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Original quantitative research

Tobacco, alcohol and marijuana use among Indigenous youth attending off-reserve schools in Canada: cross-sectional results from the Canadian Student Tobacco, Alcohol and Drugs Survey

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Abstract

Introduction: Ongoing surveillance of youth substance use is essential to quantify harms and to identify populations at higher risk. In the Canadian context, historical and structural injustices make monitoring excess risk among Indigenous youth particularly important. This study updated national prevalence rates of tobacco, alcohol, and marijuana use among Indigenous and non-Indigenous students.

Methods: Differences in tobacco, alcohol, and marijuana use were examined, using logistic regression, among 1700 Indigenous and 22 800 non-Indigenous youth in Grades 9–12 who participated in the 2014/15 Canadian Student Tobacco, Alcohol and Drugs Survey. Differences by sex were also examined. Mean age of first alcohol and marijuana use was compared in the two populations using OLS regression. Results were compared to 2008/09 data.

Results: While smoking, alcohol, and marijuana rates have decreased compared to 2008/09 in both populations, the gap between the populations has mostly not. In 2014/15, Indigenous youth had higher odds of smoking (odds ratio [OR]: 5.26; 95% confidence interval [CI]: 3.54–7.81) and past-year drinking (OR: 1.43; 95% CI: 1.16–1.76) than non-Indigenous youth. More Indigenous than non-Indigenous youth attempted quitting smoking. Non-Indigenous males were less likely to have had at least one drink in the past-year compared to non-Indigenous females. Indigenous males and females had higher odds of past-year marijuana use than non-Indigenous males (OR: 1.84; 95% CI: 1.32–2.56) and females (OR: 2.87; 95% CI: 2.15–3.84). Indigenous youth, especially males, drank alcohol and used marijuana at younger ages.

Conclusion: Additional policies and programs are required to help Indigenous youth be successful in their attempts to quit smoking, and to address high rates of alcohol and marijuana use.

Keywords: *adolescent, alcohol drinking, smoking, cannabis smoking, Indigenous population*

Highlights

- Despite decreased prevalence of smoking and increased attempts to quit, Indigenous youth had more than 5 times higher odds of being smokers compared to non-Indigenous youth.
- Indigenous youth, especially males, drank alcohol and used marijuana at a younger age compared to non-Indigenous youth.
- Compared to 2008/09, rates of past-year alcohol use, binge drinking, and marijuana use decreased in both Indigenous and non-Indigenous youth in 2014/15. Binge drinking decreased the most, by about 30% in both populations.
- Indigenous males had 1.8 higher odds of past-year marijuana use compared to non-Indigenous males, whereas females had 2.8 times higher odds compared to non-Indigenous females.

Introduction

There is evidence that Indigenous youth are more likely than other Canadian youth to use tobacco, alcohol and marijuana.[1-10] The reasons for this higher risk are complex, but social factors that potentially contribute include marginalization, the experience of discrimination, intergenerational trauma, financial hardships, and familial separation.[2,5] For example, adverse childhood and adolescence experiences such as sexual and physical abuse, household mental illness, and household substance use have been linked to substance use among Indigenous adolescents in British Columbia.[9] When children and youth are chronically exposed to stressful environments, their neurodevelopment and

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cognitive functioning can be impaired, potentially contributing to the adoption of negative coping behaviours, such as substance use.[2,11] High prevalence of substance use could also lead to its normalization in schools or communities, potentially perpetuating a cycle of use among youth.[5]

Understanding health inequities between Indigenous and non-Indigenous youth is important, especially considering that Indigenous populations are the youngest and fastest growing ethnically defined populations in Canada.[13] According to the 2016 census, self-identified First Nations, Inuit and Métis represented 4.9% of the total Canadian population,[12,13] and 16.9% were 15 to 24 years old, compared to 12.0% of the non-Indigenous population.[14] The total Indigenous identity population in Canada increased by 43% between 2006 to 2016, while the non-Indigenous population grew 9%.[14] Although substance use has been found to be high among First Nations youth living in First Nations communities,[2] in 2016, 79.1% of Indigenous youth aged 15 to 24 lived outside of First Nations reserves.[15] In the provinces, this includes a majority of Métis, who have not been part of treaties or the reserve system, as well as large proportions of both Status and non-Status First Nations.[15] Attention to the well-being of these young people is therefore essential to promoting the health of Indigenous populations and the Canadian population in general.

There are numerous health risks associated with smoking, alcohol, and marijuana use, especially for youth.[16-20] For example, the Canadian census mortality follow-up study found the risk of death from tobacco smoking-related causes was 75% higher among Métis females and 14% higher among Métis males when compared to non-Indigenous females and males.[21] Despite some evidence of high rates of drug use among Indigenous youth, there has been limited research on patterns of substance use.[22] This study compared patterns of tobacco, alcohol and marijuana use among Indigenous youth attending off-reserve schools to non-Indigenous youth using nationally representative data from the 2014/15 Canadian Student Tobacco, Alcohol and Drugs Survey[23] (CSTADS; formerly known as the Youth Smoking Survey [YSS]). The primary objective of this study was to update the analysis of Elton-Marshall et al.[1] who previously examined substance use in Indigenous and non-Indigenous youth using the 2008/09 YSS. Where possible, data from 2014/15 were compared to their results.

Methods

Research design

Cross-sectional data were obtained from 24 500 students in Grades 9 to 12 from 336 schools who responded to the 2014/15 CSTADS and reported ethnicity.[23] CSTADS is a nationally representative school-based survey of youth in Canada that collects data on tobacco, alcohol, and drug use. In 2014/15, it included youth attending private, public, and Catholic schools in nine of Canada's provinces. Schools in New Brunswick, Yukon, Nunavut, and the Northwest Territories were excluded. Youth living in institutions or attending special schools, First Nation reserve schools, or schools on Canadian Armed Forces bases were also not sampled. The sample was stratified on health region smoking rates and within each province schools were randomly selected based on their total enrollment of students. While CSTADS includes students in Grades 6 to 12, only those in Grades 9 to 12 were included in this study as secondary school students are more likely to engage in substance use. The overall participation rate was 49% of sampled school boards, 47% of sampled schools, and 66% of sampled students.

Research ethics approval for CSTADS was obtained with the University of Waterloo Human Research Ethics Committee (ORE #19531), the Health Canada/Public Health Agency of Canada Research Ethics Board (#REB 2009-0060) and from individual school boards or other appropriate bodies.

Measures

Indigeneity in the 2014/15 CSTADS was self-reported, using the question, "How would you describe yourself? (Mark all that apply)." Possible responses included White, Black, West Asian/Arab, South Asian, East/Southeast Asian, Latin American/Hispanic, Aboriginal (First Nations, Métis, Inuit, …), and Other (write-in). Although "Indigenous" has become a generally preferred term, "Aboriginal" was used on the 2014/15 CSTADS questionnaire, as in the 2016 Census,[12] following the terminology of the 1982 *Constitution Act*. Sex was assessed with a single question, "are you female or male", with binary responses.

Consistent with Health Canada's definition, a "current smoker" is someone who has smoked at least 100 cigarettes in their lifetime and at least one whole cigarette in the past 30 days.[24] A "former smoker" has smoked at least 100 cigarettes in his or her lifetime, but has not smoked in the past 30 days.[24] A "non-smoker" has not smoked 100 or more cigarettes in their lifetime but may have smoked one whole cigarette.[24] Past-year prevalence of alcohol, binge drinking, and marijuana use are also reported. Consistent with previous studies, binge drinking is defined as having five or more drinks on one occasion.[1,2]

Statistical analysis

Survey weights were used to provide population-level estimates of substance use. Bootstrap weights, which were used for calculating prevalence estimates and regression analyses, account for the effects of survey design on variance estimates.

Differences between Indigenous and non-Indigenous youth in the average age at first alcohol and marijuana use were assessed using Ordinary Least Squares regression. Differences in substance use by Indigenous ethnicity and sex were tested using binary logistic regression. Each model was assessed for the possibility that effects might be modified by one of several possible cofactors: sex, grade, and smoking status (former smokers excluded for the alcohol and marijuana analyses), median 2011 census Dissemination Area household income based on school location and geographic region. If any of these variables were found to be covariates (i.e., they changed the point estimate by more than 10%), they were included in the final model.[25-26] All analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

The CSTADS participants in Grades 9 to 12 included 24 500 students (a weighted population of 1 500 900 students), with an estimated 1700 (weighted sample of 70 000) who reported being Indigenous ("Aboriginal") (Table 1). The student sample included 12.9% from British Columbia, 6.7% from Atlantic Canada, 46.4% from Ontario, 15.9% from Québec, and 17.1% from the Canadian Prairies. Table 2 presents the

TABLE 1
Weighted sample characteristics, by sex and Indigenous ethnicity, grade 9–12 students, 2014/15

Variable	Total, in %[a]		Male, in %[a]		Female, in %[a]	
	Indigenous n = 1700	Non-Indigenous n = 22 800	Indigenous n = 800	Non-Indigenous n = 11 300	Indigenous n = 900	Non-Indigenous n = 11 600
Grade						
9	23.8	25.2	23.6	25.2	24.0	25.2
10	28.9	25.1	30.9	24.9	26.8	25.3
11	24.9	25.5	24.1	25.5	25.6	25.6
12	22.5	24.2	21.4	24.3	23.6	24.0
Smoking status[b]						
Current	21.9[c]	5.0	17.0[c]	6.0	27.3[c]	4.1
Non-smoker	78.1	95.0	83.0	94.0	72.7	95.9
Quitting behaviour[d]						
Never tried to quit	18.9	29.5	26.0	29.3	11.4	29.9
Have tried to quit at least once	81.1	70.5	74.0	70.7	88.6	70.1
Alcohol use						
Never	23.9	38.5	25.7	39.9	21.9	37.0
Only a sip or > 12 months ago	12.4	10.0	14.2	9.6	10.4	10.5
Past year	63.7	51.5	60.0	50.4	67.7	52.5
Monthly	39.3	29.7	39.0	30.6	39.6	28.8
Weekly	13.8	7.9	13.0	9.0	14.7[c]	6.7
Binge drinking[e]						
Never or > 12 months ago	40.2	48.4	40.7	47.0	39.6	49.7
Past year	59.8	51.6	59.3	53.0	60.4	50.3
Monthly	35.0	27.1	36.4	30.3	33.6	23.9
Weekly	10.7[c]	5.8	11.2[c]	7.1	10.1[c]	4.5
Ever tried marijuana	58.3	28.2	54.7	29.2	62.1	27.1
Marijuana use						
Never or > 12 months ago	55.1	78.2	61.5	77.9	53.0	79.3
Past year	44.8	21.8	38.5	22.1	47.0	20.8
Monthly	36.4	12.5	31.1	13.6	38.2	11.0
Weekly	27.5	6.9	24.7	8.2	27.7	5.2
Daily	15.8	2.4	15.2[c]	2.8	14.9[c]	1.8

Data source: 2014/15 Canadian Student Tobacco, Alcohol and Drug Survey (CSTADS).
[a] Weighted sample size represents 70 000 Indigenous students and 1 430 900 Non-Indigenous students. Among Indigenous students, weighted sample includes 35 900 male students and 34 100 female students. Among non-Indigenous students, weighted sample includes 735 200 male students and 695 700 female students.
[b] Former smokers excluded.
[c] Moderate sampling variability, interpret with caution.
[d] Among current smokers.
[e] Among those who ever tried alcohol.

association between Indigenous ethnicity and sex, and substance use behaviours.

Tobacco use

Indigenous youth were significantly more likely than non-Indigenous youth to be current smokers (odds ratio [OR]: 5.26; 95% confidence interval [CI]: 3.54–7.81) (Table 2). Among both Indigenous and non-Indigenous youth, males and females were not significantly different in their odds of smoking. Among smokers, Indigenous youth were more likely than non-Indigenous youth to have ever tried to quit (OR: 1.80; 95% CI: 0.91–3.58). Males and females were equally likely to have attempted to quit smoking among Indigenous youth and non-Indigenous youth (Table 2).

Alcohol use

Indigenous youth were more likely than non-Indigenous youth to report having used alcohol in the previous year (OR: 1.43; 95% CI: 1.16–1.76), after controlling for geographic region and smoking status, which were found to be confounders (Table 2). Indigenous males were 26% less likely to have engaged in past-year alcohol use (OR: 0.74; 95% CI: 0.54–1.0) compared to Indigenous females, a borderline statistically significant trend. Among non-Indigenous students, males were 12% less likely to have engaged in past-year alcohol use (OR: 0.88; 95% CI: 0.83–0.94) compared to females, after adjusting for geographic region and smoking status.

TABLE 2
Measures of substance use behaviours by Indigenous ethnicity and sex, grade 9–12 students, 2014/15

Variable	Estimate[a]	95% CI, lower bound	95% CI, upper bound	*p*-value
Current smoking (odds ratio)[b]				
Indigenous vs. non-Indigenous youth	5.26	3.54	7.81	< 0.001
Indigenous males vs. females	0.88	0.52	1.49	0.63
Non-Indigenous males vs. females	1.47	0.97	2.24	0.07
Attempted to quit smoking (odds ratio)[b]				
Indigenous vs. non-Indigenous youth	1.80	0.91	3.58	0.09
Indigenous males vs. females	0.37	0.12	1.13	0.08
Non-Indigenous males vs. females	1.03	0.41	2.58	0.95
Mean age of first drink that was more than just a sip (years)				
Indigenous youth	13.3	13.0	13.5	< 0.001
Non-Indigenous youth	13.8	13.7	13.8	
Indigenous males	13.0	12.4	13.5	0.003
Non-Indigenous males	13.6	13.5	13.7	
Indigenous females	13.5	13.3	13.8	0.006
Non-Indigenous females	13.9	13.8	14.1	
Past-year alcohol use (odds ratio)[c]				
Indigenous vs. non-Indigenous youth	1.43	1.16	1.76	0.001
Indigenous males vs. females	0.74	0.54	1.00	0.05
Non-Indigenous males vs. females	0.88	0.83	0.94	< 0.001
Past-year binge drinking (odds ratio)[d]				
Indigenous vs. non-Indigenous youth	1.04	0.83	1.28	0.75
Indigenous males vs. females	1.00	0.69	1.46	0.99
Non-Indigenous males vs. females	1.06	0.89	1.27	0.50
Ever tried marijuana (odds ratio)[e]				
Indigenous vs. non-Indigenous youth	3.42	2.47	4.73	< 0.001
Indigenous males vs. females	0.76	0.51	1.14	0.19
Non-Indigenous males vs. females	1.06	0.91	1.24	0.46
Mean age of first use of marijuana (years)				
Indigenous youth	13.1	12.7	13.5	< 0.001
Non-Indigenous youth	14.4	14.3	14.6	
Indigenous males	12.9	12.3	13.4	< 0.001
Non-Indigenous males	14.3	14.2	14.4	
Indigenous females	13.3	12.9	13.7	< 0.001
Non-Indigenous females	14.6	14.4	14.7	
Past-year marijuana use (odds ratio)[f]				
Indigenous vs. non-Indigenous males	1.84	1.32	2.56	< 0.001
Indigenous vs. non-Indigenous females	2.87	2.15	3.84	< 0.001

Data source: 2014/15 Canadian Student Tobacco, Alcohol and Drug Survey (CSTADS).
Abbreviation: CI, confidence interval.
[a] Confounding was defined as any variable that changed the crude odds ratio by more than 10%.
[b] Unadjusted odds ratios.
[c] Adjusted for geographic region and smoking status.
[d] Adjusted for smoking status.
[e] Adjusted for grade, geographic region, median household income based on school area, and smoking status.
[f] Adjusted for grade and smoking status. Comparison between Indigenous youth and non-Indigenous youth not computed as association is modified by sex ($p = 0.005$). Tukey–Kramer method was used to adjust for multiple comparisons.

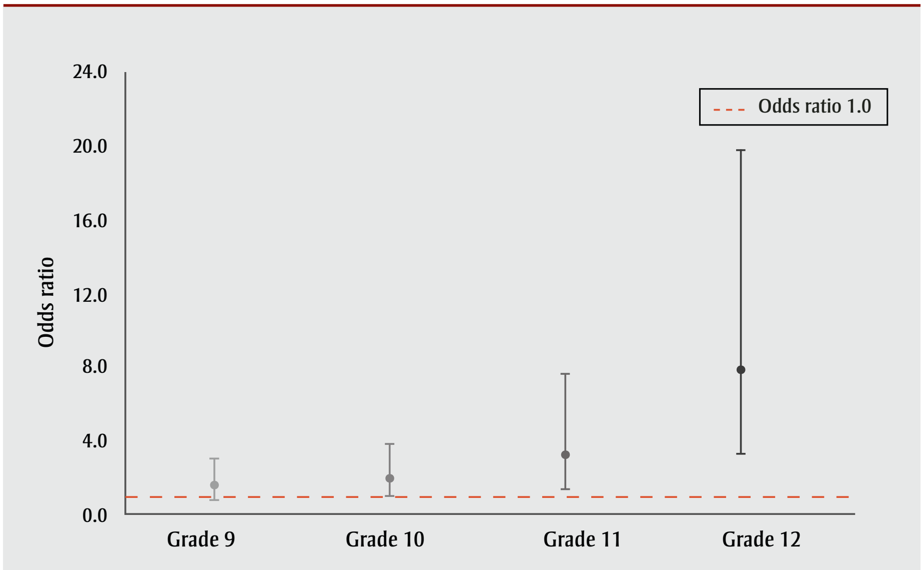
On average, Indigenous youth reported beginning drinking at slightly younger ages than did non-Indigenous students (Indigenous: 13.3 years, 95% CI: 13.0–13.5; non-Indigenous: 13.8 years, 95% CI: 13.7–13.8) (Table 2). In both populations, males begun drinking alcohol at a younger age than females (Table 2). There was no significant difference between the two populations in past-year binge drinking (OR: 1.04; 95% CI: 0.83–1.28), after controlling for smoking status. There were no significant differences in past-year binge drinking by sex among Indigenous youth or non-Indigenous youth, after adjusting for smoking status.

Marijuana use

Indigenous youth were more likely than non-Indigenous youth to have ever tried marijuana (OR: 3.42; 95% CI: 2.47–4.73), after adjusting for grade, region, median household income and tobacco smoking status (Table 2). Sex was a statistically significant modifier of the association between Indigeneity and past-year marijuana use ($p = 0.005$). Indigenous males were more likely to have used marijuana in the past year compared to non-Indigenous males (OR: 1.84; 95% CI: 1.32–2.56), and Indigenous females were almost three times more likely than non-Indigenous females to have used marijuana in the past year (OR: 2.87; 95% CI: 2.15–3.84), after controlling for grade and smoking status. Indigenous youth reported using marijuana at a younger age (mean 13.1 years; 95% CI: 12.7–13.5) than non-Indigenous youth (mean 14.4 years; 95% CI: 14.3–14.6) (Table 2). Males reported having begun using marijuana at a younger age than females among both populations.

Overall, among those who used marijuana during the past year, 15.8% of Indigenous students and 2.4% of non-Indigenous students in Grades 9 to 12 reported daily use. This association differed by grade, with no differences by sex. Among students in Grade 9, there was no difference in past-year marijuana use between the two populations. Indigenous youth were twice as likely to have used marijuana daily (OR: 2.05; 95% CI: 1.08–3.91) when in Grade 10 and three times more likely when in Grade 11 (OR: 3.30; 95% CI: 1.42–7.68). The association was most pronounced among Grade 12 students, where Indigenous youth had over eight times higher odds of daily marijuana use (OR: 8.12; 95% CI: 3.33–19.78), compared to non-Indigenous youth (Figure 1).

FIGURE 1
Odds of using marijuana daily, Indigenous youth compared to non-Indigenous students in grades 9–12, 95% confidence intervals, 2014/15



Data source: 2014/15 Canadian Student Tobacco, Alcohol and Drug Survey (CSTADS).
Notes: Analysis adjusted by geographic region. Tukey–Kramer method was used to adjust for multiple comparisons. Each line represents odds ratio with 95% confidence interval.

Changes over time – 2008/09 to 2014/15

Differences in prevalence of use from 2014/15 CSTADS were compared to results previously published from the 2008/09 YSS (Figure 2).[1] CSTADS data are considered comparable to 2008/09 YSS data.[27] Between 2008/09 and 2014/15, the estimated prevalence of smoking decreased by 17.7% in Indigenous youth (24.9% to 20.5%) and 54.8% in non-Indigenous youth (10.4% to 4.7%). Among smokers, the proportion of non-Indigenous youth that attempted to quit smoking decreased by 5.1% (74.3% to 70.5%), while among Indigenous youth it increased by 23.6% (65.6% to 81.1%). Past-year alcohol use decreased by 11.4% (from 71.9% to 63.7%) among Indigenous and 22.8% (from 66.7% to 51.5%) among non-Indigenous youth, along with past-year binge drinking, which decreased in both groups; by 28.3% (from 83.4% to 59.8%) in Indigenous and 30.1% (from 73.8% to 51.6%) in non-Indigenous youth. Past-year marijuana use decreased by 15.8% (from 53.2% to 44.8%) among Indigenous students and 36.8% (34.5% to 21.8%) among non-Indigenous students. All 2008/09 to 2014/15 changes were statistically significant.

Between 2008/09 and 2014/15, there were some changes in the role of sex in predicting substance use by Indigenous students. In 2008/09, the prevalence of smoking, quitting attempts, and alcohol and marijuana use was higher among female than among male Indigenous youth. In 2014/15, neither smoking nor quitting attempts differed significantly by sex. In 2014/15, as in 2008/09, female Indigenous youth reported higher past-year alcohol and marijuana use than did males.

In addition to changes in prevalence of substance use within both groups, the gap between the groups was examined (Figure 3). In 2008/09, Indigenous youth had 3.3 times higher odds of being current smokers relative to non-Indigenous youth, while in 2014/15 Indigenous youth had 5.3 higher odds. Notably, Indigenous youth went from being 35% less likely to attempt quitting in 2008/09, to 92% more likely to attempt quitting smoking. Indigenous youth went from being 41% more likely to engage in past-year binge drinking in 2008/09 to binge drinking at the same level as non-Indigenous youth in 2014/15. While past-year alcohol use was the same between the two populations in 2008/09, in 2014/15, Indigenous youth had 58% higher odds of past-year alcohol use when compared to non-Indigenous youth. In 2008/09, Indigenous youth were twice as likely to have ever tried marijuana, while in 2014/15, they were almost three and a half times as likely compared to non-Indigenous youth.

Discussion

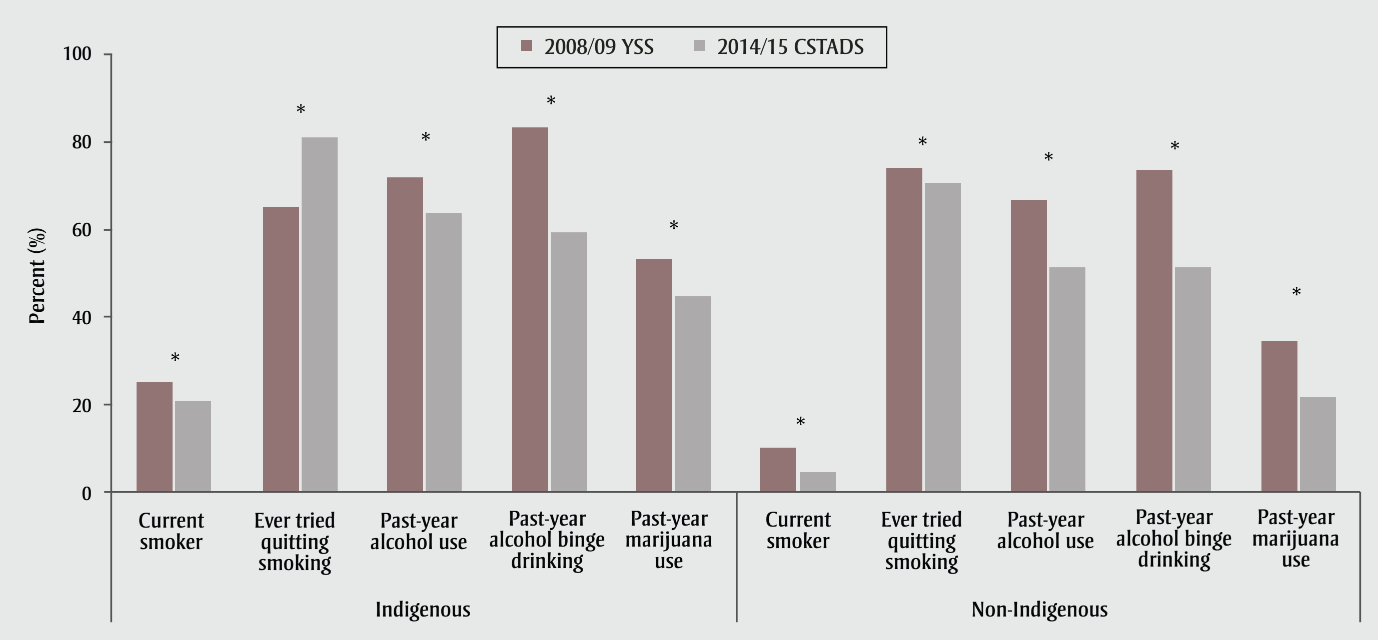
The analysis of 2014/15 CSTADS data showed some important differences between Indigenous and non-Indigenous youth on some substance use behaviours, but not on others. Indigenous youth were more likely to have smoked, used alcohol, and used marijuana in year preceding the survey, than were non-Indigenous youth. However, among current smokers, Indigenous youth were also more likely to have attempted quitting. Both populations were equally likely to have engaged in past-year binge drinking, with no differences by sex. On average, Indigenous youth reported starting drinking alcohol and using marijuana at younger ages. In both populations, males began drinking alcohol and using marijuana at a younger age than females. Past-year marijuana use differed by sex, with females reporting significantly higher rates. Daily marijuana was significantly higher among Indigenous youth relative to non-Indigenous youth, but only among students in Grades 10 to 12.

Indigenous youth were substantially more likely than the general youth population to be current smokers, and while they were more likely to attempt quitting, additional resources are needed to help this population take the desire to quit into action. This same conclusion was made by Elton-Marshall et al.[1] using 2008/09 data, suggesting that current tobacco control strategies are not enough for this high-risk population.[5]

This high rate of smoking among Indigenous youth is concerning. Moreover, it is possible that it is an underestimation of the true risk. To be considered a current smoker by Health Canada, youth must have smoked at least 100 cigarettes in their lifetime and smoked at least one whole cigarette in the past 30 days.[1,5,24] While this definition has been used across multiple studies in both youth and adult populations, it might not be appropriate for youth.[28] Compared to adults, youth have a higher sensitivity to nicotine resulting in earlier dependence and higher risk of developing severe nicotine addiction.[28] Higher sensitivity to nicotine, indicates that fewer cigarettes would need to be smoked to generate the same effects seen in adults.[28]

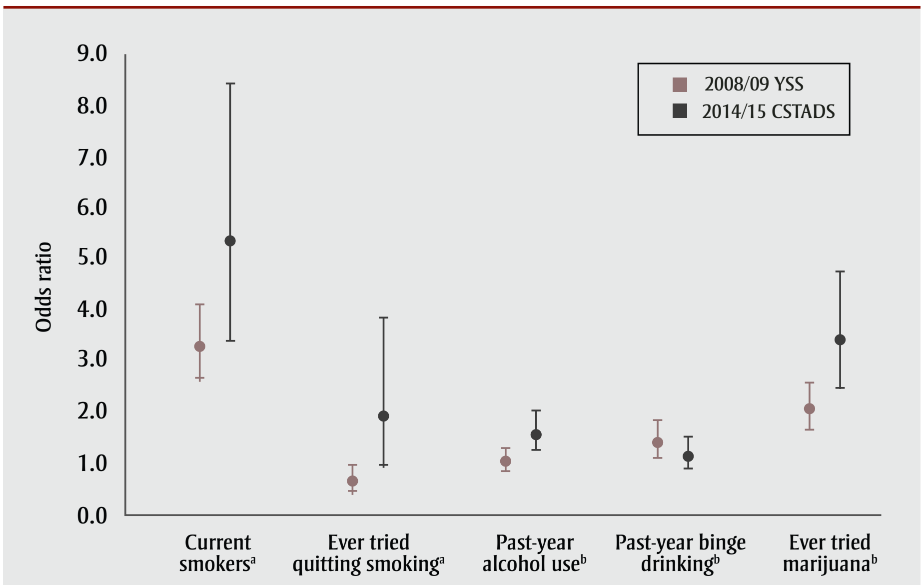
There is evidence that cessation interventions are effective in Indigenous populations,

FIGURE 2
Prevalence of tobacco, alcohol, and marijuana use among students in grades 9–12 by Indigenous ethnicity, 2008/09 and 2014/15



Data sources: 2008/09 YSS and 2014/15 CSTADS.
Abbreviations: CSTADS, Canadian Student Tobacco, Alcohol and Drug Survey; YSS, Youth Smoking Survey.
* Significant difference ($p < 0.05$).

FIGURE 3
Tobacco, alcohol, and marijuana use in Indigenous students compared to Non-Indigenous students, grades 9–12, 2008/09 and 2014/15



Data sources: 2008/09 YSS and 2014/15 CSTADS.
Abbreviations: CSTADS, Canadian Student Tobacco, Alcohol and Drug Survey; YSS, Youth Smoking Survey.
Note: Each line represents odds ratio with 95% confidence interval.
[a] 2008/09 YSS analysis controlled for sex, grade, weekly spending money and geographic region. 2014/15 CSTADS controlled for sex, grade, geographic region and median household income as weekly spending money was no longer collected. Reference group is Non-Indigenous youth.
[b] 2008/09 YSS analysis controlled for sex, grade, geographic region, weekly spending money and smoking status (current compared to non-smokers). 2014/15 CSTADS analysis controlled for sex, grade, geographic region, smoking status (current vs. non-smokers) and median household income as weekly spending money was not collected. Reference group is Non-Indigenous youth.

though the optimum method of employment and whether culturally-adapted interventions are necessary is not well known.[29] Limited evidence from a Cochrane review and a global systematic review suggests that culturally-adapted interventions can result in abstinence.[28-31] Interventions that include community engagement, Indigenous leadership, and the use of materials and activities that are designed considering culture and values were found to be the most beneficial.[30-31] Aggressive media campaigns, increasing cigarette price, specific adolescent cessation programs have also been found to be effective prevention control strategies in the general population.[32] Indigenous youth are primarily influenced by peers and household members to initiate smoking.[4] Given that a supportive home environment has been found to prevent smoking initiation in Indigenous youth, further evaluation and development of family and community-based interventions is warranted.[4]

A key consideration in intervention efforts should be the traditional use of tobacco by Indigenous populations during ceremonies and for medical purposes.[4] This traditional use is not to be confused with tobacco misuse, where misuse refers to the recreational use of cigarettes, e-cigarettes, chewing tobacco, and pipes.[4,33] During traditional use, inhalation is very minimal, as tobacco is typically ceremonially burned or placed on the ground as an offering or gift to establish a pathway to the spiritual world.[4,33] Conversely, recreational use involves inhaling large amounts of commercial tobacco with high amounts of nicotine and other toxic chemicals.[4] Tobacco use is not traditionally sacred for all Indigenous groups and Inuit only began using tobacco about one hundred years ago.[4] Non-traditional use of tobacco is often seen by Elders as disrespectful to Indigenous cultures and traditions.[4,33]

Smoking cessation programs targeted at Indigenous youth should therefore not portray all tobacco as negative, but rather make a clear distinction between sacred and recreational use.[33] Elders in Indigenous communities can play a large part in the dissemination of this knowledge. Among Indigenous youth who have attempted to quit, 6% have reported doing so to respect the cultural significance of tobacco, while 76% reported quitting to attain a healthier lifestyle and due to heightened awareness of negative effects.[2] The awareness of traditional tobacco use, in addition to the negative effects of commercial tobacco, might further increase attempts to quit and quitting effectiveness.

The public health focus on binge drinking might have proved beneficial as rates dropped by about 30% in both Indigenous and non-Indigenous youth, with no significant difference between the two populations. It is concerning that about a third of Indigenous and non-Indigenous youth engage in binge drinking monthly. CSTADS defines binge drinking as 5 or more drinks on one occasion for both males and females. This might lead to an underestimation of binge drinking in female youth as guidelines define binge drinking as 5 or more drinks on one occasion for males and 4 or more drinks on one occasion for females.[34] The developing adolescent brain exhibits a higher degree of neuroplasticity when compared to the adult brain, a process highly sensitive to alcohol.[35] As a result, youth may experience the negative health effects associated with binge drinking at lower doses.

While alcohol use has decreased over the past five years in both populations, Indigenous youth had a 43% higher odds of past-year alcohol use. Armenta et al.[36] found that discrimination and positive drinking schemas were able to independently predict alcohol use in a sample of Indigenous youth in northern US and Canada. However, after controlling for discrimination, peer drinking and gender, the effect of positive drinking schemas was attenuated.[36] These findings may help partially explain why in our study Indigenous youth began alcohol use earlier, particularly males. Both Indigenous and non-Indigenous youth, might have positive views on drinking alcohol. However, non-Indigenous youth are less likely to perceive that they have experienced discrimination. Youth with peers and household members who consume alcohol are also likely to have stronger positive drinking conceptions.[5,36] As well as working to reduce the experience of systemic discrimination of Indigenous youth, incorporating the positive value of Indigenous identity into interventions could be useful to reduce the use of alcohol as a mechanism for coping with discrimination.[36]

Although past-year marijuana use decreased overall, Indigenous youth were significantly more likely to have used marijuana, especially among females. Daily marijuana use was substantially higher among Indigenous students at 15.8%, compared to 2.4% among non-Indigenous students. Previous research has shown that younger women tend to become regular cannabis users faster than men.[37] However, in our study this was only observed among Indigenous females. This might be partly because Indigenous females first experience of marijuana was an average of 1.3 years earlier than non-Indigenous females and so they had a longer time to become regular cannabis users.

Management of harms is critical to protect these vulnerable youth populations as long term cannabis use can result in mental illness, chronic bronchitis, cancer, cognitive deficits and injuries.[2,19] In a Canadian study examining the perception of cannabis among youth, many reported consuming cannabis to fit in with peers, to cope with stress, because it is easily accessible, for medical purposes, and because of limited side effects.[38] When compared to other substances, youth viewed cannabis as the "safest"[38,p.18] drug.[38] Elders in some Indigenous communities have reported that cannabis can be used in culturally appropriate ways as a medicine and have stressed that for a medicine to be effective, it cannot be misused.[39] To prevent harms, targeted prevention efforts in communities and schools might be necessary to alleviate misconceptions, including using the wisdom of Elders in Indigenous communities.

Limitations

Despite the large sample size and generalizability of the results to the population, this study has limitations. Data were self-reported, and therefore subject to recall bias. Given response rates were less than 67% at the school board, school, and student level, there is potential for nonresponse bias. Indigenous ethnicity was reported using a question that differs from the questions used in the Census of Canada to identify Indigenous ancestry or self-identity, and therefore this population might not be comparable to the census Indigenous populations.[12-15] The question also does not allow disaggregation of First Nations, Métis and Inuit youth. CSTADS had no data on New Brunswick, Yukon Territory, Nunavut or the Northwest Territories, which decreases the generalizability of the study. The lack of Indigenous youth attending on-reserve schools is also a major limitation of this study. Although it is expected that most Indigenous youth in the sample also lived outside of reserves, it is possible that some lived in First Nations communities but attended schools off-reserve. Data on substance use among youth living in First Nations communities are available from other sources.[2]

Conclusion

Overall rates of tobacco, alcohol and marijuana use have decreased between 2008/09 and 2014/15 among both Indigenous and non-Indigenous students. There were no significant differences in past-year binge drinking between the two populations. In 2014/15, Indigenous students were five times more likely to have used tobacco, 50% more likely to have used alcohol and almost twice as likely to have used marijuana than non-Indigenous students. Indigenous youth were more likely to attempt quitting smoking. The continued higher rates of some substance use behaviours among Indigenous youth points to the importance of monitoring these behaviours and to inform policy on the needs of Indigenous youth outside of reserves.

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Conflicts of interest

The authors have no conflict of interest to disclose.

Authors' contributions and statement

CS conducted the analysis of data and drafted the article. All authors contributed to the design of the study, the interpretation of data, the revision of the article, provided final approval of the version to be published, and can act as guarantors of the work.

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Original quantitative research

Trends in chronic disease incidence rates from the Canadian Chronic Disease Surveillance System

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Abstract

Introduction: The Public Health Agency of Canada's Canadian Chronic Disease Surveillance System (CCDSS) produces population-based estimates of chronic disease prevalence and incidence using administrative health data. Our aim was to assess trends in incidence rates over time, trends are essential to understand changes in population risk and to inform policy development.

Methods: Incident cases of diagnosed asthma, chronic obstructive pulmonary disease (COPD), diabetes, hypertension, ischemic heart disease (IHD), and stroke were obtained from the CCDSS online infobase for 1999 to 2012. Trends in national and regional incidence estimates were tested using a negative binomial regression model with year as a linear predictor. Subsequently, models with year as a restricted cubic spline were used to test for departures from linearity using the likelihood ratio test. Age and sex were covariates in all models.

Results: Based on the models with year as a linear predictor, national incidence rates were estimated to have decreased over time for all diseases, except diabetes; regional incidence rates for most diseases and regions were also estimated to have decreased. However, likelihood ratio tests revealed statistically significant departures from a linear year effect for many diseases and regions, particularly for hypertension.

Conclusion: Chronic disease incidence estimates based on CCDSS data are decreasing over time, but not at a constant rate. Further investigations are needed to assess if this decrease is associated with changes in health status, data quality, or physician practices. As well, population characteristics that may influence changing incidence trends also require exploration.

Keywords: *administrative data, chronic disease surveillance, trend analysis*

Highlights

- Using data from the Canadian Chronic Disease Surveillance System (CCDSS), national incidence rates were estimated to have decreased over time for diagnosed asthma, chronic obstructive pulmonary disease, hypertension, ischemic heart disease, and stroke, but not for diabetes. Decreasing rates were also observed in many regions of Canada.
- Trends in national and regional chronic disease incidence were often non-linear over time, indicating that the rate of change has not been constant.
- Further research is needed to assess the association of changes in national and regional chronic disease incidence rates with changes in population health, administrative data quality, and/or clinician billing practices.

Introduction

Chronic diseases are the leading causes of death and disability worldwide.[1-3] Within Canada, age-standardized chronic disease prevalence, the total number of disease cases, has been increasing over time,[4] whereas age-standardized incidence, the number of new cases, appears to be decreasing for some diseases such as heart disease, stroke, and asthma.[5-18] This discrepancy may be due to aging of the population, overall growth in the Canadian population or individuals living longer with the disease. However, disease-specific mortality rates have not been consistently decreasing over time.[19]

Estimating population-based trends in prevalence and incidence can be challenging. Longitudinal population-based surveys are one potential source of data on incident and prevalent cases, but they are costly to conduct on a regular basis and

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are prone to attrition, which can result in inaccuracies in trend estimates. Moreover, survey data do not consistently contain dates relevant to identifying disease onset, such as the date of first diagnosis or the date of treatment.

Administrative health data that capture disease diagnosis information, such as hospital and physician service (i.e., billing) records are routinely collected and therefore often less expensive and timelier to use for prevalence and incidence trend estimation.[20] However, changes in data collection methods, coding and classification systems, and clinical and billing practices for chronic diseases can also affect the accuracy of longitudinal trend estimates. As well, the completeness of capture of administrative records for the entire population may change over time, which can result in selection biases. In Canada for example, Newfoundland and Labrador physician service records do not consistently capture patient information from physicians who do not bill on a fee-for-service basis, which disproportionately affects the availability of diagnostic information for rural populations.[21]

One of the routine uses of administrative health data in Canada is for chronic disease surveillance through the Canadian Chronic Disease Surveillance System (CCDSS).[22] The CCDSS[23] was created in 2009 to facilitate the collection and reporting of standardized, national estimates of diagnosed chronic disease prevalence, incidence, and health outcomes. It grew out of the National Diabetes Surveillance System (NDSS), which was established in 1999 as a collaborative network of provincial and territorial (P/T) diabetes surveillance systems and supported by Health Canada and then the Public Health Agency of Canada (PHAC).[24]

In 2016, the CCDSS Data Quality Working Group was formed.[22] It conducts ad hoc data quality studies and examines data quality information that arises from a variety of sources, such as case definition validation studies and narrative reports about changes in data coding practices from P/T administrative staff. Trends in incidence and prevalence estimates may be used, in part, to assess data quality.[25] Longitudinal trends may be influenced by changes in data quality, in addition to true changes in population health. Unexpected or unexplained changes in trends can suggest opportunities for follow-up data quality investigations.

To date, there have been few, if any, studies that have tested whether trends in chronic disease incidence from the CCDSS are changing over time. The purpose of our study was to assess incidence trends for multiple chronic diseases at national and provincial/regional levels in the CCDSS and determine if these trends are best captured using a linear effect of time.

Methods

Data source

Data were obtained from the CCDSS online infobase for multiple fiscal years over the period from 1999 to 2012, this was the most recent data available at the time of analysis.[26] The infobase includes documentation on CCDSS methods, and the rules used to identify chronic disease cases within administrative databases. We focused on incident cases of disease because incidence is often not available from survey data and is a key measure of population disease risk. Incidence data were obtained for asthma (ages one year and older, 2000–2012), chronic obstructive pulmonary disease (COPD; ages 35 years and older, 2000–2012), diabetes (ages one year and older, 2000–2012), hypertension (ages 20 years and older, 1999–2012), ischemic heart disease (IHD; ages 20 years and older, 1999–2012), and stroke (ages 20 years and older, 2003–2012). The Data Quality Working Group selected these diseases because it was expected they would have trends of different shapes and directions; these diseases affect different body systems and are therefore less likely to move in concert. Data were obtained for the following regions: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Atlantic Canada (New Brunswick, Newfoundland, Nova Scotia, and Prince Edward Island). Data from Northern Canada were excluded due to low event rates and the practical challenges with modelling sparse cell sizes. Incidence counts were grouped by age group and sex. CCDSS data are publicly available by five-year or lifecourse age groups. For this analysis five-year age groups were used.

Statistical analysis

Incidence rates were calculated as the number of new disease cases in a year divided by the total population at risk as of the end of the fiscal year (i.e., March 31st) and expressed per 1000 population. Rates were age standardized using the 2011 Canadian Census population and then described using minimum and maximum values, as well as first year and final year values.

Crude incidence data were subsequently analyzed using multivariable negative binomial regression models. The number of incident disease cases in each year was the outcome. The natural logarithm of the total population for a province or region was the model offset. Model covariates were year, age group, and sex. Age group was included as a cubic covariate based on preliminary assessments of model fit.

This study proceeded in a series of steps to assess trends for each chronic disease and region. The regional data were also combined to assess the trend for Canada as a whole for each chronic disease.

First, a negative binomial model with year as a continuous linear covariate was fit to the data. Next, we applied a series of negative binomial models to the data where year was included as a restricted cubic spline with a truncated power basis. Restricted cubic splines (RCS), or natural splines, are constrained to be linear beyond the boundaries of the first and last knots. The splines are also constrained to have continuous first and second derivatives at each knot, that is, at each location where the piecewise polynomial functions join,[27] resulting in a flexible, smooth function. Fitting an RCS to the data allowed us to test for linearity without making any assumptions about the data's overall shape.

Three different RCS models were fit to the data: year as an RCS with five knots, year as an RCS with four knots, and year as an RCS with three knots. Using greater than five knots in an RCS is rarely needed to provide a good fit to the data;[28] less than three knots is equivalent to modelling the predictor as a cubic term in the model. Knots were placed at evenly spaced quantiles based on the recommendations by Harrell.[27]

The Akaike information criterion (AIC)[29] was used to assess which RCS model best fit the data. Once the best-fitting RCS model was identified, we used a likelihood ratio test to determine if the model with year as an RCS fit the data significantly better than the model with year as a linear effect. Statistical significance was assessed using a nominal $\alpha = 0.05$.

Statistical analyses were performed using R software, version 3.4.3 (R Foundation for Statistical Computing, Vienna). The base functions and the Modern Applied Statistics with S (MASS) and Regression Modeling Strategies (rms) packages were used.

Results

Table 1 reports estimated age-standardized incidence rates per 1000 population for each chronic disease and region. These rates are provided for the first and final years of available data. In addition, the minimum and maximum estimates and their respective years are reported.

For Canada, the first and final years of available estimates coincide with the highest and lowest values, respectively, for asthma, COPD, IHD, and stroke. Estimated age-standardized incidence rates for diabetes increased from 6.60 per 1000 population in 2000 to 7.60 per 1000 population in 2006 (first year of study observation period), then subsequently decreased to 6.17 per 1000 population in 2012, which was both the final year and lowest rate observed. Hypertension age-standardized incidence rates peaked at 32.81 per 1000 population in 2000, which was 0.93 per 1000 population greater than the first year

TABLE 1
Age-standardized incidence rate estimates (per 1000 population), stratified by chronic disease and region

Region	Measure	Asthma		COPD		Diabetes		Hypertension		IHD		Stroke	
		Rate (per 1000)	Year	Rate (per 1000)	Year	Rate (per 1000)	Year	Rate (per 1000)	Year	Rate (per 1000)	Year	Rate (per 1000)	Year
Canada	First year	8.94	2000	12.03	2000	6.60	2000	31.88	1999	12.99	1999	3.83	2003
	Final year	4.74	2012	8.81	2012	6.17	2012	22.29	2012	6.80	2012	2.97	2012
	Minimum rate	4.74	2012	8.81	2012	6.17	2012	22.29	2012	6.80	2012	2.97	2012
	Maximum rate	8.94	2000	12.03	2000	7.60	2006	32.81	2000	12.99	1999	3.83	2003
Atlantic	First year	7.87	2000	13.61	2000	7.51	2000	35.51	1999	13.30	1999	3.82	2003
	Final year	3.96	2012	10.45	2012	7.05	2012	26.60	2012	6.93	2012	2.89	2012
	Minimum rate	3.96	2012	10.45	2012	6.97	2008	26.60	2012	6.93	2012	2.89	2012
	Maximum rate	7.87	2000	13.61	2000	8.01	2006	38.11	2002	13.30	1999	3.82	2003
Quebec	First year	9.11	2000	14.37	2000	6.12	2000	31.92	1999	14.38	1999	3.56	2003
	Final year	4.44	2012	7.03	2012	5.33	2012	18.61	2012	7.34	2012	2.68	2012
	Minimum rate	4.44	2012	7.03	2012	5.33	2012	18.61	2012	7.34	2012	2.67	2011
	Maximum rate	9.11	2000	14.37	2000	6.12	2000	32.02	2000	14.38	1999	3.56	2003
Ontario	First year	10.10	2000	11.04	2000	6.53	2000	31.09	1999	13.25	1999	4.00	2003
	Final year	5.27	2012	8.59	2012	5.91	2012	20.73	2012	6.46	2012	3.00	2012
	Minimum rate	5.27	2012	8.59	2012	5.91	2012	20.73	2012	6.46	2012	3.00	2012
	Maximum rate	10.10	2000	11.04	2000	8.44	2006	32.22	2000	13.25	1999	4.00	2003
Manitoba	First year	8.34	2000	13.76	2000	6.79	2000	29.83	1999	10.73	1999-2000	4.43	2003
	Final year	6.81	2012	8.59	2012	8.21	2012	28.26	2012	6.34	2010-2012	3.25	2012
	Minimum rate	5.56	2011	8.59	2012	6.32	2008	28.26	2012	6.34	2010-2012	3.25	2012
	Maximum rate	8.34	2000	13.76	2000	8.21	2012	31.87	2003	10.73	1999-2000	4.43	2003
Saskatchewan	First year	8.18	2000	10.39	2000	5.91	2000	30.57	1999	11.78	1999	4.24	2003
	Final year	4.72	2012	9.25	2012	6.40	2012	25.43	2012	6.80	2012	3.07	2012
	Minimum rate	4.72	2012	9.11	2011	5.91	2000	25.43	2012	6.80	2012	3.07	2012
	Maximum rate	8.18	2000	10.75	2007	7.29	2006	36.56	2002	11.78	1999	4.24	2003
Alberta	First year	9.06	2000	11.90	2000	6.38	2000	32.78	1999	11.96	1999	3.81	2003
	Final year	5.41	2012	10.46	2012	6.23	2012	27.80	2012	7.14	2012	3.10	2012
	Minimum rate	5.41	2012	10.22	2008	6.16	2003	27.80	2012	7.14	2012	3.10	2012
	Maximum rate	9.06	2000	11.90	2000	6.99	2009	34.75	2001	11.96	1999	3.89	2004
British Columbia	First year	7.32	2000	9.17	2000	6.22	2000	28.03	1999	10.03	1999	3.48	2003
	Final year	4.81	2012	10.15	2012	6.51	2012	21.84	2012	6.18	2012	3.18	2012
	Minimum rate	4.81	2012	7.92	2006	6.22	2000	21.84	2012	6.18	2012	3.18	2012
	Maximum rate	7.32	2000	12.83	2009	7.97	2009	33.25	2006	10.03	1999	3.52	2004

Abbreviations: COPD, chronic obstructive pulmonary disease; IHD, ischemic heart disease.
Notes: Data retrieved August 2018.
Estimated rates are presented only for the first and final years. Minimum and maximum values in the study observation period are also reported.

TABLE 2
Estimated effects of year as a continuous linear covariate (95% CIs) for the negative binomial regression models, stratified by chronic disease and region

Chronic disease	Region	Estimate (95% CI)
Asthma	Canada	−0.05 (−0.06, −0.05)[a]
	Atlantic Canada	−0.06 (−0.07, −0.05)[a]
	Quebec	−0.06 (−0.07, −0.05)[a]
	Ontario	−0.06 (−0.07, −0.05)[a]
	Manitoba	−0.02 (−0.03, −0.01)[a]
	Saskatchewan	−0.05 (−0.06, −0.04)[a]
	Alberta	−0.05 (−0.06, −0.04)[a]
	British Columbia	−0.03 (−0.04, −0.02)[a]
COPD	Canada	−0.02 (−0.02, −0.01)[a]
	Atlantic Canada	−0.02 (−0.02, −0.01)[a]
	Quebec	−0.05 (−0.06, −0.04)[a]
	Ontario	−0.01 (−0.02, −0.01)[a]
	Manitoba	−0.03 (−0.04, −0.02)[a]
	Saskatchewan	−0.01 (−0.02, < 0.00)[a]
	Alberta	−0.01 (−0.01, < 0.00)[a]
	British Columbia	0.03 (0.02, 0.03)[a]
Diabetes	Canada	> 0.00 (< 0.00, > 0.00)
	Atlantic Canada	> 0.00 (< 0.00, > 0.00)
	Quebec	< 0.00 (−0.01, > 0.00)
	Ontario	< 0.00 (−0.01, > 0.00)
	Manitoba	0.01 (> 0.00, 0.01)[a]
	Saskatchewan	0.01 (> 0.00, 0.02)[a]
	Alberta	0.01 (> 0.00, 0.01)[a]
	British Columbia	0.01 (0.01, 0.02)[a]
Hypertension	Canada	−0.02 (−0.02,−0.02)[a]
	Atlantic Canada	−0.02 (−0.02,−0.01)[a]
	Quebec	−0.04 (−0.04, −0.03)[a]
	Ontario	−0.03 (−0.03, −0.02)[a]
	Manitoba	> 0.00 (< 0.00, 0.01)
	Saskatchewan	−0.01 (−0.02, −0.01)[a]
	Alberta	−0.01 (−0.01, < 0.00)[a]
	British Columbia	−0.01 (−0.01, < 0.00)[a]
IHD	Canada	−0.04 (−0.04, −0.03)[a]
	Atlantic Canada	−0.03 (−0.04, −0.02)[a]
	Quebec	−0.04 (−0.05, −0.04)[a]
	Ontario	−0.04 (−0.05, −0.04)[a]
	Manitoba	−0.12 (−0.15, −0.09)[a]
	Saskatchewan	−0.04 (−0.04, −0.04)[a]
	Alberta	−0.02 (−0.03, −0.02)[a]
	British Columbia	−0.03 (−0.04, −0.03)[a]

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(1999), before falling to 22.29 per 1000 population in the final and lowest year (2012). Annual crude rates for each region and disease are available upon request from the authors.

Table 2 provides the estimated effects of year as a continuous linear covariate in the multivariable negative binomial regression models for each region and chronic disease. The estimates indicate the average change in the incidence rate per year, after controlling for age and sex. For Canada, asthma (−0.05, $p < 0.001$), COPD (−0.02, $p < 0.001$), hypertension (−0.02, $p < 0.001$), IHD (−0.04, $p < 0.001$), and stroke (−0.02, $p < 0.001$) all showed a statistically significant decrease in their incidence rates over time. In contrast, there was no statistically significant linear effect of year for diabetes (0.0007, $p = 0.73$).

In terms of the linear effect for the regions (Table 2), there were statistically significant decreases in incidence rates over time for all regions for asthma, COPD, and IHD. For diabetes, there was a statistically significant increase in incidence estimates over time for the western provinces (Manitoba [0.009, $p < 0.001$], Saskatchewan [0.01, $p < 0.001$], Alberta [0.005, $p = 0.03$] and British Columbia [0.01, $p < 0.001$]), but no significant change for the other regions. For hypertension, there was no statistically significant change in incidence over time for Manitoba, but for all remaining regions there were statistically significant decreases. For stroke, there was no statistically significant change in incidence over time for British Columbia, while for all other regions there were statistically significant decreases.

Results from the likelihood ratio test for departures of year from a linear trend are reported in Table 3. Overall, the results show that year departed from a linear trend in numerous regions for many diseases. Stroke incidence was most consistently linear over time, with only Manitoba departing from a linear trend ($\chi^2 = 17.2$, df = 2, $p < .001$). In contrast, hypertension incidence was non-linear over time for every region except for Manitoba. For Canada, a non-linear incidence trend over time was evident for every disease, except for IHD ($p = 0.692$) and stroke ($p = 0.964$).

Figure 1 reports the national age-standardized incidence rates for all diseases,

TABLE 2 (continued)
Estimated effects of year as a continuous linear covariate (95% CIs) for the negative binomial regression models, stratified by chronic disease and region

Chronic disease	Region	Estimate (95% CI)
Stroke	Canada	−0.02 (−0.02, −0.01)[a]
	Atlantic Canada	−0.02 (−0.03, −0.02)[a]
	Quebec	−0.02 (−0.03, −0.01)[a]
	Ontario	−0.02 (−0.03, −0.01)[a]
	Manitoba	−0.03 (−0.04, −0.03)[a]
	Saskatchewan	−0.04 (−0.04, −0.03)[a]
	Alberta	−0.02 (−0.02, −0.01)[a]
	British Columbia	< 0.00 (−0.01, 0.01)

Abbreviations: COPD, chronic obstructive pulmonary disease; IHD, ischemic heart disease.
Note: Estimates are adjusted for age and sex.
[a] Statistically significant at $\alpha = 0.05$.

TABLE 3
Fit of the negative binomial regression models with year as restricted cubic spline containing three, four, and five knots and tests for departures of year from a linear trend, stratified by chronic disease and region

Chronic disease	Region	AIC values			Test for departure from linear trend		
		5 knots	4 knots	3 knots	χ^2	df	*p*-value
Asthma	Canada	7686.3	7685.2	7683.6[a]	5.2[b]	1.0[b]	0.023[b]
	Atlantic	2020.5	2018.6	2016.8[a]	0.2	1.0	0.694
	Quebec	2386.2	2383.9[a]	2384.3	6.2[b]	2.0[b]	0.046[b]
	Ontario	2565.1	2564.8	2564.8[a]	3.9[b]	1.0[b]	0.049[b]
	Manitoba	1862.1	1861.9[a]	1864.3	31.4[b]	2.0[b]	< 0.001[b]
	Saskatchewan	1777.6	1775.6	1773.6[a]	0.1	1.0	0.791
	Alberta	2123.0	2121.6	2120.8[a]	8.1[b]	1.0[b]	0.005[b]
	British Columbia	2192.8	2191.5[a]	2193.5	5.2	2.0	0.074
COPD	Canada	4659.2[a]	4664.7	4683.8	50.2[b]	3.0[b]	< 0.001[b]
	Atlantic	1445.6	1445.2	1445.2[a]	0.0	1.0	0.933
	Quebec	1644.3	1643.4[a]	1645.6	14.7[b]	2.0[b]	< 0.001[b]
	Ontario	1744.5	1743.3[a]	1746.0	7.8[b]	2.0[b]	0.020[b]
	Manitoba	1242.9	1242.8	1241.8[a]	4.4[b]	1.0[b]	0.037[b]
	Saskatchewan	1238.4	1237.3	1235.9[a]	2.0	1.0	0.159
	Alberta	1420.5	1419.6	1417.6[a]	2.1	1.0	0.152
	British Columbia	1469.5[a]	1489.2	1517.7	63.1[b]	3.0[b]	< 0.001[b]
Diabetes	Canada	7019.3	7017.7[a]	7019.2	30.1[b]	2.0[b]	< 0.001[b]
	Atlantic	1832.9[a]	1836.1	1834.4	7.0	3.0	0.074
	Quebec	2191.3	2190.1	2188.6[a]	2.2	1.0	0.142
	Ontario	2406.1	2404.9[a]	2407.3	45.5[b]	2.0[b]	< 0.001[b]
	Manitoba	1677.1[a]	1677.9	1686.3	22.0[b]	3.0[b]	< 0.001[b]
	Saskatchewan	1640.2	1638.9[a]	1640.8	17.0[b]	2.0[b]	< 0.001[b]
	Alberta	1920.4	1918.6	1917.7[a]	2.4	1.0	0.123
	British Columbia	1995.6[a]	1995.9	2003.0	36.1[b]	3.0[b]	< 0.001[b]

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illustrating the nature of the decreasing trend over time. Diabetes incidence generally increased before beginning to decrease in 2009. Inconsistent changes in incidence rates can be observed over time for diseases where the models with year as an RCS indicated that the national data did not have a linear effect of time (e.g., asthma, COPD, diabetes, and hypertension). For example, COPD incidence displays a mildly cubic shape and hypertension incidence has a slightly quadratic shape, where decreases in incidence rates are minimal at first and begin to increase as time progresses. In contrast, both IHD and stroke show little deviation from a linear trend, as indicated by the spline model results.

Discussion

Our study assessed Canadian chronic disease incidence rates over time and determined if the trends were best captured by modelling time (i.e., year) as a linear effect. Results from the models with a linear time effect showed that chronic disease incidence rates are slowly decreasing for all diseases except diabetes; however, in many cases, allowing for departures from linearity significantly improved model fit. Therefore, to fully understand the changing patterns of chronic disease incidence within and across Canada, researchers should consider using time as a non-linear factor to summarize and explain chronic disease incidence rates.

Previous Canadian studies[4-9,11,12,30-33] about chronic disease incidence rates have described changes in incidence rates as absolute or relative differences between the first and last years of the study period, ignoring the rate patterns in the interim. Exceptions to this are two studies exploring the incidence rates of type one[15] and type two[16] diabetes in British Columbia. These studies analyzed the overall annual percent change in incidence rates and reported the years in which significant changes in rates occurred. Results from both studies indicate that changes in diabetes incidence rates were not constant over time and could not be fully described using the difference between the first and last years of observation.

Based on our findings, incidence rates demonstrate an overall downward trend for all diseases except for diabetes. These findings are consistent with findings from other studies that have examined chronic

TABLE 3 (continued)
Fit of the negative binomial regression models with year as restricted cubic spline containing three, four, and five knots and tests for departures of year from a linear trend, stratified by chronic disease and region

Chronic disease	Region	AIC values			Test for departure from linear trend		
		5 knots	4 knots	3 knots	χ^2	df	*p*-value
Hypertension	Canada	6606.8	6606.1	6605.3[a]	70.0[b]	1.0[b]	< 0.001[b]
	Atlantic	1937.1	1936.8	1936.3[a]	33.3[b]	1.0[b]	< 0.001[b]
	Quebec	2245.0	2243.3	2242.2[a]	8.6[b]	1.0[b]	0.003[b]
	Ontario	2373.0	2371.5	2370.5[a]	34.4[b]	1.0[b]	< 0.001[b]
	Manitoba	1770.6[a]	1771.1	1771.1	4.6	3.0	0.206
	Saskatchewan	1734.9[a]	1736.9	1739.5	55.9[b]	3.0[b]	< 0.001[b]
	Alberta	2066.3	2065.1[a]	2065.9	8.1[b]	2.0[b]	0.018[b]
	British Columbia	2086.7	2084.2[a]	2095.8	80.4[b]	2.0[b]	< 0.001[b]
IHD	Canada	6213.3	6212.9	6211.0[a]	0.2	1.0	0.692
	Atlantic	2017.7	2017.1	2015.9[a]	6.9[b]	1.0[b]	0.008[b]
	Quebec	2045.7	2044.0	2042.4[a]	2.5	1.0	0.116
	Ontario	2233.8[a]	2235.8	2234.1	5.6	3.0	0.131
	Manitoba[c]	636.0	634.2	634.3[a]	4.6[b]	1.0[b]	0.032[b]
	Saskatchewan	1437.2	1435.3	1433.8[a]	1.7	1.0	0.195
	Alberta	1825.7	1824.3[a]	1825.4	3.5	2.0	0.173
	British Columbia	1774.8[a]	1777.5	1778.8	14.2[b]	3.0[b]	0.003[b]
Stroke	Canada	3736.4	3734.4	3732.6[a]	0.002	1.0	0.964
	Atlantic	977.8	975.7	974.3[a]	0.9	1.0	0.357
	Quebec	1306.4	1304.5	1302.6[a]	0.9	1.0	0.351
	Ontario	1389.3	1387.5	1385.5[a]	1.1	1.0	0.290
	Manitoba	922.8	920.3[a]	922.4	17.2[b]	2.0[b]	< 0.001[b]
	Saskatchewan	896.6	894.8	892.9[a]	1.6	1.0	0.203
	Alberta	1051.7	1051.2	1049.3[a]	0.04	1.0	0.834
	British Columbia	1146.0	1145.1[a]	1147.2	4.2	2.0	0.120

Abbreviations: AIC, Akaike information criterion; COPD, chronic obstructive pulmonary disease; IHD, ischemic heart disease.
Note: Models adjusted for age and sex.
[a] Indicate which RCS model was compared to the model with year as a linear predictor.
[b] Statistically significant at $\alpha = 0.05$.
[c] Used 3 knots to test instead of 4 since limited improvement in fit with 4 knots.

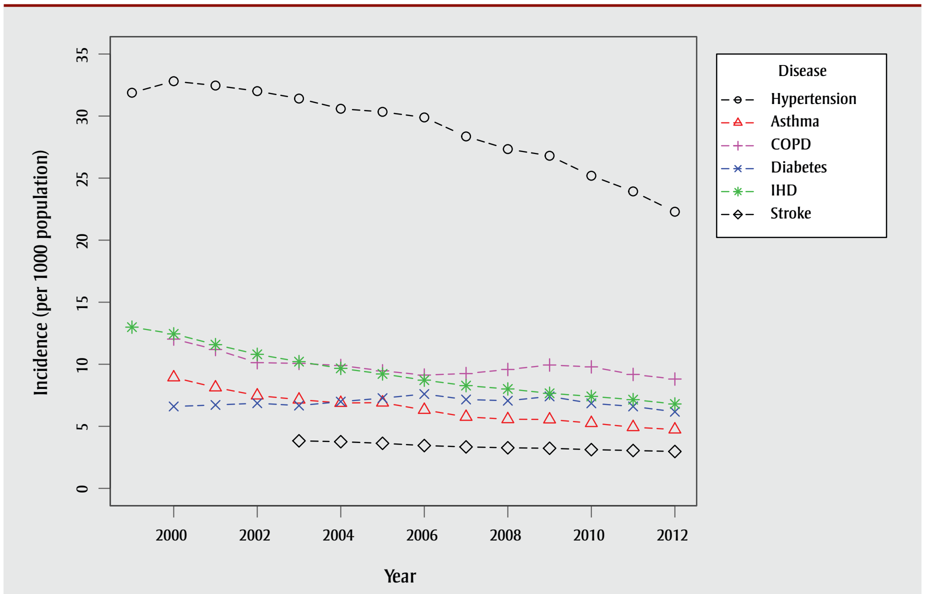
disease incidence rates within Canada using administrative health data. However, previous studies have not necessarily assessed incidence trends over the same period as was used in our study, so comparisons should be made with caution. Age- and sex-standardized stroke hospital admissions rates across Canada dropped by 0.74 per 1000 population between 1994 and 2004[6] and 0.227 per 1000 population between 2003 and 2013.[5] Age- and sex-standardized asthma incidence rates in Ontario increased between 1996–1997 and 2000–2001 then remained stable to 2004–2005 among children 14 years and younger while older age groups showed declines ranging from 0.4 to 1.3 per 1000 between 1996 and 2005.[14] In Ontario, age- and sex-standardized concurrent asthma and COPD incidence rates decreased by 0.4 per 1000 from 2002 to 2012 and age- and sex- standardized COPD incidence rates decreased by 3.3 per 1000 from 1996 to 2007.[7,8] Alberta age- and sex-standardized COPD incidence also decreased from 2002 to 2010,[10] and age- standardized incidence rates decreased by 5.1 per 1000 between 2001 and 2011 in Quebec.[9] Heart disease incidence rates (age-standardized) decreased in Quebec and Canada overall by approximately 5.6 per 1000 between 2000 and 2013,[12] and 5.5 per 1000 from 2000–2001 to 2012–2013,[13] respectively. Age-standardized heart failure incidence decreased in Ontario by 1.49 per 1000 between 1997 and 2007.[11] In contrast, diabetes incidence appears to be increasing in Alberta (1995–2006; age- and sex-adjusted) and Ontario (1997–2003; age- and sex-adjusted) but a variable trend among youth and children in British Columbia (2002–2003 to 2012–2013; age-standardized).[15-18]

Potential reasons for the overall decline in chronic disease incidence may include lower prevalence of modifiable risk factors[4] and improved prevention strategies.[34,35] Differences in incidence patterns between regions could, in part, be due to differences across provinces in the strategies used to address chronic disease and risk factor management.[36]

The decrease in hypertension, stroke, and IHD incidence for Canada is consistent with a decrease in mortality rates for cardiovascular-related diseases, including IHD, acute myocardial infarction, and heart failure.[13,19] Other diseases, such as COPD, do not exhibit consistent trends in mortality rates,[19] suggesting disease treatment may also play a role in the relationship between incidence and mortality rates. For diseases with a shorter average time between detection and death, such as stroke, mortality rates may be more indicative of changing incidence rates, rather than changes in treatment.

CCDSS methods for using administrative data to capture disease incidence have been validated for several chronic diseases, including asthma, COPD, IHD, hypertension, and diabetes.[37-41] The first date of disease diagnosis is used in administrative data as a proxy for disease onset. Incidence trends captured by the CCDSS can provide valuable insights into changes in Canadian population health; however, they may be influenced by changes in administrative data quality, such as modifications in data collection methods, coding and classification systems, or billing practices. For example, an increase in the number of healthcare practitioners paid by salary who submit administrative data via shadow-billing rather than the traditional fee-for-service method may increase the number of missing diagnoses codes.[21] Changes in clinical practice and screening and diagnoses criteria also likely influence trends in chronic disease incidence captured by the CCDSS over time. Moreover, incentive programs within different regions, such as the British Columbia Chronic Disease Incentive Program implemented in April 2006, may also erroneously influence

FIGURE 1
Age-standardized chronic disease incidence rate estimates for Canada



Abbreviations: COPD, chronic obstructive pulmonary disease; IHD, ischemic heart disease.

incidence trends, where better healthcare access and continuity of care result in increased disease detection within the first years after program implementation.[42] Factors influencing administrative data and its collection should be considered when interpreting incidence rates obtained from the CCDSS.

There are several benefits to using CCDSS data to examine chronic disease incidence within Canada. Previous studies[4,7-12,14-18,31-33,43] have only looked at diseases within one region of Canada. With CCDSS data, trends can be examined for Canada as a whole, as well as for different Canadian regions, using publicly available data. There is also good validity to compare the trends within different regions of Canada, as data were obtained using uniform case ascertainment methods. Moreover, CCDSS data can be used to assess longitudinal trends without interruption; national longitudinal survey data are often collected in waves with no available data for the years between waves.

While our analysis allowed us to determine if significant departures from linearity occurred for the time effect, it did not allow us to assess where the departures occurred. Such information would be beneficial to inform if, and how, specific changes in health policy (i.e., access to healthcare, physician reimbursement policies, billing practices), risk factors, and intervention efforts are related to disease incidence.

Future research could examine factors influencing changing incidence of chronic disease over time across Canada. Chronic disease incidence rates estimated from administrative data may be influenced by changes in population health status, clinical diagnostic and screening practices, or administrative practices within provinces, such as physician billing methods. Future analyses could focus on incidence estimates for other chronic diseases that are now a part of the CCDSS, including osteoporosis, depression, and osteoarthritis. The CCDSS Data Quality Working Group plans to explore incidence trends within Canada's P/Ts and conduct data quality surveys to help ascertain how much changing trends are due to changes in administrative practices or changes in population health.

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Conflicts of interest

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Authors' contributions and statement

All authors conceived the idea for the study. NCH and LT conducted the analyses. NCH, LML, JE, and LP prepared the draft manuscript. All authors reviewed and approved the final manuscript for submission.

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At-a-glance

2015 injury deaths in Canada

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Abstract

Injuries continue to be a public health concern in Canada. National injury death data are essential for understanding the magnitude and pattern of injuries. This paper used the Vital Statistics - Death database to examine deaths associated with injuries in 2015. Injuries were ranked against causes of death, and more in-depth analysis of injury categories was conducted by sex and age. Unintentional injuries were the 6th leading causes of death overall, with different ranking by sex. Among unintentional injury deaths, leading causes included falls, poisonings, motor vehicle traffic collisions, and suffocation, which varied by age group.

Keywords: *mortality, leading causes, injuries, unintentional injuries, suicide, falls, poisonings, motor vehicle traffic collisions*

Highlights

- Ongoing reporting of national injury death data is essential for understanding the trend and burden of injuries at the national level in Canada.
- In 2015, unintentional injuries were the 6th leading cause of death overall and the leading cause for those aged 1–34. Suicide ranked as the 2nd leading cause of death for 15–34-year-olds.
- Falls, poisonings and motor vehicle traffic collisions are the top three leading causes among unintentional injury deaths.

Introduction

An injury is defined as the transfer of energy to human beings at rates and in amounts above or below the tolerance of human tissue. The amount of the energy concentration outside the bands of tolerance of the tissue determines the severity of the injury.[1] The external causes include falls, motor vehicle traffic collisions, poisonings, suffocation, drowning, fire, struck by/against and others.[2] Injuries are classified as either unintentional or intentional. Unintentional injuries occur without an intent of harm such as when someone is hurt from a fall or burn or in a traffic collision.[2] Intentional injuries result from a deliberate act of harm to oneself or another such as suicide or homicide.[2] When the intent is unclear, the injury is classified as undetermined intent.

Injuries are a public health concern both globally and in Canada. Globally, almost 5 million people die from injuries each year, which accounts for 9% of the world's deaths.[3] According to the WHO, road traffic injuries are the leading cause of death among 15–29-year-olds, with suicide and homicide the 2nd and 4th leading causes of death in this population, respectively.[3]

In Canada, injuries claimed 16 094 lives and were the leading cause of death among 1–44-year-olds in 2010.[4] According to the Cost of Injury in Canada Report, injuries were associated with an economic burden of $26.8 billion in Canada in 2010, among which $15.9 billion were from health care expenditures and $10.9 billion were due to reduced productivity from hospitalization, disability and premature death.[4]

Monitoring why and how people die and how diseases and injuries affect people, their families, the health care system and society is important. Ongoing reporting of national injury death data are essential for understanding the trend and burden of injuries at the national level, which is important for targeted injury prevention. This paper provides Canadian statistics on injury deaths for 2015. To highlight the burden of injuries in the context of all causes of death, the paper also provides the leading causes of all deaths, allowing injury categories to be compared to other causes of mortality.

Methods

The data source used was Statistics Canada's Vital Statistics – Death 2015;[5] the causes of death were coded according to ICD-10 (International Statistical Classification of Diseases and Related Health Problems, Tenth Revision).[6] The population estimates on July 1st, 2015, from Statistics Canada[7] were used as the denominator for rate calculation.

The causes of all disease and injury deaths were classified and compared according to the ICD-10 classification. More in-depth analysis was conducted on injury deaths by intent (unintentional, suicide, homicide, legal intervention/war, or undetermined intent), as defined in ICD-10. Select external causes of injury (e.g., poisoning, suffocation) were compared with the exclusion of complications of medical and surgical care whose nature and prevention measures are different from most injuries.[2]

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Pooled and stratified (by sex and age) analyses were undertaken. The SAS Enterprise Guide version 5.1[8] was used to compile the counts and rates.

Results

In the following text, all rates are per 100 000 population and age-standardized rates (ASRs) are based on the 2015 Canadian population with both sexes combined.

Leading causes of all deaths

Table 1 shows the counts and rates for the leading causes of all deaths. Overall, cancer, circulatory and respiratory system diseases ranked as the top three leading causes for both males and females.

Unintentional injuries were the 6th leading cause of death overall (n = 11 833; rate = 33.0), and by sex, the 5th for males and 7th for females. The unintentional injury mortality rate for males (38.8; 95% confidence interval [CI]: 37.9–39.7) was significantly higher than females (27.4; 95% CI: 26.6–28.1). The difference was even larger if the ASRs are examined (43.3; 95% CI: 42.2–44.3 vs. 23.6; 95% CI: 23.0–24.3]). Across all age groups, unintentional injuries ranked among the top eight leading causes. They were the leading cause of death for those aged 1–34, the 2nd leading cause for the ages of 35–44, and 3rd for children less than 1 year of age and for those aged 45–64.

Suicide ranked as the 11th leading cause of death overall and in females, but the 9th in males. It was also among the leading cause among youth and young adults. Suicide was the 2nd leading cause of death among 15–34-year-olds and the 3rd leading cause of death among 10–14- and 35–44-year-olds. Among the older population (45–64 years), suicide was the 6th leading cause of death.

Homicide ranked among the top 10 leading causes of death among young Canadians less than 35 years old. It was the 4th, 5th and 6th leading cause of death among those aged 20–24, 15–19 and 25–34 years respectively.

Leading causes of injury deaths

Table 2 displays the counts and rates of deaths associated with injuries by intent and with additional detail on leading causes of unintentional injuries.

In 2015, there were 17 371 deaths (rate = 48.5) associated with injuries, 10 957 males and 6414 females. Unintentional injuries accounted for 68.1% of total deaths associated with injuries, followed by suicide at 25.4%. Leading causes of death among unintentional injuries included falls (39.8%), poisonings (19.9%), motor vehicle traffic collisions (MVT) (15.8%), followed by suffocation, drowning, fire/flame and struck by/against.

Males had a higher overall injury mortality rate (61.7; 95% CI: 60.5–62.8) than females (35.5; 95% CI: 34.6–36.4). Higher unintentional injury mortality rates were observed in males compared to females for all leading causes except for falls. However, the ASRs associated with falls also showed that males (15.7; 95% CI: 15.0–16.4) exceed females (11.3; 95% CI: 10.8–11.7). Males and females shared similar ranking of leading causes of unintentional deaths, except for drowning and fire/flame; however, when the ranking was examined by age groups, there was greater variation. Suffocation, MVT and poisonings were the leading cause of death, respectively, for those aged less than 1 year, 1–24 years and 25–64 years. For those 65 and over, falls accounted for 64.6% of deaths due to unintentional injury. Suicide resulted in more deaths than any cause of unintentional injuries for those aged 10–64.

Discussion

Injuries can greatly impact individuals, families and societies. This paper provides national injury death statistics by sex and age group that is critical in understanding the magnitude and pattern of injuries for effective prevention initiatives.

In 2015, unintentional injuries are one of the top 10 leading causes of death in Canada, among males and females, and across all age groups (Table 1). Males have a significantly higher mortality rate for unintentional injury compared to females. The difference in ASRs was even larger. Males displayed higher mortality rates than females in all leading causes except falls. However, the ASRs associated with falls also showed that males exceed females. This is primarily due to the facts that there are more females than males in Canada over the age of 60 and that the mortality rate associated with falls increases sharply in the older population. Detailed examination showed that males had higher mortality rates associated with falls compared to females almost across all 5-year age groups. When age differences are examined, the older age categories had much higher mortality rates from unintentional injuries than younger groups, but lower rank than younger groups due to the increase of chronic diseases. This indicates the prevention strategies should differ in various age populations.

Of note is the rise in poisonings to the 2nd leading cause of unintentional injury deaths overall (Table 2). Prior to 2014, MVT was consistently in this position. Further investigation is necessary to understand the role of unintentional poisonings from opioids and other illicit drugs in this increase.[9]

Suicide ranked as the 2nd leading cause of overall death for 15–34-year-olds behind unintentional injuries for 2015 (Table 1); however, when the external causes among unintentional injuries were examined, suicides surpassed unintentional MVT deaths in those aged 15–34 years. This highlights the need for effective suicide prevention in this population.

Limitations

The Canadian Vital Statistics – Death database only reports the underlying cause of death that initiates the train of events leading directly to death[10] and does not include other injuries which may have played a role in death, leading to potential underreporting of injury-related mortality.

This paper is only intended to provide high-level information important for stakeholders to evaluate the burden of injury in comparison to other causes of death to inform injury prevention programs. The data will be updated when newer mortality data become available.

Conclusion

Injuries remain among the leading causes of death for 2015 in Canada. Overall, men have a higher risk of death from unintentional injuries than women; however, the leading causes of death from unintentional injuries vary for Canadians across the lifespan. Unintentional injuries, suicide, and homicide are responsible for many deaths of young Canadians. This paper provides

TABLE 1
Counts and rates (per 100 000 population) of leading causes of all deaths, by sex and age group, Canada, 2015

Rank	All ages n (rate per 100 000)			Age groups n (rate per 100 000)									
	Both sexes	Males	Females	< 1	1–9	10–14	15–19	20–24	25–34	35–44	45–64	65–79	80+
1	Cancer 77 054 (215.0)	Cancer 40 410 (227.4)	Cancer 36 644 (202.8)	Conditions originating from perinatal period 1058 (276.2)	Unintentional injuries[a] 104 (3.0)	Unintentional injuries[a] 52 (2.8)	Unintentional injuries[a] 239 (11.4)	Unintentional injuries[a] 467 (19.0)	Unintentional injuries[a] 940 (18.9)	Cancer 1120 (23.6)	Cancer 17 740 (176.8)	Cancer 31 214 (728.6)	Circulatory system diseases 43 198 (2 875.9)
2	Circulatory system diseases 70 367 (196.4)	Circulatory system diseases 35 437 (199.4)	Circulatory system diseases 34 930 (193.4)	Congenital anomalies 371 (96.9)	Cancer 86 (2.5)	Cancer 45 (2.4)	Suicide 203 (9.7)	Suicide 315 (12.8)	Suicide 675 (13.6)	Unintentional injuries[a] 894 (18.8)	Circulatory system diseases 8397 (83.7)	Circulatory system diseases 17 842 (416.5)	Cancer 26 284 (1 749.9)
3	Respiratory system diseases 25 211 (70.4)	Respiratory system diseases 12 491 (70.3)	Respiratory system diseases 12 720 (70.4)	Unintentional injuries[a] 35 (9.1)[E]	Congenital anomalies 70 (2.0)	Suicide 35 (1.9)[E]	Cancer 59 (2.8)	Cancer 91 (3.7)	Cancer 408 (8.2)	Suicide 674 (14.2)	Unintentional injuries[a] 2485 (24.8)	Respiratory system diseases 7251 (169.3)	Mental and behavioural disorders 16 098 (1 071.7)
4	Mental and behavioural disorders 19 216 (53.6)	Mental and behavioural disorders 7195 (40.5)	Mental and behavioural disorders 12 021 (66.5)	Nervous system diseases 29 (7.6)[E]	Nervous system diseases 41 (1.2)	Nervous system diseases 20 (1.1)[E]	Nervous system diseases 40 (1.9)	Homicide 55 (2.2)	Circulatory system diseases 207 (4.2)	Circulatory system diseases 626 (13.2)	Digestive system diseases 2433 (24.3)	Digestive system diseases 3291 (76.8)	Respiratory system diseases 15 614 (1 039.5)
5	Nervous system diseases 13 490 (37.6)	Unintentional injuries[a] 6890 (38.8)	Nervous system diseases 7514 (41.6)	SIDS 25 (6.5)[E] Endocrine, nutritional and metabolic diseases 25 (6.5)[E]	Respiratory system diseases 27 (0.8)[E]	Endocrine, nutritional and metabolic diseases 14 (0.8)[E]	Homicide 24 (1.1)[E]	Circulatory system diseases 45 (1.8)	Nervous system diseases 102 (2.1)	Digestive system diseases 250 (5.3)	Respiratory system diseases 2116 (21.1)	Endocrine, nutritional and metabolic diseases 3278 (76.5)	Nervous system diseases 8574 (570.8)
6	Unintentional injuries[a] 11 833 (33.0)	Nervous system diseases 5976 (33.6)	Digestive system diseases 5274 (29.2)	Circulatory system diseases 16 (4.2)[E] Infectious and parasitic diseases 16 (4.2)[E]	Circulatory system diseases 20 (0.6)[E] Endocrine, nutritional and metabolic diseases 20 (0.6)[E]	Congenital anomalies 12 (0.6)[E]	Circulatory system diseases 12 (0.6)[E] Respiratory system diseases 12 (0.6)[E]	Nervous system diseases 39 (1.6)	Homicide 101 (2.0)	Endocrine, nutritional and metabolic diseases 146 (3.1)	Suicide 1815 (18.1)	Nervous system diseases 3246 (75.8)	Digestive system diseases 4840 (322.2)

Continued on the following page

TABLE 1 (continued)
Counts and rates (per 100 000 population) of leading causes of all deaths, by sex and age group, Canada, 2015

Rank	All ages n (rate per 100 000)			Age groups n (rate per 100 000)									
	Both sexes	Males	Females	< 1	1–9	10–14	15–19	20–24	25–34	35–44	45–64	65–79	80+
7	Digestive system diseases 10 933 (30.5)	Digestive system diseases 5659 (31.9)	Unintentional injuries[a] 4943 (27.4)	Respiratory system diseases 15 (3.9)[E]	Infectious and parasitic diseases 14 (0.4)[E]	Respiratory system diseases 9 (#)	Endocrine, nutritional and metabolic diseases 11 (0.5)[E]	Endocrine, nutritional and metabolic diseases 26 (1.1)[E]	Endocrine, nutritional and metabolic diseases 91 (1.8)	Nervous system diseases 141 (3.0)	Endocrine, nutritional and metabolic diseases 1586 (15.8)	Mental and behavioural disorders 2300 (53.7)	Unintentional injuries[a] 4772 (317.7)
8	Endocrine, nutritional and metabolic diseases 9914 (27.7)	Endocrine, nutritional and metabolic diseases 5274 (29.7)	Endocrine, nutritional and metabolic diseases 4640 (25.7)	Cancer 7 (#)	Diseases of blood and blood-forming organs and certain disorders involving the immune mechanism 12 (0.3)[E]	Infectious and parasitic diseases 6 (#)	Congenital anomalies 7 (#)	Congenital anomalies 22 (0.9)[E]	Digestive system diseases 86 (1.7)	Respiratory system diseases 110 (2.3)	Nervous system diseases 1258 (12.5)	Unintentional injuries[a] 1845 (43.1)	Endocrine, nutritional and metabolic diseases 4717 (314.0)
9	Genitourinary system diseases 5258 (14.7)	Suicide 3269 (18.4)	Genitourinary system diseases 2797 (15.5)	Homicide 6 (#)	Homicide 11 (0.3)[E]	Circulatory system diseases 4 (#)	Infectious and parasitic diseases 6 (#)	Digestive system diseases 17 (0.7)[E]	Congenital anomalies 45 (0.9)	Infectious and parasitic diseases 102 (2.1)	Infectious and parasitic diseases 903 (9.0)	Infectious and parasitic diseases 1315 (30.7)	Genitourinary system diseases 3681 (245.1)
10	Infectious and parasitic diseases 4964 (13.9)	Genitourinary system diseases 2461 (13.9)	Infectious and parasitic diseases 2539 (14.1)	Diseases of blood and blood-forming organs and certain disorders involving the immune mechanism 5 (#)	Digestive system diseases 7 (#)	Homicide 2 (#) Mental and behavioural disorders 2 (#)	Digestive system diseases 5 (#)	Respiratory system diseases 14 (0.6)[E]	Respiratory system diseases 43 (0.9)	Mental and behavioural disorders 90 (1.9)	Mental and behavioural disorders 675 (6.7)	Genitourinary system diseases 1208 (28.2)	Infectious and parasitic diseases 2563 (170.6)

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TABLE 1 (continued)
Counts and rates (per 100 000 population) of leading causes of all deaths, by sex and age group, Canada, 2015

Rank	All ages n (rate per 100 000)			Age groups n (rate per 100 000)									
	Both sexes	Males	Females	< 1	1–9	10–14	15–19	20–24	25–34	35–44	45–64	65–79	80+
11	Suicide 4405 (12.3)	Infectious and parasitic diseases 2425 (13.6)	Suicide 1136 (6.3)	Digestive system diseases 3 (#)	Conditions originating from perinatal period 2 (#)	Conditions originating from perinatal period 1 (#) Diseases of blood and blood-forming organs and certain disorders involving the immune mechanism 1 (#) Digestive system diseases 1 (#) Genitourinary system diseases 1 (#)	Diseases of blood and blood-forming organs and certain disorders involving the immune mechanism 4 (#) Mental and behavioural disorders 4 (#)	Mental and behavioural disorders 12 (0.5)[E]	Infectious and parasitic diseases 35 (0.7) Mental and behavioural disorders 35 (0.7)	Homicide 80 (1.7)	Genitourinary system diseases 318 (3.2)	Musculoskeletal and connective tissue diseases 534 (12.5)	Musculoskeletal and connective tissue diseases 969 (64.5)
All	All causes 264 333 (737.7)	All causes 133 441 (751.0)	All causes 130 892 (724.6)	All causes 1737 (453.5)	All causes 456 (13.1)	All causes 219 (11.7)	All causes 700 (33.4)	All causes 1273 (51.7)	All causes 3210 (64.7)	All causes 4765 (100.3)	All causes 41 712 (415.8)	All causes 75 444 (1761.1)	All causes 134 817 (8975.5)

Data source: Statistics Canada's Vital Statistics - Death 2015.

Abbreviation: SIDS, suddent infant death syndrome.

Notes: ICD-10 codes for defining the causes: unintentional injuries: V01.0-X59.9, Y85.0-Y86; suicide: X60-X84, Y87.0; homicide: X85-Y09, Y87.1; infectious and parasitic diseases: A00.0-B99; cancer: C00.0-C97; diseases of blood and blood-forming organs and certain disorders involving the immune mechanism: D50.0-D89.9; endocrine, nutritional and metabolic diseases: E00.0-E90; mental and behavioural disorders: F00.0-F99; nervous system diseases: G00.0-G99.8; circulatory system diseases: I00-I99; respiratory system diseases: J00-J99.8; digestive system diseases: K00.0-K93.8; musculoskeletal and connective tissue diseases: M00.0-M99.9; genitourinary system diseases: N00.0-N99.9; conditions originating from perinatal period: P00.0-P96.9; congenital anomalies: Q00.0-Q99.9; SIDS: R95.0-R95.9.

[E] Indicates the coefficient of variation is between 16.6% and 33.3%.

\# Indicates the rate is not reliable since the coefficient of variation is above 33.3%.

[a] Unintentional injuries do not include complications of medical and surgical care.

TABLE 2
Counts and rates (per 100 000 population) of leading causes of injury deaths, by sex and age group, Canada, 2015

	All ages n (rate per 100 000)			Age groups n (rate per 100 000)									
	Both sexes	**Males**	**Females**	**< 1**	**1–9**	**10–14**	**15–19**	**20–24**	**25–34**	**35–44**	**45–64**	**65–79**	**80+**
All injuries (excluding complications of medical and surgical care)[a]	17 371 (48.5)	10 957 (61.7)	6414 (35.5)	45 (11.7)	120 (3.4)	91 (4.9)	486 (23.2)	886 (36.0)	1880 (37.9)	1781 (37.5)	4680 (46.6)	2417 (56.4)	4985 (331.9)
Unintentional injuries (excluding complications of medical and surgical care)[a]	11 833 (33.0)	6890 (38.8)	4943 (27.4)	35 (9.1)[E]	104 (3.0)	52 (2.8)	239 (11.4)	467 (19.0)	940 (18.9)	894 (18.8)	2485 (24.8)	1845 (43.1)	4772 (317.7)
Falls	4711 (13.1)	2187 (12.3)	2524 (14.0)	0 (0)	4 (#)	2 (#)	8 (#)	13 (0.5)[E]	24 (0.5)[E]	48 (1.0)	338 (3.4)	883 (20.6)	3391 (225.8)
Poisonings	2355 (6.6)	1647 (9.3)	708 (3.9)	2 (#)	4 (#)	2 (#)	44 (2.1)	164 (6.7)	479 (9.7)	496 (10.4)	997 (10.0)	125 (2.9)	42 (2.8)
Motor vehicle traffic crashes	1871 (5.2)	1331 (7.5)	540 (3.0)	6 (#)	32 (0.9)[E]	15 (0.8)[E]	141 (6.7)	203 (8.3)	284 (5.7)	201 (4.2)	533 (5.3)	274 (6.4)	182 (12.1)
Suffocation	432 (1.2)	253 (1.4)	179 (1.0)	23 (6.0)[E]	9 (#)	7 (#)	4 (#)	5 (#)	16 (0.3)[E]	10 (0.2)[E]	91 (0.9)	104 (2.4)	163 (10.9)
Drowning	272 (0.8)	200 (1.1)	72 (0.4)	0 (0)	19 (0.5)[E]	8 (#)	12 (0.6)[E]	25 (1.0)[E]	34 (0.7)[E]	25 (0.5)[E]	91 (0.9)	42 (1.0)	16 (1.1)[E]
Fire / Flame	203 (0.6)	121 (0.7)	82 (0.5)	2 (#)	14 (0.4)[E]	8 (#)	7 (#)	5 (#)	15 (0.3)[E]	14 (0.3)[E]	54 (0.5)	57 (1.3)	27 (1.8)[E]
Struck by/against	89 (0.2)	76 (0.4)	13 (0.1)[E]	1 (#)	5 (#)	0 (0)	1 (#)	5 (#)	4 (#)	11 (0.2)[E]	36 (0.4)	16 (0.4)[E]	10 (0.7)[E]
Other unintentional injuries	1900 (5.3)	1075 (6.1)	825 (4.6)	1 (#)	17 (0.5)[E]	10 (0.5)[E]	22 (1.0)[E]	47 (1.9)	84 (1.7)	89 (1.9)	345 (3.4)	344 (8.0)	941 (62.6)
Suicide	4405 (12.3)	3269 (18.4)	1 136 (6.3)	0 (0)	0 (0)	35 (1.9)[E]	203 (9.7)	315 (12.8)	675 (13.6)	674 (14.2)	1815 (18.1)	506 (11.8)	182 (12.1)
Homicide	456 (1.3)	322 (1.8)	134 (0.7)	6 (#)	11 (0.3)[E]	2 (#)	24 (1.1)[E]	55 (2.2)	101 (2.0)	80 (1.7)	132 (1.3)	30 (0.7)[E]	15 (1.0)[E]
Undetermined intent	664 (1.9)	463 (2.6)	201 (1.1)	4 (#)	5 (#)	2 (#)	19 (1.0)[E]	45 (1.8)	162 (3.3)	132 (2.8)	243 (2.4)	36 (0.8)[E]	16 (1.1)[E]
Legal intervention / war	13 (0.0)[E]	13 (0.1)[E]	0 (0)	0 (0)	0 (0)	0 (0)	1 (#)	4 (#)	2 (#)	1 (#)	5 (#)	0 (0)	0 (0)

Data source: Statistics Canada's Vital Statistics - Death 2015.

Notes: ICD-10 codes for the injury groups: all injuries: V01.0-Y36.9,Y85.0-Y87.2,Y89(.0-.9); unintentional injuries: V01.0-X59.9, Y85.0-Y86 [falls: W00-W19; poisonings: X40-X49; motor vehicle traffic crashes: V02-V04 (.1),V02-V04 (.9), V09.2,V12-V14 (.3-.9),V19 (.4-.6),V20-V28 (.3-.9),V29 (.4-.9),V30-V79 (.4-.9),V80 (.3-.5),V81-V82(.1),V83-V86(.0-.3),V87 (.0-.8), V89.2; suffocation: W75-W84; drowning: W65-W74; fire/flame: X00-X09; struck by/against: W20-W22, W50-W52; other unintentional injuries: any codes not in the above unintentional injury categories but within V01.0-X59.9, Y85.0-Y86]; suicide: X60-X84, Y87.0; homicide: X85-Y09, Y87.1; undetermined intent: Y10-Y34, Y87.2, Y89.9; legal intervention/war: Y35.0-Y36.9,Y89(.0-.1).

[E] Indicates the coefficient of variation for rate is between 16.6% and 33.3%.

# Indicates the rate is not reliable since the coefficient of variation is above 33.3%.

[a] ICD-10 codes for complications of medical and surgical care: Y40-Y84, Y88.

useful information to evaluate the burden of injuries and understand the pattern.

Conflicts of interest

All authors declare no conflicts of interest.

Authors' contributions and statement

All authors have read and approved of the content of this article. XY was involved in conceptualization, data analysis, interpretation and manuscript preparation. RS, SM and WT were involved in conceptualization, data interpretation and manuscript preparation.

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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