

Maternal education and fetal and infant mortality in Quebec

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Abstract

Objectives

This article examines differences in fetal and infant mortality by maternal education in the province of Quebec, where the rates are among the lowest in Canada.

Data source

The data are from linked birth and infant death records (including stillbirths) for the 1990-1991 birth cohorts in Quebec.

Main results

Fetal and infant mortality rates were greater for the offspring of mothers with less than 12 years of education, compared with mothers with at least 14 years, even after adjusting for maternal age, parity, marital status and infant's sex. When intermediate factors such as birthweight or both gestational age and fetal growth were taken into account, the differentials in mortality by education diminished. If all education groups had experienced the low rates attained by the higher education group, the number of fetal and infant deaths would have been reduced by approximately 20%.

Key words

causes of death, low birthweight, small for gestational age, fetal growth, excess deaths, record linkage

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Fetal and infant mortality rates have declined rapidly in industrialized nations in the past decades. In Canada, these rates are among the lowest in the world.¹⁻³ Nevertheless, there are still marked disparities in infant mortality by socioeconomic status.⁴

Assessing the nature and extent of social inequalities in fetal and infant mortality is necessary in attempts to further reduce them.^{5,6} However, since most Canadian vital statistics records do not contain the necessary socioeconomic data, little research has been done linking fetal and infant deaths to socioeconomic status at the individual level. An exception is the province of Quebec, where, since 1976, birth registrations have included the mother's educational attainment.

Maternal education, a modifiable aspect of socioeconomic status,⁷ has consistently been found to be inversely related to infant mortality. This association is stronger in countries that do not have universal health

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Methods

Data source

This study was based on singleton live births of any birthweight or gestational age, stillbirths of 500 g or more, and infant death records from the 1990-1991 cohorts of births to mothers whose usual place of residence was Quebec. Among the 192,150 total singleton births, there were 859 stillbirths and 1,004 infant deaths. Live births were followed for one year for mortality, using a probabilistic record linkage technique to match records from the Canadian Birth Data Base to corresponding records in the Canadian Mortality Data Base. The linkage of infant death records to corresponding live birth records was successful for 94% of the infant deaths. By linking the two records, infant deaths could be cross-classified by the marital status and parity of the mother, and by the birthweight and gestational age of the infant.

The birth-death linkage was carried out using the mainframe version of the generalized record linkage system GRLS V1, based on the Fellegi-Sunter model.⁸⁻¹¹ Surnames on the birth and death records were assigned a phonetic code (NYSIIS) to allow for misspellings. Three passes of the files were completed; on each pass only records within the same "pocket" were compared. The pockets were defined as follows: 1) phonetic NYSIIS surname and sex code; 2) date of birth and sex code; and 3) date of birth alone. Rules were set to compare items common to the two files. Fields common to the two files included surname, given names, geographic variables, particulars of the father and mother, birthweight, etc. To determine if paired records from the two data bases referred to the same individual, a weight was calculated based on how closely the records matched. Threshold values were set above which the linkages were accepted or flagged as possible links. Manual resolution was carried out to decide which possible links should be accepted. Where necessary, copies of the source documents (birth and death registrations) were consulted for additional information.

Analytical techniques

Crude relative risks, as well as crude and adjusted odds ratios (using logistic regression) and hazard ratios (using survival analysis) were calculated to investigate the relationship between maternal education and fetal and infant mortality. Potential confounding factors that were examined included maternal age, parity, marital status and infant's sex.^{7,12-14} Birthweight or gestational age and fetal growth (see *Definitions*) were added to the models to determine if the influence of maternal education was modified by these intermediate factors. When gestational age and fetal growth were included in the model, low birthweight was excluded because it is known to be the result of preterm birth, fetal growth restriction, or a combination of

the two.^{7,13,15-18} In the cause-specific survival analysis, deaths due to causes other than the one of interest were considered censored upon such death. The product limit (Kaplan-Meier) method was used to estimate cumulative total mortality.

Using rates in the highest educational group (14 years or more) as an achievable standard, the number of *excess events* was calculated by subtracting expected events from observed events. The expected events were obtained by applying the achievable standard rates to all births with known maternal education. The percentage of all events that were considered avoidable was calculated by dividing excess events by observed events, then multiplying by 100.⁴ The result is more commonly known as the population attributable risk percentage (PAR%) (also known as the etiologic fraction, population attributable proportion or risk percentage).

The PAR% is commonly used to denote how much of the disease burden in a population could be attributable to the effects of certain causal factors, assuming that no confounding of the association between the exposure and the disease exists. It can be calculated as $100 \times (R_t - R_u) / R_t$, where R_t is the risk in the total population and R_u is the risk in the unexposed population; or as $100 \times (P_{exp} \times (RR - 1)) / (1 + P_{exp} \times (RR - 1))$, where P_{exp} is the prevalence of exposure, and RR is the risk ratio comparing exposed to unexposed.^{7,19-22}

Finally, because the two groups with the least maternal education (10 years or less and 11 years) were of particular concern, the attributable fraction was also calculated for these two combined exposed groups, as well as the excess events in the combined groups as a percentage of the excess events in the total cohort with known maternal education. The *attributable fraction* for the exposed is simply the excess events associated with the risk factor, expressed as a percentage of the total events for those exposed to the risk factor.

Limitations

The results are not necessarily generalizable to all of Canada, since only Quebec data are studied here. In Newfoundland, physician notices of birth have recently started collecting information on maternal education, but these data were not available for the years studied here.

Calculations of excess events using only births with known maternal education could result in conservative estimates of excess events and of the PAR % if births and adverse outcomes of unknown maternal education come disproportionately from the lower maternal education groups, which is thought likely.

insurance (such as the United States) and weaker in those with universal health care and a high overall standard of living (such as the Scandinavian countries).^{12,23-27}

Although Quebec's fetal and infant mortality rates are among the lowest in Canada,^{1,2,28,29} an average of 1,020 stillbirths and infant deaths were recorded yearly from 1990 to 1992, yielding an annual rate of 10 per 1,000 total births (livebirths plus stillbirths).¹

This article examines the effects of maternal education on fetal and infant mortality in Quebec in the early 1990s. It is based on live birth, stillbirth and infant death records for the 1990-1991 birth cohorts and is limited to singleton births to mothers who were Quebec residents at the time of the birth. Live births in these cohorts were followed for one year for mortality (see *Methods* and *Definitions*).

The analysis demonstrates that marked differences in fetal and infant mortality by education persist in Quebec, despite many years of universal access to free, high-quality health care. The results imply that if all education groups had been able to attain the low rates of the higher education group, the number of fetal and infant deaths would have been reduced by approximately 20%.

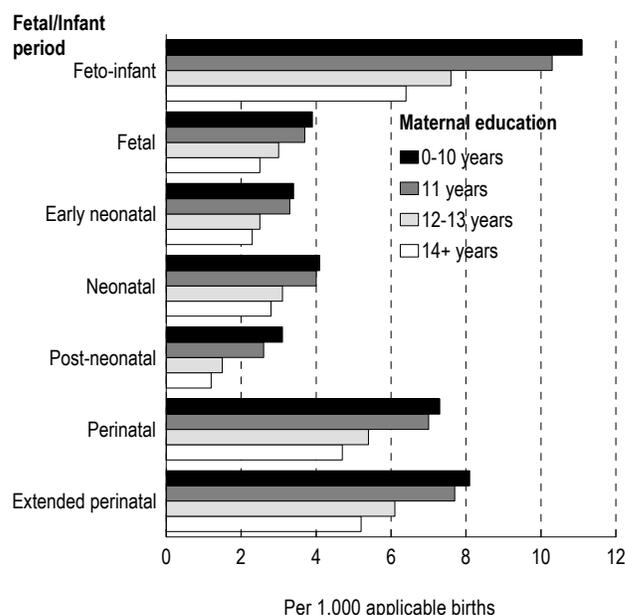
Age-specific deaths

Despite low rates of fetal and infant mortality, a total of 1,863 stillbirths and infant deaths occurred among the 192,150 members of Quebec's 1990 and 1991 cohorts of singleton births. Almost half (859) of these were stillbirths;⁹ another 664 infants died within the first 27 days, and an additional 340 children died before their first birthday.

The mother's education was strongly related to the likelihood of a stillbirth or infant death. As maternal education increased, fetal and infant mortality rates declined (Chart 1). The overall fetoinfant rate fell from 11.1 fetal and infant deaths per 1,000 births for mothers with 10 or fewer years of education to 6.4 for mothers with 14 or more years of schooling (Table 1).

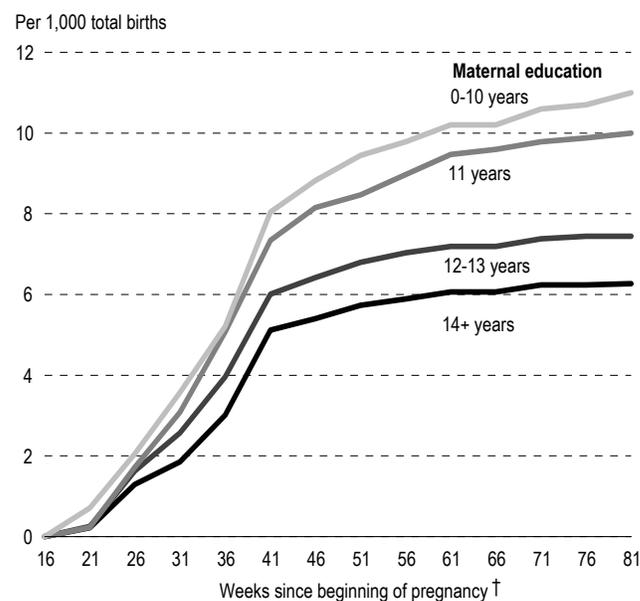
The relationship between lower maternal education and higher mortality was evident regardless of the period of fetal or infant death. The absolute difference in rates was greatest in the

Chart 1
Age-specific fetal and infant mortality rates, by maternal education, singleton live births and stillbirths, Quebec, 1990-1991



Data source: Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base

Chart 2
Cumulative mortality, by weeks since beginning of pregnancy† and maternal education, singleton live births and stillbirths, Quebec, 1990-1991



Data source: Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base
† Completed weeks of gestation for stillbirths; completed weeks of gestation at birth plus weeks of life after birth for live births

Definitions

Maternal age in years was grouped into four categories: 19 or younger, 20 to 24, 25 to 34, and 35 or older.

Legal *marital status* was divided into two categories: married and not married. The results by marital status must be interpreted with caution because of the high prevalence of common-law unions in Quebec.

Maternal education in years was grouped into four categories: 10 years or less, 11 years, 12 or 13 years, and 14 years or more. These parallel the major divisions in Quebec's education system. It takes 11 years to complete high school, 14 years to complete a vocationally oriented CEGEP (community college) program, and 16 years for a first university degree. Differences in fetio-infant mortality rates for breakdowns of educational attainment beyond 14 years were small and did not achieve statistical significance.

Parity refers to the sequential placement of the birth or stillbirth to the particular mother. Four categories were used: first, second, third and fourth or later.

Birthweight in grams was grouped into four categories: 500 to 1,499; 1,500 to 2,499; 2,500 to 4,499; and 4,500 or more. *Low birthweight* (LBW) was 500 to 2,499 g.

Gestational age in completed weeks as reported by the attending physician was grouped into four categories: 33 or less, 34 to 36, 37 to 41, and 42 or more. A *preterm* birth (PT) was less than 37 completed weeks' gestation.

Fetal growth, in terms of percentile of weight for gestational age, infant's sex and plurality (always singleton births in this analysis), was grouped into three categories, based on the most recent Canadian birthweight norms:³⁰ *small for gestational age* (SGA) (below the 10th percentile), *appropriate for gestational age* (AGA) (10th to 90th percentiles), and *large for gestational age* (LGA) (greater than the 90th percentile).

Infant (0 to 364 days), *neonatal (0 to 27 days)*, and *early neonatal (0 to 6 days)* mortality rates were defined as the number of live births resulting in death within the specified period per 1,000 live births. Except for birthweight-specific and gestational age-specific analyses, all live births were included in the denominators, regardless of birthweight or gestational age.

Late neonatal (7 to 27 days) and *post-neonatal (28 to 364 days)* mortality rates were defined as the number of infant deaths occurring within the specified period per 1,000 infants that survived past the end of the preceding period.

Overall *feto-infant (stillbirths + 0 to 364 days)*, *fetal (stillbirths)*, *perinatal (stillbirths + 0 to 6 days)*, and *extended perinatal (stillbirths + 0 to 27 days)* mortality rates were defined as the number of stillbirths plus infant deaths occurring within the specified period per 1,000 stillbirths and live births. In all cases, stillbirths were limited to fetuses weighing at least 500 g at birth, regardless of gestational age.

Rates are not additive when denominators differ. For example, the sum of the neonatal and postneonatal mortality rate does not equal the infant mortality rate.

Underlying cause of death was coded to the International Classification of Diseases, Ninth Revision (ICD-9).³¹ Using the categories proposed by the International Collaborative Effort on Perinatal and Infant Mortality, all underlying causes of deaths were grouped as follows: congenital conditions, sudden infant death syndrome (SIDS), asphyxia-related conditions, immaturity-related conditions, infections, external causes, other specific conditions, and remaining causes.³² ICD-9 codes defining these groupings are presented in Appendix Table A.

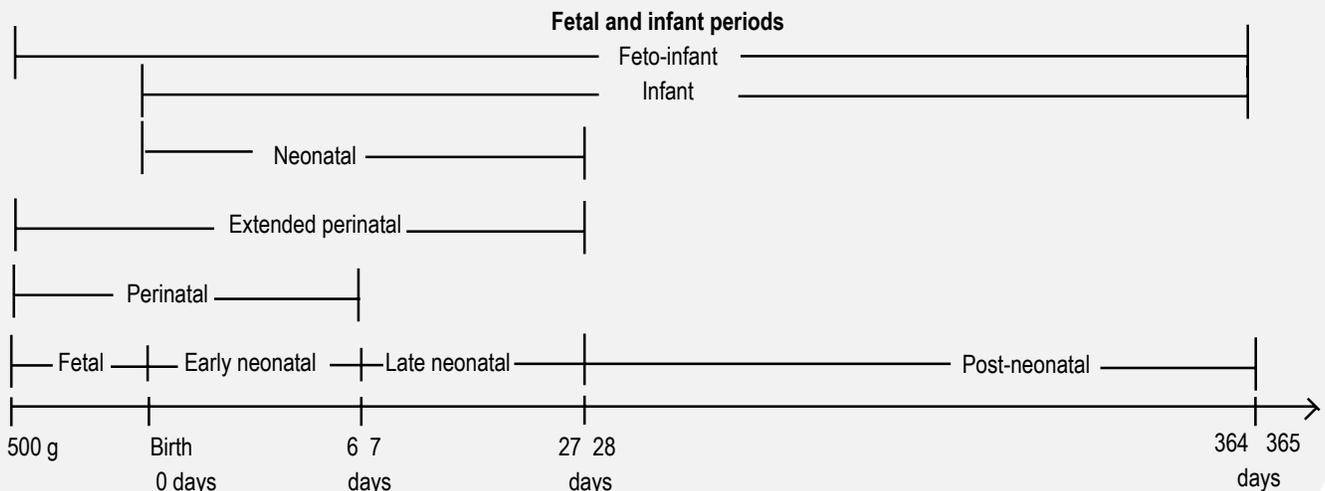


Table 1
Unadjusted fetal-infant mortality rates, by selected maternal and birth characteristics, singleton live births and stillbirths, Quebec, 1990-1991

	Number of births	% of total	Feto-infant mortality		
			Rate (per 1,000)	Rate ratio	95% confidence interval
Total	192,150	100	9.70		
Education					
0-10 years	27,624	14	11.1	1.73*	1.50, 2.01
11 years	22,719	12	10.3	1.61*	1.37, 1.89
12-13 years	62,449	33	7.6	1.19*	1.04, 1.35
14+ years†	69,292	36	6.4	1.00	...
Missing	10,066	5	40.1	6.27*	5.48, 7.17
Maternal age					
<20	8,036	4	15.4	1.77*	1.47, 2.13
20-24	39,863	21	10.7	1.23*	1.10, 1.37
25-34†	129,099	67	8.7	1.00	...
35+	15,018	8	12.4	1.43*	1.22, 1.66
Missing	134	--	74.6	8.57*	2.25, 15.98
Marital status					
Married†	116,316	61	8.6	1.00	...
Not married	75,825	39	11.4	1.33*	1.21, 1.45
Missing	9	--	111.1	12.92*	1.82, 91.81
Parity					
1	88,828	46	11.5	1.60*	1.43, 1.78
2†	66,493	35	7.2	1.00	...
3	25,980	14	8.8	1.22*	1.04, 1.43
4+	10,837	6	11.4	1.58*	1.45, 1.93
Missing	12	--	1000.0	138.89*	78.32, 246.29
Infant sex					
Male	98,833	51	10.2	1.12*	1.02, 1.23
Female†	93,317	49	9.1	1.00	...
Birthweight in grams					
500-1,499	1,648	--	432.6	116.92*	105.16, 129.99
1,500-2,499	8,268	4	42.2	11.41*	10.02, 12.99
2,500-4,499†	177,515	92	3.7	1.00	...
4,500+	2,579	1	4.7	1.27	0.72, 2.24
Missing	2,140	1	58.9	15.92*	13.16, 19.26
Gestational age					
<34 weeks	2,872	1	277.5	66.07*	59.72, 73.10
34-36 weeks	8,386	4	30.3	7.21*	6.25, 8.33
37-41 weeks†	169,145	88	4.2	1.00	...
42+ weeks	5,744	3	4.2	1.00	0.67, 1.50
Missing	6,003	3	11.7	2.79*	2.18, 3.56
Fetal growth‡					
SGA	18,433	10	25.1	3.64*	3.26, 4.06
AGA†	149,476	78	6.9	1.00	...
LGA	15,462	8	7.4	1.07	0.88, 1.30
Missing	8,779	5	29.7	4.30*	3.76, 4.93

Data source: Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base

† Reference category, for which rate ratio is always 1.00

‡ See Definitions.

... Not applicable

-- Amount too small to be expressed

* $p < 0.05$

perinatal period (Chart 1), while the relative difference was most pronounced in the post-neonatal period (odds ratios in Table 2). For all levels of maternal education, the cumulative incidence of deaths and stillbirths rose steeply between 16 and 41 weeks from the beginning of pregnancy (Chart 2). After 41 weeks, mortality rates among the children of mothers in the two lower educational groups continued to rise, while rates for those of mothers in the two higher groups nearly levelled off. This widening gap in cumulative

Table 2
Unadjusted odds ratios for fetal and infant deaths, by maternal education, singleton live births and stillbirths, Quebec, 1990-1991

Fetal and infant period/ Maternal education	Odds ratio	95% confidence interval
Fetal death		
0-10 years	1.60*	1.26, 2.04
11 years	1.52*	1.17, 1.97
12-13 years	1.21	0.98, 1.49
14+ years†	1.00	...
Early neonatal death		
0-10 years	1.50*	1.16, 1.94
11 years	1.47*	1.12, 1.94
12-13 years	1.09	0.87, 1.36
14+ years†	1.00	...
Perinatal death		
0-10 years	1.55*	1.30, 1.85
11 years	1.50*	1.24, 1.81
12-13 years	1.15	0.99, 1.34
14+ years†	1.00	...
Neonatal death		
0-10 years	1.50*	1.19, 1.89
11 years	1.44*	1.12, 1.85
12-13 years	1.13	0.93, 1.38
14+ years†	1.00	...
Extended perinatal death		
0-10 years	1.55*	1.31, 1.83
11 years	1.48*	1.23, 1.77
12-13 years	1.17*	1.01, 1.35
14+ years†	1.00	...
Post-neonatal death		
0-10 years	2.55*	1.89, 3.45
11 years	2.11*	1.51, 2.96
12-13 years	1.20	0.89, 1.62
14+ years†	1.00	...

Data source: Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base

† Reference category, for which odds ratio is always 1.00

... Not applicable

* $p < 0.05$

mortality over the remainder of the first year occurred mostly in the late neonatal and post-neonatal periods, when the vast majority of newborns had already been discharged from hospital. However, the pattern of marked socioeconomic inequality in mortality was already evident by the 28th week, indicating that the process was well under way early in the period of fetal development.

Table 3
Adjusted odds ratios for fetal and infant deaths, by maternal education, singleton live births and stillbirths, Quebec, 1990-1991

Fetal and infant period/ Maternal education	Odds ratio†	95% confidence interval
Fetal death		
0-10 years	1.72*	1.33, 2.23
11 years	1.60*	1.22, 2.08
12-13 years	1.26*	1.02, 1.55
14+ years‡	1.00	...
Early neonatal death		
0-10 years	1.47*	1.11, 1.93
11 years	1.47*	1.11, 1.96
12-13 years	1.11	0.89, 1.39
14+ years‡	1.00	...
Perinatal death		
0-10 years	1.60*	1.33, 1.93
11 years	1.54*	1.27, 1.87
12-13 years	1.19*	1.02, 1.38
14+ years‡	1.00	...
Neonatal death		
0-10 years	1.42*	1.10, 1.82
11 years	1.42*	1.10, 1.83
12-13 years	1.14	0.93, 1.40
14+ years‡	1.00	...
Extended-perinatal death		
0-10 years	1.56*	1.30, 1.87
11 years	1.50*	1.25, 1.81
12-13 years	1.20*	1.03, 1.39
14+ years‡	1.00	...
Post-neonatal death		
0-10 years	1.67*	1.20, 2.33
11 years	1.61*	1.14, 2.28
12-13 years	1.06	0.78, 1.43
14+ years‡	1.00	...

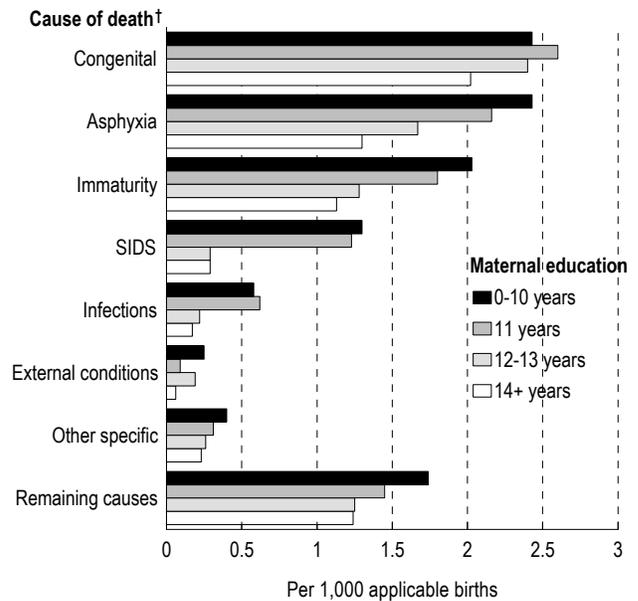
Data source: Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base
 † Adjusted for maternal age, marital status, parity and infant's sex
 ‡ Reference category, for which odds ratio is always 1.00
 ... Not applicable
 * $p < 0.05$

Adjusted effects

Many factors besides maternal education are linked to stillbirth and infant mortality rates (Table 1). For instance, rates were higher among mothers younger than 20 or older than 34, and among mothers who were not legally married. Rates were also high for first births and for fourth or later births. Boys had higher stillbirth and infant mortality rates than girls.

Yet even after adjusting for maternal age, marital status, parity and infant's sex, the effects of maternal education on fetal and infant mortality remained significant. Regardless of when the death occurred (from fetal to post-neonatal periods), the odds of death were considerably higher for mothers in the two lower educational groups, compared with those with at least 14 years of schooling (Table 3).

Chart 3
Cause-specific fetal and infant mortality rates, by maternal education, singleton live births and stillbirths, Quebec, 1990-1991



Data source: Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base
 † See Appendix Table A.

Cause-specific deaths

Overall, the major underlying causes of feto-infant mortality were congenital-related conditions (2.6 per 1,000), asphyxia (2.3 per 1,000), and immaturity (1.6 per 1,000).

Comparing the most to the least educated groups, the absolute differences in rates were greatest for asphyxia, followed by sudden infant death syndrome (SIDS) and immaturity (Chart 3). Relative differences in rates (rate ratios—not shown) were most pronounced for SIDS, followed by external conditions and infections.

Maternal education was strongly linked with fetal and infant mortality from several specific causes. Babies born to mothers with less than 12 years of schooling had an especially high risk of SIDS, compared with children of the most educated mothers (Table 4, unadjusted). On the other hand, there was no relationship between maternal education and deaths due to congenital conditions, the leading cause of feto-infant mortality. Differences in mortality risk by maternal education were evident for external conditions, although these results must be interpreted with caution, as there were only 25 cases.

Once the effects of maternal age, parity, marital status and infant's sex were taken into account, the relative risk (hazard ratio) for deaths due to asphyxia, immaturity and infections remained approximately twice as high for infants of mothers with less than 12 years of education, compared with those with 14 or more years of schooling (Table 4, adjusted). The strength of the relationship between maternal education and SIDS diminished, however, after adjusting for these confounding factors. For example, the risk ratio for children of mothers with 11 years of education fell from 4.3 before adjustment to 2.3 after adjustment. To some extent, this reduction in relative risk may have occurred because less educated mothers were more likely to be teenagers and unmarried, both groups with high relative risks of SIDS.³³

Table 4
Cox regression estimates of mortality hazard ratio, by cause of death and maternal education, singleton births, Quebec, 1990-1991

Cause of death	Unadjusted		Adjusted [†]	
	Hazard ratio	95% confidence interval	Hazard ratio	95% confidence interval
All causes of feto-infant deaths				
0-10 years	1.76*	1.52, 2.04	1.62*	1.38, 1.90
11 years	1.59*	1.35, 1.87	1.52*	1.29, 1.79
12-13 years	1.19*	1.04, 1.36	1.18*	1.03, 1.35
14+ years [‡]	1.00	...	1.00	...
All causes of infant deaths[§]				
0-10 years	1.83*	1.53, 2.20	1.52*	1.24, 1.85
11 years	1.65*	1.35, 2.01	1.48*	1.20, 1.82
12-13 years	1.16	0.98, 1.36	1.11	0.94, 1.31
14+ years [‡]	1.00	...	1.00	...
Congenital conditions				
0-10 years	1.21	0.90, 1.63	1.17	0.85, 1.60
11 years	1.25	0.91, 1.71	1.22	0.89, 1.68
12-13 years	1.19	0.94, 1.51	1.19	0.94, 1.51
14+ years [‡]	1.00	...	1.00	...
Asphyxia-related conditions				
0-10 years	1.86*	1.35, 2.57	2.04*	1.45, 2.88
11 years	1.60*	1.12, 2.29	1.72*	1.19, 2.48
12-13 years	1.31	0.98, 1.74	1.37*	1.03, 1.83
14+ years [‡]	1.00	...	1.00	...
Immaturity-related conditions				
0-10 years	1.87*	1.31, 2.66	1.86*	1.27, 2.72
11 years	1.60*	1.08, 2.37	1.65*	1.10, 2.47
12-13 years	1.21	0.88, 1.67	1.27	0.92, 1.75
14+ years [‡]	1.00	...	1.00	...
SIDS[§]				
0-10 years	4.53*	2.62, 7.83	1.74	0.95, 3.18
11 years	4.28*	2.41, 7.60	2.33*	1.28, 4.24
12-13 years	1.00	0.53, 1.89	0.72	0.38, 1.37
14+ years [‡]	1.00	...	1.00	...
Infections				
0-10 years	3.33*	1.58, 7.04	2.43*	1.08, 5.47
11 years	3.55*	1.64, 7.67	2.92*	1.31, 6.48
12-13 years	1.29	0.60, 2.79	1.17	0.54, 2.55
14+ years [‡]	1.00	...	1.00	...
External conditions				
0-10 years	4.41*	1.29, 15.05	3.69	0.98, 13.85
11 years	1.53	0.28, 8.35	1.36	0.24, 7.64
12-13 years	3.33*	1.07, 10.33	3.14*	1.00, 9.85
14+ years [‡]	1.00	...	1.00	...
Other specific/Remaining causes				
0-10 years	1.50*	1.08, 2.08	1.44*	1.02, 2.05
11 years	1.25	0.86, 1.81	1.18	0.81, 1.74
12-13 years	1.02	0.77, 1.37	1.02	0.76, 1.37
14+ years [‡]	1.00	...	1.00	...

Data source: Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base

[†] Adjusted for maternal age, marital status, parity and infant sex.

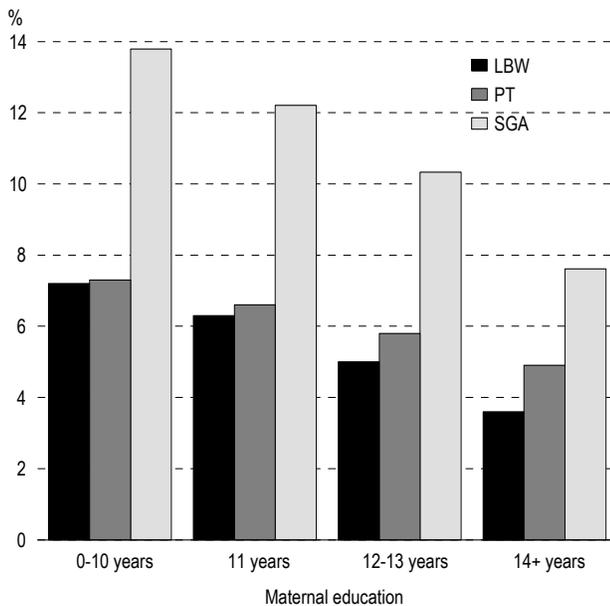
[‡] Reference category, for which hazard ratio is always 1.00

[§] Based on live births only.

... Not applicable

* $p < 0.05$

Chart 4
Low birthweight, pre-term and small-for-gestational-age births, by maternal education, singleton live births, Quebec, 1990-1991



Data source: Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base

Table 5
Odds ratios for low birthweight, pre-term and small-for-gestational-age births, by maternal education, singleton births, Quebec, 1990-1991

Birth outcome/ Maternal education	Unadjusted		Adjusted†	
	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval
LBW				
0-10 years	2.06*	1.94, 2.19	2.07*	1.94, 2.21
11 years	1.78*	1.66, 1.90	1.79*	1.67, 1.92
12-13 years	1.39*	1.32, 1.47	1.42*	1.34, 1.50
14+ years‡	1.00	...	1.00	...
PT				
0-10 years	1.53*	1.44, 1.62	1.48*	1.39, 1.58
11 years	1.36*	1.28, 1.45	1.35*	1.26, 1.44
12-13 years	1.20*	1.15, 1.26	1.21*	1.15, 1.27
14+ years‡	1.00	...	1.00	...
SGA				
0-10 years	1.94*	1.86, 2.03	2.04*	1.95, 2.15
11 years	1.69*	1.61, 1.78	1.73*	1.65, 1.82
12-13 years	1.40*	1.35, 1.46	1.43*	1.38, 1.49
14+ years‡	1.00	...	1.00	...

Data source: Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base

† Adjusted for maternal age, marital status, parity and infant sex

‡ Reference category, for which odds ratio is always 1.00

... Not applicable

* p < 0.05

Intermediate factors

Maternal education was also inversely related to low birthweight, preterm and small-for-gestational-age births. For example, the low birthweight proportion dropped steadily as maternal education increased, from 7.2% for mothers with 10 or fewer years of schooling to 3.6% for those with at least 14 years (Chart 4). The odds of a low birthweight, pre-term or small-for-gestational-age birth were significantly

Table 6
Odds ratios for fetal and infant deaths, by maternal education adjusted for selected adverse birth outcomes, singleton live births and stillbirths, Quebec, 1990-1991

Fetal and infant period/ Maternal education	Odds ratio†	95% confidence interval	Odds ratio‡	95% confidence interval
Fetal death				
0-10 years	1.07	0.79, 1.45	1.12	0.84, 1.49
11 years	1.22	0.90, 1.67	1.18	0.88, 1.59
12-13 years	1.09	0.85, 1.39	1.06	0.84, 1.33
14+ years§	1.00	...	1.00	...
Early neonatal death				
0-10 years	0.99	0.73, 1.34	0.92	0.68, 1.25
11 years	1.11	0.81, 1.52	1.07	0.78, 1.47
12-13 years	0.92	0.71, 1.18	0.88	0.69, 1.13
14+ years§	1.00	...	1.00	...
Perinatal death				
0-10 years	1.03	0.83, 1.29	1.02	0.82, 1.27
11 years	1.17	0.93, 1.47	1.13	0.90, 1.41
12-13 years	1.00	0.83, 1.20	0.97	0.81, 1.15
14+ years§	1.00	...	1.00	...
Neonatal death				
0-10 years	0.95	0.72, 1.26	0.93	0.70, 1.22
11 years	1.07	0.80, 1.43	1.06	0.80, 1.41
12-13 years	0.96	0.77, 1.20	0.93	0.74, 1.16
14+ years§	1.00	...	1.00	...
Extended perinatal death				
0-10 years	1.01	0.81, 1.24	1.01	0.82, 1.24
11 years	1.14	0.91, 1.41	1.12	0.90, 1.38
12-13 years	1.01	0.85, 1.20	0.98	0.83, 1.16
14+ years§	1.00	...	1.00	...
Post-neonatal death				
0-10 years	1.39	0.98, 1.96	1.40	1.00, 1.96
11 years	1.35	0.94, 1.94	1.38	0.97, 1.97
12-13 years	0.93	0.68, 1.27	0.95	0.70, 1.29
14+ years§	1.00	...	1.00	...

Data source: Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base

† Adjusted for maternal age, marital status, parity, infant sex, gestational age and fetal growth

‡ Adjusted for maternal age, marital status, parity, infant sex and birthweight

§ Reference category, for which odds ratio is always 1.00

... Not applicable

higher for all educational levels less than 14 years, whether or not these were adjusted for maternal age, marital status, parity and infant's sex (Table 5).

Low birthweight, pre-term and small-for-gestational-age births were at high risk of fetal and infant mortality. For example, just 5% of singleton births with known birthweight weighed less than 2,500 g, but they accounted for 60% of fetal and neonatal deaths (data not shown).

When either birthweight or both gestational age and fetal growth were adjusted for, educational differences in fetal and infant mortality at different ages of death disappeared for the two lowest educational groups (odds ratios close to 1.0) except for the post-neonatal period (odds ratio of 1.4) (Table 6). These factors are key intervening variables that strongly mediate the association between the mothers' education and fetal and infant mortality.

Room for improvement

Assuming that the low levels of fetal and infant mortality and other adverse birth outcomes (low birthweight, pre-term and small-for-gestational-age births) among mothers with 14 or more years of

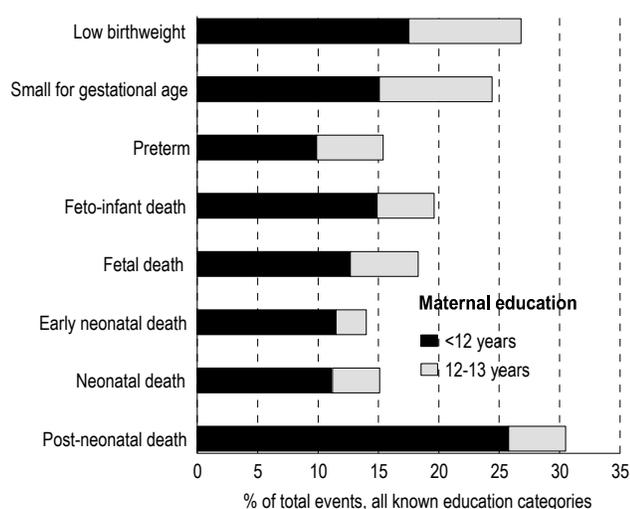
education could be achieved by all, a considerable proportion of the observed events could be considered "excess," or potentially avoidable (Chart 5 and Appendix Table B). Births to mothers with 14 or more years of education accounted for 38% of all births with known maternal education.

If the rates for mothers with the highest level of education had prevailed among all mothers, 27% of all low birthweight births could have been avoided. As well, 15% of pre-term births and 24% of small-for-gestational-age births were potentially avoidable. Twenty percent of fetal and infant deaths were excess, with post-neonatal deaths having the most potential for reduction among age-specific deaths (31%). For specific causes, the highest excess was for deaths due to SIDS and to infections/external causes (both 48%).

Since mothers with less than 12 years of education had the highest rates of fetal and infant mortality and other adverse outcomes, the corresponding excesses were also higher. Although this group represented slightly more than one-quarter (28%) of all births with known maternal education, they accounted for about two-thirds of excess low birthweight, pre-term and small-for-gestational-age births. In addition, 69% of excess fetal deaths and 80% of excess infant deaths, including 85% of post-neonatal and 100% of excess SIDS deaths occurred among the offspring of these mothers.

Chart 5

Excess adverse birth outcomes based on rates for births to mothers with 14 or more years of education, singleton live births and stillbirths, Quebec, 1990-1991



Data source: Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base

Smoking and teenage childbearing

Cigarette smoking during pregnancy has been identified as an important modifiable risk factor for perinatal mortality, low birthweight, pre-term and small-for-gestational-age births.^{7,16,34,35} Women with low educational attainment are more likely to smoke before and during pregnancy, and to smoke more heavily, than those with more education.³⁶⁻³⁹

A recent study of perinatal care in Nova Scotia reported that smoking during pregnancy doubled the risk of low birthweight and that teenage mothers and unmarried mothers were more likely to smoke when they were pregnant.⁴⁰ The present analysis of Quebec data shows that teenage mothers and unmarried mothers tended to be in the low educational group. Nonetheless, even after

controlling for maternal age, marital status, parity and infant's sex, the effects of education on low birthweight remained important and significant. It is likely that maternal educational differences in low birthweight, and ultimately, in fetal and infant mortality, are at least partially accounted for by differences in smoking behaviour.

In Sweden, excess infant mortality among mothers with less education has been partially attributed to teenage childbearing and "delay in seeking medical care or non-compliance with medical care," even though access to medical care is universal.^{25,41} A recent Canadian study documents a persistent income inequality in the utilization of prenatal care in Winnipeg and suggests that "universal health insurance does not remove all barriers to access."⁴² However, in Quebec, few births were to teenage mothers, and those births appear to have accounted for only a small part of the total maternal educational differences in fetal and infant mortality.

Education is important, not only because of its direct effects, but also because it is intertwined with many other factors directly and indirectly relevant to health, such as adequate income, better pre-conception health of the mother, good nutrition during pregnancy and after birth, effective access to pre- and post-natal care, knowledge of risk factors, and avoidance of risk behaviours.

Concluding remarks

Quebec has among the lowest fetal and infant mortality rates in Canada. However, marked differences in fetal and infant mortality by maternal education persist despite many years of universal access to publicly funded, high-quality health care. If all mothers had been able to attain the low rate of fetal and infant mortality already achieved by Quebec mothers with the highest educational attainment, one-fifth of all fetal and infant deaths and nearly one-third of post-neonatal deaths could have been avoided.

Maternal education affects fetal and infant mortality largely through the key intervening factors of low birthweight, or pre-term and small-for-

gestational-age births. Consequently, reductions in fetal and infant mortality will require addressing the causes of these intervening factors. Breaking the link between maternal education and the associated risk factors, such as smoking, would further reduce Quebec's already low level of fetal and infant mortality. The highest potential for improvement exists among mothers with less than 12 years of education, who accounted for a disproportionately large share of excess deaths, especially in the post-neonatal period and for non-congenital-related conditions. ●

Acknowledgements

The authors thank Statistique Québec for providing the data on maternal education. Health Canada, through the Canadian Perinatal Surveillance System, supported the linkage of birth and death records on the Canadian Birth Data Base and the Canadian Mortality Data Base.

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Appendix

Table A

ICD-9^f codes for cause of fetal and infant mortality

Congenital conditions	270-275, 277-279, 282, 284, 286-288, 330, 335, 343, 359, 394-411, 414-417, 424-426, 550-553, 560, 571, 572, 740-759, 777.1
Asphyxia-related conditions	761.6, 761.7, 762.0-762.2, 762.4-762.6, 763, 766-768, 770.1, 772.2, 779.0, 779.2
Immaturity-related conditions	761.3-761.5, 761.8, 761.9, 762.7, 764, 765, 769, 770.2-770.9, 772.1, 774, 777.5, 777.6, 778.2, 779.6, 779.8
Infections	001-139, 254.1, 320-326, 382, 420-422, 460-466, 475-477, 480-491, 510, 511, 513, 540, 541, 566, 567, 570, 572.0, 590, 591, 770.0, 771, 790
Other specific conditions	140-250, 251-253, 283, 331, 423, 430-432, 441, 442, 493, 494, 514-516, 556-559, 762.3, 762.8, 762.9, 772.0, 772.3-772.9, 773, 775, 776, 778.0, 779.4, 779.5
Sudden infant death syndrome (SIDS)	798, 799, E913
External conditions [‡]	260-263, 507, E800-E912, E914-E999
Remaining causes	All remaining codes

Data source: Reference 32

[†] International Classification of Diseases, Ninth Revision (Reference 31)

[‡] External conditions refer to all deaths from injury and poisoning (ICD-9 Chapter 17), except accidental mechanical suffocation (E913), classified according to the "events, circumstances and conditions" that caused them, plus protein-calorie malnutrition (ICD 260-263) and pneumonitis due to inhalation of solids and liquids (ICD 507).

Table B

Excess adverse birth outcomes for all births with known maternal education, and for births to mothers with less than 12 years of education, singleton live births and stillbirths, Quebec, 1990-1991

Birth outcome	Rate in births to mothers with 14+ years of education (1)	All births with known maternal education					Births to mothers with less than 12 years of education					< 12 years as % of all (12)
		Adverse outcomes					Adverse outcomes					
		Births (2)	Observed (3)	Expected (4)	Excess (5)	PAR% (6)	Births (7)	Observed (8)	Expected (9)	Excess (10)	Attributable fraction (11)	
Low birthweight	0.03636	180,107	8,948	6,549	2,399	26.8	49,737	3,376	1,808	1,568	46.4	65.4
Preterm	0.04906	176,419	10,233	8,655	1,578	15.4	48,944	3,412	2,401	1,011	29.6	64.1
Small for gestational age	0.07606	173,914	17,491	13,228	4,263	24.4	48,137	6,294	3,661	2,633	41.8	61.8
Fetal deaths	0.00247	182,084	551	450	101	18.3	50,343	194	124	70	36.1	69.3
Early neonatal deaths	0.00226	181,533	477	410	67	14.0	50,149	168	113	55	32.7	82.1
Neonatal deaths	0.00276	181,533	590	501	89	15.1	50,149	204	138	66	32.4	74.2
Post-neonatal deaths	0.00122	180,943	318	221	97	30.5	49,945	143	61	82	57.3	84.5
Perinatal deaths	0.00472	182,084	1,028	859	169	16.4	50,343	362	238	124	34.3	73.4
Extended perinatal deaths	0.00522	182,084	1,141	950	191	16.7	50,343	398	263	135	33.9	70.7
Feto-infant deaths	0.00644	182,084	1,459	1,173	286	19.6	50,343	541	324	217	40.1	75.9
Infant deaths	0.00398	181,533	908	723	185	20.4	50,149	347	200	147	42.4	79.5
Sudden infant death syndrome (SIDS)	0.00029	182,084	102	53	49	48.0	50,343	64	15	49	76.6	100.0
Asphyxia	0.00130	182,084	310	237	73	23.5	50,343	116	65	51	44.0	69.9
Immaturity	0.00113	182,084	255	206	49	19.2	50,343	97	57	40	41.2	81.6
Infection/External causes	0.00023	182,084	81	42	39	48.1	50,343	39	12	27	69.2	69.2
Congenital	0.00202	182,084	416	368	48	11.5	50,343	126	102	24	19.0	50.0
Other specific/Remaining	0.00147	182,084	295	268	27	9.2	50,343	99	74	25	25.3	92.6

Data source: Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base

Note: PAR%=Population attributable risk percentage

(4)=(1)*(2); (5)=(3)-(4); (6)=100*(5)/(3); (9)=(1)*(7); (10)=(8)-(9); (11)=100*(10)/(8); (12)=100*(10)/(5).