An Age-Period-Cohort Approach to Analyzing Trends in Suicide in Quebec Between 1950 and 2009

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ABSTRACT

OBJECTIVE: Suicide rates in Quebec over the second half of the 20th century show a wide range of variation depending on age and time period. However, few studies have verified the presence of a cohort effect affecting trends in Quebec suicide rates. This study is designed to evaluate the potential effects of age, period and cohort (APC) on trends in suicide between 1950 and 2009 in Quebec.

METHOD: For these APC analyses, we used a multiphase approach combining a graphical inspection followed by an analysis that isolates the cohort effect from age and period effects (linear regression of the residuals from a median polish of the rates).

RESULTS: The graphical inspection of trends in rates points to combined effects of age, period and cohort among both men and women. However, the median polish analysis attributes primary importance to period effects, followed by age effects, but also shows weak cohort effects that are significant only among men born between 1950 and 1979.

CONCLUSION: The variation in Quebec suicide rates appears to be primarily a reflection of period, age and, to a lesser degree, birth cohort. Thus, in addition to sex, selection of risk groups should be based more on age and time period than on birth cohort.

KEY WORDS: Quebec; suicide; age-period-cohort; cohort effect; median polish

La traduction du résumé se trouve à la fin de l'article.

Can J Public Health 2013;104(2):e118-e123

Suicide ranks tenth among all causes of death in Canada and is the principal cause of death by trauma.¹ In Quebec there were more than 1,100 deaths by suicide in 2009, nearly double the number associated with motor vehicles.² For a number of years, Quebec's suicide rates were the highest in Canada.³ The rate tripled between 1950 and 2000 – an increase that occurred primarily among men. For more than 60 years, suicide rates in Quebec have peaked during adulthood and then declined among the elderly, in contrast to the prevailing situation in most other industrialized countries where the rate continues to rise with age.⁴ In addition, suicide rates among young Quebecers increased from the 1970s through the end of the 1990s, but declined thereafter. Beaupré and St-Laurent³ suspected a cohort effect on suicide rate among generations born after World War II (baby boomers).

Age-period-cohort analyses (APC) have been used for decades to study numerous health problems such as cancers, hip fractures and suicide.⁵⁻⁷ In trends analysis, age (A) is often considered to be a physiological change in individuals, but also an accumulation of exposures influencing the onset of disease. Time period (P), on the other hand, represents an external influence affecting almost all individuals simultaneously and including major events such as wars and economic crises that influence the course of a population's state of health. Cohort effect (C), for its part, is often defined as being a risk specific to a group of individuals born within the same years.⁸ These three variables are interconnected, since birth cohort is calculated by subtracting date of death (period) from age

(C = P - A). Due to the interdependence or collinearity among these variables, all of which are associated with time (age, time period and cohort), identifying the impact of a particular variable in a given instance may be problematical. This interdependence is also known as an identification problem. Various statistical methods have been developed over the years to mitigate this identification problem and make it possible to more readily distinguish each variable's respective effects.⁹

The current study is designed to verify the presence of age, period and cohort effects in the distribution of Quebec suicide rates between 1950 and 2009. A secondary goal is to evaluate the impact of these three effects on suicide rate trends.

Source of data

This study covers 49,093 suicides that occurred in Quebec between 1950 and 2009 (men: 35,536). Suicide data are derived from previous compilations by the Ministère des Affaires sociales du Québec¹⁰ for the 1950-1979 period and the register of deaths of the Ministère

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Conflict of Interest: None to declare.

Table 1. Suicide Rate (per 100,000) for Periods and Age Groups, According to Sex, Quebec, 1950 to 2009

		Calendar Period											
	Age (years)	1950-1954	1955-1959	1960-1964	1965-1969	1970-1974	1975-1979	1980-1984	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009
Males	15-19	2.1	2.5	2.8	6.9	12.4	15.8	23.1	25.3	29.3	32.3	21.9	12.4
	20-24	4.4	4.8	8.1	14.8	23.6	34.8	39.0	36.7	42.8	43.9	32.7	23.2
	25-29	5.9	9.3	10.5	14.2	20.8	29.7	36.4	36.6	37.2	41.2	32.0	23.9
	30-34	7.7	9.6	10.1	13.4	18.6	29.0	35.3	36.1	40.0	43.7	34.9	27.9
	35-39	7.8	10.5	12.2	16.2	21.2	26.2	28.5	35.0	38.0	45.2	39.1	31.9
	40-44	10.0	13.3	13.7	16.9	20.3	24.6	34.9	32.2	34.5	45.6	39.4	38.7
	45-49	13.4	16.6	14.9	19.3	24.4	26.1	30.3	31.1	34.9	44.8	42.4	38.1
	50-54	16.2	17.6	19.3	22.5	24.9	27.6	34.7	31.4	33.4	38.7	38.5	35.0
	55-59	14.0	20.4	17.9	21.9	23.9	25.9	33.5	33.0	31.8	33.9	31.6	30.0
	60-64	20.1	25.4	22.1	15.9	25.9	23.2	34.7	27.7	26.1	30.0	26.2	25.3
	65-69	14.9	13.6	15.6	17.8	20.3	22.7	26.9	26.5	23.5	26.8	20.0	21.6
	70-74	15.6	13.3	14.0	13.2	17.0	22.3	32.1	31.5	27.5	31.6	24.7	20.5
	75-79	16.7	18.5	14.5	8.2	20.4	18.8	29.2	28.6	30.4	32.9	30.9	22.3
	80-84	16.8	13.8	10.5	8.6	11.6	17.0	32.4	26.5	30.9	25.0	24.5	24.6
Females	15-19	0.3	0.4	1.0	1.1	3.1	3.6	3.1	4.4	5.2	8.8	8.0	4.6
	20-24	2.3	1.6	3.0	4.0	5.0	8.2	6.6	5.7	5.8	7.2	7.3	7.2
	25-29	3.1	2.9	3.2	6.2	8.3	11.1	9.5	8.0	6.7	8.4	6.4	5.2
	30-34	3.0	4.4	4.0	7.3	7.9	11.1	10.9	10.5	9.3	9.2	7.4	5.7
	35-39	3.0	5.4	4.4	7.7	9.2	11.6	11.6	12.1	10.1	12.3	12.2	8.5
	40-44	5.7	3.6	5.9	6.8	9.3	11.9	15.7	12.0	12.5	15.6	11.1	10.9
	45-49	6.9	5.8	6.2	7.0	10.4	11.2	13.3	13.7	11.5	15.6	14.1	11.9
	50-54	5.4	6.3	6.5	10.4	8.8	13.5	14.9	11.1	10.8	12.0	13.5	12.5
	55-59	3.9	6.1	4.4	10.8	7.8	13.4	12.9	8.5	8.6	10.7	9.2	11.3
	60-64	8.8	5.5	4.8	5.8	7.2	8.5	11.2	8.4	6.4	8.3	6.5	7.7
	65-69	2.1	3.9	2.4	5.6	8.6	7.0	8.0	7.3	4.9	7.2	7.4	5.8
	70-74	2.4	2.6	3.3	3.5	5.1	7.0	8.9	3.9	6.5	6.3	4.4	5.5
	75-79	3.9	1.7	2.3	2.0	1.8	1.9	4.5	6.3	3.5	5.0	3.5	4.3
	80-84	0.0	3.3	4.3	3.8	3.9	3.9	5.1	3.6	4.9	4.0	2.4	3.1

de la Santé et des Services sociaux du Québec (CIM-9: E950-E959, CIM-10: X60-X84, Y87.0) for the 1980-2009 period. The same definition of suicide was used in these decades but it could be interpreted in various ways by the coroners through time.¹⁰ Since there are some differences in suicide behaviour between men and women, the analyses are stratified by sex, as done by previous authors.^{3,11-13}

Statistical analyses

Mortality rates by suicide were calculated by five-year period for each sex and by five-year age group (ages 15-19 to ages 80-84) using the corresponding census population estimates from census data as the denominator. The 12 periods that extend from 1950-1954 to 2005-2009 are grouped together in a table covering 15 age groups with diagonals that determine 25 birth cohorts beginning in 1870-1874. Table 1 presents suicide rates by age group and period for each sex. The last age group (85+) was excluded from our analyses because it represents an open-ended class for which it is difficult to associate a specific cohort. Less than 1% (N=267) of all suicides occur in this age group.

Analysis of the results was carried out in several phases for each sex as proposed by Keyes et al.⁸ As in all APC studies, the first step involves a graphic approach to visually represent changes in mortality rates according to periods and cohorts. The second step consists of a median polish of the logarithmic transformation of those rates. The median polishing serves to eliminate the additive effect of age and period and is done by subtracting the median from each row and column in the table of suicide rates by age and period. After several iterations, this technique rapidly converges toward a matrix of residual values that includes two components: a systematic component (cohort effect) and a non-systematic component (random error).¹⁴ A linear regression of these residuals then allows an estimate of the effect of each cohort. The results of the analyses are reported in the form of rate ratios using the following as refer-

Table 2. Estimated Risk Ratio (95% confidence interval) for the Cohort Effect Resulting on Residuals From Median Polish Method According to Sex, Quebec, 1950 to 2009

Cohort	Males		Females	
	RR	(95% CI)	RR	(95% CI)
1870-1874	2.2*	(1.3-3.8)	—†	
1875-1879	1.7*	(1.2-1.6)	2.5*	(1.6-3.7)
1880-1884	1.6*	(1.2-2.3)	1.5*	(1.0-2.1)
1885-1889	1.4*	(1.0-1.9)	1.2	(0.9-1.6)
1890-1894	1.3	(0.9-1.7)	1.4*	(1.0-1.9)
1895-1899	1.5*	(1.1-1.9)	1.0	(0.8-1.3)
1900-1904	1.5*	(1.2-2.0)	1.1	(0.9-1.5)
1905-1909	1.4*	(1.1-1.7)	1.2	(0.9-1.6)
1910-1914	1.2	(0.9-1.6)	1.1	(0.8-1.4)
1915-1919	1.1	(0.9-1.3)	1.0	(0.8-1.3)
1920-1924	1.2	(0.9-1.5)	1.1	(0.9-1.4)
1925-1929	1.1	(0.9-1.4)	1.1	(0.8-1.3)
1930-1934	1.1	(0.8-1.3)	1.0	(0.8-1.3)
1935-1939	0.9	(0.7-1.1)	0.9	(0.7-1.2)
1940-1944	Reference			
1945-1949	1.1	(0.9-1.4)	1.1	(0.8-1.4)
1950-1954	1.3*	(1.0-1.7)	1.2	(0.9-1.5)
1955-1959	1.4*	(1.1-1.9)	1.3	(0.9-1.6)
1960-1964	1.5*	(1.2-1.9)	1.1	(0.9-1.5)
1965-1969	1.5*	(1.2-1.9)	1.1	(0.8-1.4)
1970-1974	1.5*	(1.1-2.0)	1.1	(0.8-1.5)
1975-1979	1.4*	(1.1-1.9)	1.2	(0.8-1.6)
1980-1984	1.4	(0.9-1.9)	1.5*	(1.0-2.1)
1985-1989	1.2	(0.8-1.9)	2.0*	(1.3-3.0)
1990-1994	1.0	(0.6-1.7)	1.6	(0.9-2.8)

* p<0.05.

† This cohort was removed in regression model due to suicide rate = 0.

ence categories: the 65-69 age group, the 2004-2009 period, and the 1940-1944 cohort, because these categories present the lowest suicide rates.

RESULTS

Graphic approach

Suicide rates in Quebec rose rapidly between 1950 and 1970, stabilized in the 1980s, began to rise again in the 1990s, and then

Figure 1. Suicide rates by age and calendar periods, males–females, Quebec, 1950 to 2009

declined. These rate fluctuations were more pronounced among men than women. The distribution of rates according to age shows that suicide increases in adulthood, peaks for men toward the end of their forties, then declines among those in the ≥ 65 years age group (Figure 1). However, suicide rates according to age have changed considerably over time, with a significant increase among Quebecers under age 30 during the 1960s and 1970s. Thereafter, the highest rates were among adult men during the 1990s and 2000s, as previous studies had shown.^{10,15} The effect of age on suicide rates is more constant among women, with the highest rates occurring among those aged 50 to 54.

Figure 2 shows the variation in rates by cohort, with an increase in rates particularly before age 50. An appreciable period effect is

also observed, with peak rates that overlap for the cohorts born between 1950 and 1969. These curves also indicate an age effect, with suicide rates among men tending to rise rapidly after adolescence, and then declining toward their mid-forties, an age at which the curves tend to coincide. Also noteworthy is the fact that suicide rates for cohorts born after 1945 tended to rise over time up to the end of the 1980s.

Analysis of cohort effects by median polish

Table 2 shows the suicide rates for the various cohorts, adjusted for age and period. Among men, the cohorts born between 1870 and 1909, except for cohort 1890-1895, show a significantly higher risk of suicide, with risk ratios (RR) varying from 1.4 to 2.2 compared

Figure 2. Suicide rates by age and cohorts, males–females, Quebec, 1950 to 2009

with men born in 1940-1944. Men born between 1950 and 1979 also show a significantly higher risk (RR 1.31 to 1.49).

We also analyzed cohort effects in the three male cohorts born from 1955 to 1969 by comparing the curve for suicide rates, first with and then without the cohort effect (Figure 3). The three cohorts illustrated in the example appear to have slightly lower rates compared to the rates observed once the cohort effect is eliminated. This weak cohort effect did not modify trends in suicide rates over age for the 1955 to 1969 cohorts.

DISCUSSION

Analysis of the age, period and cohort components in Quebec suicide rates over a period of 60 years using a multiphase approach including a graphic analysis and a median polish modelling shows, as its primary result, an effect related to age and period, and certain significant but lesser cohort effects. Variation in suicide rates is especially linked to age among women, whereas period seems to be a more important factor among men. It is interesting to note that this age effect has been present in Quebec for several decades.

Figure 3. Suicide rate with or without cohort effect, males, Quebec, 1950 to 2009

The results obtained from combined APC analyses point to a relatively weak cohort effect only among men born between 1870 and 1909 and men born between 1950 and 1979. This cohort effect for men appears to be due primarily to rising suicide rates among the young during the 1970s and 1980s, with a sudden decline occurring in the 2000s. Among women, only two groups showed a significant (but weak) cohort effect: those born between 1875 and 1894 and between 1980 and 1989.

The results of the current study confirm those obtained in Quebec and Canada, where cohort effects were reported primarily among men, and on a more modest scale among women.^{3,7,11,12} Recent studies conducted in other countries using analysis methods to obviate the identification problem due to collinearity among age, period and cohort effects generally show a weaker effect for cohort than for age or period.^{16,17} In the United States, Keyes and Li (2012) conducted a study based on more than a century of suicide data using the same statistical analysis method with a median polish approach. They found a progressively increasing cohort effect among men born after World War II, with a risk more than three times higher among men born after 1980 compared to the reference cohort (1910-1914).¹³ However, contrary to our result, Keyes and Li did not find any period effect on trends in American suicide rates.

A period effect is observed and is present especially among men in our study. Quebec suicide rates have varied widely over the last six decades, particularly in the 1995-1999 period, which registered a record number of deaths. These rate variations affected practically all age groups, but more particularly men. Such period effects had also been observed in other countries, with rate increases associated with economic recessions and major natural events in rural regions (e.g., severe droughts in Australia). Suicide rate reductions are also correlated with reduced access to means of suicide such as carbon monoxide or firearms.¹⁸⁻²²

We should also underline the potential impact of integrated approaches (like “Stratégie Québécoise de prévention du suicide”) and prevention programs implemented in Quebec in the late 1990s in contributing to the reduction of suicide rates. Availability to early detection and treatments of depression by general practitioners can reduce an important factor for suicide.²¹ Also, tighter monitoring of suicidal people, restricted access to means for suicide, and programs targeted to teenagers implemented in the last decade can contribute to suicide reduction.¹⁸ The effect of these actions on the suicide rates was not evaluated in Quebec, but they can contribute to their decrease as seen elsewhere.^{21,23}

The results of the current study show no obvious cohort effect on the variation in suicide rates over the past 60 years. Thus, for prevention programs, selection of risk groups should be based on characteristics such as age and other known risk factors for suicide in both women and men.

Certain limitations of the APC analysis should be noted. First, the results may be affected by the quality of the data used across time and by age group. Numerous publications concerning the validity of suicide data suggest that suicide is under-reported, with the degree of under-reporting depending on period, age, sex, country, social acceptability, and especially the system for determining cause of death.^{24,25} A recent meta-analysis suggests that in industrialized countries, approximately 10% of suicides are attributed to another cause.²⁶ This meta-analysis is further corroborated by a French study which, after reclassification of a sample of deaths, indicated a suicide misclassification rate of 9%, with even higher percentages among the elderly and women.²⁷ It seems highly likely that suicide is also under-reported in the Quebec data, but all indications seem to be that the degree of under-reporting remains acceptable across time and that the data provide a valid basis for a longitudinal study.^{10,28} Also, change of ICD classification from 9 to 10 in 2000 does not affect suicide rate, as shown in a Canadian

study.²⁹ We conducted a supplementary sensitivity analysis for the 1970-2009 period in order to evaluate the potential effect of an increase in under-reporting in the 1950s and 1960s. The same multi-phase analysis made over this shorter period (data not presented, available on request) did not change our conclusions, which demonstrate the predominance of period effects among men and of age effects among women, with weaker cohort effects.

The recent phenomenon of increasing life expectancy implies that there will be more and more elderly in Quebec, especially people aged 85 years and over. There are few historical data on suicide for this age group and it is difficult to anticipate what sorts of behaviours will be adopted by individuals arriving at advanced old age. Our analysis cannot provide details for this specific age group.

CONCLUSION

The use of a method that simultaneously controls for APC effects shows that Quebec suicide rates over the past 60 years are influenced primarily by an age effect and a period effect. A cohort effect is also observed, weak but significant among men born in the 1950s, 1960s and 1970s. There is no pronounced cohort effect among women. Based on the data for the past 60 years, it appears likely that for cohorts arriving at what is commonly referred to as their "senior years", the suicide rate will decline, just as it did for their predecessors, with a greater decline among women than men. Quebec has seen a drop in suicide rates for all age groups since the beginning of the 2000s, with a marked decline among the young and with nothing currently suggesting that rates are likely to rise again. However, it is unwise to assume that suicide rates will remain constant and it is difficult to predict how a period effect due to external circumstances might affect this trend. This type of APC analysis provides an additional tool for chronological study of the incidence of death across the population.

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Received: October 22, 2012

Accepted: February 15, 2013

RÉSUMÉ

OBJECTIF : Au Québec, le taux de suicide a connu de fortes variations au cours de la seconde moitié du XX^e siècle, mais très peu d'études ont vérifié la présence d'un effet de cohorte. Cette étude vise à estimer les effets potentiels d'âge, de période ou de cohorte (APC) dans l'évolution des suicides au Québec entre 1950 et 2009.

MÉTHODE : Une approche multiphase combinant une analyse graphique suivie d'une approche statistique permettant d'isoler l'effet de cohorte des effets d'âge et de période a été utilisée pour effectuer ces analyses APC (régression des résidus obtenus par polissage des taux sur médiane).

RÉSULTATS : L'analyse graphique de l'évolution des taux laisse entrevoir des effets combinés d'âge, de période et de cohorte tant chez les hommes que chez les femmes. Toutefois, l'analyse de polissage sur médiane permet d'identifier d'abord des effets de période, puis d'âge et aussi des effets de cohorte faibles, significatifs uniquement chez les hommes nés entre 1950 et 1979.

CONCLUSION : La variation des taux de suicide au Québec serait principalement associée à la période temporelle et l'âge et, dans une moindre mesure, à la cohorte de naissances. En plus du sexe, le choix de groupe à risque devrait davantage reposer sur l'âge et la période temporelle plutôt que la cohorte de naissance.

MOTS CLÉS : Québec; suicide; âge-période-cohorte; effet de cohorte; polissage sur médiane