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Original quantitative research

Area-based socioeconomic disparities in mortality due to unintentional injury and youth suicide in British Columbia, 2009–2013

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Abstract

Introduction: The association between health outcomes and socioeconomic status (SES) has been widely documented, and mortality due to unintentional injuries continues to rank among the leading causes of death among British Columbians. This paper quantified the SES-related disparities in the mortality burden of three British Columbia's provincial injury prevention priority areas: falls among seniors, transport injury, and youth suicide.

Methods: Mortality data (2009 to 2013) from Vital Statistics and dissemination area or local health area level socioeconomic data from CensusPlus 2011 were linked to examine five-year age-standardized mortality rates (ASMRs) and disparities in ASMRs of unintentional injuries and subtypes including falls among seniors (aged 65+) and transport-related injuries as well as the intentional injury type of youth suicide (aged 15 to 24). Disparities by sex and geography were examined, and relative and absolute disparities were calculated between the least and most privileged areas based on income, education, employment, material deprivation, and social deprivation quintiles.

Results: Our study highlighted significant sex differences in the mortality burden of falls among seniors, transport injury, and youth suicide with males experiencing significantly higher mortality rates. Notable geographic variations in overall unintentional injury ASMR were also observed across the province. In general, people living in areas with lower income and higher levels of material deprivation had increasingly higher mortality rates compared to their counterparts living in more privileged areas.

Conclusion: The significant differences in unintentional and intentional injury-related mortality outcomes between the sexes and by SES present opportunities for targeted prevention strategies that address the disparities.

Keywords: *socioeconomic status, health outcome disparities, unintentional injuries, youth suicide and self-harm, mortality*

Highlights

- Mortality due to unintentional injuries and youth suicide continue to rank among the leading causes of death among British Columbians.
- In BC, males and those living in areas with lower income experience significantly higher mortality burden due to youth suicide, unintentional injuries from falls among seniors and transport incidents.
- Disparities in unintentional and intentional injury-related mortality outcomes between the sexes and by socioeconomic status could provide evidence for targeted injury prevention strategies to narrow the gap and increase overall population-level health outcome.

Introduction

The association of health outcomes with socioeconomic status (SES) has been widely documented.[1-3] In particular, international as well as Canadian literature is accumulating a growing body of evidence that both all-cause mortality and mortality for specific causes of death are higher among people of lower SES, using individual-level socioeconomic data[4-10] and small area-based socioeconomic data with or without controlling for individual SES.[4,7,10-18] This evidence suggests that in addition to individual level factors, contextual factors that operate at the aggregate level may contribute independently to population-level disparities in mortality through socioeconomic mechanisms linked to the availability and accessibility of health services and healthy choices, as well as levels of stress and social support.[19-21] Understanding the impact of these factors on population-level health

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outcomes, such as all-cause and cause-specific mortality, could provide important evidence supporting the development and implementation of public health promotion and disease prevention programs.

In Canada, unintentional injuries and intentional self-harm ranked the 5th and 9th leading causes of death in 2015, respectively.[22] British Columbia (BC) is the third most populous province in the country with a population of more than 4.6 million. In BC, unintentional injuries and intentional self-harm claimed a combined total of 1718 lives in 2015, among which one in three were under 44 years of age at the time of death.[23]

In 2017, the BC Injury Prevention Committee identified three provincial injury prevention priorities: seniors falls, transport-related injuries (young drivers, pedestrians, cyclists, and motor vehicle occupants), as well as youth suicide and self-harm.[24] This paper aims to support provincial evidence-informed planning and programming efforts by focusing on these priority injury causes and conduct descriptive analyses to quantify the demographic, geographic, and socioeconomic disparities of injury mortalities.

Methods

Ethics

Ethics approval for this project was granted by the University of British Columbia and Children's and Women's Research Ethics Board, Vancouver, BC. Ethics certificate number: H16-01758.

Data sources

BC Mortality data for the period January 1, 2009 to December 31, 2013 were extracted from Vital Statistics (VS) for this analysis. Everyone's 6-digit residential postal code was translated into a unique Census dissemination area (DA) and local health area (LHA). Postal codes were translated into DAs through the Postal Code Conversion File (PCCF, 2016), a digital file that provides correspondence between the Canada Post Corporation (CPC) 6-digit postal codes and Statistics Canada's standard geographic areas for which census data are created.[25] A DA is a small and standard Canadian census geographic unit with a population of 400 to 700 people, and Canada is divided into an estimated 54 000 DAs[26] including over 7000 in BC. Postal codes not matched through the PCCF were matched through Geocoding Self Services provided by the BC Ministry of Health, which was also used to assign each death record to one of 89 LHAs in BC. Population sizes based on 2011 Census data were extracted from BC Stats at LHA and DA levels[27] and used as average denominator populations for calculating rates.

Outcome classification

Following the ICD-10 (International Version) code book,[28] mortality due to unintentional injury data were extracted based on underlying cause of death with the ICD-10 codes V01-V99, W00-W99, X00-X99, Y00-Y36, Y85-Y87, or Y89. Analyses of fall-related mortality among seniors were restricted to those aged 65 years and older, and analyses of young driver mortality were restricted to those between 16 and 24 years of age. Mortality due to suicide among youth data were extracted based on underlying cause of death with the ICD-10 codes X60-X84 or Y870. Analyses of suicide were restricted to those between 15 and 24 years of age, based on VS reported age. These age groups reflect the provincial injury prevention priorities defined by BC Injury Prevention Committee. Table 1 contains a listing of ICD-10 codes with applicable age restrictions as used in the analyses.

Socioeconomic stratification

Using measured variables from the 2011 CensusPlus dataset, a model-based approach was used to develop the social deprivation (SD) and material deprivation (MD) indices; details on the indices can be found elsewhere.[29] In brief, at the macro-level, deprivation was represented via two overarching variables each built on three subconstructs: SD (lone parenting, living alone, and stability) and MD (employment, income and education). SD and MD indices for all DAs in BC were divided into 5 categories from most deprived (quintile 1) to least deprived (quintile 5). In addition, LHA-level scores for selected socioeconomic sub-constructs, namely income, education, and employment, were linked to VS data to examine disparities for these specific stratifications.

Rate calculations

Numerator data consisted of counts for injury-related mortality between 2009 and 2013 by 5-year age groups and aggregated at the LHA or DA level, depending on the socioeconomic stratification and as the data allowed. When calculating five-year age-standardized mortality rates (ASMRs) for each socioeconomic stratification (e.g., income), denominator data consisted of age-specific Census population within the various categories for each socioeconomic stratification, down to the DA or LHA levels. Due to the lack of actual annual population counts, the 2011 Census population was used as the denominator population for years 2009 to 2013 combined. To account for differences in the age distribution of the population across various geographic areas, crude mortality rates were directly standardized to the 2011 Canadian population, and were expressed as five-year total rates per 100 000 population. In

TABLE 1
International classification of disease (ICD-10 International Version) codes for causes of deaths from unintentional injury and intentional self-harm

Underlying cause of death (age restrictions as applicable)	ICD-10 codes
Unintentional injury overall	V01-V99, W00-W99, X00-X99, Y00-Y36, Y85-Y87, or Y89
Falls (65+)	W00-W99
Transport	V01-V99, Y850, Y859
Motor vehicle occupants	V30-V799, V870-V878, V880-V888, V890, V892, V89
Pedestrians	V01-V099
Motorcyclists	V20-V299
Cyclists	V10-V199
Young drivers (16–24)	V30-V80
Youth suicide (15–24)	X60-X84, Y870

Abbreviation: ICD, International Classification of Diseases.

addition, 95% confidence intervals (CIs) were calculated using gamma distribution function algorithm. Absolute disparities in unintentional injury and intentional self-harm related mortality were assessed by the disparity rate difference (DRD), calculated by subtracting ASMRs for the least deprived Quintile 5 from ASMRs for the most deprived Quintile 1 ($ASMR_{Q1} - ASMR_{Q5}$). Furthermore, relative disparities in unintentional injury and intentional self-harm related mortality were assessed by the disparity rate ratio (DRR), calculated by dividing ASMRs for Quintile 1 by ASMRs for Quintile 5 ($ASMR_{Q1}/ASMR_{Q5}$). Corresponding 95% CIs were calculated. Further information on DRD and DRR including CI calculations have been detailed previously.[30] DRR CIs that did not overlap with 1 and DRD CIs that did not overlap with 0 were considered significant. Mortality rates based on death counts below 16 were not shown in tables and figures due to poor statistical reliability.[31,32] All statistical analyses were conducted using SAS 9.4.[33]

Results

Unintentional injuries

Between 2009 and 2013, there were a total of 10 444 unintentional injury deaths in BC, of which 64.7% were among males (Table 2). The ASMR for unintentional injuries among the BC population during this period was 230.2 (95% CI: 225.8–234.6) per 100 000 population. For females, death due to falls among seniors (age 65+) was one of the major specific causes of unintentional injury-related mortality, accounting for 1544 (41.9%) of the total 3684 deaths. Of the 6760 unintentional injuries among males, falls among seniors (65+) and transport incidents were the major causes, leading to 1136 (16.8%) and 1226 (18.1%) deaths, respectively (Table 2). When comparing sexes, ASMR was significantly higher among males for overall unintentional injury at 321.9 (95% CI: 314.3–329.6) per 100 000 population, compared to 145.5 (95% CI: 140.8–150.2) per 100 000 population among females. Males also had significantly higher ASMR compared to females for all the specific types of unintentional injuries examined, namely falls among seniors (age 65+) and transport incidents including those involving motor vehicle occupants, pedestrians, motorcyclists, cyclists, and young drivers aged 16 to 24.

Figure 1 illustrates age-specific mortality rates for all unintentional injuries for the overall population of BC during 2009 to 2013. Mortality rate was low before 15 years of age and peaked for those aged 85 years and over for both males and females. Unintentional injury-related crude mortality was relatively stable between age groups 20 to 74. At age 75 and over, as age increased, there was a corresponding increase in trend for the overall unintentional injury-related mortality rate. While males had a consistently higher mortality rate due to all unintentional injury causes at every age category, the ratio gap in mortality rates between males and females was most pronounced for age groups 25 to 29, 35 to 39 and 45 to 49.

Overall unintentional injury-related mortality is not evenly distributed among LHAs in BC, ranging from 117.0 (95% CI: 101.4–132.6) per 100 000 population in Richmond LHA in the Lower Mainland to 649.1 (95% CI: 389.4–908.9) per 100 000 population Upper Skeena LHA in Northwest BC (Figure 2). In general, ASMR for overall unintentional injuries in both sexes was lowest in the Lower Mainland area surrounding Metro Vancouver and in southern Vancouver Island area surrounding Victoria, and higher in other parts of the province including several LHAs in southern Fraser Valley (Figure 2).

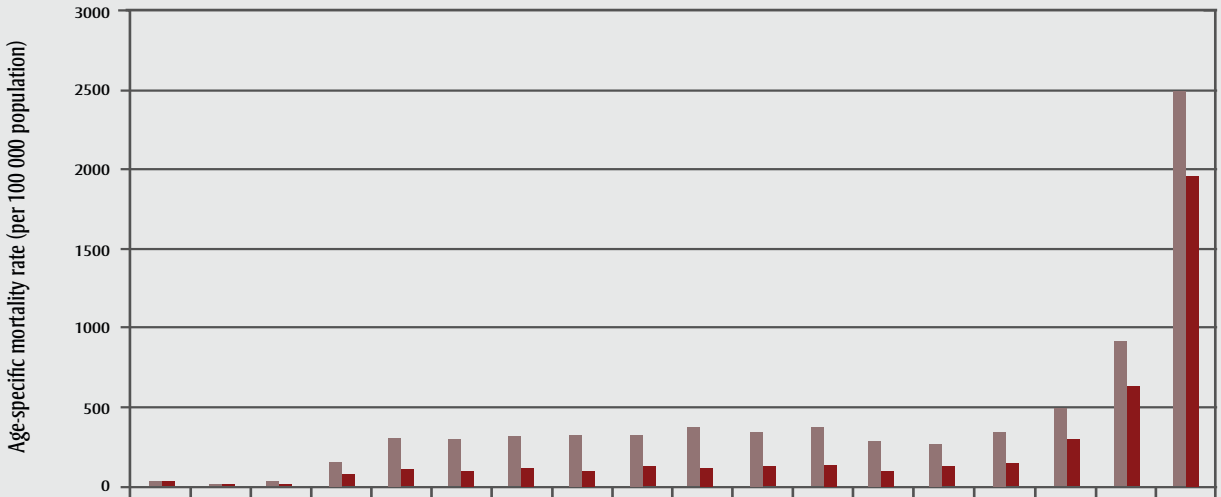
Overall unintentional injury-related mortality showed a clear stepped gradient by income, education, material and social deprivation, with higher mortality rates for people living in areas of lower income, lower education, and higher MD and SD. The DRR between the rate among British Columbians living in areas with the lowest quintiles and that among those living in areas with the highest quintiles of income, education, MD and SD were 4.9 (95% CI: 4.6–5.2), 3.2 (95% CI: 2.9–3.5), 1.8 (95% CI: 1.7–1.9), and 2.0 (95% CI: 1.9–2.1), respectively (Table 3). Percentage excess showed that if the whole population had experienced the ASMR of those living in areas with the highest quintiles of income, education, MD or SD, the ASMR for deaths due to unintentional injuries would have been 20.0%, 21.5%, 16.5%, or 28.0% lower, respectively, representing 46, 50, 38, or 64 fewer deaths per 100 000 population (Table 3). Overall unintentional injury-related mortality did

TABLE 2
Five-year age-standardized mortality rates per 100 000 population for deaths from overall and selected causes of unintentional injury and youth suicide in BC, total and by sex, 2009 to 2013

Cause of death	Total			Males			Females		
	Deaths[a] (n)	ASMR	(95% CI)	Deaths (n)	ASMR	(95% CI)	Deaths (n)	ASMR	(95% CI)
Unintentional injury overall	10 445	230.2	(225.8–234.6)	6 760	321.9	(314.3–329.6)	3 684	145.5	(140.8–150.2)
Falls (65+)	2 680	56.5	(54.4–58.7)	1 136	61.6	(58.0–65.2)	1 544	53.1	(50.4–55.7)
Transport	1 731	38.8	(36.9–40.6)	1 226	57.0	(53.8–60.2)	505	21.8	(19.9–23.7)
Motor vehicle occupants	912	20.5	(19.2–21.8)	592	27.6	(25.4–29.8)	320	13.8	(12.3–15.4)
Pedestrians	298	6.6	(5.9–7.4)	174	8.3	(7.0–9.5)	124	5.2	(4.3–6.2)
Motorcyclists	153	3.4	(2.9–3.9)	S			S		
Cyclists	68	1.5	(1.2–1.9)	S			S		
Young drivers (16–24)	103	2.4	(2.0–2.9)	72	3.3	(2.5–4.1)	31	1.5	(1.0–2.0)
Youth suicide (15–24)	257	6.0	(5.3–6.8)	180	8.3	(7.1–9.5)	77	3.7	(2.9–4.5)

Abbreviations: ASMR, five-year age-standardized mortality rate; BC, British Columbia; CI, confidence interval; S, suppressed to avoid reporting or deduction of small death counts.
[a] Excludes unintentional injury-related deaths not categorized under falls among seniors, transport, or youth suicide. However, total death counts include deaths with a missing or unknown gender.

FIGURE 1
Five-year age-specific mortality rate per 100 000 population for deaths from overall unintentional injury in British Columbia, by sex, 2009 to 2013



	0–4	5–9	10–14	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85+
Males	28.6	11.6	26.1	152.5	308.5	299.7	309.9	327.0	322.3	367.6	346.4	367.7	286.0	265.0	345.2	495.7	917.1	2494.6
Females	25.1	5.6	12.9	71.9	101.1	91.5	110.8	99.0	122.0	111.1	127.6	129.6	99.1	122.3	146.4	290.6	629.2	1961.3
Male to female ratio	1.1	2.1	2.0	2.1	3.1	3.3	2.8	3.3	2.6	3.3	2.7	2.8	2.9	2.2	2.4	1.7	1.5	1.3

Age groups (years)

not follow a clear stepped pattern with respect to area-based employment measure, although for all stratifications examined, DRD and DRR were significant when comparing the least to the most privileged quintiles (Table 3).

Similar patterns were observed for unintentional injury-related mortality due to falls among seniors, with the exception of absence of a clear pattern for SD. Our analyses showed a stepped gradient by levels of income, education, and MD with higher mortality rates for people living in areas with lower income, lower education, and higher MD. The DRR between the rate among British Columbians living in areas with the lowest quintiles and that among those living in areas with the highest quintiles of income, education, and MD were 1.8 (95% CI: 1.5–2.2), 1.9 (95% CI: 1.6–2.3), and 1.2 (95% CI: 1.1–1.4), respectively (Table 3). Percentage excess showed that if the whole population had experienced the ASMR of those living in areas with the highest quintiles of income, education, or MD in BC, the ASMR for deaths due to falls among seniors would have been 10.4%, 10.6%, or 5.5% lower, respectively (Table 3). Similar to overall unintentional injury, deaths due to falls among seniors did not follow a clear stepped pattern with respect to area-based employment or social deprivation measure. DRDs and DRRs were significant comparing the least to most privileged quintiles for all stratifications examined (Table 3).

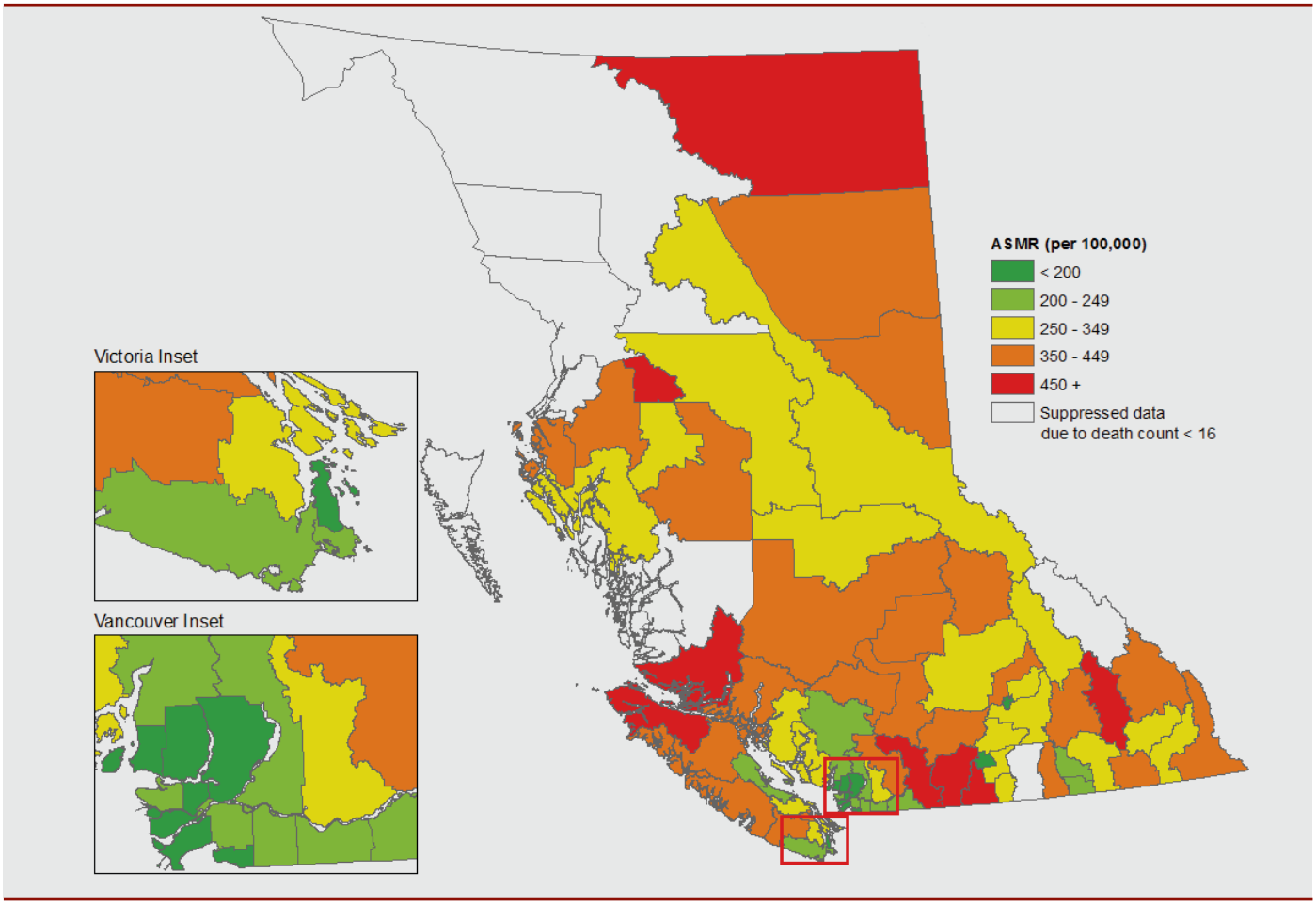
For unintentional injuries due to causes related to transport, a stepped gradient was observed for levels of income and MD with higher mortality rates for people living in areas with lower income and increased deprivation in terms of MD. The DRR between the rate among British Columbians living in areas with the lowest quintiles and that among those living in areas with the highest quintiles of income and MD were 3.4 (95% CI: 2.8–4.1) and 2.4 (95% CI: 2.0–2.8), respectively (Table 3). Percentage excess showed that if the whole population had experienced the ASMR of those living in areas with the highest quintiles of income or MD in BC, the ASMR for deaths due to transport would have been 28.9% or 34.8% lower, respectively (Table 3). While ASMR for deaths due to causes related to transport did not follow a clear stepped pattern with respect to area-based education, employment, or social deprivation measures, DRDs and DRRs were significant comparing the most to least privileged quintiles for all stratifications examined (Table 3).

Youth suicide

Between 2009 and 2013, suicide claimed 257 lives among BC youth 15 to 24 years of age (Table 2). The ASMR for youth suicide in BC during this period was 6.0 (95% CI: 5.3–6.8) per 100 000 population for both sexes combined and significantly higher for males at 8.3 (95% CI: 7.1–9.5) per 100 000 population compared to 3.7 (95% CI: 2.9–4.5) per 100 000 population for females (Table 2).

Between 2009 and 2013 in BC, both females and males between 20 to 24 years of age experienced higher suicide rates when compared to 15- to 19-year-olds, although the difference in age-specific mortality rate was more pronounced for males between 20 and 24 years of age at 79.4 per 100 000 population, compared with 47.3 per 100 000 population for age groups 15 to 19 years. Males had twice the

FIGURE 2
Five-year age-standardized mortality rate per 100 000 population for deaths from overall unintentional injury based on residential local health areas in BC, both sexes, 2009 to 2013



Data source: Statistics Canada. Vital statistics. Map prepared by BC Centre for Disease Control, Provincial Health Services Authority.
Abbreviations: ASMR, five-year age-standardized mortality rate; BC, British Columbia.

age-specific mortality rate from suicide as compared to females, in both age groups (Figure 3).

ASMR for youth suicide also showed a stepped gradient by the measured SES stratifications. The DRR between the rate among British Columbians living in areas with the lowest quintiles and that among those living in areas with the highest quintiles of income, education, and employment were 3.0 (95% CI: 1.7–5.2), 3.6 (95% CI: 2.2–6.0), and 5.3 (95% CI: 3.0–9.4), respectively (Table 4). Percentage excess showed that if the whole population had experienced the ASMR of those living in areas with the highest quintiles of income, education, or employment in BC, the ASMR for deaths due to youth suicide would have been 18.3%, 26.7%, or 20.0% lower, respectively. Youth suicide-related mortality did not follow discernible pattern with respect to MD and appeared to show an N-shaped pattern with respect to SD, whereas compared to people who live in areas of either highest or lowest social deprivation quintiles, those living in areas with moderate social deprivation had higher ASMR due to suicide (Table 4). Comparing the least to most privileged quintiles, DRDs and DRRs were significant for income, education, and employment but were not significant for MD and SD (Table 4).

Discussion

An equity lens was applied to a quantitative analysis of the mortality burden of the three BC provincial injury prevention priority areas: falls among seniors, transport injury, and youth suicide. Our study highlights significant sex differences, with males experiencing significantly higher mortality rates for examined causes. In addition, notable geographic variations were observed throughout the province. overall, people living in areas with lower income and higher levels of material deprivation had significantly higher mortality compared to their counterparts living in more privileged areas.

This analysis confirmed findings from other Canadian studies that males experience significant, 2- to 3-fold higher rates of mortality due to overall and specific causes of unintentional injury compared to females.[9,23] This analysis also suggests an important link between mortality and socioeconomic characteristics including income, education, employment, and material deprivation, being broadly consistent with prior research in Canada and internationally based on populations with diverse demographic characteristics.[4,9,11,18]

We observed significantly higher ASMRs due to falls among seniors for those with

TABLE 3
Five-year age-standardized mortality rates per 100 000 population for deaths from overall and selected causes of unintentional injury in BC by area-based socioeconomic characteristics, both sexes, 2009 to 2013

	Unintentional injury overall			Senior Falls (65+)			Transport		
	Deaths (n)	ASMR	(95% CI)	Deaths (n)	ASMR	(95% CI)	Deaths (n)	ASMR	(95% CI)
Total	10 445	230.0	(225.8–234.6)	2 680	56.5	(54.4–58.7)	1731	38.8	(36.9–40.6)
Income									
Quintile 1 – lowest	1 179	903.2	(851.6–954.7)	122	93.2	(76.7–109.7)	124	94.4	(77.8–111.0)
Quintile 2	1 272	373.2	(352.7–393.7)	270	70.8	(62.3–79.2)	248	76.1	(66.6–85.6)
Quintile 3	1 717	282.8	(269.4–296.2)	492	67.4	(61.5–73.4)	285	49.4	(43.6–55.1)
Quintile 4	3 163	252.6	(243.8–261.4)	864	63.5	(59.3–67.7)	541	44.4	(40.7–48.1)
Quintile 5 – highest	3 522	183.9	(177.8–189.9)	932	50.6	(47.7–53.9)	533	27.6	(25.3–29.9)
Disparity rate difference (Q1 − Q5)		719.3	(667.4–771.2)		42.6	(25.7–59.5)		66.8	(50.0–83.6)
Disparity rate ratio (Q1/Q5)		4.9	(4.6–5.2)		1.8	(1.5–2.2)		3.4	(2.8–4.1)
Excess (Total − Q5)		46.1			5.9			11.2	
Excess % (Total − Q5)/Total		20.0			10.4			28.9	
Education									
Quintile 1 – lowest	677	572.1	(529.0–615.2)	104	94.3	(76.1–112.4)	200	167.7	(144.4–190.9)
Quintile 2	1 236	404.7	(382.1–427.3)	278	84.5	(74.6–94.4)	260	86.7	(76.1–97.2)
Quintile 3	1 954	310.3	(296.6–324.1)	483	71.9	(65.5–78.3)	411	66.2	(59.8–72.5)
Quintile 4	2 761	255.9	(246.3–265.4)	685	63.5	(58.7–68.3)	385	35.6	(32.1–39.2)
Quintile 5 – highest	3 817	180.5	(174.8–186.2)	1 130	50.5	(47.6–53.5)	1232	55.5	(52.4–58.6)
Disparity rate difference (Q1 − Q5)		391.6	(348.1–435.1)		43.8	(25.4–62.2)		112.2	(88.8–135.6)
Disparity rate ratio (Q1/Q5)		3.2	(2.9–3.5)		1.9	(1.6–2.3)		3.0	(2.6–3.5)
Excess (Total − Q5)		49.5			6.0			−16.7	
Excess % (Total − Q5)/Total		21.5			10.6			−43.0	
Employment									
Quintile 1 – lowest	570	709.0	(650.8–767.2)	114	117.3	(95.8–138.9)	138	180.6	(150.5–210.8)
Quintile 2	1 094	267.0	(251.2–282.8)	254	58.4	(51.2–65.6)	221	54.3	(47.2–61.5)
Quintile 3	3 135	248.5	(239.8–257.2)	793	62.3	(58.0–66.7)	546	43.3	(39.6–46.9)
Quintile 4	2 338	284.5	(273.0–296.1)	538	63.4	(58.1–68.8)	403	49.6	(44.8–54.5)
Quintile 5 – highest	3 308	196.9	(190.2–203.7)	981	55.2	(51.7–58.7)	423	25.9	(23.5–28.4)
Disparity rate difference (Q1 − Q5)		512.1	(435.5–570.7)		62.1	(40.3–83.9)		154.7	(124.5–184.9)
Disparity rate ratio (Q1/Q5)		3.6	(3.3–3.9)		2.1	(1.7–2.5)		7.0	(5.8–8.5)
Excess (Total-Q5)		33.1			1.3			12.9	
Excess % (Total-Q5)/Total		14.4			2.3			33.2	
Material deprivation									
Quintile 1 – most deprived	2 473	352.7	(338.8–366.6)	633	66.3	(61.1–71.4)	395	59.5	(53.7–65.4)
Quintile 2	2 396	274.1	(263.1–285.1)	684	65.6	(60.7–70.5)	388	46.6	(60.7–70.5)
Quintile 3	2 158	243.0	(232.8–253.3)	559	61.2	(56.1–66.3)	390	44.4	(40.0–48.8)
Quintile 4	1 808	206.5	(197.0–216.1)	458	54.8	(49.8–59.8)	336	38.1	(34.1–42.2)
Quintile 5 – least deprived	1 607	192.1	(182.7–201.4)	346	53.4	(47.8–59.0)	222	25.3	(22.0–28.7)
Disparity rate difference (Q1 − Q5)		160.6	(143.8–177.4)		12.9	(5.3–20.5)		34.2	(27.5–40.9)
Disparity rate ratio (Q1/Q5)		1.8	(1.7–1.9)		1.2	(1.1–1.4)		2.4	(2.0–2.8)
Excess (Total − Q5)		37.9			3.1			13.5	
Excess % (Total − Q5)/Total		16.5			5.5			34.8	

Continued on the following page

TABLE 3 (continued)
Five-year age-standardized mortality rates per 100 000 population for deaths from overall and selected causes of unintentional injury in BC by area-based socioeconomic characteristics, both sexes, 2009 to 2013

	Unintentional injury overall			Senior Falls (65+)			Transport		
	Deaths (n)	ASMR	(95% CI)	Deaths (n)	ASMR	(95% CI)	Deaths (n)	ASMR	(95% CI)
Social deprivation									
Quintile 1 – most deprived	3 147	323.3	(312.0–334.6)	809	64.8	(60.3–69.3)	371	40.9	(36.7–45.0)
Quintile 2	2 539	299.8	(288.2–311.5)	752	71.7	(66.5–76.8)	453	57.2	(51.9–62.5)
Quintile 3	1 937	245.7	(234.7–256.6)	479	58.9	(53.6 –64.1)	363	46.5	(41.8–51.3)
Quintile 4	1 550	202.8	(192.7–212.9)	354	53.4	(47.9 –59.0)	304	38.1	(33.8–42.4)
Quintile 5 – least deprived	1 269	165.6	(156.5–174.7)	286	48.2	(42.6–53.7)	240	29.0	(25.3–32.7)
Disparity rate difference (Q1 − Q5)		157.7	(143.2–172.2)		16.6	(9.4–23.8)		11.9	(6.4–17.4)
Disparity rate ratio (Q1/Q5)		2.0	(1.9–2.1)		1.3	(1.1–1.5)		1.4	(1.2–1.6)
Excess (Total − Q5)		64.4			8.3			9.8	
Excess % (Total − Q5)/Total		28.0			14.7			25.3	

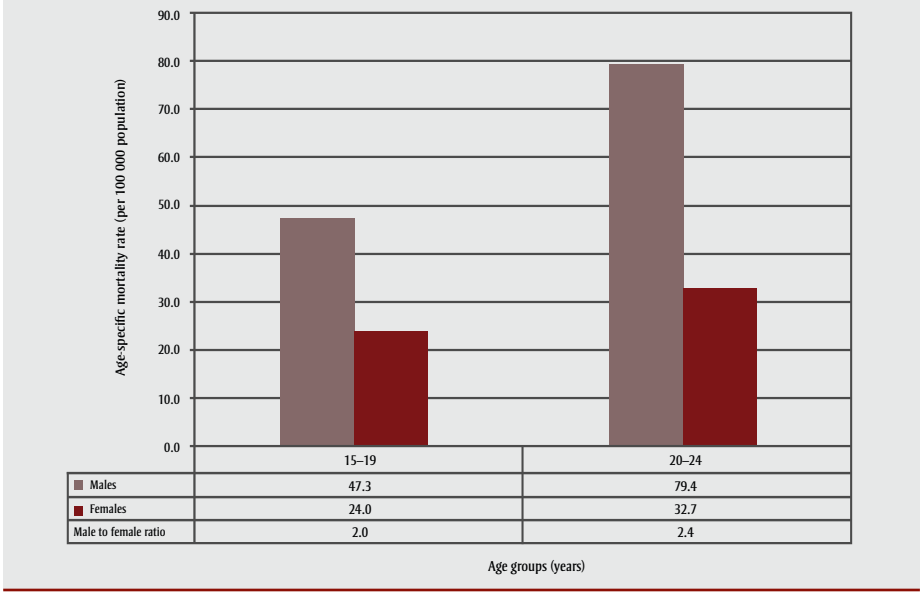
Abbreviations: ASMR, five-year age-standardized mortality rate; BC, British Columbia; CI, confidence interval; DRD, disparity rate difference; DRR, disparity rate ratio.

Notes: DRR CI: significant if CI does not overlap with 1.
DRD CI: significant if CI does not overlap with 0.

lower socioeconomic status as measured by living in areas of lower income and employment rate. Another study using population data for Canadians living in census metropolitan areas and looking at an injury group consisting largely of falls among seniors showed similar results, where mortality rates for those living in the poorest income quintile showed persistent and significant disadvantage, compared to those in the highest income group.[14] Conversely, another Canadian study found significant association between falls and income among male seniors but not females,[4] suggesting a potential sex modifier effect. Even though specific measures of employment varied slightly, other studies reported similar findings regarding the association between employment and mortality due to falls among seniors.[4,8,34]

The finding of significantly higher transport-related mortality rate among British Columbians living in areas of lower income agreed with a few studies conducted in Canada and the United States,[4,35,36] but not others.[4] In another Canadian study, it was reported that deaths specific to motor vehicle occupants showed an inverted association with area-based income.[14] Other analyses were consistent with the current study findings for transport-related injury deaths being significantly higher for those living in areas with lower socioeconomic status as measured by education and employment.[4,8,34] We demonstrated significant and step-wise lower ASMR due to transport-related incidents among British Columbians living in areas from least to most deprived of material resources, consistent with another Canadian study, although their results were only significant for males.[4]

FIGURE 3
Five-year age-specific mortality rate per 100 000 population for deaths from youth suicide in British Columbia (ages 15–24 years), by sex, 2009 to 2013



The wide geographic variations in unintentional injury ASMR as observed across the local health areas in BC was similar to another Canadian study of transport fatalities.[17] A precise public health approach that targets high-risk areas for unintentional injuries throughout the province may be valuable to consider.

The analysis of ASMR for youth suicide revealed similar patterns to those for unintentional injuries, suggesting that intent may not play a big role in observed differences by sex, area, and socioeconomic characteristics in injury-related mortality rates. Our results that demonstrated significant links between youth suicide and income, education, and employment have also been reported by other Canada-based studies.[8-10,14]

TABLE 4
Five-year age-standardized mortality rates per 100 000 population for deaths from youth suicide in BC by area-based socioeconomic characteristics, both sexes, 2009 to 2013

	Intentional self-harm		
	Deaths (n)	ASMR	(95% CI)
Total	257	6.0	(5.3–6.8)
Income			
Quintile 1 – lowest	15	14.8	(7.3–22.4)
Quintile 2	33	12.5	(8.2–16.8)
Quintile 3	50	10.0	(7.2–12.8)
Quintile 4	62	5.2	(3.9–6.5)
Quintile 5 – highest	97	4.9	(3.9–5.8)
Disparity rate difference (Q1 − Q5)		9.9	(2.3–17.5)
Disparity rate ratio (Q1/Q5)		3.0	(1.7–5.2)
Excess (Total − Q5)		1.1	
Excess % (Total − Q5)/Total		18.3	
Education			
Quintile 1 – lowest	18	16.0	(8.6–23.4)
Quintile 2	33	12.2	(8.0–16.4)
Quintile 3	50	8.2	(5.9–10.5)
Quintile 4	67	6.4	(4.9–8.0)
Quintile 5 – highest	89	4.4	(3.5–5.3)
Disparity rate difference (Q1 − Q5)		11.6	(4.2–19.0)
Disparity rate ratio (Q1/Q5)		3.6	(2.2–6.0)
Excess (Total − Q5)		1.6	
Excess % (Total − Q5)/Total		26.7	
Employment			
Quintile 1 – lowest	14	25.4	(12.1–38.8)
Quintile 2	39	10.1	(7.0–13.3)
Quintile 3	81	6.5	(5.1–7.9)
Quintile 4	49	6.3	(4.5–8.0)
Quintile 5 – highest	74	4.8	(3.7–5.9)
Disparity rate difference (Q1 − Q5)		20.6	(7.2–34.0)
Disparity rate ratio (Q1/Q5)		5.3	(3.0–9.4)
Excess (Total − Q5)		1.2	
Excess % (Total − Q5)/Total		20.0	
Material deprivation			
Quintile 1 – most deprived	46	7.2	(5.1–9.3)
Quintile 2	31	3.9	(2.5–5.3)
Quintile 3	59	6.8	(5.1–8.6)
Quintile 4	56	6.5	(4.8–8.3)
Quintile 5 – least deprived	47	5.6	(4.0–7.1)
Disparity rate difference (Q1 − Q5)		1.6	(−1.0–4.2)
Disparity rate ratio (Q1/Q5)		1.3	(0.87–2.0)
Excess (Total − Q5)		0.4	
Excess % (Total − Q5)/Total		6.7	
Social deprivation			
Quintile 1 – most deprived	54	6.6	(4.9–8.4)
Quintile 2	45	6.2	(4.4–7.9)
Quintile 3	59	8.0	(6.0–10.1)
Quintile 4	50	6.0	(4.4–7.7)
Quintile 5 – least deprived	49	5.1	(3.6–6.5)
Disparity rate difference (Q1 − Q5)		1.5	(−0.77–3.8)
Disparity rate ratio (Q1/Q5)		1.3	(0.88–1.9)
Excess (Total − Q5)		0.9	
Excess % (Total − Q5)/Total		15.0	

Abbreviations: ASMR, five-year age-standardized mortality rate; BC, British Columbia; CI, confidence interval; DRD, disparity rate difference; DRR, disparity rate ratio.

Notes: DRR CI: significant if CI does not overlap with 1.
DRD CI: significant if CI does not overlap with 0.

Strengths and limitations

This study was the first to quantify the socioeconomic and geographic disparities in mortality outcomes due to unintentional injury as well as the socioeconomic disparities related to youth suicide among British Columbians in support of program planning and policy development related to provincial injury prevention priorities. However, some data limitations should be recognized in the interpretation of the results. Geographic assignment of death records to census or health boundaries based on residential 6-digit postal codes could not differentiate between those that live at home and those that live in group homes. Our analysis is restricted to area-based socioeconomic status data and thus does not explore or account for the impact of individual-level socioeconomic status factors on injury-related mortality. Since dissemination areas and local health areas vary in geographic and population sizes as well as population characteristics, the overall socioeconomic status measures of income, education, employment as well as MD and SD represent the average socioeconomic characteristics in each dissemination area or local health area. Further, any associations observed at the provincial level might not necessarily hold true at the individual or aggregate levels including dissemination area or local health area. The ecological nature of this descriptive analytical approach and the inability to control for other potential confounders also precluded causal inferences on the association between injury-related mortality rates and social determinants of health. While the use of composite socioeconomic status measures such as the material and social deprivation indices acted to control for factors that may be potential confounders and yet highly correlated, the interplay between multiple factors may be further examined through multivariate analyse as a potential future direction for this work. This study is also limited by the use of all deaths occurring during the period from 2009 to 2013, while the 2011 Census population was used as the average denominator population for 2009 to 2013 combined, due to the lack of annual population data aggregated by age-groups and dissemination areas or local health areas. Furthermore, due to a change in BC Vital Stats Agency coding policy in 2010, there was a potential for over-estimation of falls-related deaths among seniors during the study period, 2009 to 2013. However, the change was

not expected to influence any observed correlation between mortality and socioeconomic status.

Conclusion

In conclusion, not only does mortality due to unintentional injuries—especially falls among seniors and transport incidents—continue to rank among the leading causes of death among British Columbians, there are significant differences in unintentional and intentional injury-related mortality outcomes between males and females, and by socioeconomic status. Having recognized these as provincial injury prevention priority areas,[24] there are opportunities for targeted injury prevention strategies in the province among high-risk geographic areas and segments of the population to address disparities in injury-related mortality outcomes.

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Conflicts of interest

None to declare.

Authors' contributions and statement

IP and DR were involved in design and conceptualisation of the work. MZ, LRZ, DK, FR, KT, and AZ were involved in the acquisition and/or analysis of the data. MZ and LRZ drafted the paper. All authors provided input for the interpretation of the results and revision of the paper.

The content and views expressed in this article are those of the authors and do not necessarily reflect those of the Government of Canada.

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Original mixed methods research

Assessing the content and comprehensiveness of provincial and territorial indoor tanning legislation in Canada

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Abstract

Introduction: Canadian provincial and territorial governments have enacted legislation in response to health risks of artificial ultraviolet radiation from indoor tanning. This legislation, which differs from jurisdiction to jurisdiction, regulates the operation of indoor tanning facilities. The content and comprehensiveness of such legislation—and its differences across jurisdictions—have not been analyzed. To address this research gap, we conducted a systematic, comprehensive scan and content analysis on provincial and territorial indoor tanning legislation, including regulations and supplementary information.

Methods: Legislative information was collected from the Canadian Legal Information Institute database and an environmental scan was conducted to locate supplementary information. Through a process informed by the content of the legislation, previous research and health authority recommendations, we developed a 59-variable codebook. Descriptive statistics were calculated.

Results: All provinces and one of three territories have legislation regulating indoor tanning. Areas of strength across jurisdictions are youth access restrictions (n = 11), posting of warning signs (n = 11), penalties (n = 11) and restrictions on advertising and marketing targeted to youth (n = 7). Few jurisdictions, however, cover areas such as protective eyewear (n = 4), unsupervised tanning (n = 4), provisions for inspection frequency (n = 4), misleading health claims in advertisements directed toward the general public (n = 2) and screening of high-risk clients (n = 0).

Conclusion: All provinces and one territory have made progress in regulating the indoor tanning industry, particularly by prohibiting youth and using warning labels to communicate risk. Legislative gaps should be addressed in order to better protect Canadians from this avoidable skin cancer risk.

Keywords: *health policy, ultraviolet radiation, skin cancer, melanoma, indoor tanning, suntan, ultraviolet rays, skin neoplasms*

Highlights

- All Canadian provinces and one of three territories have enacted indoor tanning legislation.
- There was a strong emphasis in the legislation on restricting youth access to indoor tanning and advertising and marketing of indoor tanning services to youth.
- Other well-covered areas were presence of warning signs and indication of penalties for infractions.
- Areas that likely require stronger legislative action include risk information provided to clients, client protection with respect to areas such as eyewear and exposure dose and restrictions on advertising and marketing to the general public.
- Very few jurisdictions identified inspection frequency, which may have implications for compliance by indoor tanning businesses.

Introduction

Skin cancer, commonly classified as either melanoma or non-melanoma skin cancer (NMSC), is the most common type of cancer in Canada.[1] The incidence of melanoma, the most fatal form of skin cancer, is increasing steadily—2.1% in males and 2.0% in females[1,2] every year between 1992 and 2013. In 2017, it was projected that 7200 Canadians would be newly diagnosed with melanoma and 1250 would die from this cancer.[2] Exposure to ultraviolet (UV) radiation, including that from tanning equipment, has been demonstrated to increase the risk of skin cancer, including potentially fatal cutaneous and ocular melanomas.[3,4] UV radiation has been classified by the World Health Organization (WHO) as a human carcinogen.[3]

The risk of skin cancer due to indoor tanning is especially pronounced if first use occurs at an early age: there is a 59% higher risk of cutaneous melanoma among people who begin using indoor tanning devices before the age of 35 than among those who have never used tanning beds.[5] Studies have also reported increased odds of ocular melanoma if exposure to tanning equipment begins before age 20.[3] The use of these devices before the age of 25 can also increase the risk of developing non-melanoma skin cancer, including basal cell carcinoma and squamous cell carcinoma.[4] Table 1 summarizes the risks associated with UV tanning found in the literature.[3,4,6-10]

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TABLE 1
Negative outcomes associated with UV tanning

Skin effects	Melanoma,[3] basal cell carcinoma,[4] squamous cell carcinoma,[4] skin burns,[6] premature skin aging (wrinkling,[7] changes in pigmentation,[7] loss of elasticity[8])
Eye effects	Ocular melanoma,[3] photokeratitis,[6] photoconjunctivitis,[6] cataracts,[8] pterygium[8]
Other effects	Immune suppression,[9] dependence[7,10]

Despite these risks, an estimated 1.35 million Canadians participated in this activity in 2014.[11] In addition, though the risk of skin cancer is higher if first use of indoor tanning devices occurs early in life[4,5] and melanoma is one of the most commonly diagnosed cancers in youth aged 15 to 29,[12] use of indoor tanning devices is highest among young people, particularly young women.[11] These trends may be due in part to the propagation of tanned skin as a beauty ideal, conflicting information on the dangers of indoor tanning in the media[13] and misleading claims from the indoor tanning industry.[14]

Legislation regulating indoor tanning facilities influences the use of these devices, especially by young people. For example, a study in the United States of America (USA) determined that adolescent females in states with indoor tanning legislation were less likely to tan indoors.[15] In addition, legislation has been noted as possibly contributing to declines in smoking rates and changes in attitudes toward smoking, as well as reduced incidence of traffic deaths related to impaired driving and absence of seatbelts.[16-18] As it has for these issues, health policy may impact indoor tanning behaviours.

In Canada, legislation addressing indoor tanning exists at the federal level as the *Radiation Emitting Devices (RED) Act* and Regulations.[19,20] This legislation regulates certain features of indoor tanning equipment sold in Canada, such as timers and UV bulbs used in the devices, and manufacturers' labels.[20] Health Canada has also developed the voluntary *Guidelines for Tanning Salon Owners, Operators, and Users*, which contain recommendations for the use of indoor tanning devices.[6] However, the responsibility of regulating tanning salon operation falls on the provincial and territorial governments, who, along with some municipalities, have enacted legislation in this area. These laws are often described in Acts enacted by provincial legislative assemblies.[21] Acts may also designate a person or group to develop additional rules and further guide the Act through pieces of legislation known as regulations.[21]

Though it is known that provincial and territorial indoor tanning legislation does exist, a comprehensive analysis of this policy across provinces and territories has not yet been conducted. Analyses of such legislation in the USA by Woodruff et al. and Gosis et al. have provided useful comparisons in the indoor tanning legislation between states and across several key aspects of tanning facility operation.[22,23] They have also highlighted areas of strength and areas for potential improvement in the legislation.[22,23] Similarly, analyses of other forms of health legislation covering areas such as tobacco, alcohol and behaviours surrounding obesity have been conducted.[24-28] These have provided valuable information on the state and coverage of these health policies.[24-28] Analyzing the content of Canadian indoor tanning legislation will therefore allow for the collection of information that may assist in future policy developments in this field. To obtain this information and fill the current gap in the research on Canadian indoor tanning legislation, we collected all provincial and territorial legislative and supplementary information and conducted a content analysis of these laws.

This paper outlines the collection of this legislative information; development of a codebook to conduct the content analysis; and the results and applications of this research.

Methods

Content analyses are a useful approach for studying and comparing legislative content.[29] The methodology of this study involved systematically collecting all Canadian provincial and territorial indoor tanning legislation; locating any material supplementary to the legislation; developing a codebook to analyze the legislation; and conducting a comprehensive content analysis on all information collected.

Collection of legislation and supplementary information

We located current Acts and regulations in the "Legislation" category of the Canadian Legal Information Institute (CanLII) database using the "Document Text" search function. Search parameters were restricted to one province or territory at a time. Search terms included the disease ("skin cancer"), the activity ("tanning") and the exposure ("ultraviolet light," "UV light," ultraviolet radiation," "UV radiation"). For each piece of legislation, CanLII provided links to regulations and enabling statutes where applicable. Some pieces of indoor tanning legislation also described additional Acts that address areas such as enforcement. These Acts were collected in CanLII with the name of the legislation as the search term. Table 2 contains all legislative and supplementary information collected, as well as the enforcement status of each law.

Indoor tanning legislation was not located for Nunavut and Yukon on CanLII. The absence of indoor tanning legislation in these territories was confirmed using each territory's legislative website.

In many cases, provincial and territorial indoor tanning legislation was accompanied by supplementary materials to provide information beyond the legislative contents and to help tanning salon operators and clients interpret the legislation. Common examples of this supplementary information included guidelines for tanning salon operators, copies of warning signs for posting on the premises and webpages provided by provincial or territorial health authorities with more information on areas such as enforcement and inspection.

An environmental scan was used to collect any relevant supplementary information or materials related to each province's indoor tanning legislation. We obtained this information using the search functions on provincial and territorial health ministry websites. Search terms used on each of these websites included "tanning" and "indoor tanning." To obtain more information on inspection, we also included the search term "tanning inspection" on all health ministry websites. In Quebec, we also included the search term "bronzage" in order to capture material in French.

Codebook development and application

Once all legislative information was collected, we developed a comparison chart of indoor tanning legislation to highlight common features of Canadian indoor

TABLE 2
Canadian indoor tanning legislative and supplementary information collected and status of legislation

Province/Territory	Act	Status as of August 2018	Regulation	Associated documents
British Columbia (BC)	*The Public Health Act, 2008*	In force	Regulated Activities Regulation	"BC Tanning Bed Ban" (BC Government webpage) "Required Signage for Tanning Bed Facilities" (BC Government webpage) "How to Follow the Under-18 Ban: Tips for Tanning Bed Operators" (BC Government webpage)
Alberta (AB)	*Skin Cancer Prevention (Artificial Tanning) Act, 2015*	In force (except section on age identification and prescriptions for minors)	Artificial Tanning Regulation (233/2017)	"Skin Cancer Prevention (Artificial Tanning) Act and Regulation 2018" (Alberta Government webpage) "Standards for Artificial Tanning Facility Signage"
Saskatchewan (SK)	*The Public Health Act, 1994*	In force	The Health Hazard Regulations	"Personal Service Facilities" (Saskatchewan Government webpage)
Manitoba (MB)	*The Public Health Act, 2009*	In force	Tanning Regulation (58/2012)	"Guide to Laws and Regulations on Use of Tanning Equipment for Operators and Managers of Commercial Tanning Operations" "Guide to Laws on Use of Tanning Equipment" (Manitoba Government webpage)
Ontario (ON)	*Skin Cancer Prevention Act (Tanning Beds), 2013*	In force	O. Reg. 99/14	Tanning Beds Compliance Protocol, 2014
Quebec (QC)	*An Act to Prevent Skin Cancer Caused by Artificial Tanning, 2013*	In force	n/a	*Act Respecting the Legal Publicity of Enterprises* *Act Respecting Health Services and Social Services* "Guide explicatif à l'usage des salons de bronzage"
New Brunswick (NB)	*Artificial Tanning Act, 2013*	In force	n/a	"Guide for Commercial Tanning Bed Owners and Tanning Salon Operators in New Brunswick" *Personal Offences Procedures Act* "Public Health Inspector" (NB Government webpage)
Nova Scotia (NS)	*Tanning Beds Act, 2010*	In force	Tanning Facilities Regulations	Guide to the Nova Scotia *Tanning Beds Act* & Tanning Facilities Regulations for Tanning Bed Owners "Environmental Health" (NS Government webpage)
Prince Edward Island (PE)	*Public Health Act, 1988*	In force	Tanning Facility Regulations	"Tanning Facility Inspection and Equipment Registration" (Prince Edward Island Government webpage)
Newfoundland and Labrador (NL)	*Personal Services Act, 2012*	In force	Personal Services Regulations	"Health and Safety Standards for Tanning Facilities" "Personal Services Act and Regulations" (Newfoundland and Labrador Government webpage)
Northwest Territories (NT)	*The Public Health Act, 2007*	In force	Personal Service Establishment Regulations	"Standards for Personal Service Establishments" "Personal Service Establishment Inspections and Permits" (Northwest Territories Government webpage)
Yukon (YT)	n/a	n/a	n/a	n/a
Nunavut (NU)	n/a	n/a	n/a	n/a

Abbreviation: n/a, not applicable.

tanning legislation, which we incorporated into the codebook. The codebook was also informed by research and recommendations from major public health authorities. For example, variables sourced from guidelines developed by WHO for tanning salon operators included the refusal of services to clients prone to sunburn and prohibition of misleading health claims in advertisements.[8] Some variables sourced from Health Canada's 2014 *Guidelines for Tanning Salon Owners, Operators, and Users* included compliance with tanning device manufacturers' recommended maximum exposure duration and use of protective eyewear.[6] These recommendations from WHO and Health Canada served as examples of contents that the ideal indoor tanning legislation may have.

Some variables used in the studies on US indoor tanning legislation, such as enforcement authority,[23] proof of operator training[22] and provisions for checking client age identification,[23] were also incorporated in this codebook. One of these studies did not provide the full scoring tool used in the research; this was obtained by contacting the principal investigator.

We developed the codebook and applied it to the legislation through a consensus-based process. A draft incorporating the information described above was created, and then applied to a sample of provinces or territories while any coding issues were discussed among the research team. We then revised the codebook, and repeated this process until a final version was developed. We applied this final codebook to all legislative contents while regularly discussing the process and any remaining issues. Throughout the codebook development and final coding process, we obtained and incorporated feedback from policy experts and public health professionals in cases where the legislative language was ambiguous.

The final codebook consists of 12 categories, which are subdivided into 59 variables, each aligned to one legislative component. For most variables, coding was dichotomous and on a "presence" or "absence" basis for legislative components. However, some required more coding options to convey more detail about the legislative components. For example, it was necessary to create three coding options in the variable that analyzed indoor tanning prohibitions for youth: these options were "no," "minimum age to access tanning services is 1–17" and "minimum age is 18 or 19." When it was important to determine the specificity of the legislative language for a particular variable, coding options were created to reflect this. For example, in the inspection authority variable under the enforcement category, there were three main coding options: "no," "nonspecific person/group given as inspector" and "specific person/group given as inspector." This methodological approach was informed by the scoring tool developed by Gosis et al.[23] Other variables required information that was specific to each province or territory, such as the number of warning signs required and details of penalties for violation of the legislation. In these cases, there were no coding options, but the information was entered directly into the data spreadsheet.

Once all materials were coded, we calculated descriptive statistics (frequencies) using SPSS version 25.0 for Mac (IBM, Armonk, NY, USA). These statistics included the proportions of provinces and territories that were given each coding option for each variable.

Results

All 10 provinces and one of the three territories in Canada have introduced legislation to regulate indoor tanning; this equates to a national legislative coverage of 85%. Table 3 summarizes the results across all variables for the 11 provinces/territories that have indoor tanning legislation.

Access restrictions

All provinces/territories prohibit youth under the age of 18 or 19 (minors) from accessing indoor tanning services. However, no region has placed such prohibitions on those beyond this age group (i.e. adults are not prohibited from tanning in any jurisdiction). No jurisdiction allows exemptions to these laws for minors who have parental consent. However, five provinces/territories allow minors who have a medical prescription to access indoor tanning services.

All provinces and territories require salon operators to check the ages of potential clients through photo identification to ensure that they meet the minimum age requirement. Nine have this requirement for persons who appear to be under the minimum age of 18 or 19, and two have this requirement for any potential client appearing to be under the age of 25.

Advertising and marketing

Of the 11 provinces and territories with indoor tanning legislation, seven have some restriction on advertising and marketing of indoor tanning services. All of these prohibit indoor tanning advertisements directed to youth, while none prohibit these advertisements from targeting members of other age groups (i.e., adults). Four provide specific language to explain provisions against youth-oriented advertisements (e.g., prohibitions on advertising in certain locations or media accessed frequently by youth). Five prohibit advertisements with misleading health claims directed to youth, while two prohibit these claims from targeting other age groups. Two jurisdictions with advertising restrictions require advertisements to disclose the minimum age requirements and health risks of indoor tanning with respect to people of all ages.

Warning signs

All provinces/territories with indoor tanning legislation require at least one warning sign to be posted in tanning facilities. The number of unique warning signs to be posted in indoor tanning facilities ranges from one (BC, SK, MB, PE) to four (AB, ON). Warning signs in all jurisdictions inform clients of the minimum age to access indoor tanning services. All but one province/territory require warning signs to indicate at least one health risk of indoor tanning (e.g., "skin cancer," "serious injury" or "burns"). Eight include warning signs that indicate at least one aesthetic risk of indoor tanning (e.g., "premature aging" or "skin wrinkling"). In addition, about half mandate warning signs to communicate at least one personal characteristic (e.g., certain medical conditions, medications and skin types) that would increase a person's likelihood of experiencing the adverse effects of indoor tanning.

The number of unique locations for warning signs in a tanning facility ranges from one (BC, SK) to four (AB, ON). The legislation for seven provinces/territories provides specific descriptions of required warning sign locations, such as maximum distance from tanning equipment or cash

TABLE 3
Comprehensiveness of indoor tanning legislation in eleven Canadian provinces/territories

Legislative provision	Provinces/territories with provision	Number of jurisdictions with provision, *n* (%)
Access restrictions (general public)		
Indoor tanning prohibited for all ages	—	0 (0)
Access restrictions (youth)		
Indoor tanning prohibited for youth		
Minimum age is 1–17	—	0 (0)
Minimum age is 18 or 19	BC, AB, SK, MB, ON, QC, NB, NS, NL, PE, NT	11 (100)
Exception for parental consent	—	0 (0)
Exception for medical prescription	BC, AB, SK, MB, PE	5 (45.5)
Provisions for checking age identification		
Under minimum age of 18 or 19	BC, SK, MB, QC, NB, NS, NL, PE, NT	9 (81.8)
Under age of 25	AB, ON	2 (18.2)
Advertising and marketing		
Advertising/marketing restricted	AB, SK, MB, ON, QC, NB, PE	7 (63.6)
Advertising and marketing (youth)		
Prohibited if directed toward youth		
Yes (nonspecific)	QC, NB, PE	3 (27.3)
Yes (specific)	AB, SK, MB, ON	4 (36.4)
False claims prohibited toward youth	SK, MB, ON, QC, NB	5 (45.5)
Disclose age ban in advertisements	AB, QC	2 (18.2)
Disclose health risks specific to youth in advertisements	AB, QC	2 (18.2)
Advertising and marketing (general public)		
Prohibited toward the general public	—	0 (0)
False claims prohibited toward general public	QC, NB	2 (18.2)
Disclose health risks specific to general public	AB, QC	2 (18.2)
Warning signs		
Required	BC, AB, SK, MB, ON, QC, NB, NS, NL, PE, NT	11 (100)
Entrance door	AB, ON, QC, NB, NS	5 (45.5)
Point of sale (facing client)	AB, BC, MB, ON, QC, NB, NS, NL, PE, NT	10 (90.9)
Point of sale (employee reminder)	AB, ON, NS	3 (27.3)
On or near tanning equipment	AB, MB, ON, NB, NS, NL, PE, NT	8 (72.7)
Other or vague location	SK, MB	2 (18.2)
Additional location requirements		
Yes (vague)	BC, SK, QC, NB	4 (36.4)
Yes (specific)	AB, MB, ON, NS, NL, PE, NT	7 (63.6)
At least one health risk conveyed	AB, SK, MB, ON, QC, NB, NS, NL, PE, NT	10 (90.9)
At least one personal risk factor conveyed	MB, NB, NS, NL, NT	5 (45.5)
At least one aesthetic risk conveyed	SK, MB, QC, NB, NS, NL, PE, NT	8 (72.7)
Age ban conveyed	BC, AB, SK, MB, ON, QC, NB, NS, NL, PE, NT	11 (100)

Continued on the following page

registers at point of sale. Four provide vague descriptions by stating that signage must be "prominent" or "easily viewed." In terms of exact locations, five jurisdictions require warning signs to be posted on or near an entrance door to the premises, 10 require a sign to be visible to the client at point of sale, three require a sign to be visible to employees at the point of sale to remind them of the minimum age requirement and eight require a warning sign to be posted on or near tanning equipment. Two describe other or vague locations where warning signs must be posted: in Saskatchewan, the sign must be placed in a prominent or easily viewed location; in Manitoba, there is an option to place one of the required signs in any location where it can be seen by a person entering the facility.

Protective eyewear

In total, four provinces/territories contain provisions for client use of protective eyewear while using indoor tanning equipment. All four also require that this eyewear comply with the specifications laid out in the RED Regulations and two of these provinces/territories state that the eyewear must securely cover the eyes of the user. Requirements for the provision of protective eyewear to clients varied across jurisdictions. One province allows clients to provide their own eyewear for use but does not specify that operators must examine the eyewear to determine compliance with the legislation. Another province states that clients may provide their own eyewear, but the operator must inspect it for compliance, while two other provinces/territories mandate that the tanning facilities provide the eyewear for purchase or use. In addition, two require operators to instruct clients on the proper use of protective eyewear before allowing access to indoor tanning equipment.

Unsupervised tanning

Four provinces/territories prohibit indoor tanning facilities from selling access to equipment that does not require monitoring by an attendant (i.e., coin-operated devices or any other equipment that clients can operate on their own).

Operator training

Salon operator training is mentioned in the legislation of three provinces/territories. One of these jurisdictions provides

TABLE 3 (continued)
Comprehensiveness of indoor tanning legislation in eleven Canadian provinces/territories

Legislative provision	Provinces/territories with provision	Number of jurisdictions with provision, *n* (%)
Protective eyewear		
Required	MB, ON, NL, NT	4 (36.4)
Compliance with federal regulations	MB, ON, NL, NT	4 (36.4)
Securely covers eyes	MB, ON	2 (18.2)
Provision of eyewear		
Clients can provide their own (operator not required to check for compliance)	ON	1 (9.1)
Clients can bring their own (operator must check for compliance)	MB	1 (9.1)
Provided by operator	NL, NT	2 (18.2)
Operator must instruct client on proper use	MB, ON	2 (18.2)
Unsupervised tanning		
Prohibited	AB, MB, ON, NL	4 (36.4)
Operator training		
Training required	BC, MB, ON	3 (27.3)
Training information provided	BC	1 (9.1)
Proof of training	—	0 (0)
Exposure dose		
Compliance with recommended exposure duration	—	0 (0)
Compliance with recommended exposure frequency	—	0 (0)
Client information/Acknowledgement of risks		
Information other than warning signs provided	AB, NL	2 (18.2)
Client must acknowledge risks	—	0 (0)
Information must convey at least one health risk	AB, NL	2 (18.2)
Information must convey at least one personal risk factor	NL	1 (9.1)
Information must convey at least one aesthetic risk	NL	1 (9.1)
Screening		
Refuse tanning services for high-risk clients	—	0 (0)
Enforcement (reporting of operation)		
Registration of tanning facilities	SK, ON, QC, NL, PE, NT	6 (54.5)
List of tanning facilities kept up-to-date	SK, ON, QC, NL, PE, NT	6 (54.5)
Enforcement (compliance and inspection)		
Inspections conducted	BC, AB, SK, MB, ON, QC, NB, NS, NL, PE, NT	11 (100)
Enforcement authority		
Non-specific	QC	1 (9.1)
Specific	BC, AB, SK, MB, ON, NB, NS, NL, PE, NT	10 (90.9)

Continued on the following page

further information on how this training is to be conducted. None of the collected pieces of legislation state that operators must have proof of training.

Exposure dose

No jurisdiction requires tanning facilities to comply with the maximum exposure times or the minimum interval times between consecutive exposures, as recommended by the manufacturer.

Client information and acknowledgement of risks

Two provinces/territories require risk information be provided to clients in a format above and beyond warning signs. The client information provided by salon operators in both jurisdictions must contain at least one health risk of indoor tanning. However, only one jurisdiction (NL) requires that client information disclose at least one aesthetic risk and at least one personal factor that could increase a client's risk of adverse effects. No province or territory requires clients to acknowledge verbally or with a signature that they understand the risk information provided.

Screening

No Canadian jurisdiction has made it mandatory for operators to recommend or require that certain high-risk potential clients (e.g. those with type 1 skin [highly sensitive, always burns, never tans]) avoid using indoor tanning devices.

Enforcement

Reporting of operation

Six provinces/territories require indoor tanning facilities to be registered with a health authority. All of these either describe methods of keeping registries of active tanning facilities accurate and up-to-date or mention authorities responsible for this task.

Compliance and inspection

All provinces/territories with indoor tanning legislation require inspections of indoor tanning facilities to help ensure compliance. Two jurisdictions (SK, ON) mandate that inspections of indoor tanning facilities occur primarily in response to complaints. The legislation in five jurisdictions also indicates the possibility for proactive inspections (i.e., those that are not in response to complaints). Four provinces/

TABLE 3 (continued)
Comprehensiveness of indoor tanning legislation in eleven Canadian provinces/territories

Legislative provision	Provinces/territories with provision	Number of jurisdictions with provision, *n* (%)
Enforcement (compliance and inspection) (continued)		
Inspection frequency		
Vague	NL, NS, PE	3 (27.3)
Specific	NT	1 (9.1)
Complaint-only inspections	SK, ON	2 (18.2)
Proactive inspections		
No	SK, ON	2 (18.2)
Unclear	—	0 (0)
Yes	BC, AB, MB, QC, NB	5 (45.5)
Yes, and frequency given	NS, NL, PE, NT	4 (36.4)
Inspector must provide notice		
Not stated	AB, MB, ON, QC, NB, NS, NL, PE	8 (72.7)
No	BC, SK, NT	3 (27.3)
Penalties		
Penalties for non-compliance		
Yes (nonspecific)	—	0 (0)
Yes (specific)	BC, AB, SK, MB, ON, QC, NB, NS, NL, PE, NT	11 (100)
Escalating/repeating penalties	BC, AB, SK, MB, ON, QC, NB, NS, NL, PE, NT	11 (100)

Abbreviations: AB, Alberta; BC, British Columbia; MB, Manitoba; NB, New Brunswick; NL, Newfoundland and Labrador; NS, Nova Scotia; NT, Northwest Territories; ON, Ontario; PE, Prince Edward Island; QC, Quebec; SK, Saskatchewan.

territories clearly indicate a requirement for these proactive inspections by providing a frequency at which indoor tanning facilities must be inspected: one provides a specific interval ("yearly" in NT) and three give vague frequencies ("regularly" in NL, "from time to time" in NS, "routinely" in PE).

In 10 jurisdictions, the legislation identifies at least one specific person or group responsible for conducting inspections, most commonly environmental health officers/consultants (n = 5) or public health inspectors/officers (n = 5). It is explicitly stated in the legislation of three provinces/territories that these inspectors may enter indoor tanning facilities without providing prior notice to owners or operators.

Penalties

Specific penalties are outlined in the legislation for all provinces/territories. Penalties are either described in the indoor tanning legislation or included in general penalties for violations of all provisions within public health acts. All penalties increase in severity for repeated or continued offences, or repeat for each day an offence continues. All provinces/territories describe fines as penalties for offences. However, some public health acts also mention imprisonment as the penalty for an offence. In Nova Scotia, suspensions from providing indoor tanning services are also possible penalties. In Quebec, there is a $100 fine for minors who were found accessing indoor tanning services.

Discussion

Most provinces and territories have introduced legislation to protect Canadians from the health risks associated with artificial tanning, which represents important progress considering no provincial or territorial indoor tanning legislation existed seven years ago. This legislation is very much focused on youth access restrictions. Coverage of warning signs, penalties and advertising directed to youth were also strong. However, there were some gaps across jurisdictions in terms of other forms of risk communication, screening of potential clients, unsupervised tanning restrictions, compliance with manufacturer exposure recommendations and protective eyewear requirements. In addition, while all jurisdictions mandate inspections, the way these provisions are laid out in the legislation may not ensure sufficient enforcement.

Indoor tanning legislation was not present in Nunavut and Yukon, each with a population of 36 000.[30,31] An Internet search indicates there are few tanning facilities operating in each territory. We are not aware if these territories have the resources for regulating these issues. However, it may be possible for them to adopt other provincial laws. In addition, an existing bylaw in the City of Whitehorse, Yukon, likely covers the majority of tanning salons in Yukon.[32]

The fact that all jurisdictions with indoor tanning legislation prohibit the sale of indoor tanning services to minors is likely due to findings that the risks of indoor tanning are especially pronounced in this group, as well as to the legal precedent of restricting alcohol and tobacco to youth. This is an important step, as it was found that female high school students in the USA, for example, were less likely to use these services if they live in states with age restriction laws;[15] in Canada, the highest prevalence of indoor tanning is among young women.[11] However, although the risk of developing cutaneous melanoma from indoor tanning devices is particularly high in those who first use them before age 35,[5] incidence is higher in older Canadians.[1] Despite this, no laws in Canada prevent those over 18 or 19 from using indoor tanning beds.

Other high-risk Canadians may also be permitted to undergo harmful exposure to UV radiation under provincial and territorial legislation, since most jurisdictions do not require that clients be screened prior to using indoor tanning devices. For example, 28% of Canadian indoor tanning device users are reported to have skin that is susceptible to sunburn[11] while Health Canada recommends that people who always burn and never tan should be advised against indoor tanning.[6]

Most, but not all, provinces and territories with indoor tanning legislation require that health and aesthetic risks, as well as personal risk factors, of indoor tanning be displayed in warning labels in tanning facilities. This is promising, given the success of tobacco warning labels. However, and of concern, approximately half of indoor tanning users do not consult the posted warning signs each time they tan.[11] Thus, there is a need for risk information through other means, such as documents or verbal communication provided by salon operators. However, only two provinces currently require operators to do this, representing a potential area for improvement.

While warning signs are important, the people seeing them are already somewhat committed to the behaviour. Therefore, communicating health risks and preventing misinformation through advertisements is also important. However, most jurisdictions do not require tanning facilities to disclose this risk information when advertising their services. In addition, in most—but not all—provinces and territories, regulation of misleading advertisements directed toward youth was common, while misleading advertisements directed toward the remainder of the public were rarely restricted. The indoor tanning industry is known to downplay the risks of indoor tanning while emphasizing the supposed benefits, and many of their claims have been disproven.[14] Limited regulation of these claims may contribute to misinformation about the hazards of indoor tanning. For example, 62% of indoor tanning users aged 12 and over have said that obtaining a base tan—a misleading claim used by indoor tanning salons—as the reason for their usage of these devices.[11,33] The potential for misinformation does not end at the age of 18, and thus protection from misleading advertisements for all ages is necessary.

The ocular effects of indoor tanning are important to consider when regulating tanning facilities. Thus, it is a concern that less than half of provinces and territories with indoor tanning legislation require clients to use protective eyewear. The federal RED Regulations require protective eyewear with certain specifications to be included with indoor tanning equipment sold in Canada, but do not contain provisions for client use of this eyewear.[20] The provinces and territories must shoulder some responsibility to ensure that clients are adequately protected by eyewear while tanning.

The RED Regulations require tanning device manufacturers to label each piece of equipment with the recommended exposure schedule, yearly maximum exposure time and minimum interval between indoor tanning sessions.[20] However, no provinces or territories had legislation mandating that these recommendations must be followed, despite Health Canada's *Guidelines for Tanning Salon Owners, Operators, and Users*, which state that the first and maximum exposure times on these labels are not to be exceeded.[6] There appears to be a gap between federal and provincial legislative coverage in all jurisdictions, despite evidence suggesting a dose–response relationship between indoor tanning and skin cancer.[5,34] The extent to which indoor tanning facilities are following these recommendations is unclear, though 18% of indoor tanning users have reported not following the exposure schedule recommended by manufacturers.[11] This is also a concern since only four provinces/territories prohibit unsupervised use of indoor tanning equipment and only three mention operator training in the legislation. Thus, there may be more opportunities for the misuse of these devices. To reduce risks to clients, WHO advises against the use of unsupervised tanning equipment and recommends the presence of an operator who is trained in procedures such as recognizing clients' personal risk factors and emergency protocols.[8]

Legislative impact can only be maximized through comprehensive enforcement protocols by authorities and compliance by salon operators. All provinces and territories require inspections for compliance and outline specific penalties, which may help to deter tanning facility operators from violating the legislation. However, the legislation in most provinces/territories does not mention how often indoor tanning facilities must be inspected for compliance. In those provinces and territories that do state a frequency, only one is specific. In a study of 3647 indoor tanning facilities in the USA, Pichon et al. found that facilities were more likely to comply with youth access restrictions if there were frequent inspections.[35] Regular inspections may therefore have an impact on compliance with indoor tanning legislation and should be outlined in more detail in provincial and territorial laws.

Based on legislative gaps that we have identified in our analysis, we provide recommendations for provincial and territorial governments (Table 4). In addition, we recommend that the federal government issue an evidence-based document to inform provincial and territorial indoor tanning legislation. This may help provinces and territories incorporate additional, evidence-based regulations or strengthen existing ones. We acknowledge that additional evidence would make these recommendations more robust.

Strengths and limitations

This study is the first comprehensive analysis of provincial and territorial indoor tanning legislation in Canada. By incorporating laws, regulations and supplementary information, we have conducted a content analysis that is significant in both breadth and depth. This enabled us to highlight areas of strong coverage, as well as limitations within each jurisdiction and across Canada. This research lays the necessary foundation for future comparisons and evaluations and provides policy stakeholders with the information necessary to investigate effectiveness and advocate for improved legislative coverage. It also provides provincial and territorial authorities with detailed information about the landscape of indoor tanning legislation across the country, which may motivate legislative improvements and, ultimately, gold standard legislation.

Though the enforcement content of the legislation was analyzed in this study, the actual enforcement practices were not included because published enforcement data were not readily available at the time of writing. In order for true legislative effectiveness to be examined, future research should investigate the practices of enforcement authorities with respect to indoor tanning legislation. Compliance with the legislation was also not measured in this study. If compliance with the provincial and territorial legislation is low, these laws will not be effective. Indeed, there is evidence from the USA that compliance with some aspects of indoor tanning legislation (labelling, risk communication, false claims) is low.[33,36] To accurately measure the effectiveness of indoor tanning legislation, it is important to investigate compliance in each province and territory. For example, mixed results have been found regarding the success of the provincial indoor tanning legislation in Ontario.[37]

TABLE 4
Recommendations for provincial and territorial governments for more comprehensive indoor tanning legislation

Category	Recommendations
Advertising and marketing	Introduce or broaden restrictions on misleading advertisements to include those targeted toward all members of the public
	Require tanning advertisements to contain a statement describing the known health effects of tanning
Protective eyewear	Mandate the use and provision of protective eyewear during indoor tanning sessions
	Require that protective eyewear complies with federal regulations and securely covers the eyes of the user
	Require operators to provide protective eyewear to clients and instruct clients on proper use of the eyewear
Unsupervised tanning	Prohibit unsupervised or self-serve indoor tanning services
Operator training	Require training for tanning salon operators and explicitly state what this training should include
Exposure dose	Require compliance with manufacturer-recommended exposure duration and frequency
Client information	Require the distribution of additional information on the risks of indoor tanning to clients to supplement warning sign contents
Screening	Prohibit operators from providing UV tanning to high-risk individuals (i.e. those who are highly susceptible to sunburn, taking certain medications)
Enforcement	Mandate the frequency at which protective inspections of indoor tanning facilities must occur

One of the challenges of this research was interpreting the legal language. It has been said that "the law is a profession of words" and, as such, the meaning of words within legal documents is sometimes ambiguous in the same way they can be in other contexts.[38] Although we addressed ambiguity in legal language by consulting with public health and policy experts and health authorities in some of the jurisdictions studied, there may be alternative interpretations.

Future research

It would be helpful to have an objective, numerical method for between-jurisdiction comparisons of indoor tanning legislative coverage. The results of this content analysis could inform the development and validation of a scoring tool for Canadian provincial/territorial indoor tanning legislation, similar to those introduced by Gosis et al. and Woodruff et al.[22,23] The scores may also be useful in determining whether higher legislative coverage, indicated by a higher score, corresponds to higher levels of compliance and enforcement, and lower prevalence of use, especially among youth.

Though this research focused on provincial and territorial legislation, analyses of indoor tanning bylaws should also be conducted. This will provide valuable information on what is being covered by municipalities and allow for comparisons between these bylaws and provincial and territorial legislation. While collecting legislation for this analysis, we found indoor tanning bylaws in British Columbia (Capital Regional District), Ontario (Region of Peel, Mississauga, Brampton, Oakville, Belleville) and Yukon (Whitehorse). Because the bylaws in these municipalities may contain different provisions than their respective provinces, it is important their content be analyzed in future work.

Conclusion

All Canadian provinces and one of three territories have enacted legislation to regulate the operation of indoor tanning facilities. This represents an encouraging response by governments to the research on the health risks of this activity and related public health recommendations. Most of these laws focus on youth. Legislative coverage of warning sign requirements, penalties, advertising directed toward youth and inspection requirements were also strong. Good first steps have been made in terms of legislation to protect Canadians from skin cancer and other health effects related to indoor tanning, but amendments in some areas could protect the public more effectively. We recommend more legislative attention in the areas of client information, client protection (e.g. protective eyewear, screening of high-risk clients and restrictions on duration and frequency of use), advertising in general (especially health claims) and inspection frequency to ensure that Canadians are well-protected and facilities are following the law.

The results of this study provide policy stakeholders with a detailed overview of the current state of indoor tanning laws across Canada, including how the content of this legislation varies across the country, as well as legislative areas that are receiving high coverage and areas where increased legislative efforts may be needed. Combined with future research needed to determine compliance with, and impact of, indoor tanning legislation, this research contributes to a clearer picture of indoor tanning legislation and activity in Canada.

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Conflicts of interest

The authors have no conflicts of interest to disclose.

Authors' contributions and statement

Both authors contributed substantially to the design of the research study, the acquisition and analysis of the data and writing the paper. SG contributed most significantly to data acquisition and drafting the paper. JEM contributed most significantly to the study design and analysis, and in revising the paper.

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At-a-glance

The impact of poisoning-related mortality on life expectancy at birth in Canada, 2000 to 2016

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Abstract

Increases in opioid-related mortality have contributed to declines in life expectancy at birth in the United States and British Columbia. Canadian national mortality data from 2000 to 2016 were analyzed to determine the contribution of poisoning-related mortality to changes in life expectancy at birth by age group and sex. From 2000 to 2016, life expectancy at birth increased by almost three years; however, mortality due to unintentional poisonings, including those involving opioids, curbed this increase by 0.16 years. Although a national decrease in life expectancy at birth has not been observed in Canada during this period, current trends suggest that the national opioid overdose crisis will continue to attenuate gains to life expectancy.

Introduction

Both Canada and the United States have experienced recent, dramatic increases in opioid-related mortality. There were more than 9000 apparent opioid-related deaths in Canada between January 2016 and June 2018.[1] In the United States in 2016 alone, opioids were involved in approximately 42 000 overdose deaths, representing a 21.5% increase in the age-adjusted poisoning overdose mortality rate from 2015.[2] This growing mortality burden, which disproportionately affects younger adults,[1,2] has the potential to impact life expectancy in affected regions. While life expectancy at birth in the United States increased by two years from 2000 to 2015, drug poisoning mortality more than doubled during the same period and contributed a loss of 0.28 years of life expectancy at birth; of this, opioid-involved poisonings contributed a loss of 0.21 years.[3] Between 2015 and 2016 alone, Kochanek et al. reported an overall decrease of 0.1 years in life expectancy at birth in the United States, driven by a 0.2-year decrease among males and no change in life expectancy among females.[4] British Columbia, one of the provinces that experienced the earliest impacts and heaviest burden of the opioid overdose crisis in Canada,[5] has reported a decrease in life expectancy at birth of 0.38 years between 2014 and 2016, with a third of this decrease being attributed to illicit drug overdoses, primarily opioids.[6] The impact of the opioid overdose crisis on life expectancy at birth in Canada at the national level has not yet been demonstrated.

The purpose of this study is to examine changes in life expectancy at birth in Canada between 2000 and 2016, and between 2014 and 2016 with a focus on unintentional, intentional, and undetermined poisonings. Changes in life expectancy were decomposed by cause of death, age group, and sex. These analyses will contribute to further understanding the impact of opioid poisoning-related mortality on life expectancy at birth in Canada.

Methods

Data from the Canadian Vital Statistics – Deaths Database were obtained from Table 13-10-0156-01[7] and population estimates were obtained from Statistics Canada Table 17-10-0005-01[8]. Mortality data were grouped in the following categories: unintentional poisoning by and exposure to narcotics [X42], intentional self-poisoning by and exposure to narcotics [X62], poisoning of undetermined intent by and exposure to narcotics [Y12], other unintentional poisoning [X40, X41, X43-49], other intentional self-poisoning [X60, X61, X63-X69], other poisoning of undetermined intent [Y10, Y11, Y13-Y19], other intentional self-harm [X70-X84], transport accidents [V01-V99], other external causes not already included [W00-W99, X00-X39, X50-X59, Y20-Y89], and residual causes (all other ICD-10 chapters).

Abridged life tables were produced using standard age groups: less than 1 year, 1 to 4 years, and in five-year age groups thereafter, with 90 years and older as the last age group. Life expectancy at birth was calculated using Chiang's method,[9] and the life table was closed using Hsieh's method.[10] Period life expectancy represents the life expectancy a hypothetical individual could be expected to live, if they experienced the observed age group and sex-specific probabilities of death during a given period. Arriaga's method was used to decompose changes in life expectancy into age group, sex and cause of death components, using Excel spreadsheets developed by Auger et al.[11] This

Note: Under the guidelines of the International Committee of Medical Journal Editors (www.icmje.org) about the dissemination of information relevant to a public health crisis, a summary of these results was made available to stakeholders and the public ahead of publication through a quarterly technical report, and is available at the following address: https://www.canada.ca/en/health-canada/services/substance-use/problematic-prescription-drug-use/opioids/data-surveillance-research/harms-deaths/measuring-impact-on-life-expectancy.html

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approach considers both the direct and indirect effects of age group, sex and cause specific mortality. Analyses were conducted overall for 2000 to 2016 and 2014 to 2016, and for males and females separately for 2000 to 2016. Age group and cause-specific contributions to the difference in life expectancy at birth between males and females in 2016 were also examined.

Results

Life expectancy at birth increased by almost three years, from 79.27 in 2000 to 82.25 in 2016 for males and females combined. Most of the observed increases were attributable to residual causes other than injuries (Table 1). However, while the category of injury-related mortality contributed a small overall increase to the change in life expectancy at birth (0.11 years), within this category, two causes of death contributed a loss to life expectancy at birth for males and females combined: unintentional poisonings by and exposure to narcotics (−0.08) and other unintentional poisonings (−0.08). The increase in life expectancy at birth between 2000 and 2016 was larger for males (3.48 years) than females (2.52 years), and the negative impact of unintentional poisonings (both by and exposure to narcotics and other substances) on life expectancy was larger for males (−0.23 years) than females (−0.09 years). Apart from "other causes of injury" for females from 2000 to 2016, all remaining categories of injury-related mortality contributed either no change or contributed to an increase in life expectancy. Of all injury-related causes, the reduction in deaths due to transport accidents contributed the most to the increase in life expectancy. Much of the impact of unintentional poisonings (both by narcotics and other substances) on life expectancy at birth has accrued since 2014. Between 2014 and 2016, life expectancy at birth increased by 0.53 years for males and females combined (Table 1); however, unintentional poisonings contributed a loss of 0.09 years.

In 2016, life expectancy at birth for males was 4.20 years lower than for females (Table 1). Higher mortality due to unintentional poisonings by and exposure to narcotics among males accounted for 0.13 years of this gap and other unintentional poisonings accounted for 0.09 years. Among all other injury-related causes of death, other intentional self-harm contributed the most to this difference between the sexes, at 0.33 years.

As shown in Table 2, most age groups contributed an increase to life expectancy at birth between 2000 and 2016, for both males and females. However, the age groups of 25–29 and 30–34 years old for males each contributed a small decrease. Between 2014 and 2016, for both sexes combined, almost all age groups from 10–14 through to 45–49 years old contributed a small loss to life expectancy at birth, which was offset by gains in life expectancy at birth contributed by adults 55–59 years and older.

Figure 1 shows cause-specific contributions to changes in life expectancy at birth by age group between 2000 and 2016 for

TABLE 1
Decomposition of cause-specific contributions to differences in life expectancy at birth between 2000, 2014 and 2016, overall, males and females; and between males and females for 2016

Cause of death category			2000 to 2016			2014 to 2016	2016
			Overall	Males	Females	Overall	Males as compared to females[a]
Injury-related causes of death	Unintentional poisoning	Unintentional poisoning by and exposure to narcotics and psycho-dysleptics [hallucinogens], not elsewhere classified [X42]	−0.08	−0.12	−0.04	−0.04	−0.13
		Other unintentional poisonings [X40, X41, X43 to X49]	−0.08	−0.11	−0.05	−0.05	−0.09
	Intentional poisonings	Intentional self-poisoning by and exposure to narcotics and psycho-dysleptics [hallucinogens], not elsewhere classified [X62]	0.00	0.00	0.00	0.00	0.00
		Other intentional poisonings [X60, X61, X63 to X69]	0.02	0.04	0.00	0.01	−0.01
	Poisonings with undetermined intent	Poisoning by and exposure to narcotics and psycho-dysleptics [hallucinogens], not elsewhere classified, undetermined intent [Y12]	0.00	0.00	0.00	0.02	0.00
		Other undetermined poisonings [Y10, Y11, Y13 to Y19]	0.01	0.01	0.00	0.03	0.00
	Other intentional self-harm [X70 to X84]		0.02	0.05	0.03	0.01	−0.33
	Transport accidents [V01 to V99]		0.16	0.22	0.10	0.02	−0.14
	Other injuries [W00-W99, X00-X39, X50-X59, Y20-Y89]		0.06	0.10	−0.02	0.04	−0.14
Residual causes of death [all other ICD-10 chapters]			2.88	3.30	2.50	0.49	−3.35
Total change in life expectancy			2.99	3.48	2.52	0.53	−4.20

Note: Estimates may not sum to column totals due to rounding.
[a] The negative values represent a negative contribution to the difference in life expectancy among males as compared to females.

TABLE 2
Decomposition of age-specific contribution to changes in life expectancy at birth between 2000, 2014 and 2016, overall, males and females; and between males and females for 2016

Age group (years)	2000 to 2016			2014 to 2016	2016
	Overall	Males	Females	Overall	Males as compared to females[a]
Less than 1	0.05	0.09	0.01	0.02	−0.02
1–4	0.01	0.01	0.01	0.00	−0.01
5–9	0.02	0.02	0.01	0.00	0.00
10–14	0.01	0.01	0.01	−0.01	−0.01
15–19	0.05	0.07	0.03	0.00	−0.06
20–24	0.03	0.05	0.02	−0.02	−0.12
25–29	−0.01	−0.02	0.00	−0.01	−0.15
30–34	0.00	−0.01	0.00	−0.01	−0.13
35–39	0.03	0.04	0.01	0.00	−0.10
40–44	0.05	0.07	0.04	−0.01	−0.11
45–49	0.06	0.08	0.04	−0.01	−0.13
50–54	0.10	0.12	0.08	0.00	−0.16
55–59	0.16	0.21	0.11	0.03	−0.24
60–64	0.24	0.32	0.16	0.03	−0.33
65–69	0.35	0.45	0.23	0.04	−0.40
70–74	0.44	0.57	0.31	0.09	−0.42
75–79	0.46	0.57	0.37	0.07	−0.47
80–84	0.40	0.45	0.38	0.08	−0.49
85–89	0.30	0.26	0.38	0.09	−0.43
90 and older	0.22	0.13	0.32	0.16	−0.42
Total	2.99	3.48	2.52	0.53	−4.20

Note: Estimates may not sum to column totals due to rounding.
[a] The negative values represent a negative contribution to the difference in life expectancy among males as compared to females.

both sexes combined. Most gains in life expectancy occurred among older adults and residual causes not related to injuries. However, both unintentional poisonings by and exposure to narcotics and other unintentional poisonings for age groups 20–24 through 55–59 years old contributed a loss to life expectancy of at least 0.01 years.

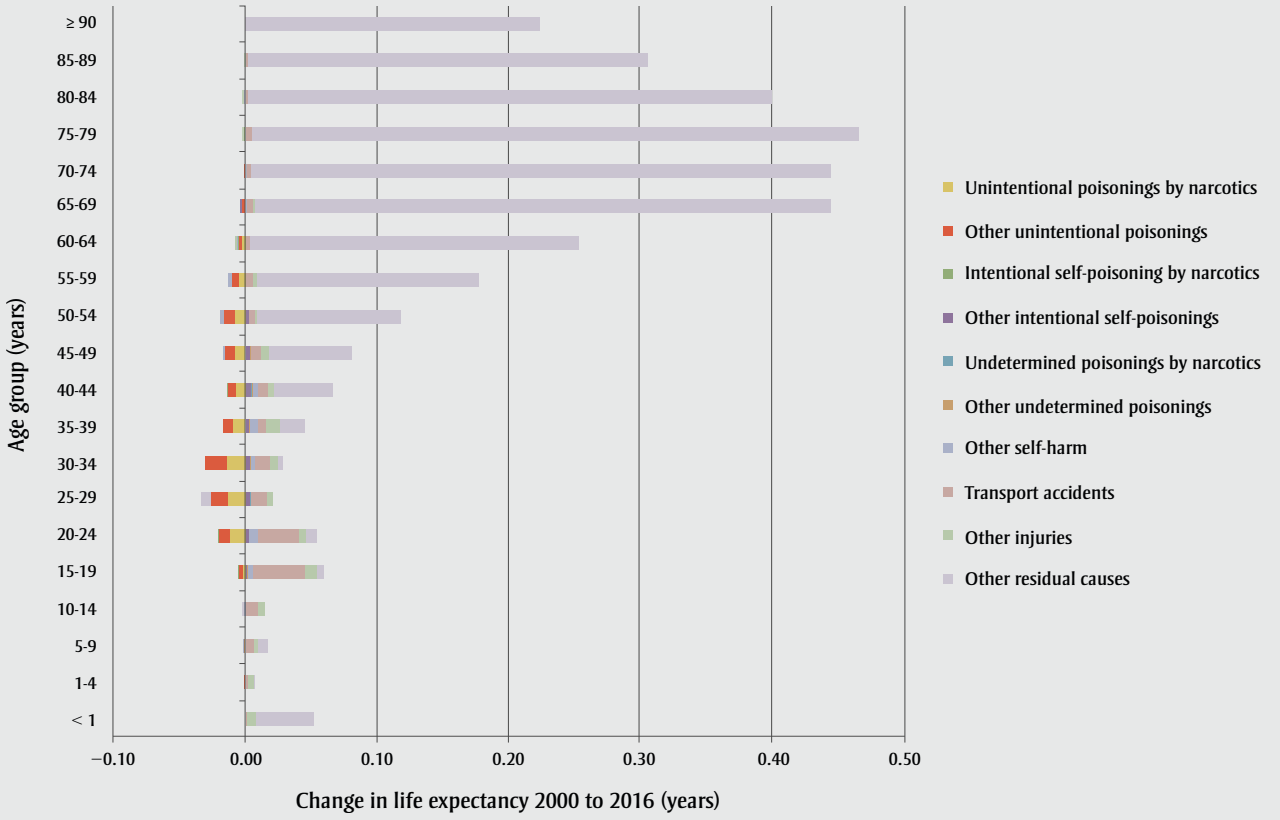
Discussion

Life expectancy at birth in Canada at the national level continues to rise, however gains between 2000 and 2016 and 2014 and 2016 have been attenuated by increases in death due to unintentional poisonings, both those associated with narcotics, as well as other substances. While an overall decline in life expectancy at birth at the national level was not observed, as was observed in the United States and the province of British Columbia,[3-5] this may reflect substantial regional variation in mortality across Canada, and that both British Columbia and the United States experienced relatively earlier impacts of the opioid overdose epidemic, as compared to other regions of Canada. The absence of a decrease, however, does not indicate that Canada is not facing a public health crisis. Decreases in life expectancy are very rare events. Based on life expectancy at birth reported by Statistics Canada for 1921 to 2011, year over year decreases occurred only for a small number of periods in the 1920s and 1930s.[12] The similar negative contribution by both unintentional poisonings by and exposure to narcotics and other unintentional poisonings to life expectancy at birth is of note. In this study, we used ICD-10 cause of death codes, but not associated diagnostic T codes, due to data disclosure restrictions. As a result, it is likely that not all deaths due to unintentional poisoning by and exposure to narcotics [X42] were associated with opioids, and conversely, that some other unintentional poisonings [X40, X41, X43-49] were associated with opioids. However, given the similar pattern of increasing mortality associated with both cause of death categories, it is important to consider the category of unintentional poisoning as a whole. In the United States, 0.21 of the 0.28-year loss contributed by unintentional poisonings was associated with opioids[3] and British Columbia reported that illicit drug overdoses contributed 0.12 years of the decline of 0.38 years of life expectancy at birth between 2014 and 2016.[6] Available national data indicate that approximately 76% of accidental (unintentional) apparent opioid-related deaths in Canada between January 2016 and June 2018 also involved one or more types of non-opioid substances.[1] Further refinement of the present analyses using diagnostic T codes would provide additional precision. At the time of this analysis, complete mortality data up to 2016 were available. These analyses will be updated when final mortality data for 2017 become available; given the notable increase in apparent opioid-related deaths in 2017 compared to 2016, as well as preliminary mortality counts for the first half of 2018, it is anticipated that the impact on life expectancy will continue to increase.[1] We did not conduct regional analyses. As such, the results presented here summarise the national experience. Future analyses may examine regional variations in the contribution of poisoning-related mortality to changes in life expectancy.

It is also of note that deaths due to intentional self-poisoning by and exposure to narcotics, and poisoning by and exposure to narcotics of undetermined intent did not contribute a loss to the gain in life expectancy at the national level during the observed time periods. This suggests that the opioid overdose crisis has not influenced rates of mortality of intentional self-poisoning by and exposure to narcotics at the national level, consistent with recent evidence from Alberta.[13]

While the decrease in most injury-related causes of death contributed to gains in life expectancy at birth in Canada, unintentional poisonings have attenuated overall gains to life expectancy at birth during the observed time periods, for both males and females. Both unintentional poisonings by and exposure to narcotics, and other unintentional poisonings have contributed to this attenuation. While life expectancy at birth continues to increase in Canada,

FIGURE 1
Cause-specific contributions to the change in life expectancy at birth by age group, males and females, 2000 to 2016



consistent with international trends in similar high-income countries,[14,15] this increase may continue to be slowed by the ongoing opioid overdose crisis and associated increases of deaths due to unintentional poisonings. These findings may change as additional data become available, given the comparative increase in opioid-related deaths reported for 2017 and data for the first half of 2018.[1]

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Conflicts of interest

We declare that we have no conflicts of interest related to this work.

Authors' contributions and statement

JH and DG conceived the project. HO conducted the data analysis and wrote the paper. JJL, DG and JH contributed to interpreting the data and critically revising the paper.

The content and views expressed in this article are those of the authors and do not necessarily reflect those of the Government of Canada.

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Letter to the Editor

Eulogy for the Canadian health-promoting hospitals movement

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The Health-Promoting Hospitals (HPH) concept and movement grew out of the fifth priority action area of the Ottawa Charter (Reorient Health Services) nearly 30 years ago.[1-5] As a setting for health promotion, hospitals were a natural focus since they represent the largest concentration of health care system resources. Unfortunately, this work has had limited influence on health care delivery in Canada today.[1,3,4] Few Canadian hospitals have been meaningfully "reoriented" toward health promotion. The Ontario HPH network is defunct, and the Québec HPH network is headed in the same direction[6]—there have never been HPH networks in other provinces or territories. It is rare to find a Canadian hospital that adheres to either the five standards of the International HPH Network or to Health Canada's Framework for Health Promotion in Healthcare Facilities.[7,8] This leads us believe that the HPH movement is failing and may soon be dead.

In preparation for the death of the Canadian HPH movement, we respectfully submit this eulogy:

Popularized in Canada in the 1980s, following the Beyond Healthcare Conference and publication of the Ottawa Charter, the HPH movement sought to help hospitals "develop a community conscience rather than an institutional loyalty."[9(p.23)] HPH prioritized prevention and the promotion of health with patients, with hospital staff and in the community, in tandem with the treatment of illness and injuries. In Europe, the HPH concept continues to be investigated and refined, and the movement is supported by the World Health Organization's Regional Office for Europe.[10]

In turn, the HPH movement is popular with European and Asian hospitals, and we know more about HPH than ever before. This includes recent publication of the largest-ever study conducted on HPH with 159 European and Asian hospitals.[11] Study results indicated that hospitals with any of the following in place had considerably higher chances of sustained implementation of health promotion activities:

- regular implementation of health promotion projects and organization-wide programs; or
- an established health promotion team and system; or
- integration of health promotion into hospital quality standards.

While there was initial enthusiasm for HPH concepts in Canada, the movement never had much traction. In 1989, Lalonde characterized the response of Canadian hospitals to health promotion as "let somebody else do it; we already have too much to do."[12(p.40)] However, studies indicate this was not the whole story. Many Canadian hospital leaders have reported a desire to increase health promotion activities in their settings over the past 30 years.[13,14] Unfortunately, HPH activities have seen limited uptake and support for HPH networks has ceased.

The cause of death was likely multifactorial, but evidence points to the main cause being longstanding financial and accountability disincentives within provincial/territorial health care systems.[3,4] These disincentives have made health-promoting activities prohibitive for hospitals dating back to at least 1986, when despite calls from Health Canada and the Canadian Hospital Association to support hospital reorientation toward health promotion, provincial Deputy Ministers of Health unanimously indicated that Canadian hospitals would not be reimbursed for health promotion activities, because this was the responsibility of public health.[2] The unsurprising result of their position has been that hospitals direct energy toward the activities for which they are remunerated.

The HPH movement is survived by a number of exciting concepts that it helped to create. Most notable are the notions of environmentally conscious health care delivery, a population health lens in hospital decision-making, clinical population health practice (or clinical health promotion), and the notion that hospitals are anchor institutions in their communities and should be accountable for community benefit beyond provision of medical treatment.[15-18]

Condolences can be sent to the countless individuals who worked to reorient Canadian health care systems through HPH – most being grassroots health promotors and public health leaders.

Rest in peace Canadian HPH movement.

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Erratum

This erratum is being published to correct a data error on page 389 of the following article:

CCDI Steering Committee. At-a-glance – How Healthy are Canadians? A brief update. Health Promot Chronic Dis Prev Can. 2018; 38(10):385-90. doi: 10.24095/hpcdp.38.10.05.

Before correction

General health	% of population that reports their mental health is "very good" or "excellent," population aged 12+ years	68.5%	CCHS (2016)

After correction

General health	% of population that reports their mental health is "very good" or "excellent," population aged 12+ years	70.8%	CCHS (2016)

Erratum

This erratum is being published to correct a reference error on page 248 of the following article:

Ye X, Sutherland J, Henry B, Tyndall M, Kendall PRW. At-a-glance – Impact of drug overdose-related deaths on life expectancy at birth in British Columbia. Health Promot Chronic Dis Prev Can. 2018;38(6):248-51. doi: 10.24095/hpcdp.38.6.05.

Before correction

The contribution of drug overdose deaths to life expectancy change has rarely been quantified. Between 2000 and 2014, unintentional poisonings (mostly drug and alcohol overdoses) contributed a loss of 0.338 years in life expectancy at birth (LE0) for the non-Hispanic white population in the United States of America (USA), the greatest negative impact by cause of death.[4]

with reference 4 as the following:

4. Kochanek KD, Murphy SL, Xu J, Arias E. Mortality in the United States, 2016 Key findings Data from the National Vital Statistics System. NCHS Data Brief. 2016;293:1-8. Available from: https://www.cdc.gov/nchs/data/databriefs/db293.pdf

After correction

The contribution of drug overdose deaths to life expectancy change has rarely been quantified. Between 2000 and 2014, unintentional poisonings (mostly drug and alcohol overdoses) contributed a loss of 0.338 years in life expectancy at birth (LE0) for the non-Hispanic white population in the United States of America (USA), the greatest negative impact by cause of death.[4]

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4. Kochanek KD, Arias E, Bastian BA. The effect of changes in selected age-specific causes of death on non-Hispanic White life expectancy between 2000 and 2014. NCHS Data Brief. 2016;250:1-8. Available from: https://www.cdc.gov/nchs/products/databriefs/db250.htm

Other PHAC publications

Researchers from the Public Health Agency of Canada also contribute to work published in other journals. Look for the following articles published in 2018:

Boyko JA, Riley BL, Willis CD, […] **Robinson K, Chia M**. Knowledge translation for realist reviews: a participatory approach for a review on scaling up complex interventions. Health Res Policy Syst. 2018;16(1):1-9. doi: 10.1186/s12961-018-0374-1.

Ford-Gilboe M, Wathen CN, Varcoe C, Herbert C, **Jackson BE**, et al. How equity-oriented health care affects health: key mechanisms and implications for primary health care practice and policy. Milbank Q. 2018. doi: 10.1111/1468-0009.12349.

GBD 2017 Causes of Death Collaborators (including **Badawi A** and **Orpana HM**). Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980–2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018;392(10159):1736-1788. doi: 10.1016/S0140-6736(18)32203-7.

GBD 2017 DALYs and HALE Collaborators (including **Lang JJ**). Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018;392(10159):1859-1922. doi: 10.1016/S0140-6736(18)32335-3.

GBD 2017 Risk Factor Collaborators (including **Badawi A**, **Lang JJ** and **Orpana HM**). Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018;392(10159):1923-1994. doi: 10.1016/S0140-6736(18)32225-6.

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