. The most common causes of maternal death have not changed since then, in spite of heterogeneity between the ICD-codes and differences between ICD-9 and ICD-10 reducing the comparability of these data [31, 94].

According to OECD data, the Canadian maternal mortality rate decreased from 7.6 per 100,000 live births in 1980 to 2.5 in 1990. In the following years, the rate increased steadily to reach a peak of 9.0 per 100,000 live births in 2008, falling rather dramatically (and encouragingly) to 4.8 in the just-released 2011 data. Thus, Canada's ranking among OECD countries worsened from 2nd place in 1990 to 22nd place in 2008, and improved slightly to 19th place in 2011 [37]. Whether the increasing trend that started in 2000 has abated or not will be confirmed over the next few years. Worldwide, the overall rate was 210 per 100,000 live births in 2010 and the lowest recorded OECD rate for 2011 was Sweden at 0.9 per 100,000 live births [3, 37]. The WHO reports use an adjustment coefficient for Canada of 60% upward to correct for underreporting, based on previous measurements of underascertainment [30, 95-99]. Based on this correction, the maternal mortality rate in Canada will appear to have risen to 11 per 100,000 live births in 2010 and the current prediction for 2013 assumes the same number [100].

Reduction of mortality

The 2005 theme of World Health Day, the yearly celebration of the establishment of the WHO, was healthy mothers and children, with as its slogan "Make every mother and child count." The overall objective was to raise awareness regarding maternal, perinatal, infant and child mortality. The importance of healthy mothers and children is recognized by several other initiatives, including the Millennium Development Goals (MDG) of the UN. The MDGs are eight international development goals, established in 2000 after the adoption of the United Nations Millennium Declaration on the Millennium Summit. All member states at the time, as well as 23 international organizations, committed to achieving these goals by 2015. Among those goals is the improvement of maternal health and reduction of child mortality. More specifically, MDG 5 aims to reduce maternal mortality by 75% between 1990 and 2015, while MDG 4 is directed at reducing child mortality by 75% during this period [101]. While the original targets will not be achieved by the end of 2015, very encouraging progress has been made to reduce MMR by 45% to 210 per 100,000 live births, worldwide [3, 56].

In 2010, UN Secretary-General Ban Ki-moon launched the "Every Women, Every Child" initiative, which aims to save the lives of 16 million children and women by 2015 and provides a new opportunity for improving the health of women and children around the world [102]. On a national level, Canada's top international development priority is maternal, newborn and child health. At the G-8 summit in 2010, Canada's

Prime Minister, Stephen Harper, pledged \$ 1.1 billion, increasing Canada's contribution for maternal, newborn and child health to \$ 2.8 billion [103]. At the *Every Woman, Every Child: Within Arm's Reach Summit* in Toronto in May 2014, the Prime Minister renewed this pledge by committing another \$ 3.5 billion in order to improve the health of mothers and children [104].

All these initiatives aim at reducing the number of perinatal, infant and maternal deaths throughout the world. While most of the work needs to be done in developing countries, developed countries also have room for improvement, as data from Canada show.

Indigenous peoples of Canada

The Canadian Constitution Act of 1982 recognizes three groups of Indigenous peoples: First Nations (North-American Indians, either Status Indians on reserve, Status Indians off reserve and non-Status Indians), Inuit and Métis [105]. This is an under appreciation, however, of the variety of Indigenous peoples in Canada as there are over 600 First Nations governments or bands [106]. In 2011, there were approximately 1.4 million people who identified as Aboriginal in Canada, equalling 4.3% of the total population. Statistics regarding Indigenous peoples are often inaccurate given major deficiencies in both coverage and quality of the data collected, in addition to the existence of substantial variation in the way data are collected. This is despite the fact that Indigenous peoples are a large and growing population, with a birth rate at 2.6 *vs.* the national rate of 1.5 [107]. Currently, reliable data are only available for some subgroups. Indigenous women are not a homogenous group, with birth outcomes differing between various Aboriginal populations in Canada [108]; therefore, data from subgroups cannot be generalized to the entire Aboriginal population.

The deficiency of data is, at least in part, due to the lack of ethnicity identifiers on birth and death registrations. Only Quebec offers the possibility to identify as either First Nations or Inuit, based on the maternal mother tongue, which is registered on the birth registration. Using this method, 50 to 60% of births to Indigenous mothers are detected. Maternal mother tongue is often used as a surrogate measure of ethnicity [109, 110].

It is widely recognized that Indigenous peoples worldwide experience inequities in birth outcomes and infant mortality, even in developed countries such as Canada, New Zealand, Australia and the USA [111-115]. The most striking disparities include up to four times higher infant mortality rates and increased rates of SIDS [69]. Nunavut, where 85% of inhabitants self-identified as Inuit, has more adverse early child health out-

comes, such as infant mortality, congenital anomalies, prematurity and low birth weight than any other region in Canada [55, 68, 116, 117].

Canadian Indigenous populations, as every population in the world that experiences greater marginalization than the general population, have worse perinatal health outcomes than the Canadian general population. Many of the modifiable risk factors for adverse pregnancy outcomes and infant mortality are present at higher rates among these women, including known medical and obstetric risk factors [68]; these include low socioeconomic status, lower education level, high levels of perceived stress, high pre-pregnancy BMI and life-style factors including smoking [118, 119]. Smoking is very prevalent among Indigenous populations, and is the single greatest modifiable risk factor for adverse birth outcomes and infant mortality [120]. Childhood abuse is known to initiate smoking [121] and Edwards *et al.* argue that smoking may be maintained due to high Adverse Childhood Experience (ACE) scores based upon work in a general population. We demonstrated high ACEs are associated with PTB in a general population [122], and in rats, transgenerational stress leads to worse perinatal outcomes [123]. Cumulatively these data suggest that abuse, depression and stress over generations may be associated with poor perinatal outcomes and suggest the possibility that historical child abuse, such as that derived from the abuse of residential schools [124], has a residual and multigenerational effect upon modifiable health behaviours and directly or indirectly upon perinatal outcomes. Other factors such as the degree of rural isolation and the geographical location (North *vs.* South) also appear associated with risks of multiple adverse birth outcomes and infant mortality [109, 125, 126].

Traditionally, Aboriginal women in rural and remote areas give birth in their communities, supported by family members, traditional midwives or both; however, the use of and respect for midwives decreased dramatically in the first half of the 20th century in North America. The belief that midwife-attended births were not safe meant that by 1950, almost all births occurred in hospitals. This virtual disappearance of midwifery meant the loss of many ancient birthing and midwifery practices, with only a few midwives left to pass on the Indigenous knowledge [127, 128].

Since the 1970's, the practice of maternal and child health care for Aboriginal peoples has included evacuation in the 36th-37th week of pregnancy from the community to secondary or tertiary care centers [129, 130]. The removal from the community has profound consequences such as substantial degrees of stress, both for the pregnant woman and her family, as well as financial, social and psychological costs, with feelings of isola-

tion, separation and social disruption [131]. This evacuation practice also leads to higher levels of postpartum depression, as well as increased risks of maternal and newborn complications [132, 133]. Non-Aboriginal women living in rural or remote areas have similar experiences and consequences [112, 125, 126, 134].

Midwife-led maternity care could possibly offer a solution in giving Aboriginal women a choice between childbirth at home, in a birthing center or in the hospital. Although increasing evidence exists that midwife-led care may be a safe alternative for low-risk women [129, 135-139], and there is considerable promotion for this as a major care initiative [140, 141], concern remains about its safety and effectiveness [142]. The Netherlands is often cited as an example of how midwifery can be advantageous; however, the distances in Canada are much greater, with less access to technological help in remote areas [143]. Sweden also has a long history of midwifery, having had a national health strategy in which midwives and doctors assumed complementary roles in maternity care [144]. This strategy had led to major declines in both maternal and perinatal mortality in the 19th century [145].

Maternal mortality, preterm birth, infant mortality and congenital anomalies among Indigenous peoples of Canada

There are no data for maternal mortality and there is no consistent tracking of the rates of PTB or infant mortality for the three Indigenous population groups on a regional, provincial/territorial or national level, which leads to issues in identifying the health problems that may exist, their possible causes and ways to deal with them. Inconsistent data suggest that First Nations and Inuit have higher PTB rates than the Canadian national average, with a PTB rate for the Inuit in the Baffin Region between 1998 and 2000 of three times the national average, and increased rates for First Nations from British Columbia and Manitoba as well [68, 112, 146, 147]. Better data collection and a deeper understanding of the environmental and historical context in which people exist (e.g., what role does food security play amongst the Inuit of Baffin Island or how did residential schools impact upon particular outcomes?) would help to identify the risk factors that need to be dealt with and suggest means to improve outcomes. For instance, PTB is more prevalent in obese women because of underlying medical, obstetric or historical/social issues, and since higher pre-pregnancy BMI is more common in Indigenous women, this could be a modifiable risk factor for PTB in this population [148].

Disparities across ethnic groups and socio-economic classes are more strongly evident in the postnatal infant mortal-

ity rates, since these are a reflection of social and environmental factors. Similarly, the inconsistent data that exist for infant mortality rates demonstrate persistent and sizeable disparities between the Aboriginal and non-Aboriginal populations, with Aboriginal IMR being approximately twice that of the overall Canadian rate. Worse, in Inuit populations, the IMR is four times higher than the national level. Again, better quality data would help shape policy and practice to identify and respond to the conditions leading to infant morbidity and mortality among Aboriginal people [149]. Other areas of concern and where data accumulation and examination can be improved is congenital anomalies, such as orofacial clefts, and Down syndrome, which has the highest rate in Nunavut.

Much of the increased risk for these problems amongst Indigenous peoples may be due to higher rates of obesity, smoking and diabetes, which are risk factors for congenital anomalies, birth defects and maternal and perinatal complications, including stillbirth [150]. Since the data quality is poor, it is unlikely that relative Canadian OECD rankings are affected to any significant extent by data from Aboriginal peoples, especially in regard to maternal mortality. Nevertheless, until more in-depth investigation occurs, greater understanding is achieved, Indigenous culture and practices are respected and better and appropriate interaction between indigenous and non-Indigenous Canadians in response to these problems is attained, there is little hope of diminishing what appear to be intractable perinatal health problems. This is a very important issue to address since all Canadians share the same land and resources and are building a future together.

Pregnancy-related mortality rates in other OECD countries

As indicated, the lack of standardization when reporting perinatal, infant and maternal mortality rates between countries can result in misleading international comparisons; however, there are numerous insights that can be gained by comparing perinatal practices from various countries against the backdrop of relative perinatal mortality rates. Canada should learn from the gains or shortcomings from others and then apply proven strategies and principles to research and policy making in our own country. We selected three countries, Japan, Australia and the Netherlands, for in depth comparisons. Australia is comparable in many aspects to Canada, including having a large number of immigrants, a marginalized Indigenous population of roughly similar proportions and a large landmass. the Netherlands is often cited as a good example of how midwifery can be integrated into maternity care services. Japan, a rather homogeneous population, has exceptional perinatal, infant and maternal mortality rates.

Australia

Maternity care in Australia is among the safest in the world, when compared to other OECD countries, as evidenced by the low maternal mortality in the general population of 3.4 per 100,000 live births in 2010. This ranked Australia as 11th among OECD countries, compared with Canada at 23rd place. The Australian infant mortality rate, on the other hand, was 3.8 per 1,000 live births in 2011, putting Australia in 22nd place, while Canada was 27th. The IMR has since declined to 3.3 per 1,000 live births in 2012. As for perinatal mortality, Australia deviates from the OECD definition in that since 2006 it includes all fetal deaths with a gestational age of at least 20 weeks or a birth weight of 400 g. This makes adequate comparisons difficult, because more fetal deaths are included in the Australian data. It also leads to a higher perinatal mortality rate of 8.4 per 1,000 live births in 2011, which corresponds to the 28th place in OECD rankings, while Canada was in 21st place [37, 151].

Unfortunately, these are rates for the general population, and does not reflect the rates for the Aboriginals and Torres Strait Islanders, Australia's Indigenous people, who constitute about 2.5% of the entire population [152, 153]. Maternal, perinatal and infant mortality are all higher in Indigenous people than in the general population. For instance, the perinatal mortality rate over the period 2004-2008 was 13 per 1,000 live births while for the general population it was 9 per 1,000 live births; the IMR and MMR were almost double the rate of the non-Indigenous population [153, 154]. The disparities in Australia appear to be even larger than those in other developed countries with an Indigenous population, such as Canada or the USA [153, 155-159].

The majority (75%) of Indigenous people in Australia live in urban settings and non-remote regional areas, although the geographical localization differs between the states. Regardless of location, most Australian women, 97% in 2011, deliver in a hospital. There are hardly any homebirths (0.8%), while deliveries in birth centres account for 2.2% [160]; however, Indigenous Australians are more likely to present for antenatal care later in pregnancy [161]. Australia also sees a trend towards regionalization of care since, in the past 15 years, several birthing services have been closed, due to lack of workforce, lack of access to on-site Caesarean section, as well as concerns about safety. These concerns persist despite the growing evidence, as mentioned earlier, that birth for low-risk women is safe at home or in small birthing centers [162].

Several governmental programs to decrease the disparities between Indigenous and non-Indigenous Australians and improve the health of women and children have been imple-

mented. One example is the National Maternity Services plan, started in 2010, that sets out the following five-year vision: *"Maternity care will be woman centered, reflecting the needs of each woman within a safe and sustainable quality system. All Australian women will have access to high-quality, evidence-based, culturally competent maternity care in a range of settings close to where they live. Provision of such maternity care will contribute to closing the gap between the health outcomes of Aboriginal and Torres Strait Islander people and non-Indigenous Australians. Appropriately trained and qualified maternity health professionals will be available to provide continuous maternity care to all women."* In this plan, particular attention is given to the need to improve birth outcomes among Indigenous Australians, and other disadvantaged populations [152]. Furthermore, numerous initiatives have been developed in recent years, under the umbrella of the Closing the Gap initiative of the Council of Australian Governments. This initiative aims to improve the lives of Indigenous Australians and to provide a better future for Indigenous children [163]. Australia is also looking at Canada to learn from its strategies in reducing the gap between Indigenous and non-Indigenous people's perinatal health, specifically at the Inuit experience in returning birthing care to remote areas [162].

The Netherlands

Perinatal mortality in the Netherlands was among the lowest in Europe until 1990. Since then the decline in other countries has been faster than the decline in the Netherlands. Perinatal mortality has decreased significantly between 2000 and 2011, from 9.0 to a rate of 5.5 per 1,000 births for infants born after 24 weeks and 4.8 per 1,000 births for gestational age at delivery of more than 28 weeks [164, 165]. In 2011, the Netherlands ranked ahead of Canada for all perinatal health indicators, with an infant mortality rate of 3.6 per 1,000 live births, 16th place for perinatal mortality (5.5 in 2011) and a maternal mortality rate of 1.7 per 100,000 live births, corresponding to 7th place in the OECD ranking. The WHO adjusted the MMR to account for underestimation to 6 per 100,000 for 2010 instead of 2.2, as compared with 12 to 100,000 live births in Canada [166, 167].

The Dutch maternity care system has adopted the basic principle that pregnancy, childbirth and puerperium are, in essence, physiological processes, therefore giving the midwife a substantial role as primary care giver for low-risk women. If the pregnancy, delivery or postpartum period is uncomplicated, the patient can remain under the care of the midwife; however if complications occur or threaten to occur, it is the midwife's responsibility to refer the patient for specialist obstetrical care.

The obstetrician will take over the care for as long as it is deemed necessary. Situations requiring specialist care are listed in the “List of Obstetric Indications” (LOI), an instrument for look at both risk selection and professional cooperation, which is evidence-based and multidisciplinary. The basic principle of the LOI is that the midwife will provide the primary antenatal and perinatal care, unless explicitly stated otherwise. It also adopts the principle that medicalization of obstetric care should be avoided and actively opposed [168, 169]. The role of the obstetrician has been increasing continuously, while the role of the midwife, as well as the general practitioner as primary care giver, has diminishing greatly. This is also reflected by the percentage of women delivering in hospital, which was about two out of every three births in 1998-2001, but has since risen to more than 75% in 2010-2012 [170]. Nevertheless, the midwife still has a considerable role, with preventive activities increasing steadily. The important role of the midwife is obvious from the fact that in 2007 more than 75% of women initiated pregnancy care with a midwife. Although the basic principle of the Dutch maternity care system is apparently being applied less frequently, the Netherlands had the highest rate of spontaneous childbirth, a very low 15% Caesarean section rate, about 10% assisted vaginal births and more than 25% home-births in 2010 [168]. Several countries, including Canada, have contemplated the reintroduction of midwifery care and home births, while a reverse trend has been seen in the Netherlands [128, 171, 172]; perhaps there is a happy and appropriate middle ground.

Finally, in the Netherlands it is observed that there are several advantages that accrue from involving the primary health care system. Among other benefits, it reduces the likelihood of medical intervention during childbirth, as well as the risk of perianal tears and episiotomies; the odds of having a vaginal birth are higher, and so is the maternal satisfaction. On the level of statistical coverage, 99% of Dutch hospitals, as well as 99% of midwifery practices, report their data to the National Perinatal Registry. Obstetricians have been recording since 1982, while midwives started reporting their primary care provisions since 1985 [168].

Japan

Japan's infant and neonatal mortality rates are now among the lowest in the world – a remarkable improvement in health considering the country's infant mortality rate was 60.1 per 1,000 in 1950 [173]. Since then there has been a rapid decrease to the current levels of 2.3 per 1,000 and 2.8 per 1,000 for infant and perinatal mortality rates, respectively [37, 174, 175], ranking Japan at second place among the OECD countries. Several

explanations have been proposed for the rapid improvements and the current low rates, and many developing and developed countries are looking at Japan to learn from their experiences. Some reasons include the introduction of the “Pregnant Mother's Handbook” in 1942, the designation of maternal and child health as an important field of public health as of 1947, abolition of illegal abortion and implementation of legal abortion by qualified medical specialists under certain conditions in 1948, and the introduction of universal health insurance coverage in 1961. Furthermore, the major programs for maternal and child health have been in place since the 1980's [173] allowing them sufficient time to impact perinatal health rates. Another major contributor has been the move to institutional birth, which currently reaches almost 100% of women [176]. The Child Welfare Law (1947), the Mother's Body Protection Law (1948, formerly the Eugenic Protection Law), and the Maternal and Child Health Law (1965) have attributed importantly to these changes as well [173].

The Pregnant Mother's Handbook has been revised approximately every decade and has been called the “Maternal and Child Health Handbook” since 1966. The latest update was in 2012. It includes birth planning, pregnancy-related health check-up schedules and information on emergency care, delivery, postnatal care, family planning, immunization and neonatal and child health care until the age of 6 [177]. It is issued to every pregnant woman in Japan when she files her pregnancy notification at her municipality of residence. The book was originally proposed as a registering tool, since it is issued to all pregnant women in Japan, regardless of origin and immigration status. Since immigration is increasing in Japan, the handbook is now available in eight languages. It is also used as a communication tool between pregnant women and health care providers, thereby ensuring the continuity of maternal, neonatal and child health care [178]. With the cooperation of the Japan International Cooperation Agency (JICA), it is currently utilized in several other countries who have adjusted it to the needs of their local communities [173].

Despite increases in preterm births and low birth weight infants, the Japanese infant and neonatal mortality rates are still decreasing, with improvements in PTB-related mortality as a possible explanation. Interestingly though, Japan has a lower neonatal than postnatal mortality, while other OECD countries report 2/3 neonatal and 1/3 post-neonatal deaths [61, 179, 180].

Japan has also been successful in lowering the maternal mortality rate, though not to the same extent as the neonatal and infant mortality. The MMR in Japan in 1950 was 176.1 per 100,000 live births, while over the past 10 years, the rate

has fluctuated between 3.8 and 6.2 per 100,000, with a rate of 4.1 per 100,000 in 2011 [37, 181, 182]. This ranked Japan in 17th place in 2011, while Canada was 19th. There are four main interventions listed as contributing to this drop in MMR. First is access to family planning, which prevents unwanted pregnancies. This is reflected by a very low total fertility rate of just 1.32 children per woman, as well as a low level of adolescent fertility, at just 4 births per 1,000 women aged 15-19 years. Second, Japan provides universal access to skilled delivery care, with nearly 100% of births occurring in the presence of health professionals. This has also greatly contributed to the prevention of sepsis. Furthermore, the Maternal and Child Health Handbook is a major factor in offering a continuum of care before, during and after pregnancy. Last, timely access to emergency care is available for all pregnant women experiencing complications through a health care system that connects pregnant women with health care providers [182].

Conclusion

Canadians can take great pride in their health care systems and that over the past fifty years they have made substantial progress in reducing perinatal mortality rates to among the lowest levels in the world. They have earned the right to lead and support other nations, especially those in resource-poor settings, in reducing their perinatal mortality rates. Indeed, this has become Canada's top international development priority, and it is a worthy effort. Yet in spite of its achievements at home and abroad, Canadians, and especially their health care and policy leaders, need to realize that considerably more can and needs to be achieved domestically, especially at a time when the federal government is emphasizing its international aid programs for lowering the perinatal mortality rates in other countries. For instance, Canada's rankings among OECD countries for perinatal, infant and maternal mortality have been worsening over the past decades, although the absolute perinatal and infant rates are continuing to decrease. Why are other OECD countries decreasing their rates faster than Canada? More worrying, maternal mortality has been on the rise in Canada since 2001, although the most recent statistics are hopeful of the onset of a new plateau or downward trend. It is clear that we must continue to be vigilant to assure that everything possible is being done on the provincial, territorial and national levels to make every mother and child count.

What needs to be achieved? To begin, there are large disparities within Canada, as well as between Canada and other OECD members, in the way that perinatal, infant and maternal mortality rates are determined. These differences can, at least in part, be explained by variations in registration and

under-ascertainment of mortality, urging care to be taken when making comparisons, both on a national and international level. Such differences in surveillance may contribute to the changing relative rank of Canada within OECD countries. Within Canada, the registration variation regarding perinatal, fetal, neonatal and infant mortality is fortunately limited; however questions about data quality in Ontario remain, meaning published data for Canada are incomplete. Likewise, Quebec data are excluded from certain indicators because Quebec does not contribute to CIHI's Discharge Abstract Database, which is the data source for maternal mortality information as well as for the congenital anomalies data. At the international level, there are considerable differences between Canada's registration of extremely low birth weight and very premature infants and the registration practices of other countries. These differences diminish comparability of perinatal, fetal and infant mortality. Publication of separate, standardized statistics for international comparisons could possibly offer a solution.

Canada does not have a standardized system to synthesize and report on maternal mortality. Furthermore, incomplete ascertainment and inconsistent coding, as well as incomplete coverage of data collection, are important limitations to maternal death registration. Enhanced surveillance mechanisms are necessary to allow comparisons, both on the national and international level, and to evaluate trends over time. Canada could learn from the UK's CEMD by reviewing maternal deaths nationwide and on a timely basis with a national requirement to report all maternal deaths for confidential enquiries. This could lead to better ascertainment, as well as better comparability, and would be an improvement of civil registration systems.

Internationally, there is a need for more accurate classification of stillbirths based on the cause of death. Currently, the stillbirth classification is suboptimal leading to a loss of information. These data are important for understanding the etiology of stillbirth, a crucial element for the reduction of perinatal mortality. Postmortem examinations, yielding new information in the majority of cases, are of essence in this matter, and should therefore be encouraged.

Canada's perinatal statistics for its Indigenous peoples are inaccurate and insufficient. There are deficiencies both in coverage and data quality for all indicators. There are no data on maternal mortality among the Aboriginal population. A prominent reason for this absence of data is the lack of ethnicity identifiers on both birth and death registration. Regardless of the shortage of accurate information, it is evident that Indigenous people experience much worse birth outcomes and

infant mortality, although it is unlikely that these data contribute to the change in OECD rank for Canada due to their small impact on national statistics, especially in regard to maternal mortality. This lack of reliable data makes it more difficult to identify and target the conditions leading to these higher rates; poor data leads to poor health care delivery.

Canada's ranking among the OECD countries could be improved by examining effective practices in other countries. Australia, for instance, has several national programs aimed at reducing the gap between Indigenous and non-Indigenous Australians, such as the National Maternity Services plan. Canada may be able to implement the Australian methods into its own National Birthing Initiative, which was proposed in 2007 [183]. Canada can also emulate the Netherlands' National Perinatal Registry, which has data coverage of up to 99%.

Implementing more midwifery services, such as those offered in the Netherlands, may be beneficial, especially considering the remoteness of certain populations in Canada. Only a few provinces and one territory allow registration of midwives as primary care providers, which makes midwives unavailable for a considerable portion of the population. They can play a major role in prenatal and postnatal care, as well as offer preventive services and complementary roles with the obstetrician and the primary care physician in maternity care. The "List of Obstetric Indications" is a good guideline for the development of the exact role of the midwife, especially for remote and rural communities [169].

In Japan both the obligatory filing of a pregnancy notification after confirmation of pregnancy plus receipt of the Maternal and Child Health Handbook, obtained by every pregnant woman regardless of origin or immigration, assure registration as well as a continuum of care. Additionally, Japan's success in family planning, as evident from the low fertility and adolescent pregnancy rates, has been an important contributor to the reduction of maternal mortality and may be of benefit for Canada as well.

In conclusion, while Canada has achieved a considerable amount in reducing its perinatal mortality statistics, to avoid losing OECD rank, to maintain its current international standing and indeed to improve it, several challenges, but also several opportunities, present themselves. A considerable amount can be learned from other countries and from our own Indigenous cultures on how to improve our pregnancy outcomes. With a concerted national effort, led federally, we can minimize the problems and maximize a healthy start to the lives of all Canadians.

Acknowledgments

This work was supported by a PhD Fellowship of the Research Fund Flanders, the Canadian Institutes of Health Research (CIHR) and Juntendo University, Faculty of Medicine.

References

1. Government of Canada. Maternal, Newborn and Child Health (MNCH) Summit. 2014. Accessed: 27-06-2014. Available from: <http://mnch.international.gc.ca/index-en.html>
2. Government of Canada. Maternal, newborn and child health. Canada's leadership. 2014. Accessed: 27-06-2014. Available from: <http://www.international.gc.ca/development-developpement/priorities-priorites/mnch-smne/index.aspx?lang=eng>
3. World Health Organization. World Health Statistics 2012. Geneva: WHO, 2012.
4. OECD. OECD Health Statistics 2014. Definitions, sources and methods. OECD, 2014.
5. World Health Organization. International Statistical Classification of Diseases and Related Health Problems, 10th revision. Vol. 2. Instruction Manual. Geneva: WHO, 1992.
6. Public Health Agency of Canada. Perinatal Health Indicators for Canada 2013: a Report of the Canadian Perinatal Surveillance System. Ottawa, ON: 2013.
7. World Health Organization. Neonatal and perinatal mortality. Country, regional and global estimates. Geneva: WHO, 2006.
8. Statistics Canada. Table 102-4514 - Fetal deaths (20 weeks or more of gestation) and late fetal deaths (28 weeks or more of gestation), Canada, provinces and territories. 2013.
9. United Nations. Handbook of Vital Statistics Systems and Methods. United Nations Studies in Methods, Glossary, Series F, No. 35. Volume 1: Legal, Organisational and Technical Aspects. New York: United Nations; 1991.
10. Public Health Agency of Canada. Canadian Perinatal Health Report, 2008 Edition. Ottawa, ON: 2008.
11. World Health Organization. Manual of the International Statistical Classification of Diseases, Injuries and causes of Death. 9th revision. Vol. 1. Geneva: WHO, 1977.
12. World Health Organization. International Classification of Diseases 11th Revision. 2014. Accessed: 14-05-2014. Available from: <http://www.who.int/classifications/icd/revision/en/>
13. World Health Organization. The WHO application of ICD-10 to deaths during pregnancy, childbirth and puerperium: ICD MM. Geneva: WHO, 2012.
14. King JC. Strategies to reduce maternal mortality in developed countries. *Curr Opin Obstet Gynecol*. 2013;25(2):117-23.
15. United Nations Statistics Division. UNData. A world of information. 2014. Accessed: 28-11-2014. Available from: data.un.org.
16. Liu SL, Joseph KS, Kramer MS, Allen JC, Sauve R, Rusen I, et al. Relationship of prenatal diagnosis and pregnancy termination

- to overall infant mortality in Canada. *JAMA*. 2002;287(12):1561-7.
17. Joseph KS, Kramer MS. Recent trends in infant mortality rates and proportions of low-birth-weight live births in Canada. *CMAJ*. 1997;157(5):535-41.
 18. Woodward GL, Bienefeld MK, Ardal S. Under-reporting of live births in Ontario: 1991-1997. *Can J Public Health*. 2003;94(6):463-7.
 19. Canadian Institute for Health Information. Discharge Abstract Database (DAD) Metadata. 2014. Accessed: 13-06-2014. Available from: http://www.cihi.ca/CIHI-ext-portal/internet/en/document/types+of+care/hospital+care/acute+care/dad_metadata
 20. Liu SL, Joseph KS, Wen SW. Trends in fetal and infant deaths caused by congenital anomalies. *Seminars in Perinatology*. 2002;26(4):268-76.
 21. Graafmans WC, Richardus JH, Macfarlane A, Rebagliato M, Blondel B, Verloove-Vanhorick SP, et al. Comparability of published perinatal mortality rates in Western Europe: the quantitative impact of differences in gestational age and birthweight criteria. *BJOG*. 2001;108(12):1237-45.
 22. Joseph KS, Kramer MS. Recent trends in Canadian infant mortality rates: effect of changes in registration of live newborns weighing less than 500 g. *CMAJ*. 1996;155(8):1047-52.
 23. Joseph KS, Liu S, Rouleau J, Lisonkova S, Hutcheon JA, Sauve R, et al. Influence of definition based versus pragmatic birth registration on international comparisons of perinatal and infant mortality: population based retrospective study. *BMJ*. 2012;344:e746.
 24. Mohangoo AD, Blondel B, Gissler M, Velebil P, Macfarlane A, Zeitlin J, et al. International comparisons of fetal and neonatal mortality rates in high-income countries: should exclusion thresholds be based on birth weight or gestational age? *PLoS One*. 2013;8(5):e64869.
 25. Kramer MS, Platt RW, Yang H, Haglund B, Cnattingius S, Bergsjö P. Registration artifacts in international comparisons of infant mortality. *Paediatr Perinat Epidemiol*. 2002;16(1):16-22.
 26. Joseph KS, Huang L, Dzakupas S, McCourt C. Regional disparities in infant mortality in Canada: a reversal of egalitarian trends. *BMC Public Health*. 2009;9:4.
 27. Statistics Canada. Table 102-0030 - Infant mortality, by sex and birth weight, Canada, provinces and territories. 2013.
 28. Euro-Peristat. European Perinatal Health Report: Health and Care of Pregnant Women and Babies in Europe in 2010. 2013.
 29. Australian Bureau of Statistics. 3303.0 Causes of death, Australia, 2012. 2014.
 30. Turner LA, Cyr M, Kinch RA, Liston R, Kramer MS, Fair M, et al. Under-reporting of maternal mortality in Canada: a question of definition. *Chronic Dis Can*. 2002;23(1):22-30.
 31. Lisonkova S, Bartholomew S, Rouleau J, Liu S, Liston RM, Joseph KS, et al. Temporal trends in maternal mortality in Canada I: estimates based on vital statistics data. *J Obstet Gynaecol Can*. 2011;33(10):1011-9.
 32. Lisonkova S, Liu S, Bartholomew S, Liston RM, Joseph KS, Maternal Health Study Group of the Canadian Perinatal Surveillance System. Temporal trends in maternal mortality in Canada II: estimates based on hospitalization data. *J Obstet Gynaecol Can*. 2011;33(10):1020-30.
 33. Health Canada. Special Report on Maternal Mortality and Severe Morbidity in Canada — Enhanced Surveillance: The Path to Prevention. Ottawa, ON: 2004.
 34. Berg CJ, Callaghan WM, Syverson C, Henderson Z. Pregnancy-related mortality in the United States, 1998 to 2005. *Obstet Gynecol*. 2010;116(6):1302-9.
 35. Chang J, Elam-Evans LD, Berg CJ, Herndon J, Flowers L, Seed KA, et al. Pregnancy-related mortality surveillance--United States, 1991--1999. *MMWR Surveill Summ*. 2003;52(2):1-8.
 36. Centre for Maternal and Child Enquiries (CMACE). Saving Mothers' Lives: reviewing maternal deaths to make motherhood safer: 2006--08. The Eighth Report on Confidential Enquiries into Maternal Deaths in the United Kingdom *BJOG*. 2011;118(Suppl. 1):1-203.
 37. OECD. "OECD Health Data: Health status", OECD Health Statistics (database). 2013.
 38. Statistics Canada. Table 102-0508 - Perinatal mortality (number and rates) and components, Canada, provinces and territories. 2013.
 39. Kramer MS, Liu S, Luo Z, Yuan H, Platt RW, Joseph KS, et al. Analysis of perinatal mortality and its components: time for a change? *Am J Epidemiol*. 2002;156(6):493-7.
 40. Joseph KS, Kinniburgh B, Hutcheon JA, Mehrabadi A, Basso M, Davies C, et al. Determinants of increases in stillbirth rates from 2000 to 2010. *CMAJ*. 2013;185(8):E345-51.
 41. Stillbirth Collaborative Research Network Writing G. Causes of death among stillbirths. *JAMA*. 2011;306(22):2459-68.
 42. Korteweg FJ, Erwich JJ, Holm JP, Ravise JM, van der Meer J, Veeger NJ, et al. Diverse placental pathologies as the main causes of fetal death. *Obstet Gynecol*. 2009;114(4):809-17.
 43. Pinar H, Carpenter M. Placenta and umbilical cord abnormalities seen with stillbirth. *Clin Obstet Gynecol*. 2010;53(3):656-72.
 44. Collins SA, Surmala P, Osborne G, Greenberg C, Bathory LW, Edmunds-Potvin S, et al. Causes and risk factors for infant mortality in Nunavut, Canada 1999-2011. *BMC Pediatr*. 2012;12:190.
 45. McClure EM, Dudley DJ, Reddy UM, Goldenberg RL. Infectious causes of stillbirth: a clinical perspective. *Clin Obstet Gynecol*. 2010;53(3):635-45.
 46. Coletta J, Simpson LL. Maternal medical disease and stillbirth. *Clin Obstet Gynecol*. 2010;53(3):607-16.
 47. Simpson LL. Maternal medical disease: risk of antepartum fetal death. *Semin Perinatol*. 2002;26(1):42-50.

48. Goldenberg RL, Kirby R, Culhane JF. Stillbirth: a review. *J Matern Fetal Neonatal Med.* 2004;16(2):79-94.
49. McClure EM, Goldenberg RL. Infection and stillbirth. *Semin Fetal Neonatal Med.* 2009;14(4):182-9.
50. Tanaka S, Stock SJ, Yamamoto Y, Kondejewski J, Olson DM. Understanding perinatal mortality. *Obstetrics, Gynaecology and Reproductive Medicine.* 2010;20(11):317-22.
51. Public Health Agency of Canada. Congenital anomalies in Canada 2013: A Perinatal Health Surveillance Report. Ottawa, ON: 2013.
52. Gordijn SJ, Erwich JJ, Khong TY. Value of the perinatal autopsy: critique. *Pediatr Dev Pathol.* 2002;5(5):480-8.
53. Gardosi J, Kady SM, McGeown P, Francis A, Tonks A. Classification of stillbirth by relevant condition at death (ReCoDe): population based cohort study. *BMJ.* 2005;331(7525):1113-7.
54. Statistics Canada. Table 102-0504 - Deaths and mortality rates, by age group and sex, Canada, provinces and territories. 2013.
55. Statistics Canada. Table 102-0507 - Infant deaths and mortality rates, by age group, Canada, provinces and territories. 2013.
56. World Health Organization. World Health Statistics 2014. Geneva: WHO; 2014.
57. OECD. Health at a glance 2013: OECD indicators. OECD; 2013.
58. Cole S, Hartford RB, Bergsjö P, McCarthy B. International collaborative effort (ICE) on birth weight, plurality, perinatal, and infant mortality. III: A method of grouping underlying causes of infant death to aid international comparisons. *Acta Obstet Gynecol Scand.* 1989;68(2):113-7.
59. Liu L, Oza S, Hogan D, Perin J, Rudan I, Lawn JE, et al. Global, regional, and national causes of child mortality in 2000-13, with projections to inform post-2015 priorities: an updated systematic analysis. *Lancet.* 2014.
60. World Health Organization. Preterm birth. Fact sheet N°363. 2014. Accessed: 26-01-2015. Available from: <http://www.who.int/mediacentre/factsheets/fs363/en/>
61. OECD. OECD Factbook 2014: OECD Publishing; 2014.
62. Statistics Canada. Table 102-0562 - Leading causes of death, infants, by sex, Canada. 2014.
63. March of Dimes, PMNCH, Save the Children, WHO. Born Too Soon: The Global Action Report on Preterm Birth. Howson CP, Kinney MV, Lawn JE, editors. Geneva: WHO; 2012.
64. Ezzati M, Lopez AD, Rodgers A, Vander Hoorn S, Murray CJ, Comparative Risk Assessment Collaborating Group. Selected major risk factors and global and regional burden of disease. *Lancet.* 2002;360(9343):1347-60.
65. Pennell CE, Jacobsson B, Williams SM, Buus RM, Muglia LJ, Dolan SM, et al. Genetic epidemiologic studies of preterm birth: guidelines for research. *Am J Obstet Gynecol.* 2007;196(2):107-18.
66. Saigal S, Doyle LW. An overview of mortality and sequelae of preterm birth from infancy to adulthood. *Lancet.* 2008;371(9608):261-9.
67. Burris HH, Collins JW, Jr. Race and preterm birth - the case for epigenetic inquiry. *Ethn Dis.* 2010;20(3):296-9.
68. Muggah E, Way D, Muirhead M, Baskerville B. Preterm delivery among Inuit women in the Baffin Region of the Canadian Arctic. *Int J Circumpolar Health.* 2004;63 Suppl 2:242-7.
69. Crengle S, Freemantle CJ, Gallaher G, McAullay D, McShane K, Tauli M. Indigenous children's health report: health assessment in action. 2009.
70. Joseph KS, Kramer MS, Marcoux S, Ohlsson A, Wen SW, Allen A, et al. Determinants of preterm birth rates in Canada from 1981 through 1983 and from 1992 through 1994. *N Engl J Med.* 1998;339(20):1434-9.
71. Canadian Institute for Health Information. Too Early, Too Small: A Profile of Small Babies Across Canada. Ottawa, ON: 2009.
72. Statistics Canada. Table 102-4303 - Birth-related indicators (low and high birth weight, small and large for gestational age, pre-term births), by sex, three-year average, Canada, provinces, territories, health regions and peer groups. 2010.
73. Statistics Canada. Table 102-4512 - Live births, by weeks of gestation and sex, Canada, provinces and territories. 2013.
74. Ananth CV, Liu S, Joseph KS, Kramer MS, Fetal, Infant Health Study Group of the Canadian Perinatal Surveillance System. A comparison of foetal and infant mortality in the United States and Canada. *Int J Epidemiol.* 2009;38(2):480-9.
75. Kramer MS, Platt R, Yang H, Joseph KS, Wen SW, Morin L, et al. Secular trends in preterm birth: a hospital-based cohort study. *JAMA.* 1998;280(21):1849-54.
76. Melamed N, Chen R, Soiberman U, Ben-Haroush A, Hod M, Yoge Y. Spontaneous and indicated preterm delivery in pregestational diabetes mellitus: etiology and risk factors. *Arch Gynecol Obstet.* 2008;278(2):129-34.
77. Shand AW, Bell JC, McElduff A, Morris J, Roberts CL. Outcomes of pregnancies in women with pre-gestational diabetes mellitus and gestational diabetes mellitus; a population-based study in New South Wales, Australia, 1998-2002. *Diabet Med.* 2008;25(6):708-15.
78. Mercer BM, Macpherson CA, Goldenberg RL, Goepfert AR, Hauguel-de Mouzon S, Varner MW, et al. Are women with recurrent spontaneous preterm births different from those without such history? *Am J Obstet Gynecol.* 2006;194(4):1176-84; discussion 84-5.
79. Ananth CV, Getahun D, Peltier MR, Salihu HM, Vintzileos AM. Recurrence of spontaneous versus medically indicated preterm birth. *Am J Obstet Gynecol.* 2006;195(3):643-50.
80. Bloom SL, Yost NP, McIntire DD, Leveno KJ. Recurrence of preterm birth in singleton and twin pregnancies. *Obstet Gynecol.* 2001;98(3):379-85.
81. Balasch J, Gratacos E. Delayed childbearing: effects on fertility and the outcome of pregnancy. *Fetal Diagn Ther.* 2011;29(4):263-73.

82. Tough SC, Newburn-Cook C, Johnston DW, Svenson LW, Rose S, Belik J. Delayed childbearing and its impact on population rate changes in lower birth weight, multiple birth, and preterm delivery. *Pediatrics*. 2002;109(3):399-403.
83. Joseph KS, Allen AC, Dodds L, Turner LA, Scott H, Liston R. The perinatal effects of delayed childbearing. *Obstet Gynecol*. 2005;105(6):1410-8.
84. Kenny LC, Lavender T, McNamee R, O'Neill SM, Mills T, Khashan AS. Advanced maternal age and adverse pregnancy outcome: evidence from a large contemporary cohort. *PLoS One*. 2013;8(2):e56583.
85. Chen XK, Wen SW, Fleming N, Demissie K, Rhoads GG, Walker M. Teenage pregnancy and adverse birth outcomes: a large population based retrospective cohort study. *Int J Epidemiol*. 2007;36(2):368-73.
86. Bai J, Wong FW, Bauman A, Mohsin M. Parity and pregnancy outcomes. *Am J Obstet Gynecol*. 2002;186(2):274-8.
87. Goldenberg RL, Culhane JF, Iams JD, Romero R. Epidemiology and causes of preterm birth. *Lancet*. 2008;371(9606):75-84.
88. Ananth CV, Joseph KS, Oyelese Y, Demissie K, Vintzileos AM. Trends in preterm birth and perinatal mortality among singletons: United States, 1989 through 2000. *Obstet Gynecol*. 2005;105(5 Pt 1):1084-91.
89. Joseph KS, Demissie K, Kramer MS. Obstetric intervention, stillbirth, and preterm birth. *Semin Perinatol*. 2002;26(4):250-9.
90. Joseph KS, Liston RM, Dodds L, Dahlgren L, Allen AC. Socio-economic status and perinatal outcomes in a setting with universal access to essential health care services. *CMAJ*. 2007;177(6):583-90.
91. Bull C. Current and potential impact of fetal diagnosis on prevalence and spectrum of serious congenital heart disease at term in the UK. *British Paediatric Cardiac Association*. *Lancet*. 1999;354(9186):1242-7 ik.
92. Germanakis I, Sifakis S. The impact of fetal echocardiography on the prevalence of liveborn congenital heart disease. *Pediatr Cardiol*. 2006;27(4):465-72.
93. Canadian Institute for Health Information. ICD-10-CA / CCI Implementation Schedule. Accessed: 14-05-2014. Available from: http://www.cihi.ca/CIHI-ext-portal/internet/en/document/standards+and+data+submission/standards/classification+and+coding/codingclass_icd10status
94. Statistics Canada. Table 102-0535 - Deaths, by cause, Chapter XV: Pregnancy, childbirth and the puerperium (O00 to O99), age group and sex, Canada. 2014.
95. Bouvier-Colle MH, Varnoux N, Costes P, Hatton F. Reasons for the underreporting of maternal mortality in France, as indicated by a survey of all deaths among women of childbearing age. *Int J Epidemiol*. 1991;20(3):717-21.
96. Karimian-Teherani D, Haidinger G, Waldhoer T, Beck A, Vutuc C. Under-reporting of direct and indirect obstetrical deaths in Austria, 1980-98. *Acta Obstet Gynecol Scand*. 2002;81(4):323-7.
97. Gissler M, Deneux-Tharaux C, Alexander S, Berg CJ, Bouvier-Colle MH, Harper M, et al. Pregnancy-related deaths in four regions of Europe and the United States in 1999-2000: characterisation of unreported deaths. *Eur J Obstet Gynecol Reprod Biol*. 2007;133(2):179-85.
98. Schuitemaker N, Van Roosmalen J, Dekker G, Van Dongen P, Van Geijn H, Gravenhorst JB. Underreporting of maternal mortality in the Netherlands. *Obstet Gynecol*. 1997;90(1):78-82.
99. Deneux-Tharaux C, Berg C, Bouvier-Colle MH, Gissler M, Harper M, Nannini A, et al. Underreporting of pregnancy-related mortality in the United States and Europe. *Obstet Gynecol*. 2005;106(4):684-92.
100. World Health Organization. Trends in maternal mortality: 1990 to 2013. Estimates by WHO, UNICEF, UNFPA, The World Bank and the United Nations Population Division. Geneva: WHO, 2014.
101. World Health Organization. Millennium Development Goals (MDGs). Accessed: 26-05-2014. Available from: http://www.who.int/topics/millennium_development_goals/en/
102. United Nations Foundation. Every woman, every child. Accessed: 13-06-2014. Available from: <http://www.everywomaneverychild.org/>
103. Harper S. Prime Minister announces Canada's contribution to the Muskoka Initiative on Maternal, Newborn and Child Health. 2010. Accessed: 13-06-2014. Available from: <http://www.pm.gc.ca/eng/news/2010/06/25/pm-announces-canadas-contribution-muskoka-initiative-maternal-newborn-and-child#sthash.L2o4RnC8.dpuf>
104. Harper S. Canada's forward strategy saving every woman, every child: within arm's reach. 2014. Accessed: 13-06-2014. Available from: <http://www.pm.gc.ca/eng/news/2014/05/29/canada-continues-lead-world-maternal-newborn-and-child-health>
105. Smylie J, Anderson M. Understanding the health of Indigenous peoples in Canada: key methodological and conceptual challenges. *CMAJ*. 2006;175(6):602.
106. Assembly of First Nations: Description of the AFN. Accessed: 10-07-2014. Available from: <http://www.afn.ca/index.php/en/about-afn/description-of-the-afn>
107. Statistics Canada. Aboriginal Peoples in Canada: First Nations People, Métis and Inuit. National household survey, 2011. Catalogue no. 99-011-X2011001. 2011.
108. Wenman WM, Joffres MR, Tataryn IV, Edmonton Perinatal Infections G. A prospective cohort study of pregnancy risk factors and birth outcomes in Aboriginal women. *CMAJ*. 2004;171(6):585-9.
109. Luo ZC, Wilkins R, Heaman M, Smylie J, Martens PJ, McHugh NG, et al. Birth outcomes and infant mortality among First Na-

- tions Inuit, and non-Indigenous women by northern versus southern residence, Quebec. *J Epidemiol Community Health*. 2012;66(4):328-33.
110. Wassimi S, Wilkins R, McHugh NG, Xiao L, Simonet F, Luo ZC. Association of macrosomia with perinatal and postneonatal mortality among First Nations people in Quebec. *CMAJ*. 2011;183(3):322-6.
 111. Luo ZC, Kierans WJ, Wilkins R, Liston RM, Mohamed J, Kramer MS, et al. Disparities in birth outcomes by neighborhood income: temporal trends in rural and urban areas, british columbia. *Epidemiology*. 2004;15(6):679-86.
 112. Luo ZC, Kierans WJ, Wilkins R, Liston RM, Uh SH, Kramer MS. Infant mortality among First Nations versus non-First Nations in British Columbia: temporal trends in rural versus urban areas, 1981-2000. *Int J Epidemiol*. 2004;33(6):1252-9.
 113. Freemantle CJ, Read AW, de Klerk NH, McAullay D, Anderson IP, Stanley FJ. Patterns, trends, and increasing disparities in mortality for Aboriginal and non-Aboriginal infants born in Western Australia, 1980-2001: population database study. *Lancet*. 2006;367(9524):1758-66.
 114. Freemantle CJ, Read AW, de Klerk NH, McAullay D, Anderson IP, Stanley FJ. Sudden infant death syndrome and unascertainable deaths: trends and disparities among Aboriginal and non-Aboriginal infants born in Western Australia from 1980 to 2001 inclusive. *J Paediatr Child Health*. 2006;42(7-8):445-51.
 115. Baldwin LM, Grossman DC, Casey S, Hollow W, Sugarman JR, Freeman WL, et al. Perinatal and infant health among rural and urban American Indians/Alaska Natives. *Am J Public Health*. 2002;92(9):1491-7.
 116. Statistics Canada. Table 102-4304 - Birth-related indicators (low and high birth weight, small and large for gestational age, pre-term births), by sex, three-year average, Canada, provinces, territories, census metropolitan areas and metropolitan influence zones. 2010.
 117. Arbour L, Gilpin C, Millor-Roy V, Platt R, Pেকেles G, Egeland GM, et al. Heart defects and other malformations in the Inuit in Canada: a baseline study. *Int J Circumpolar Health*. 2004;63(3):251-66.
 118. Heaman M, Kingston D, Chalmers B, Sauve R, Lee L, Young D. Risk factors for preterm birth and small-for-gestational-age births among Canadian women. *Paediatr Perinat Epidemiol*. 2013;27(1):54-61.
 119. Oliveira AP, Kalra S, Wahi G, McDonald S, Desai D, Wilson J, et al. Maternal and newborn health profile in a first nations community in Canada. *J Obstet Gynaecol Can*. 2013;35(10):905-13.
 120. Mehaffey K, Higginson A, Cowan J, Osborne GM, Arbour LT. Maternal smoking at first prenatal visit as a marker of risk for adverse pregnancy outcomes in the Qikiqtaaluk (Baffin) Region. *Rural Remote Health*. 2010;10(3):1484.
 121. Edwards VJ, Anda RF, Gu D, Dube SR, Felitti VJ. Adverse childhood experiences and smoking persistence in adults with smoking-related symptoms and illness. *Perm J*. 2007;11(2):5-13.
 122. Christiaens I, Olson DM, Metz GA. Stress and Preterm Birth. In: Zhang L, Longo LD, editors. *Stress and Developmental Programming of Health and Disease: Beyond Phenomenology*. New York: Nova Science Publishers, Inc; 2014. (In Press).
 123. Yao Y, Robinson AM, Zucchi FC, Robbins JC, Babenko O, Kovalchuk O, et al. Ancestral exposure to stress epigenetically programs preterm birth risk and adverse maternal and newborn outcomes. *BMC Med*. 2014;12:121.
 124. Bombay A, Matheson K, Anisman H. The impact of stressors on second generation Indian Residential School survivors. *Transcult Psychiatry*. 2011;48(4):367-91.
 125. Luo ZC, Wilkins R. Degree of rural isolation and birth outcomes. *Paediatr Perinat Epidemiol*. 2008;22(4):341-9.
 126. Luo ZC, Wilkins R, Heaman M, Martens P, Smylie J, Hart L, et al. Birth outcomes and infant mortality by the degree of rural isolation among first nations and non-first nations in Manitoba, Canada. *J Rural Health*. 2010;26(2):175-81.
 127. National Aboriginal Health Association. Midwifery and Aboriginal Midwifery in Canada. 2004.
 128. Society of Obstetricians and Gynaecologists Canada. A report on best practices for returning birth to rural and remote aboriginal communities. *Journal of Obstetrics and Gynaecology Canada*. 2007;29(3):250-60.
 129. Van Wagner V, Osepchuk C, Harney E, Crosbie C, Tulugak M. Remote midwifery in Nunavik, Quebec, Canada: outcomes of perinatal care for the Inuulitsivik health centre, 2000-2007. *Birth*. 2012;39(3):230-7.
 130. Van Wagner V, Epoo B, Nastapoka J, Harney E. Reclaiming birth, health, and community: midwifery in the Inuit villages of Nunavik, Canada. *J Midwifery Womens Health*. 2007;52(4):384-91.
 131. Joint Position Paper Working Group. Joint position paper on rural maternity care. *Canadian Journal of Rural Medicine*. 2012;17(4):135-41.
 132. Klein M, Christilaw J, Johnston S. Loss of maternity care: the cascade of unforeseen dangers. *Canadian Journal of Rural Medicine*. 2002;7:120-21.
 133. Klein M, Johnston S, Christilaw J, Carty E. Mothers, babies, and communities. Centralizing maternity care exposes mothers and babies to complications and endangers community sustainability. *Can Fam Physician*. 2002;48:1177-9, 83-5.
 134. Simonet F, Wassimi S, Heaman M, Smylie J, Martens P, McHugh NG, et al. Individual- and Community-Level Disparities in Birth Outcomes and Infant Mortality among First Nations, Inuit and Other Populations in Quebec. *Open Womens Health J*. 2010;4:18-24.
 135. Martijn LL, Jacobs AJ, Maassen, II, Buitendijk SS, Wensing MM. Patient safety in midwifery-led care in the Netherlands. *Midwifery*. 2013;29(1):60-6.

136. Hutton EK, Reitsma AH, Kaufman K. Outcomes associated with planned home and planned hospital births in low-risk women attended by midwives in Ontario, Canada, 2003-2006: a retrospective cohort study. *Birth*. 2009;36(3):180-9.
137. Olsen O, Clausen JA. Planned hospital birth versus planned home birth. *Cochrane Database Syst Rev*. 2012;9:CD000352.
138. Amelink-Verburg MP, Verloove-Vanhorick SP, Hakkenberg RM, Veldhuijzen IM, Bennebroek Gravenhorst J, Buitendijk SE. Evaluation of 280,000 cases in Dutch midwifery practices: a descriptive study. *BJOG*. 2008;115(5):570-8.
139. Fullerton JT, Navarro AM, Young SH. Outcomes of planned home birth: an integrative review. *J Midwifery Womens Health*. 2007;52(4):323-33.
140. Lalonde AB, Butt C, Bucio A. Maternal health in Canadian Aboriginal communities: challenges and opportunities. *J Obstet Gynaecol Can*. 2009;31(10):956-62.
141. Government of Nunavut, Department of Health and Social Services. *Nunavut Maternal and Newborn Health Care Strategy 2009-2014*. Iqaluit, NU: 2009.
142. Simonet F, Wilkins R, Labranche E, Smylie J, Heaman M, Martens P, et al. Primary birthing attendants and birth outcomes in remote Inuit communities--a natural "experiment" in Nunavik, Canada. *J Epidemiol Community Health*. 2009;63(7):546-51.
143. National Aboriginal Health Organization. *Birthing Through First Nations Midwifery Care*. 2009. Accessed: 25-06-2014. Available from: <http://www.naho.ca/documents/fnc/english/Midwifery.pdf>
144. Hogberg U. The decline in maternal mortality in Sweden: the role of community midwifery. *Am J Public Health*. 2004;94(8):1312-20.
145. Andersson T, Hogberg U, Bergstrom S. Community-based prevention of perinatal deaths: lessons from nineteenth-century Sweden. *Int J Epidemiol*. 2000;29(3):542-8.
146. Auger N, Fon Sing M, Park AL, Lo E, Trempe N, Luo ZC. Pre-term birth in the Inuit and First Nations populations of Quebec, Canada, 1981-2008. *Int J Circumpolar Health*. 2012;71:17520.
147. Heaman MI, Gupton AL, Moffatt ME. Prevalence and predictors of inadequate prenatal care: a comparison of aboriginal and non-aboriginal women in Manitoba. *J Obstet Gynaecol Can*. 2005;27(3):237-46.
148. Catalano PM. Management of obesity in pregnancy. *Obstet Gynecol*. 2007;109(2 Pt 1):419-33.
149. Smylie J, Fell D, Ohlsson A, Joint Working Group on First Nations Indian I, Metis Infant Mortality of the Canadian Perinatal Surveillance S. A review of Aboriginal infant mortality rates in Canada: striking and persistent Aboriginal/non-Aboriginal inequities. *Can J Public Health*. 2010;101(2):143-8.
150. Crane JM, Murphy P, Burrage L, Hutchens D. Maternal and perinatal outcomes of extreme obesity in pregnancy. *J Obstet Gynaecol Can*. 2013;35(7):606-11.
151. Australian Bureau of Statistics. *3302.0 Deaths Australia 2012*. 2013.
152. Australian Health Ministers' Conference (AHMC). *National Maternity Services Plan*. Canberra: Commonwealth of Australia, 2011.
153. Australian Institute of Health and Welfare. *The health and welfare of Australia's Aboriginal and Torres Strait Islander people: an overview*. 2011.
154. Sullivan EA, Hall B, King JF. *Maternal deaths in Australia 2003-2005*. Maternal deaths series no. 3. Cat. no. PER 42. . Sydney: AIHW National Perinatal Statistics Unit, 2007.
155. Kildea S, Stapleton H, Murphy R, Kosiak M, Gibbons K. The maternal and neonatal outcomes for an urban Indigenous population compared with their non-Indigenous counterparts and a trend analysis over four triennia. *BMC Pregnancy Childbirth*. 2013;13:167.
156. Alexander GR, Wingate MS, Bader D, Kogan MD. The increasing racial disparity in infant mortality rates: composition and contributors to recent US trends. *Am J Obstet Gynecol*. 2008;198(1):51 e1-9.
157. Alexander GR, Wingate MS, Boulet S. Pregnancy outcomes of American Indians: contrasts among regions and with other ethnic groups. *Matern Child Health J*. 2008;12 Suppl 1:5-11.
158. Sayers SM. Indigenous newborn care. *Pediatr Clin North Am*. 2009;56(6):1243-61.
159. Luo ZC, Wilkins R, Platt RW, Kramer MS, Fetal, Infant Health Study Group of the Canadian Perinatal Surveillance System. Risks of adverse pregnancy outcomes among Inuit and North American Indian women in Quebec, 1985-97. *Paediatr Perinat Epidemiol*. 2004;18(1):40-50.
160. Li Z, Zeki R, Hilder L, Sullivan E. *Australia's mothers and babies 2011*. Perinatal statistics series no. 28. Cat. no. PER 59 Canberra: AIHW National Perinatal Epidemiology and Statistics Unit 2013 Report No.
161. Rumbold AR, Cunningham J. A review of the impact of antenatal care for Australian Indigenous women and attempts to strengthen these services. *Matern Child Health J*. 2008;12(1):83-100.
162. Kildea S, Kruske S, Barclay L, Tracy S. 'Closing the Gap': how maternity services can contribute to reducing poor maternal infant health outcomes for Aboriginal and Torres Strait Islander women. *Rural Remote Health*. 2010;10(3):1383.
163. Australian Government, Department of Social Services. *Closing the gap, the Indigenous reform agenda*. 2013. Accessed: 12-06-2014. Available from: (<http://www.dss.gov.au/our-responsibilities/indigenous-australians/programs-services/closing-the-gap>)
164. Statistics Netherlands. *Gezondheid en zorg in cijfers 2013*. Den Haag: Centraal bureau voor de statistiek, 2013.
165. Statistics Netherlands. *Mortality; key figures*. 2012.
166. Central Intelligence Agency. *The World Factbook: Netherlands*. 2010. Accessed: 09-06-2014. Available from: <https://www.cia.gov/library/publications/the-world-factbook/g eos/nl.html>

167. Unicef. At a glance: Netherlands. 2013. Accessed: 09-06-2014. Available from: http://www.unicef.org/infobycountry/netherlands_statistics.html
168. Amelink-Verburg MP, Buitendijk SE. Pregnancy and labour in the Dutch maternity care system: what is normal? The role division between midwives and obstetricians. *J Midwifery Womens Health*. 2010;55(3):216-25.
169. CVZ Commissie Verloskunde Verloskundig Vademecum. *Obstetric Manual 2003*. College voor Zorgverzekeringen, Diemen, the Netherlands: 2003.
170. Statistics Netherlands. *Bevalling, lengte en gewicht bij geboorte, borstvoeding*. 2013.
171. van der Kooy J, Poeran J, de Graaf JP, Birnie E, Denktass S, Steegers EA, et al. Planned home compared with planned hospital births in the Netherlands: intrapartum and early neonatal death in low-risk pregnancies. *Obstet Gynecol*. 2011;118(5):1037-46.
172. Society of Obstetricians and Gynaecologists Canada. Returning birth to Aboriginal, rural and remote communities. *Journal of Obstetrics and Gynaecology Canada*. 2010;32(12):1186-8.
173. Institute for International Cooperation JICA. *Japan's Experiences in Public Health and Medical Systems*. Chapter 3: Maternal and Child Health. 2005.
174. OECD. "Infant mortality", *Health: Key tables from OECD*, No. 14. 2013.
175. Leppert PC. An analysis of the reasons for Japan's low infant mortality rate. *J Nurse Midwifery*. 1993;38(6):353-7.
176. Hiraizumi Y, Suzuki S. Perinatal outcomes of low-risk planned home and hospital births under midwife-led care in Japan. *J Obstet Gynaecol Res*. 2013;39(11):1500-4.
177. Bhuiyan SU, Nakamura Y. Continuity of maternal, neonatal and child health care through MCH Handbook for ensuring the quality of life. 2008.
178. Hagiwara A, Ueyama M, Ramlawi A, Sawada Y. Is the Maternal and Child Health (MCH) handbook effective in improving health-related behavior? Evidence from Palestine. *J Public Health Policy*. 2013;34(1):31-45.
179. Yorifuji T, Naruse H, Kashima S, Murakoshi T, Kato T, Inoue S, et al. Trends of preterm birth and low birth weight in Japan: a one hospital-based study. *BMC Pregnancy Childbirth*. 2012;12:162.
180. Yorifuji T, Tanihara S, Inoue S, Takao S, Kawachi I. The role of medicine in the decline of post-War infant mortality in Japan. *Paediatr Perinat Epidemiol*. 2011;25(6):601-8.
181. Maeda K. Progress of Perinatal Medicine in Japan. *J Health Med Informat*. 2013;S11:002.
182. World Health Organization. Japan: Setting an example to the world in reducing maternal mortality. 2008. Accessed: 13-06-2014. Available from: <http://www.who.int/pmnch/media/news/2008/japanexample.pdf>
183. Society of Obstetricians and Gynaecologists Canada. *A National Birthing Initiative for Canada*. 2008.
184. Cammu H, Martens E, Van Mol C, Jacquemyn Y. *Perinatale activiteiten in Vlaanderen 2012*. Brussel: SPE, 2013.
185. Statistics Canada. Table 102-4515 - Live births and fetal deaths (stillbirths), by type (single or multiple), Canada, provinces and territories. 2013.