Homicide mortality rates in Canada, 2000–2009: Youth at increased risk

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ABSTRACT

OBJECTIVES: To estimate and compare Canadian homicide mortality rates (HMRs) and trends in HMRs across age groups, with a focus on trends for youth.

METHODS: Data for the period of 2000 to 2009 were collected from Statistics Canada's CANSIM (Canadian Statistical Information Management) Table 102-0540 with the following ICD-10-CA coded external causes of death: X85 to Y09 (assault) and Y87.1 (sequelae of assault). Annual population counts from 2000 to 2009 were obtained from Statistics Canada's CANSIM Table 051-0001. Both death and population counts were organized into five-year age groups. A random effects negative binomial regression analysis was conducted to estimate age group-specific rates, rate ratios, and trends in homicide mortality.

RESULTS: There were 9,878 homicide deaths in Canada during the study period. The increase in the overall homicide mortality rate (HMR) of 0.3% per year was not statistically significant (95% CI: -1.1% to +1.8%). Canadians aged 15–19 years and 20–24 years had the highest HMRs during the study period, and experienced statistically significant annual increases in their HMRs of 3% and 4% respectively ($p < 0.05$). A general, though not statistically significant, decrease in the HMR was observed for all age groups 50+ years. A fixed effects negative binomial regression model showed that the HMR for males was higher than for females over the study period [$RR_{\text{female/male}} = 0.473$ (95% CI: 0.361, 0.621)], but no significant difference in sex-specific trends in the HMR was found.

CONCLUSION: An increasing risk of homicide mortality was identified among Canadian youth, ages 15–24, over the 10-year study period. Research that seeks to understand the reasons for the increased homicide risk facing Canada's youth, and public policy responses to reduce this risk, are warranted.

KEY WORDS: Homicide; Canada; violence; adolescent

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

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The homicide mortality rate (HMR) is an important indicator of a population's health, related to the constituent factors of a healthy community. The HMR provides a proxy measure of community safety (related to the rate of non-fatal violent injury), indicates the burden of physical, psychological and emotional trauma present due to violence, and is correlated with the social determinants of health.^{1–5} A recent study of homicide among young black men in Toronto presented evidence of a rising rate of homicide death among this population, increasing from 2.4 deaths per 100,000 in the 1990s to 10.1 deaths per 100,000 in 2004.⁶ The increased rate of homicide mortality among this population was attributed to deterioration in the social determinants of health and the focus on a "tough on crime" approach, as opposed to a more holistic public health approach.

In the United States, the staggering rate of homicide deaths, and the failure of enhanced criminal penalties (i.e., deterrence approach), has prompted new approaches to violence prevention, including a public health model.⁷ A public health or epidemiological model looks at three aspects of violence: time, person, place.⁸ Understanding the burden of and trends in the risk of homicide death is vital to developing policy responses.⁸ As with any health risk, trend analysis of homicide risk is necessary to measure progress towards reducing this risk in a population. The age distribution of homicide death risk would not be expected to change significantly in a short period of time just as the risk factors

for homicide death would not be expected to change significantly from year to year. A similar age-distribution of homicide deaths and risk factors for homicide death is generally maintained over time, regardless of whether the overall homicide mortality rate or the prevalence of risk factors for homicide mortality have increased or declined.⁹

Has Canada become a more dangerous place for youth? This question was the basis for the current study. Specifically, we wanted to know whether the risk of homicide mortality had increased for youth in Canada over a relatively short (10-year) time period. At the time of writing, no published statistical analyses of trends in Canada's HMR could be found. Statistics Canada reported a stable or declining homicide rate, with a rate of 1.62 per 100,000 in 2010 – "its lowest level since 1966".¹⁰ A more recent report echoes this message of a declining homicide rate in Canada, but did

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not investigate whether youth homicide has increased or decreased in Canada in recent times.¹¹

Differences in data sources (police-reported homicides as opposed to vital statistics data) made these reports unsuitable for answering our research question: has there been a rise in youth homicide mortality over the last decade?

As part of a program of intervention research focusing on youth violence in Winnipeg and Manitoba, we sought to understand whether there has been any change in homicide mortality for youth in Canada. The question of whether homicide risk had increased for youth in Canada originated from one author's experiences in emergency medicine in Toronto and Winnipeg. The study aim was to identify any trends in age-specific homicide mortality, over a 10-year period, beginning in 2000. However, we also describe homicide mortality rates by province and sex to provide context for the age-specific analysis.

METHODS

The unit of analysis for this study was age group, used to determine age-specific HMRs and trends in HMRs. The unit of observation was the annual count of homicide deaths occurring within each age group, offset by the annual population count of the age group.

Data were obtained from Statistics Canada as homicide death counts in five-year age groups (19 in total) from 0–4 to 90+ years with 10 homicide counts per age group (one per year) for a total sample size of $n = 190$ observed homicide counts.¹² Age-specific annual population estimates were obtained from Statistics Canada for each year in the study period.¹³ Homicide deaths were those having as the primary cause of death one of the following ICD-10-CA codes: X85-Y09 (assault) and Y87.1 (sequelae of assault). The use of annual population estimates from Statistics Canada provides an advantage over studies using a single population count. The Health Research Ethics Board of the University of Manitoba determined that this analysis did not require ethics review.

Four variables were used in the analysis of age-specific HMRs: 1) *homicide death count*, the outcome variable, and three predictor

variables: *age group*, *population estimate* (denominator, or offset term) and *year* (2000–2009). A random effects regression model (random intercept and random slope) with a negative binomial distribution was used to estimate age-specific homicide risk, measured by the HMR. The age-specific rate ratios (RRs) are defined as the exponentiated difference between the logarithm of the age-specific HMRs and the logarithm of the national age-adjusted HMR estimated by the model. The negative binomial distribution was chosen for the outcome variable because it is an overdispersed count variable. In order to determine if there was a difference between males and females in homicide trend, we conducted a separate analysis of sex-specific HMRs using both fixed effects and random effects models.

The age-specific homicide rate of the current year is related to the age-specific homicide rate of the previous year, and so on, having an auto-regressive correlation structure – the relation deteriorating as time passes. To account for correlation of age-specific homicide risk, we used a random effects negative binomial regression model, nesting *years* within *age groups*, to determine the age-specific rates, rate ratios and trends in homicide risk in Canada during the period of 2000 to 2009. We chose to use a random intercept and random slope model as this allowed us to estimate age-specific rate ratios and trends in homicide risk simultaneously, without over-fitting the model by including interaction terms for each age group-by-year pairing. We wanted to make the age groups as fine-grained as possible, and because age-specific homicide mortality data could only be accessed at the five-year age-group level, this was the resolution used for modelling purposes. In the model, each age group has its own intercept (i.e., HMR) and its own slope (i.e., change in annual HMR). The age group-specific intercepts and slopes are measured as deviations from a common intercept and common slope that are estimated both within and between age groups. The use of the negative binomial distribution for the outcome variable ensures that overdispersion (where the variance of the outcome variable is greater than the mean) is also accounted for, something which the Poisson distribution does not do.^{14–16} This

Figure 1. Box-plot of age-specific homicide mortality rates, Canada, 2000–2009: Crude estimates.

Figure 2. Age-specific trends in homicide mortality, Canada, 2000–2009: Empirical Bayes smoothed estimates using 10-year age groups.

makes the negative binomial distribution more appropriate and conservative for trend analysis than the Poisson distribution in the presence of overdispersed data.¹⁵ Therefore, a statistically significant increase in the age-specific HMR during this short period of time (less than a generation) should be considered an epidemic.

Age group-specific RRs and trends were calculated by exponentiation of the empirical Bayes (EB) predicted values from the random intercept and slope model. Predicted age-specific trends in HMRs are presented as annual RRs of the HMR. We assessed our model's fit using the Pearson chi-square to degrees of freedom ratio, which should be close to one for good fit to the data. The analyses were conducted in SAS/Base software, Version 9.2 of the SAS System for Windows (SAS Institute Inc., Cary, NC).

RESULTS

There were 9,878 homicide deaths in Canada during the years 2000–2009, inclusive. During this period, the crude HMR was 2.65 per 100,000 person-years. From the random intercept and slope model, the estimated HMR during the entire study period was 2.21 (95% CI: 1.70 to 2.76) per 100,000 person-years. The model fit the data reasonably well with a conditional Pearson chi-square to degrees of freedom ratio of 0.92, which is close to the ideal value of 1.0.¹⁵ The random intercept and slope model-based trend in the HMR was estimated to be a 0.3% annual increase, which also was not statistically significant (95% CI: –1.1% to +1.8%). Therefore, no statistically significant trend in Canadians' risk of homicide mortality was observed over the study period. However, statistically significant trends in age-specific risk of homicide mortality were identified.

Figure 1 presents the crude age-specific HMRs for Canada over the study period. Figures 2 and 3 present age-specific trends in the HMR. Due to the larger number of five-year age groups (19), and crowded age-specific graphs these age groups offered us, a second analysis of the data was conducted using 10-year age groups (0–9, 10–19, 20–29, 30–39, 40–49, 50–59, 60–69, 70–79, 80–89, 90+ years) to obtain smoothed age-specific trend lines. The second analysis, which followed the same methodology as the first (with the exception of age group definition), showed statistically significant upward trends for ages 10–19 and 20–29 years. These

Figure 3. Age-specific trends in homicide mortality, Canada, 2000–2009: Empirical Bayes estimates of age-specific slope deviations from average age-adjusted slope.

trends are visible in the smoothed regression lines from this analysis (Figure 2). We examined age-specific trends on the log-scale by plotting the deviations in age-specific slopes from the overall slope for year (Figure 3). Figure 3 shows upward trends in homicide mortality for young Canadians (with the exception of infants), and indicates that there may have been a decrease in homicide mortality for older Canadians, although not statistically significant (Table 1).

Statistically significant upward trends in the HMRs were found for some but not all youth age groups. For ages 10–14 years, the HMR increased by 3% annually from an initial rate of 2.30 per 100,000 in 2000, rising to 3.17 per 100,000 in 2009 (Table 1). For the 15–19 years age group, the HMR increased by 4% annually

Table 1. Homicide mortality rates by age group, 2000–2009: Estimates and trends

Age group (years)	Trend (change in HMR per year)	95% CI	Year 2000 HMR per 100,000	Year 2009 HMR per 100,000
0–4	0.98	0.95–1.01	1.59	1.38
5–9	1.01	0.98–1.04	1.66	1.84
10–14	1.03	1.00–1.07	2.30	3.17
15–19	1.04	1.02–1.07	4.70	7.07
20–24	1.04	1.01–1.06	5.25	7.61
25–29	1.02	1.00–1.05	4.61	5.81
30–34	1.01	0.98–1.03	4.13	4.63
35–39	1.00	0.98–1.03	3.79	4.08
40–44	1.01	0.98–1.03	3.04	3.36
45–49	1.00	0.97–1.03	1.62	1.68
50–54	1.00	0.97–1.02	2.02	2.03
55–59	1.00	0.97–1.02	1.85	1.83
60–64	0.98	0.95–1.01	1.77	1.54
65–69	0.97	0.94–1.01	1.68	1.38
70–74	0.99	0.96–1.02	1.74	1.63
75–79	0.99	0.96–1.02	1.63	1.52
80–84	0.98	0.95–1.01	1.46	1.29
85–89	0.98	0.95–1.01	1.37	1.18
90+	0.97	0.93–1.01	1.12	0.87

HMR = homicide mortality rate; CI = confidence interval.

Figure 4. Crude female homicide mortality rates: Canadian provinces, 2000–2009. **Figure 5.** Crude male homicide mortality rates: Canadian provinces, 2000–2009.

from 4.70 homicide deaths per 100,000 in 2000 to 7.07 per 100,000 in 2009 (Table 1). The HMR of the 20–24 years age group rose 4% annually from 5.25 per 100,000 in 2000 to 7.61 per 100,000 in 2009 (Table 1). Finally, the HMR of the 25–29 years age group increased by 2% per year, from 4.61 per 100,000 in 2000 to 5.81 per 100,000 in 2009 (Table 1). However, only the trends for 15–19 and 20–24 year olds were statistically significant.

While there were no significant *decreases* in the HMR for any age group, there was a general pattern of upward rates for all five-year age groups falling within the range of 5–49 years. A general pattern of decreases was observed for the age groups between 50 to 90+ years (as well as for ages 0–4 years), although these were not statistically significant (Table 1).

Sex-specific HMRs are presented in Figures 4 and 5, which show Manitoba's rate being the highest for both males and females frequently during the study period. An increase in the male HMR is also apparent for Manitoba and, to a lesser extent, Saskatchewan (Figure 4).

Using a fixed effects negative binomial regression model to compare male and female trends in homicide (i.e., interaction between *year* and *sex*), we found no significant difference in trend

with $RR_{sex \times year} = 0.968$ (95% CI: 0.921, 1.018), although females had a significantly lower overall risk of homicide death than males with $RR_{female/male} = 0.473$ (95% CI: 0.361, 0.621), which means females are on average less than half as likely to be a victim of homicide as males in Canada. A random effects trend model comparing male and female trends in homicide, which accounted for correlation in the outcome within age groups, yielded a similar result of no statistically significant difference in trend between male and female HMRs with $RR_{sex \times year} = 0.968$ (95% CI: 0.936, 1.002). This model also fit the data reasonably well, as would be expected given the previous model's fit, with the same conditional Pearson's chi-square to degrees of freedom ratio of 0.92.

DISCUSSION

The increase in homicide mortality among Canadian youth, ages 15–24, is a disturbing finding. This means that youth were more likely to be murdered in 2009 than in 2000. This finding should be interpreted as a call to action to address the risk factors for youth violence (prevention), to help Canadian youth exit gangs (intervention), and to deal with the health and social consequences of increased loss of Canadian youth to violence (postvention).⁸ The United States Centers for Disease Prevention and Control have

estimated the total medical and productivity-related costs of violence in the US to exceed \$70 billion annually.⁹ Investments in reducing violence may have substantial economic benefits as well.

Despite the general perception that homicide is a declining phenomenon in Canada, our study actually found a modest *increase* in the HMR for all Canadians of 0.3% per year during the period of 2000–2009 using the random effects negative binomial regression model. Although this trend estimate was not statistically significant, that itself is an important finding: indicating that, for Canada as a whole, no progress was made towards reducing homicide mortality. Moreover, no statistically significant *decreases* in the HMR were found for any age group.

Different study periods and data sources preclude direct comparisons with existing national homicide reports. Our data are different than those reported by Statistics Canada in their annual *Homicide in Canada* reports because they use police-reported homicide cases whereas this study used national vital statistics mortality data (i.e., death certificate data) and ICD-10-CA codes for assault deaths, which captures more homicide deaths in Canada than police data.^{10,11} The rates reported in this study are likely a better approximation of the true incidence rate of homicide in Canada.

A key limitation of our study is the lack of variables to explain the age-specific trends we observed. Risk factors for being killed or injured by violence are varied, difficult to define, and operate at numerous levels: individual, family, community and society. Documented individual risk factors include substance use, little education, low socio-economic status (SES) and poor mental health.^{17–19} Relationship risk factors include family conflict and gang involvement.^{20,21} Community risk factors include social disintegration (breakdown of norms that exist in a community), neighbourhood SES, and low community efficacy (the ability of a group to act collectively).^{4,22,23} Societal risk factors include weapon availability, income inequality and media influences.^{24,25} Data on these risk factors are not readily available in Canada, which hinders monitoring and action towards prevention of violence.

This study raises three important questions: 1) Why did the homicide mortality rate increase for Canadian youth during the period of 2000–2009? 2) Are homicide mortality rates continuing to rise for Canadian youth? 3) What is being done and what *can* be done to reduce youth homicide mortality in Canada? Every life lost to homicide is a preventable death. This implies that the HMR can be reduced through preventive action, based on public health principles and an epidemiological model. An epidemiological and public health model that addresses individual-, community- and system-level risk and protective factors is needed. A clearly defined policy objective of reducing the HMR is warranted. We suggest a national strategy of ongoing monitoring of the HMR, research into factors that have potentially contributed to the rise in youth homicide mortality based on an epidemiological model, and investment in successful policies and programs to reverse these trends.

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RÉSUMÉ

OBJECTIF : Estimer et comparer les taux de mortalité par homicide (TMH) et les tendances des TMH dans les divers groupes d'âge au Canada, en particulier les tendances chez les jeunes.

MÉTHODE : Les données pour la période de 2000 à 2009 ont été recueillies dans le *tableau 102-0540* du Système canadien d'information socio-économique (CANSIM) de Statistique Canada avec les codes suivants de la CIM-10-CA pour les causes externes de mortalité : X85 à Y09 (agressions) et Y87.1 (séquelles d'agressions). Les chiffres annuels de population de 2000 à 2009 ont été obtenus dans le *tableau CANSIM 051-0001* de Statistique Canada. Les chiffres de mortalité et de population ont été organisés en groupes d'âge de cinq ans. Nous avons effectué une analyse de régression binomiale négative à effets aléatoires pour estimer les taux par groupe d'âge, les ratios des taux et les tendances de la mortalité par homicide.

RÉSULTATS : Il y a eu 9 878 décès par homicide au Canada durant la période de l'étude. La hausse de 0,3 % par année du taux de mortalité par homicide (TMH) global n'était pas significative (IC de 95 % : -1,1 % à

+1,8 %). Les Canadiens de 15 à 19 ans et de 20 à 24 ans ont eu les TMH les plus élevés durant la période de l'étude et ont présenté des hausses annuelles significatives de leurs TMH, soit de 3 % et de 4 % respectivement ($p < 0,05$). Une baisse générale mais non significative du TMH a été observée dans tous les groupes d'âge de 50 ans et plus. Un modèle de régression binomiale négative à effets fixes a montré que le TMH des hommes était supérieur à celui des femmes au cours de la période de l'étude [$RT_{\text{femme/homme}} = 0,473$ (IC de 95 % : 0,361–0,621)], mais aucun écart significatif sexospécifique n'a été constaté dans les tendances du TMH.

CONCLUSION : On a observé un risque croissant de mortalité par homicide chez les jeunes Canadiens de 15 à 24 ans au cours des 10 années de l'étude. Il serait justifié de pousser la recherche pour comprendre les raisons du risque accru d'homicide chez les jeunes au Canada et de réduire ce risque au moyen de politiques publiques.

MOTS CLÉS : homicide; Canada; violence; adolescent