

The Matthew Effect: Infant Mortality in Canada and Internationally

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ABSTRACT. *Objective.* To examine whether the magnitude of improvement in the health status of a population over time is dependent on the previous health status of that population.

Design and Setting. A study of infant mortality rates in Canada's 12 provinces and territories between the periods 1961–1965 and 1991–1995, and of infant mortality rates in 133 countries between 1960 and 1995.

Main Outcome Measures. Spearman's rank correlations, relative risks, and risk differences to measure the relationship between infant mortality in the 1960s and changes in infant mortality between the 1960s and 1990s.

Results. In Canada, regional rankings based on infant mortality rates in 1961–1965 were strongly correlated (inversely) with rankings based on the percent change in infant mortality between 1961–1965 and 1991–1995 (correlation coefficient = $-.85$). In contrast, internationally, rankings based on infant mortality rates in 133 countries in 1960 were positively correlated with percent change between 1960 and 1995 (correlation coefficient = $.56$). Regional differences in infant mortality rates, measured using relative risks, declined in Canada (highest relative risk: 4.2, compared with Ontario in the 1960s; highest relative risk: 2.2, compared with Ontario in the 1990s) but increased globally (highest relative risk: 5.0, compared with industrialized countries in 1960; highest relative risk: 15.1, compared with industrialized countries in 1995).

Conclusions. Canadian regions with higher infant mortality rates in 1961–1965 achieved larger improvements compared with regions with initially lower infant mortality rates. The pattern observed within Canada is unlike the pattern observed internationally. *Pediatrics* 2000;106(1). URL: <http://www.pediatrics.org/cgi/content/full/106/1/e5>; *infant mortality, Canada, health status, industrialized countries, international.*

The magnitude of improvement in the health status of a population over time seems to be linked to the previous health of that population. For instance, it has been demonstrated that the change in the infant mortality rate (number of deaths among infants <1 year of age per 1000 live births) in 122 countries between 1965 and 1985 was inversely

related to the infant mortality rates in these countries in 1965.¹ Specifically, countries with a low infant mortality rate in 1965 (eg, Japan) achieved substantial further declines over the next 20 years, whereas in countries with a high infant mortality rate (eg, Rwanda and Ethiopia) infant mortality rates barely declined at all or even increased.¹ This paradox has been labeled the Matthew effect after a similar psychosocial phenomenon described by Merton²:

“Unto every one that hath shall be given, and he shall have abundance; but from him that hath not shall be taken away even that which he hath” (Matthew 25:29).³

The Canadian health care system embodies the egalitarian ideal of distributive justice by providing universal access to health care services.⁴ Although infant mortality rates in Canada have declined dramatically in recent decades, the situation with regard to regional disparities in infant mortality is less clear. We attempted to quantify changes in regional disparities in infant mortality rates in Canada between 1961–1965 and 1991–1995. To provide a context for the pattern observed in Canada, we also examined changes in international disparities in infant mortality rates between 1960 and 1995.

METHODS

We used published data on the number of live births and infant deaths in each of Canada's 10 provinces and 2 territories.^{5–7} Infant mortality rates were calculated for each province and territory for the periods 1961–1965 and 1991–1995. Data for 5 years were aggregated to increase the stability of the estimates of infant mortality. Infant mortality rates in 1960 and 1995 were obtained for 133 countries from a United Nations Children's Fund publication.⁸ Data on countries of the former Soviet Union (eg, Ukraine) are absent from our analysis owing to lack of comparable data over the study.

Regions of Canada and countries were ranked according to their infant mortality rate in the 1960s. They were also ranked according to observed changes in their infant mortality rates over time. To estimate the relationship between infant mortality rates in the 1960s and the subsequent change over time, we calculated Spearman's rank correlation⁹ between infant mortality rate rankings in the 1960s and rankings of change over time. Only the results comparing the 1960s and 1990s are presented, although comparisons between other periods (eg, between the 1960s and 1980s) showed a similar pattern.

Two options were available for quantifying changes in infant mortality rates over time—differences in rates and percent change over time. Although the difference measure would seem to be of greater significance from a public health standpoint, we chose percent change over time as the principal index for quantifying change. This decision was based on the fact that percent change is the parsimonious (invariant) measure, whereas rate differences are dependent on background rates.¹⁰ Under this form of analysis, a region whose infant mortality declined from 100/1000 live births to 50/1000 live births would show a change identical to another region whose infant mortality fell from 50/1000 live births to 25/1000 live births.

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Comparisons of infant mortality rates between populations at specific points in time were made using relative risks (primary measure) and risk differences (secondary measure). Ontario was used as the reference region within Canada because of its size and because it had the lowest infant mortality rate in 1961–1965. For international comparisons, we calculated relative risks and differences for all 133 countries and for 6 country groupings (based on a United Nations Children’s Fund classification). For ease of presentation, we only report relative risks and differences for the 6 country groupings. For this analysis, industrialized countries were used as the reference group because they had the lowest infant mortality rates in 1960.

RESULTS

Infant mortality rates declined steadily and substantially between 1961–1965 and 1991–1995 in all Canadian provinces and territories (Fig 1). Over the 30-year period, the percent change in infant mortality rates ranged from –67.9% in Saskatchewan to –85.8% in the Northwest Territories. Differences in infant mortality rates ranged from –16.1/1000 live births in Ontario to –79.6/1000 live births in the Northwest Territories (Table 1).

Regional rankings based on infant mortality rates in 1961–1965 were not significantly correlated with ranks based on infant mortality rates in 1991–1995 (correlation coefficient = .21; $P > .05$). In 1961–1965, Ontario, British Columbia, and Alberta had the lowest infant mortality rates, whereas by 1991–1995, Quebec, Prince Edward Island, and Nova Scotia had the lowest rates (Table 1).

Regional rankings based on infant mortality rates in 1961–1965 were strongly correlated (inversely) with regional rankings based on the percent change in rates between 1961–1965 and 1991–1995 (correlation coefficient = $-.85$; $P < .01$). They were also strongly correlated (inversely) with the difference in rates between 1961–1965 and 1991–1995 (correlation coefficient = $-.98$; $P < .01$). The Northwest Territories had the highest infant mortality rate in 1961–1965 but witnessed the most substantial improvement. Ontario and British Columbia had the lowest infant mortality rates in 1961–1965, but ranked 9th and 8th, respectively, in terms of percent change and 12th and 11th in terms of difference in infant mortality rates (Table 1).

Table 2 lists the relative risks and risk differences in infant mortality rates within Canada, with Ontario as the reference region. The infant mortality rate in the Northwest Territories in 1961–1965 was 4.2 times that in Ontario during the same period. In 1991–1995, the rate of infant death in the Northwest Territories was 2.2 times higher than in Ontario. In general, relative risks and risk differences were lower in 1991–1995 than in 1961–1965. In 1961–1965, 10 of 11 provinces and territories had significantly higher infant mortality rates compared with Ontario. By 1991–1995, only 5 regions (Alberta, Manitoba, Saskatchewan, Newfoundland, and the Northwest Territories) had infant mortality rates significantly higher than

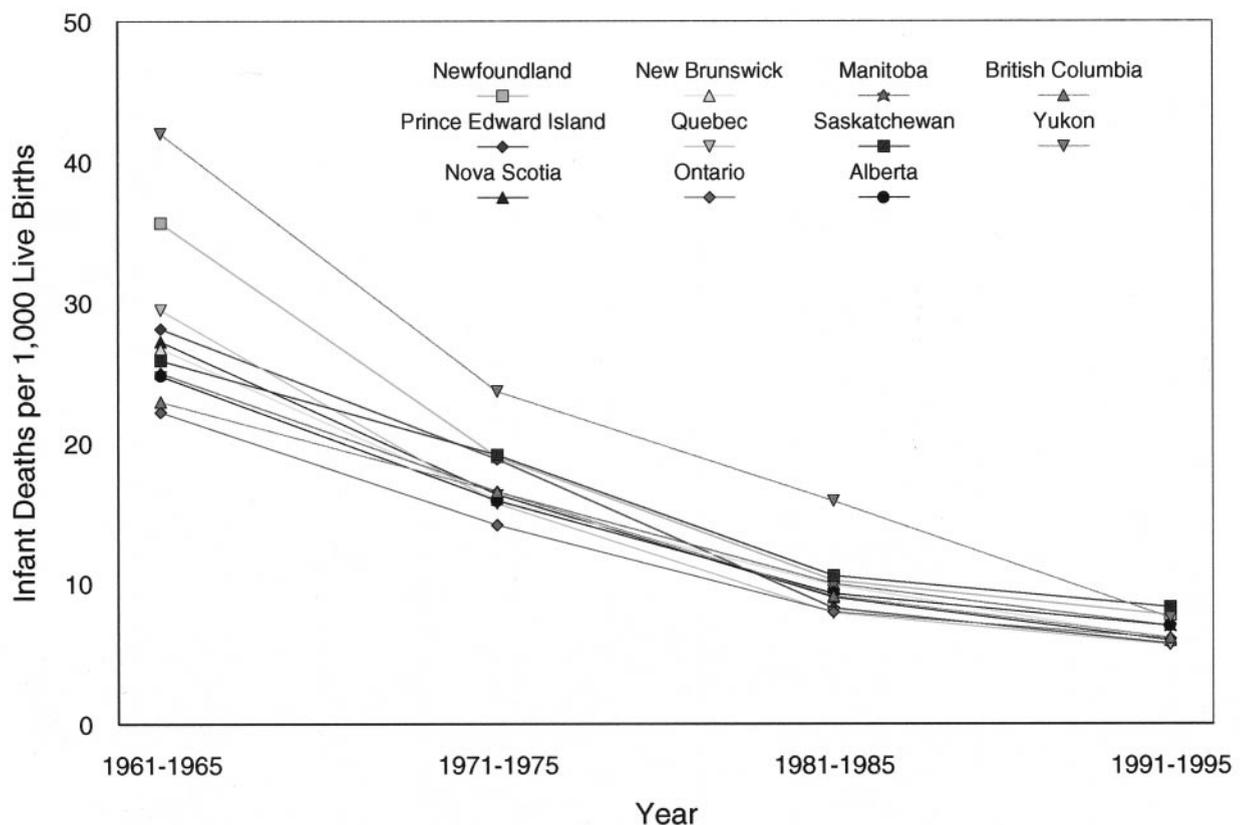


Fig 1. Infant mortality rates in Canadian provinces and the Yukon between 1961–1965 and 1991–1995. Data for the Northwest Territories were excluded attributable to extreme value for infant mortality rate in 1961–1965 (the pattern observed in this region is consistent with changes in other regions; see Table 1). The graphical pattern of trends in regional infant mortality rates was not altered by the use of a log scale for the y-axis.

TABLE 1. Infant Mortality Rates, Percentage Change, and Difference: Canadian Provinces and Territories, 1961–1965 and 1991–1995

Province/Territory	Infant Mortality Rate (Rank)		Change, 1961–1965 through 1991–1995 (Rank)	
	1961–1965	1991–1995	Percent Change	Difference
Ontario	22.2 (1)	6.07 (5)	–72.7 (9)	–16.1 (12)
British Columbia	23.0 (2)	6.15 (6)	–73.2 (8)	–16.8 (11)
Alberta	24.8 (3)	6.99 (8)	–71.8 (11)	–17.8 (9)
Manitoba	25.0 (4)	6.97 (7)	–72.1 (10)	–18.0 (8)
Saskatchewan	25.9 (5)	8.31 (11)	–67.9 (12)	–17.6 (10)
New Brunswick	26.7 (6)	5.96 (4)	–77.7 (7)	–20.8 (7)
Nova Scotia	27.2 (7)	5.95 (3)	–78.1 (6)	–21.3 (6)
Prince Edward Island	28.1 (8)	5.69 (2)	–79.8 (4)	–22.4 (5)
Quebec	29.5 (9)	5.63 (1)	–80.9 (3)	–23.8 (4)
Newfoundland	35.5 (10)	7.74 (10)	–78.3 (5)	–27.9 (3)
Yukon	42.0 (11)	7.55 (9)	–82.0 (2)	–34.5 (2)
Northwest Territories	92.9 (12)	13.22 (12)	–85.8 (1)	–79.6 (1)

TABLE 2. Relative Risks and Risk Differences for Infant Mortality Rates: Canadian Provinces and Territories, 1961–1965 and 1991–1995

Province/Territory	1961–1965		1991–1995	
	Relative Risk (95% Confidence Interval)	Risk Difference	Relative Risk (95% Confidence Interval)	Risk Difference
Ontario†	1.00	.00	1.00	.00
British Columbia	1.03 (1.00–1.07)	.75	1.01 (.96–1.08)	.08
Alberta	1.12 (1.08–1.15)	2.59	1.15 (1.09–1.22)	.92
Manitoba	1.13 (1.08–1.17)	2.77	1.15 (1.05–1.25)	.91
Saskatchewan	1.17 (1.12–1.21)	3.69	1.37 (1.26–1.49)	2.24
New Brunswick	1.20 (1.15–1.26)	4.52	.98 (.87–1.11)	–.11
Nova Scotia	1.23 (1.18–1.28)	5.04	.98 (.88–1.10)	–.12
Prince Edward Island	1.27 (1.15–1.40)	5.92	.95 (.72–1.25)	–.38
Quebec	1.33 (1.30–1.36)	7.27	.93 (.88–.97)	–.44
Newfoundland	1.61 (1.54–1.67)	13.45	1.28 (1.13–1.45)	1.67
Yukon	1.90 (1.57–2.31)	19.83	1.28 (.82–1.99)	1.48
Northwest Territories	4.19 (3.83–4.58)	70.70	2.19 (1.80–2.66)	7.16

† Ontario was the reference region.

those observed in Ontario. Quebec had a significantly lower rate.

Table 3 presents changes in infant mortality rates between 1960 and 1995 for selected countries. Most countries showed improvements in infant mortality over this 35-year period. Declines of >80.0% were observed in 25 countries including the United Arab Emirates, Oman, Portugal, Chile, and Japan. Declines of <20.0% were observed in 6 countries: Uganda, Nigeria, Zambia, Mozambique, Angola, and Niger. Niger experienced no change in its infant mortality rate, which was 191/1000 live births in 1960 and 1995. Rate differences in infant mortality ranged

from –160/1000 live births in Oman to –8/1000 live births in Nigeria and no change in Niger.

There was a strong positive correlation between a country's ranking according to infant mortality rates in 1960 and its ranking based on infant mortality in 1995 (133 countries, correlation coefficient = .88; $P < .01$). Notable exceptions to this trend were the United Arab Emirates, and Oman, whose rankings improved substantially from 98th to 39th and 113th to 44th, respectively. There was also a positive correlation between a country's 1960 infant mortality rate ranking and rankings of the percent change in infant mortality over time (133 countries, correlation coef-

TABLE 3. Infant Mortality Rates, Percentage Change, and Difference: Selected Countries, 1960 and 1995

Country	Infant Mortality Rate (Rank)		Change, 1960–1995 (Rank)	
	1960	1995	Percent Change	Difference
Sweden	16 (1)	4 (1)	–75.0 (39)	–12 (130)
Japan	31 (15)	4 (2)	–87.1 (6)	–27 (112)
Cuba	39 (22)	9 (27)	–76.9 (35)	–30 (110)
Nigeria	122 (66)	114 (117)	–6.6 (132)	–8 (132)
India	144 (84)	76 (94)	–47.2 (101)	–68 (55)
Cameroon	156 (95)	66 (86)	–57.7 (80)	–90 (33)
United Arab Emirates	160 (98)	16 (39)	–90.0 (2)	–144 (3)
Oman	180 (113)	20 (44)	–88.9 (4)	–160 (1)
Afghanistan	215 (129)	165 (131)	–23.3 (127)	–50 (79)
Yemen	230 (132)	76 (92)	–67.0 (63)	–154 (2)

ficient = .56; $P < .01$). Countries such as Afghanistan and Niger with high infant mortality rates in 1960 (rank: 129 and 119, respectively) ranked 127th and 133rd, respectively, in terms of percent change in infant mortality rates between 1960 and 1995. Countries such as Japan and Germany with low infant mortality rates in 1960 (rank: 15 and 18, respectively) ranked 6th and 20th, respectively, in terms of percent change in infant mortality between 1960 and 1995.

There was a negative correlation between a country's 1960 infant mortality ranking and the rankings of the rate difference in infant mortality over time (correlation coefficient = $-.66$, $P < .01$). That is, countries with higher infant mortality rates in 1960 were more likely to have experienced larger absolute reductions in their infant mortality rates (Table 3).

Table 4 contrasts the magnitude of the differences in infant mortality rates between country groups. Unlike the results observed in Canada, relative risks of infant mortality comparing global regions increased between 1960 and 1995. Infant mortality rates in sub-Saharan Africa and South Asia were over 10 times higher than the rates in industrialized countries in 1995, compared with <5 times higher in 1960. In 1995, infant mortality rates in countries in Latin America, East Asia, and the Pacific, and Middle East and North Africa were 5 to 7 times higher than the rates in industrialized countries, compared with 3 to 5 times higher in 1960.

DISCUSSION

Our study shows that Canadian provinces and territories with higher infant mortality rates in 1961–1965 witnessed larger improvements over time compared with provinces and territories that had lower infant mortality rates in 1961–1965. In contrast, analysis of international infant mortality rates showed that countries with higher infant mortality rates in 1960 tended to experience the smallest percent reductions. As a result of these trends, regional infant mortality differentials declined within Canada, while increasing internationally.

The favorable regional trends witnessed in Canada have also been observed with regard to infant mortality rates within socioeconomic groups in Canada. In 1971, the infant mortality rate ratio and difference between the highest and lowest income groups in urban Canada was 2.0 and 9.8 per 1000 infants, respectively.¹¹ By 1991, the infant mortality rate ratio

and difference had dropped to 1.6 and 2.9 per 1000 infants, respectively.¹² The reduction in disparities, on both a geographical and an income basis, indicates that between the 1960s and 1990s Canada achieved a more equitable distribution of health throughout its population.

Our findings contrast with those observed in some other industrialized countries. Studies of infant and perinatal mortality in Italy between 1955 and 1984, and South Australia between 1981 and 1994, reported no substantial reductions in regional and socioeconomic disparities.^{13,14} In the United States, in 1964–1966 mortality among infants born to white women with 0 to 8 years of education was 1.6 times higher than that among infants born to white women with 16 or more years of education.¹⁵ By 1987, this ratio had increased to 2.2.¹⁵

The trends observed in Canada are likely attributable to several factors. In 1968, the Medical Care (Medicare) Act of 1966 was enacted, instituting national medical insurance.⁴ This resulted in the Canadian federal government acting to ensure similar per capita health expenditures across the different provinces and territories in Canada.¹⁶ It is also noteworthy that Quebec and Prince Edward Island, 2 provinces that experienced substantial improvement over the study period differ from other Canadian provinces in that their system of health care delivery is amalgamated with the provincial ministry of community and social services. In addition to universal access to health services, other possible contributing factors must also be acknowledged. Over the period covered by our study, there were undoubtedly improvements across the country in factors, such as maternal education, per capita income, and general health status, which influence infant mortality rates. It is possible that these improvements occurred in such a way to reduce regional disparities in these factors, thereby contributing to the observed trend.

Unlike the trend in Canada, relative inequalities in infant mortality increased internationally. Although more variation in infant mortality rates would be expected between countries than within a single country, the pattern of increasing disparities between industrialized and other countries is cause for concern. It suggests growing inequality in health status worldwide. It is difficult to interpret the observed trends in terms of specific socioeconomic, technological, or political changes. It is likely that improvements in socioeco-

TABLE 4. Infant Mortality Rates and Related Indices: Grouped Countries, 1960 and 1995

Country Group	1960			1995			Change, 1960–1995	
	Infant Mortality Rate	Relative Risk	Risk Difference	Infant Mortality Rate	Relative Risk	Risk Difference	Percent Change	Difference
Industrialized countries*	31	1.0	0	7	1.0	0	-77.4	-24
Latin America and Caribbean	106	3.4	75	38	5.4	31	-64.2	-68
East Asia and the Pacific	133	4.3	102	42	6.0	35	-68.4	-91
South Asia	146	4.7	115	82	11.7	75	-43.8	-64
Sub-Saharan Africa	153	4.9	122	106	15.1	99	-30.7	-47
Middle East and North Africa	154	5.0	123	46	6.6	39	-70.1	-108

* Industrialized countries were the reference group.

conomic status and availability of general health care explain much of the variation in improvements between countries. Political stability is likely also a major factor. The importance of political stability is supported by previous studies that have demonstrated an association between infant mortality and military spending.^{1,17} That is, countries with increased military spending over time (relative to health spending) tend to have a poorer record of improvements in infant mortality.

A limitation of our study is our inability to exclude live births weighing <500 g from infant mortality rate calculations. Such live births, which are increasingly being registered in Canada in recent years, can affect regional and temporal comparisons of infant mortality.^{18,19} However, the relative changes in infant mortality rates between the 1960s and 1990s were large making it unlikely that the rankings would have been influenced by this small correction. Reporting and mortality registration differences across countries may also have affected some of our international comparisons.

CONCLUSION

In summary, our descriptive study provides an overview of trends in infant mortality and quantifies differences that exist in Canada and globally. Our results indicate that although disparities in infant mortality rates in Canada remain, there is a trend toward a reduction of these inequalities. This trend is not occurring internationally.

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