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Original quantitative research

Cannabis cessation among youth: rates, patterns and academic outcomes in a large prospective cohort of Canadian high school students

Alexandra M. Zuckermann, PhD (1,2); Mahmood R. Gohari, PhD (1); Margaret de Groh, PhD (2); Ying Jiang, MD (2); Scott T. Leatherdale, PhD (1)

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Abstract

Introduction: Following cannabis legalization in Canada, a better understanding of the prevalence of unprompted cannabis use reduction and subsequent effects on youth academic outcomes is needed to inform harm reduction and health promotion approaches.

Methods: We analyzed a longitudinally linked sample ($n = 91\,774$) from the COMPASS prospective cohort study of Canadian high school students attending Grades 9–12 in Ontario and Alberta between 2013–2014 and 2016–2017. We investigated the prevalence of spontaneous cannabis use reduction and cessation between grade transitions (Grades 9–10, 10–11, 11–12) and the effect of cessation on academic achievement (current or recent math and English course marks) and rigour (usual homework completion and past-month truancy).

Results: Only 14.8% of cannabis users decreased their use between grades. Of these, two-thirds made only incremental downward changes, a pattern which held true for all three transitions. Cessation rates from daily and weekly use decreased every year. After cessation, students had better odds than continuing users (OR = 1.23, 95% CI: 1.03–1.48) and worse odds than never-users (OR = 0.55, 95% CI: 0.31–0.97) for some sub-categories of math performance. Students who quit cannabis universally improved class attendance (OR = 2.48, 95% CI: 1.93–3.19) and homework completion (OR = 2.32, 95% CI: 1.85–2.92) compared to continuing users.

Conclusion: Increased academic rigour may underlie any improvements seen in academic performance after cannabis cessation. High school students who use cannabis likely need targeted support to facilitate reduction or cessation and subsequent academic recovery. This indicates that a school-based focus on cannabis harm reduction is justified.

Keywords: *cannabis, cessation, youth, secondary schools, academic performance, truancy*

Introduction

Canadian youth use cannabis at the highest rates globally, and this usage may be becoming more prevalent still.^{1–3} High frequency and early age of initiation of cannabis use have been reliably linked to adverse outcomes in youth, including poor

academic performance, which negatively affect their subsequent adult lives.^{4–9} Many teenagers consider cannabis less harmful than alcohol and underestimate its risks; the perceived comparative safety may dovetail with the recent legalization of cannabis and the concurrent impact on social norms to increase use in this age

Highlights

- Cannabis use change was investigated in a large sample of high school students.
- Only 14.8% who used cannabis reduced their use between grades.
- Most use reductions were incremental.
- Class attendance and homework completion universally improved after cessation.
- Cessation was not sufficient to improve academic performance (course marks).
- Targeted support for high school students who use cannabis is needed.

group.^{10–13} Cannabis use among youth must therefore be a key focus of harm reduction research and policy.

While the factors related to initiation of cannabis use are being increasingly examined, little is known about patterns of spontaneous cannabis reduction or cessation among youth. Studies indicate that youth are less likely to quit using cannabis than other illicit drugs and that those who start young use more heavily, have worse outcomes and are less likely to stop than those who start later.^{4,14,15} A recent review found that hardly any promising interventions for drug abuse in youth have been documented, especially for those under 15 years of age.¹⁶ Evidence on unprompted reductions may be beneficial in aligning substance use intervention

Author references:

1. University of Waterloo, School of Public Health and Health Systems, Waterloo, Ontario, Canada
2. Public Health Agency of Canada, Applied Research Division, Ottawa, Ontario, Canada

Correspondence: Alexandra Zuckermann, University of Waterloo, School of Public Health and Health Systems, 200 University Avenue, Waterloo, ON N2L 3G1; Email: alex.zuckermann@uwaterloo.ca

programs with these trends, increasing their likelihood of success.

Research suggests that young cannabis users who decrease or cease their use improve their outcomes.¹⁶⁻¹⁸ However, most investigations characterize the effects of cessation either in adulthood (following long-term substance use) or in the very short term (days to weeks). Youth who have quit using cannabis have been found to improve their functioning in most neurocognitive domains (e.g. executive function) to the extent of reversing almost all negative effects, except those on learning and memory.^{19,20} However, little is known about medium-term effects (months to a year) of cannabis cessation in adolescence on academic outcomes, which significantly contribute to subsequent life trajectories.

In a study using a population similar to one we use in the current study, Patte et al. describe the negative effect of cannabis use on academic outcomes.⁴ That investigation found that students who began using cannabis were less likely to regularly attend class, complete homework and achieve high marks than students who abstained. However, whether cannabis use cessation reversed or modified these outcomes was not examined. Knowing that cannabis initiation affects academic outcomes, the aim of this work was to determine whether and how cannabis cessation affects such outcomes among youth in the medium term, that is, during their school career and prior to their transition into adulthood.

The objectives of this investigation were to describe the prevalence and rates of cannabis use reductions in youth; to establish their impacts on academic achievement (math and English marks); and to investigate their effect on academic rigour (class attendance and homework completion).

Methods

Study

The prospective cohort study COMPASS collects hierarchical data once a year from a sample of Grade 9–12 students (student-level data) and the secondary schools they attend.²¹ This report used student-level linked-longitudinal²² data from Year 2 (Y2; 2013–2014), Year 3 (Y3; 2014–2015), Year 4 (Y4; 2015–2016) and Year 5 (Y5; 2016–2017). Students were linked over time

with anonymous identifier codes. The COMPASS student-level questionnaire was used during class time to collect data on student demographics and measures relevant to multiple behavioural domains, such as substance use, nutrition, physical activity and mental health, as well as their correlates. Items were based on national guidelines or national surveillance tools as previously described.²¹ Measures used for this report are those for cannabis use frequency, academic achievement in math and English, homework completion and truancy.

A full description of the COMPASS study methods, including a series of in-depth technical reports, and ethical approval is available in print²¹ and online (www.compass.uwaterloo.ca).

Data

Data were collected from a convenience sample of secondary schools in Ontario ($n = 79$) and Alberta ($n = 10$) that permitted use of active-information passive-consent parental permission protocols.²¹ Y2 data were collected from 45 298 students in the 89 schools (79.2% participation rate, mean [SD] age 16.0 [5.8] years); Y3 data from 42 355 students in 87 schools (78.8%, 16.0 [6.1] years); Y4 data from 40 436 students in 81 schools (79.9%, 16.1 [6.5] years); and Y5 data from 43 245 students in 88 schools (76.6%, 16.0 [6.1] years).

Three-quarters (75.6%) of students identified their race/ethnicity as White. A further 10.9% reported “Other/mixed,” 5.3% Asian, 3.6% Black, 2.7% Aboriginal and 1.9% Latin American/Hispanic race/ethnicity.

Data were linked between any two consecutive years,²³ resulting in a dataset containing 91 774 linked reports generated by 37 231 students (51.9% female). To model longer-term effects of cessation, students were linked for three consecutive years, resulting in 42 861 reports generated by 13 476 students (52.2% female). The reduction in sample size was as a result of students missing data collection due to scheduled spares, absences from class for other reasons or changing schools between data collections.

As previously reported,²³ COMPASS students who could not be linked were more

likely to report use of cannabis, alcohol and tobacco.

Cannabis use

Consistent with national surveillance measures on youth substance use,²⁴ students were asked, “In the last 12 months, how often did you use marijuana or cannabis?” One of nine responses was possible: “I have never used marijuana,” “I have used marijuana but not in the last 12 months,” “Less than once a month,” “Once a month,” “2 or 3 times a month,” “Once a week,” “2 or 3 times a week,” “4 to 6 times a week” and “Every day.” Consistent with previous work,⁴ responses were recoded for analysis into non-use (never used or no use in the past 12 months); rare (less than once a month); monthly (1–3 times a month); weekly (1–6 times a week); and daily (every day) use.

The rates of non-response to this question were 1.7% (Y2), 1.5% (Y3), 1.6% (Y4) and 1.5% (Y5).

In the two-year linked sample, changes in cannabis use frequency from baseline to follow-up were categorized as non-use (no use at baseline or follow-up); use (use reported at both time points with frequency remaining constant or increasing between time points); reduction (use reported at both time points with frequency decreasing from baseline to follow-up); and cessation (cannabis use reported at first time point with non-use reported at the second). Students reporting continued non-use at second follow-up a year later (cannabis use pattern Yes–No–No) were included in the “continuing cessation” group. The two reference groups consisted of “continuing users” who reported use and “never-users” who reported non-use at all relevant time points.

Substance use variables

Students were asked the following questions: “On how many of the last 30 days did you smoke one or more cigarettes?” and “In the last 12 months, how often did you have 5 drinks of alcohol or more on one occasion?” Students who indicated they had smoked at least one cigarette in the last 30 days were classified as current smokers, while students who reported drinking five or more alcoholic drinks at least once a month were classified as current binge drinkers.

Academic variables

Students were asked about their academic performance with two questions, one each for math and English performance: "In your current or most recent Math/English course, what is your approximate overall mark?" The same seven response options were given for both subjects: "90–100%," "80–89%," "70–79%," "60–69%," "55–59%," "50–54%" and "less than 50%." Consistent with previous work,⁴ the last three options were recoded into "less than 60%" and used as the reference category during analysis.

Students were then asked about their academic rigour with two questions. The first asked about truancy, "In the last 4 weeks, how many classes did you skip when you were not supposed to?" There were six response options: "0 classes," "1 or 2 classes," "3 to 5 classes," "6 to 10 classes," "11 to 20 classes" and "more than 20 classes." For the analysis, the first option (no classes skipped) was used as given, with the remaining options recoded into "1–5 classes skipped" (options 2 and 3) and "6 or more classes skipped" (options 4 to 6). The latter was used as the reference category. The second question to do with academic rigour asked about homework completion with the question "How often do you go to class without your homework complete?" Four response options were offered: "never," "seldom," "often" and "usually." For the analysis, "usually" was used as the reference category. Baseline missing rates for these variables were 2.6% (math mark), 3.1% (English mark), 1.8% (truancy) and 2% (homework completion).

Statistical analysis

Analyses were conducted in SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). A multinomial logit transition model was used to account for bivariate dependencies between observations at two consecutive time points. The transition model, as a type of Markov model, concentrates on overall gross changes between consecutive occasions, for example, before and after a school grade transition. The multinomial logit transition model is a regression model in which the odds of choosing higher categories of the response variable rather than other categories are assumed to depend on the values of response(s) in previous time points.²⁵

The transitional model used here is the first-order Markov model in which Y_t is assumed to depend only on the state at $t - 1$, and not on responses at earlier occasions. This modelling approach is well-established and has previously been used to analyse transitions in similar contexts.^{26,27} Here, log odds of cannabis use status at time t rather than the reference category of non-user are described as:

$$\log \left(\frac{p(Y_{it} = j | X_{it}, Y_{it-1})}{p(Y_{it} = 1 | X_{it}, Y_{it-1})} \right) = \beta X_{ij} + \alpha_1 Y_{it-1} \quad j = 2,3,4$$

where Y_{it-1} denotes the response of individual i at previous cannabis use status, X represent the vector of covariates with the corresponding coefficients of β , and j indicates cannabis use status. Available case analysis was used for multinomial regression models, which were adjusted for grade, current smoking, current binge drinking and academic performance at baseline.

Results

Sample characteristics

Of the reports contained in the sample, 20.9% ($n = 18916$) included cannabis use at any level (Table 1). Rates of binge drinking were similar (19.1%) while smoking rates were substantially lower (8.3%). Cannabis use prevalence steeply decreased with increasing frequency of use, such that approximately two-thirds (68.9%) of use reports described monthly or rare use and one-third (31.1%) recorded weekly or daily use. Male students were more likely to report substance use of any category.

Reports of academic performance favoured female students for both math and English marks. Female students were also more likely to never attend class without homework complete and were less likely to have not skipped any classes in the preceding four weeks. Male students were more likely to report skipping more than six classes. Overall, less than one-third of reports indicated skipped classes or leaving homework incomplete often or usually.

Reduction and cessation rates

Only 14.8% ($n = 2805$) of cannabis use reports showed any magnitude of decrease in frequency, with total cessations ($n = 1596$) being the most common (56.9%). Decreases from low levels of use accounted for a

sizable proportion of total reports, with 42.7% of reductions from monthly to rare (Figure 1A) and 56.6% of cessations from rare use (Figure 1B). The majority (78.4%) of reductions reported ($n = 948$) were incremental, that is, from one frequency category to the next lowest. Taken together with the high number of cessation reports from rare use, two-thirds (66.0%) of reported decreases were between adjacent use categories.

Reduction rates (Figure 1C) were highest between adjacent use categories, with cessation rates (Figure 1D) peaking at either end of the frequency spectrum (rare and daily use). This pattern held true for both male and female students and the three grade transitions examined. Reductions were most likely to occur from monthly to rare use (5.2-fold), with those from daily use lower by 1.3-fold (to weekly), 2.5-fold (to monthly) and 3.0-fold (to rarely). Reductions from weekly use also occurred 1.2-fold (to monthly) and 2.4-fold (to rare) less often. Cessations from daily use occurred at rates 1.4-fold lower than those from rare use, with those from monthly and weekly use (1.8- and 2.0-fold) still less prevalent.

Several different trajectories were observed for individual rates. Cessation rates from daily and weekly use decreased with grade (-5.6% and -6.6% in total, respectively) as did the rate of reductions from weekly to rare use (-1.8%). Continuing increases between grades were observed for reduction rates from daily to rare ($+2.1\%$), weekly to monthly ($+2.6\%$) and monthly to rare use ($+4.7\%$). Rates of reduction from daily to monthly and cessation from rare use first decreased (-3.2% and -1.6% , respectively) and then plateaued ($\pm 0.0\%$ and $+0.7\%$, respectively) with advancing grade, while the reverse was true of cessations from monthly use ($+0.3\%$, then -2.0%) and reduction from daily to weekly use (1.6% , then -1.8%).

Total average cessations rates decreased (-3.7%) and total average reduction rates slightly increased ($+0.7\%$) with increasing grade. The highest average rates were reported for cessations from rare use and for reductions from monthly to rare use, while the lowest were observed for reductions from daily use to rare and monthly use. On average, the

TABLE 1
Substance use and academic performance at baseline of all reports collected from high school students taking part in COMPASS between 2013/2014 and 2016/2017

	Total (%)	Female (%)	Male (%)	p value
Cannabis use				
Total	18 916 (20.9)	9 634 (20.7)	9 282 (21.8)	< .001
Daily	2 062 (2.3)	684 (1.5)	1 378 (3.2)	< .001
Weekly	3 820 (4.2)	1 691 (3.6)	2 129 (5.0)	
Monthly	5 101 (5.6)	2 661 (5.7)	2 440 (5.7)	
Rarely	7 933 (8.8)	4 598 (9.9)	3 335 (7.8)	
Tobacco smoking				
Total	7 438 (8.3)	3 476 (7.4)	3 962 (9.2)	< .001
Binge drinking	17 210 (19.1)	8 461 (18.1)	8 749 (20.3)	< .001
Grade				
9	20 208 (22.5)	10 255 (21.9)	9 953 (23.1)	
10	29 264 (32.5)	15 117 (32.3)	14 147 (32.8)	
11	24 970 (27.8)	13 257 (28.4)	11 713 (27.2)	
12	15 438 (17.2)	8 124 (17.4)	7 314 (16.9)	
Math course mark				
100–90%	17 774 (20.2)	9 767 (21.3)	8 007 (19.1)	< .001
89–80%	26 406 (30.0)	14 480 (31.5)	11 926 (28.4)	
79–70%	21 657 (24.6)	10 965 (23.9)	10 692 (25.5)	
69–60%	12 155 (13.8)	6 072 (13.2)	6 083 (14.5)	
≤ 59%	9 914 (11.4)	4 662 (10.1)	5 255 (12.5)	
English course mark				
100–90%	12 114 (13.8)	8 252 (17.9)	3 862 (9.3)	< .001
89–80%	34 481 (39.3)	20 197 (44.0)	14 284 (34.2)	
79–70%	26 667 (30.4)	12 147 (26.4)	14 520 (34.7)	
69–60%	9 659 (11.0)	3 755 (8.2)	5 904 (14.1)	
≤ 59%	4 828 (5.5)	1 597 (3.5)	3 231 (7.7)	
Attend class without homework complete				
Never	18 175 (20.2)	10 557 (22.4)	7 618 (17.7)	< .001
Seldom	48 857 (54.2)	26 289 (55.9)	22 568 (52.4)	
Often	15 979 (17.7)	7 220 (15.3)	8 759 (20.3)	
Usually	7 140 (7.9)	3 012 (6.4)	4 128 (9.6)	
Classes skipped in past 4 weeks				
0	67 695 (75.0)	34 784 (73.8)	32 911 (76.4)	< .001
1–5	19 905 (22.1)	11 094 (23.5)	8 811 (20.4)	
6+	2 637 (2.9)	1 245 (2.7)	1 392 (3.2)	

Notes: Sample contains individuals linked for any two consecutive years. Values indicate reports. Pertinent *p* values for gender differences are given.

combined reduction and cessation rate decreased with increasing grade (–1.5%).

Effect of cessation on academic performance

Students who ceased cannabis use improved in some aspects of academic achievement compared to those who continued to use (Table 2). At first follow-up (Year 2), those students who quit using cannabis had significantly higher odds

(OR = 1.23, 95% CI: 1.03–1.48) of achieving a math mark of 80–89% (compared to one of less than 60%); at second follow-up (Year 3), they had significantly higher odds (OR = 2.01; 95% CI: 1.08–3.71) of achieving a math mark of 90–100%. There was no difference in their odds of achieving higher English marks compared to continuing users at either follow-up. In addition, the nonsignificant improvements in odds seen at first follow-up were mostly reversed at second follow-up.

Compared to never-users, continuing abstainers mostly did not have significantly different odds of achieving math or English marks above 60%. A difference was observed for a single category, at second follow-up, where abstainers had significantly lower odds of achieving math (OR = 0.55, 95% CI: 0.31–0.97) and English (OR = 0.48, 95% CI: 0.24–0.95) marks between 80% and 89%. All nonsignificant odds ratios, compared to never users, were less than 1.

Overall, few significant differences were observed, and confidence intervals increased at second follow-up. Cessation and continued abstinence led to some improvements in math marks compared to continuing users, but negative differences to never-users remained; this was also observed for English marks. Simultaneously, confidence intervals increased between the first and second follow-up by up to 5-fold—at least by 2-fold for most categories and by 2.37-fold on average.

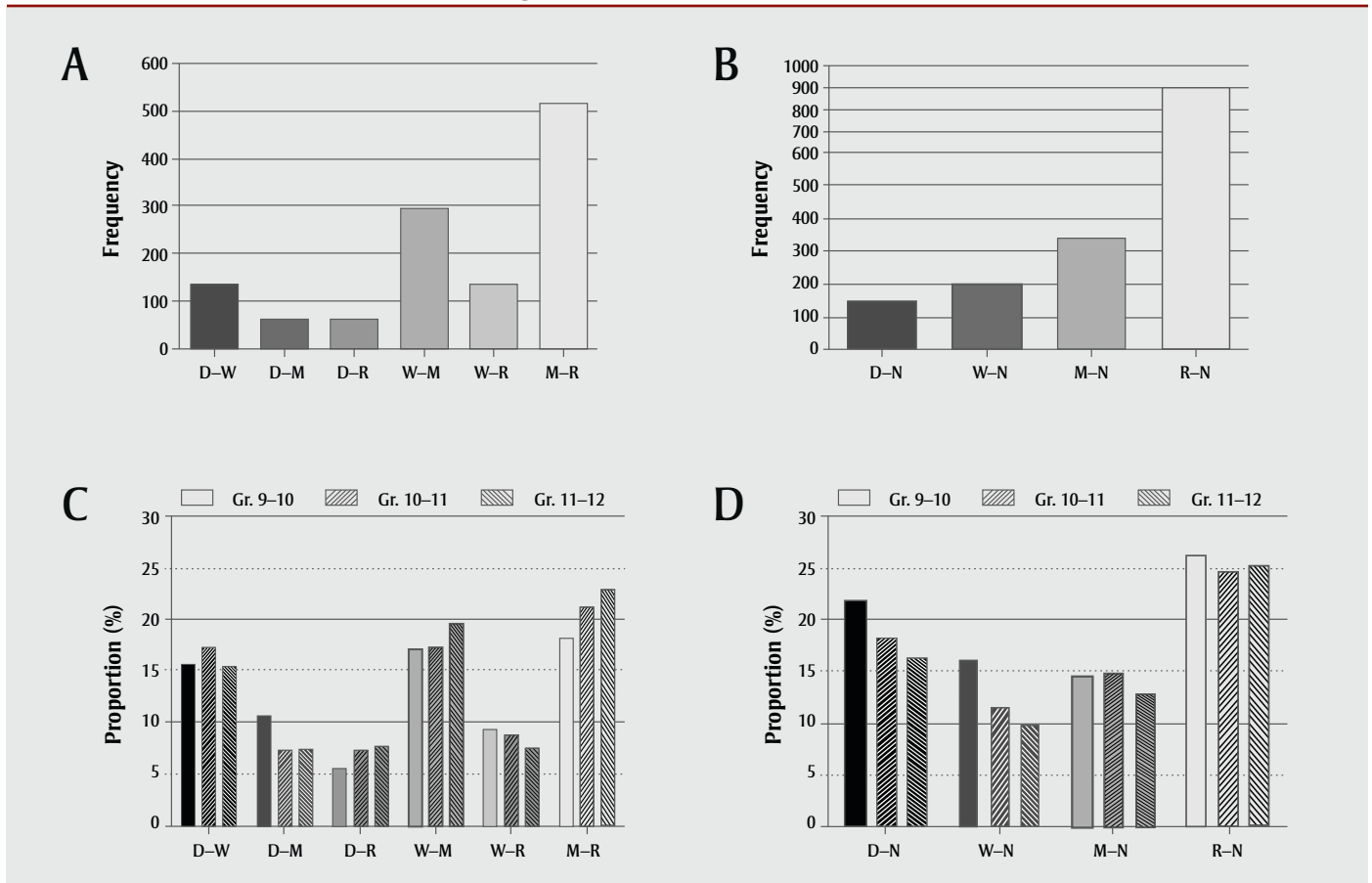
Effect of cessation on academic rigour

Cannabis cessation had a beneficial effect on academic rigour (Table 3). Students who quit using cannabis had significantly higher odds of never (OR = 2.32, 95% CI: 1.85–2.92) or seldom (OR = 1.52, 95% CI: 1.25–1.85) attending class without their homework complete compared to students who continued using. Those who continued to abstain also had significantly higher odds at second follow-up of never (OR = 2.52; 95% CI: 1.19–5.34) leaving their homework incomplete.

Cessation significantly improved students' odds of skipping no (OR = 2.48, 95% CI: 1.93–3.19) or less than six (OR = 1.45, 95% CI: 1.13–1.86) classes, with continuing abstinence also significantly improving odds of never skipping class (OR = 4.12, 95% CI: 1.78–6.49).

Students who stopped using cannabis and/or continued to abstain from use did not differ significantly from never-users in terms of their odds of completing homework and attending class. They had similar odds of completing homework and lower (though nonsignificant) odds of skipping less than six classes. However, confidence interval ranges for all measures increased 3.5-fold on average between the first and second follow-up.

FIGURE 1
Cannabis use reduction and cessation frequencies and proportions among high school students taking part in COMPASS between 2013/2014 and 2016/2017



Abbreviations: D, daily; M, Monthly; N, no use; R, rarely; W, weekly.

Notes: Figures A and B: Total frequencies of reductions (A) and cessations (B) reported in the study sample. Frequency of use is described by letter abbreviations. The letter before the dash indicates frequency of use at a given baseline; the letter after the dash indicates frequency of use at follow-up a year later.

Figures C and D: Proportion of reductions (C) in and cessations (D) of cannabis use by grade step. Data are reports by individuals linked for any two consecutive grades (baseline and follow-up). Each column represents the proportion for a given magnitude of change. Grade labels indicate grade at baseline before the dash and grade at follow-up after the dash.

Discussion

To our knowledge, this study is the first to describe incidence and rates of cannabis cessation among Canadian high school students. In this large sample, very few students reduced their use. Though half of those reductions were complete cessations, this result may be explained by proportionally higher rates of cessation from commonly occurring rare use. This suggests that a large contingent of students who experiment with cannabis as part of normal risk-taking behaviour never transition to regular use. Rates for cessation from daily use were second most common, potentially because students using at such a high frequency are liable to be severely affected in their daily lives^{4,28} and more likely to perceive this as a problem themselves and to be targeted by parents and teachers as in need of intervention.

Overall reduction rates decreased as students aged, a finding in accordance with previously published studies.^{14,29}

Few regular users spontaneously reduce their use. As any decrease in cannabis use will improve health status, universal intervention programs are necessary to broadly promote cannabis use reduction and cessation.

Most reductions observed in this sample were by one frequency category only, which may be an indication of both the lack of impetus for and the difficulty of more extensive change. This conclusion is in part derived from knowledge of their institutional environment: none of the schools participating in the COMPASS study reported implementing programs to promote cannabis use reduction or cessation. Reviews of the evidence on drug use

interventions have found that effective programs include aspects of self-control training and social norm adjustments, with the most commonly relied-on knowledge-based efforts insufficient to prompt change.^{16,30}

Canadian youth perceive cannabis as less harmful and easier to quit than other substances while describing long-term negative effects on behaviour after cessation.¹³ In line with this, the lowest average cessation rate was observed among weekly users, who, though significantly affected in terms of their academic achievement,⁴ are more likely than monthly users to experience withdrawal^{31,32} and less likely than daily users to perceive a problem with their use.^{13,33} The low rates observed for high magnitude reductions and cessations from weekly use suggest that many regular users persist in behaviours that will significantly increase their morbidity

TABLE 2
Impact of cessation of cannabis use on odds of improved academic performance among high school students taking part in COMPASS between 2013/2014 and 2016/2017

	Nominal odds (95% CI) per course mark range			
	60–69%	70–79%	80–89%	90–100%
Cessation and continuing abstinence vs. continuing use (Ref.)				
Mathematics vs. ≤ 59% (Ref.)				
Cessation (Follow-up 1)	1.05 (0.87–1.27)	1.19 (1.00–1.42)	1.23 (1.03–1.48)*	1.20 (0.97–1.49)
Continued cessation (Follow-up 2)	0.80 (0.42–1.50)	1.17 (0.68–1.99)	0.95 (0.53–1.72)	2.01 (1.08–3.71)*
English vs. ≤ 59% (Ref.)				
Cessation (Follow-up 1)	1.11 (0.87–1.41)	1.20 (0.96–1.50)	1.18 (0.94–1.49)	1.26 (0.95–1.67)
Continued cessation (Follow-up 2)	0.67 (0.30–1.50)	0.84 (0.42–1.69)	0.69 (0.34–1.41)	1.07 (0.47–2.43)
Cessation and continuing abstinence vs. never use (Ref.)				
Mathematics vs. ≤ 59% (Ref.)				
Cessation (Follow-up 1)	0.96 (0.80–1.16)	0.98 (0.82–1.17)	0.92 (0.76–1.11)	0.83 (0.66–1.05)
Continued cessation (Follow-up 2)	0.64 (0.36–1.15)	0.78 (0.48–1.30)	0.55 (0.31–0.97)*	0.94 (0.50–1.78)
English vs. ≤ 59% (Ref.)				
Cessation (Follow-up 1)	0.92 (0.72–1.18)	0.92 (0.73–1.15)	0.86 (0.67–1.10)	0.83 (0.61–1.13)
Continued cessation (Follow-up 2)	0.63 (0.30–1.32)	0.60 (0.31–1.15)	0.48 (0.24–0.95)*	0.57 (0.26–1.26)

Abbreviations: CI, confidence interval; Ref., reference.

Notes: Reports from students linked for consecutive years who use cannabis in the first year and abstain in the following year (Follow-up 1, pattern Yes–No) or two years (Follow-up 2, pattern Yes–No–No) with those who continue to use (Yes–Yes or Yes–Yes–Yes, respectively). Comparison of year 1 with year 2 or 3, respectively. Models corrected for marks at baseline, current binge drinking and current smoking.

* $p < .01$.

burden. These students, of key concern from a public health perspective, may benefit most from targeted interventions promoting small changes as a stepping-stone to ultimate cessation.

Previous work on a similar sample of COMPASS students found that all levels of cannabis use significantly and negatively affects academic achievement, leading to lower course marks in both math and

English.⁴ In this work, students who ceased use did not significantly differ from never-users in terms of their course marks; neither were many significant differences to continuing users found. Our

TABLE 3
Impact of cessation of cannabis use on odds of improved academic rigour^a among high school students taking part in COMPASS between 2013/2014 and 2016/2017

	Nominal odds (95% CI) per homework noncompletion and truancy		
	Never	Seldom	Often
Cessation and continuing cessation vs. continuing use (Ref.)			
No homework vs. usually (Ref.)			
Cessation (Follow-up 1)	2.32 (1.85–2.92)*	1.52 (1.25–1.85)*	1.22 (0.99–1.50)
Continued cessation (Follow-up 2)	2.52 (1.19–5.34)*	1.33 (0.70–2.53)	1.29 (0.66–2.52)
Classes skipped vs. 6 or more (Ref.)			
Cessation (Follow-up 1)	2.48 (1.93–3.19)*	1.45 (1.13–1.86)*	–
Continued cessation (Follow-up 2)	4.12 (1.78–6.49)*	1.68 (0.73–3.89)	–
Cessation and continuing abstinence vs. never use (Ref.)			
No homework vs. usually (Ref.)			
Cessation (Follow-up 1)	1.18 (0.94–1.49)	1.02 (0.84–1.24)	0.99 (0.81–1.23)
Continued cessation (Follow-up 2)	1.36 (0.67–2.76)	0.99 (0.54–1.82)	1.18 (0.64–2.19)
Classes skipped vs. 6 or more (Ref.)			
Cessation (Follow-up 1)	0.78 (0.58–1.03)	0.93 (0.70–1.23)	–
Continued cessation (Follow-up 2)	0.63 (0.26–1.55)	0.75 (0.35–1.99)	–

Abbreviations: CI, confidence interval; Ref., reference.

Notes: Reports from students linked for consecutive years who use cannabis in the first year and abstain in the following year (Follow-up 1, pattern Yes–No) or two years (Follow-up 2, pattern Yes–No–No) with those who continue to use (Yes–Yes or Yes–Yes–Yes respectively). Comparison of year 1 with year 2 or 3 respectively. Models corrected for homework completion and truancy at baseline, current binge drinking and current smoking.

^a Homework completion and truancy.

* $p < .01$.

modelling indicates that, compared to continued use, cessation may improve math performance, a differential effect that may be partially explained by the effects of cannabis use being more harmful on English than on math scores.⁴ Self-reports of math-related academic achievement tend to be more accurate than those relating to language studies, which are more consistently (if only slightly) overreported.³⁴ Applied to our study, these data further underline the likelihood of differential impacts of cannabis cessation. Neurocognitive studies also suggest a greater effect of cannabis use on language skills and verbal IQ, as well as a faster post-cessation recovery of executive function skills, which underlie mathematical reasoning.^{19,20,28,35} However, these studies also show that negative effects on memory and learning, likely to markedly hinder academic performance, remain in the long term. In addition, the withdrawal process itself may impede functioning and obstruct academic recovery.³⁶ The increasing confidence interval ranges in our data suggest that individual trajectories vary widely and the comparatively lower odds ratios of improved performance in ex-users suggest that cessation may be insufficient to recover academic performance.

While academic outcomes were only slightly affected by cannabis use cessation, regular class attendance and homework completion were significantly and overwhelmingly improved compared to continued use. Ex-users did not significantly differ from never-users in these measures. This suggests that improved academic rigour may underlie much of any improvement seen in academic performance. However, in view of the relatively small scale of those improvements, this also suggests that always attending class and completing homework is insufficient to reverse the negative effects of cannabis use on academic outcomes. Taken together, our data indicate that students may require additional academic support following cannabis cessation to achieve or regain their potential. This may seem intuitive, given that course content routinely builds on what has been studied previously and that regular users may have underperformed for several years before quitting cannabis use, but in practice interventions often focus exclusively on reducing drug use and do not consider the need for additional academic support.¹⁶

In the light of the recent cannabis legalization, a focus on educational support post-cessation may be integral to attenuating the harmful effects of increased cannabis use among youth. Future work should aim to understand which students are targeted or referred for cannabis use cessation; to establish whether a step-wise approach to cannabis use reduction results in higher reduction or cessation rates; and to determine how academic support measures can feasibly be integrated into harm reduction programs to improve student outcomes. Overall, more evidence is needed on the medium-term outcomes following cannabis cessation in adolescence.

Strengths and limitations

The strengths of the COMPASS study include its prospective design, the verified validity of survey measures based on national guidelines or surveillance tools,²¹ the large sample size and the linkage of individuals between collection points. The latter inherently accounts for interindividual variability of time-stable covariates, removing some sources of potential confounding. Models accounted for academic performance at baseline, further accounting for factors that may influence both cannabis use change and academic outcomes.

This study also has several limitations. Self-report questionnaires are subject to recall and social desirability biases, leading to potential underreporting of cannabis consumption. However, report linkage may account for individual differences and therefore mitigate overall response bias. Individuals maintaining a high frequency of cannabis use are more likely to drop out,³⁷ leading to potential overreporting of reduction or cessation rates in our longitudinal study.

Previous work has found that students who quit using cannabis are less likely to co-use multiple substances.³⁸ As this mode of engagement carries fewer risks than poly-substance use and is therefore likely to lead to better outcomes, this may have resulted in an overestimation of the benefits of cessation in our work.

As students were followed over two to three years, results should be interpreted with caution in terms of potential effects in the longer term. Students may have changed over time in terms of factors pertinent to academic performance and cannabis use change. As a result, residual

confounding may have affected analyses, though it is unlikely that this variation would be so consistently pronounced as to notably affect results.

The schools included in our study were from a convenience sample and the results are therefore not generalizable. However, utilizing a passive-consent protocol decreased opportunities for introducing selection biases within schools while the large sample size suggests that results will apply to a substantial proportion of high school students in the provinces studied (Alberta and Ontario).

Conclusion

This study showed that few high school students who use cannabis reduce their use; that most of those who do take only incremental steps towards cessation; and that weekly users are the most likely to maintain their use. Post-cessation, some improvements in academic achievement were described, likely due to the observed comprehensive increase in class attendance and homework completion. However, most students may require additional academic support to counteract lingering negative effects. In the context of legalization, targeted school-based focussed support to attenuate the harmful effects of increased cannabis use is justified.

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Conflict of interest

None.

Authors' contributions and statement

All authors contributed to the design of the work. MG analyzed the data; AZ and MG interpreted the data; MdG, YJ and SL contributed to the interpretation of the data; AZ drafted the manuscript; and all authors revised the manuscript.

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Evidence synthesis

Physical activity and social connectedness interventions in outdoor spaces among children and youth: a rapid review

Alexander Wray, HBES (1,2); Gina Martin, PhD (1,2); Emma Ostermeier, HBSc (1,2); Alina Medeiros, HBHSc (1,2); Malcolm Little, HBA (1,2); Kristen Reilly, PhD (1,2); Jason Gilliland, PhD (1,2,3)

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Abstract

Introduction: The rise in sedentary behaviour, coupled with the decline in overall mental health among Canadian children and youth in recent decades, demonstrates a clear need for applied research that focusses on developing and evaluating cross-disciplinary interventions. Outdoor spaces provide opportunities for physical activity and social connectedness, making them an ideal setting to address these critical health concerns among children and youth.

Methods: We conducted a rapid review of peer-reviewed ($n = 3096$) and grey literature ($n = 7$) to identify physical activity and/or social connectedness outdoor space interventions targeted at children and youth (19 years and under) in Australia and New Zealand, Canada, Europe and the United States. We determined if interventions were effective by analyzing their research design, confidence intervals and reported limitations, and then conducted a narrative synthesis of the effective interventions.

Results: We found 104 unique studies, of which 70 (67%) were determined to be effective. Overall, 55 interventions targeted physical activity outcomes, 10 targeted social connectedness outcomes and 5 targeted both. Play ($n = 47$) and contact with nature ($n = 25$) were dominant themes across interventions, with most taking place in a school or park. We report on the identifying features, limitations and implications of these interventions.

Conclusion: The incorporation of natural and play-focussed elements into outdoor spaces may be effective ways to improve physical activity and social connectedness. There is a considerable need for more Canadian-specific research. Novel methods, such as incorporating smartphone technology into the design and evaluation of these interventions, warrant consideration.

Keywords: *environment design, exercise, social capital, recreational park, nature, adolescent, child, review*

Introduction

Adequate amounts of daily physical activity are important for the optimal growth and development of children and youth. Routine moderate-to-vigorous physical activity is linked to multiple health benefits including reduced risk of high blood pressure, obesity, heart disease, stroke, different

types of cancer and depression.^{1,2} Beyond health indicators, additional moderate-to-vigorous physical activity has been linked to greater academic achievement, improved cognitive performance and higher self-esteem.³

Social connectedness has also been linked to outdoor spaces, although the evidence

is not as robust as for the link between physical activity and outdoor spaces. Green spaces have been linked to a stronger sense of place which, in turn, leads to stronger community identity and more vibrant relationship networks.⁴ Other individual and group-level factors affect social connectedness, but outdoor spaces can reinforce these associations.^{5,6} For example, recreational activities in neighbourhood outdoor spaces provide opportunities for interaction with others, thus promoting

Highlights

- Contact with nature and play are integral elements of interventions that effectively promote higher physical activity and improve social connectedness among children and youth in outdoor spaces.
- Technology is an emerging delivery mechanism for outdoor-based interventions that target physical activity and social connectedness outcomes among primary school (5–12 years old) and teenage (13–19 years old) populations.
- Youth (13–19 years old) are an understudied population for interventions with physical activity and social connectedness outcomes.
- Canadian-specific research about physical activity and social connectedness among children and youth in outdoor spaces is limited, even though there is government policy tailored to address these activities.

Author references:

1. Human Environments Analysis Lab, Department of Geography, Western University, London, Ontario, Canada
2. Children's Health Research Institute, London, Ontario, Canada
3. School of Health Studies, Department of Paediatrics, Department of Epidemiology & Biostatistics, Western University, London, Ontario, Canada

Correspondence: Jason Gilliland, Social Science Centre Rm. 2333, 1151 Richmond Street, London, ON N6A 3K7; Email: jgillila@uwo.ca

the formation of social connections across populations.^{5,7}

The notable decline in physical activity levels and rise in a sense of social isolation experienced by Canadian children and youth in recent decades demonstrates a clear need for applied research that focusses on developing and evaluating interventions to address physical activity and social interaction.^{8,9} Outdoor spaces, which we define as including all natural, water, sporting, playground and hard-scaped public open spaces, typically provide opportunities to connect with nature, pursue recreational activities and facilitate social connection.¹⁰ Such spaces provide ideal settings, in our view, to deliver interventions that address physical inactivity and lack of social interaction.¹¹

Interaction with outdoor spaces, specifically natural and naturalized urban spaces, has been associated with positive outcomes across physical, mental, social, emotional and cognitive measures of health and well-being.^{7,12,13} Areas with naturally derived obstacles—dynamic play-scapes—can particularly encourage children and youth to engage in active, thrilling and risky play. These opportunities for play can independently test their abilities and limits, thereby fostering the development of social resilience.^{14,15}

Outdoor spaces play an important role in encouraging physical activity and promoting social contact between children and youth.^{5,16} Specifically, research has found a positive relationship between naturalized spaces and leisure-time activities, such as active play, walking and cycling.⁵ Trails in outdoor spaces may be suitable for active transportation, which is an effective way for children and youth to achieve recommended levels of daily physical activity.¹⁷ Further, the natural aesthetic of these environments significantly increases the desirability of walking and cycling.¹⁸

While substantial cross-sectional evidence exists on the effects of outdoor settings on various dimensions of mental health, there has been little research on how such spaces can be designed to increase social connection.¹² Childhood wellness has been directly tied to social connection.¹⁹ Specifically, increased interactions between children and youth appear to improve social skills, which increases social

connection to others.²⁰ The creation of positive relationships at a young age may protect against poor health outcomes later in life.^{20,21} On the contrary, poor social relationships at younger ages have been associated with substance abuse, depression, anxiety, poor relationships and decreased academic performance in late youth.²² Social connection and physical activity are routinely shaped by outdoor space, making it an ideal setting for population health interventions.

The links between the characteristics of outdoor spaces and physical activity or social connectedness show how built environment factors influence health behaviours in children and youth. However, to understand how physical activity and social connectedness, in particular, may be improved through outdoor spaces, we need to examine interventions that target both these spaces and populations. Much of the evidence base that focusses on the role of outdoor spaces in shaping physical activity and social connectedness is cross-sectional, with little testing of interventions that alter health behaviours through environmental or social modifications.^{4-6,8,9,19} Accordingly, this review identifies and synthesizes peer-reviewed and grey literature that addresses outdoor space interventions targeted at physical activity and/or social connectedness among children and youth.

Rationale

The Chief Public Health Officer of Canada's *Report on the State of Public Health in Canada 2017: Designing Healthy Living* explored the influences of community design and infrastructure on physical and mental health.²³ Outdoor spaces, such as parks, public plazas, forests and trails, were identified as important settings for promoting change that positively affects the health of the Canadian population. Federal, provincial and territorial governments have also recognized the importance of these spaces and places in shaping physical activity through the *2018 Common Vision for Increasing Physical Activity and Reducing Sedentary Living in Canada: Let's get moving*.¹¹ This document recognizes that children and youth are the most efficient population to receive targeted interventions given the ability to build the foundations for lifelong healthy habits. In addition, interventions targeted at children and youth could promote healthier and more socially engaging

environments that are beneficial to everyone. Although all populations are equally deserving of intervention-based research and policy initiatives, research focussing on adult populations was beyond the scope of this review.

To investigate the Public Health Agency of Canada's policy priority of increasing physical activity and improving social connectedness among children and youth, we undertook a rapid review of outdoor space interventions. Our aim was to identify interventions that have the greatest positive effects on childhood physical activity and social connectedness. This review critically synthesizes interventions in outdoor spaces that have outcome measures for physical activity or social connectedness among children and youth (aged 19 years and less) from Australia, Canada, Europe (including Turkey), New Zealand and the United States of America (USA). This is a research-focussed summary of the findings from a review, undertaken at the request of the Public Health Agency of Canada's Centre for Chronic Disease Prevention and Health Equity in early 2019.

Methods

We undertook a rapid review of peer-reviewed and grey literature using a two-stage open-ended process. A rapid review is a systematic assessment of established knowledge about a topic that captures the volume and overall direction of the literature. We elected to use a rapid review approach because of the need for an expedited timeline to inform further research and policy in this area. The comprehensiveness of the search, thoroughness of the quality assessment and details of the synthesis are limited by this methodology.²⁴

Search strategy

This rapid review used a two-stage process. In the first stage, we undertook a keyword search in PAIS Index, PubMed, Scopus and Web of Science for systematic literature reviews and meta-analyses published between 2000 and 2018 (Table 1). These studies explored outdoor settings from the perspective of physical activity or social connectedness.

This stage of the search returned 3103 reviews, of which 298 were determined to be potentially relevant to our investigation.

TABLE 1
Search strings used to identify systematic literature reviews

Database	Search string
PAIS Index	(NOFT(("built environment" OR "social environment" OR "natural environment" OR "outdoor space" OR greenspace OR "green space" OR brownfield OR "public space" OR "open space" OR "recreational space" OR playground OR school) AND ("physical activity" OR exercise OR "outdoor play" OR "outdoor activity" OR "physical health" OR "social cohesion" OR "social interaction" OR "social capital" OR (social AND (connect*)) OR "mental health" OR wellbeing OR well-being OR wellness)) AND NOFT(infant OR toddler OR child OR children OR childhood OR adolescent OR teen OR teenager OR youth)) AND NOFT(review AND (rapid OR scoping OR systematic OR "of reviews" OR literature))
PubMed	((Environment Design[MeSH Terms] AND ("Adolescent"[Mesh] OR "Child"[Mesh])) AND "Review" [Publication Type])
Scopus	(TITLE-ABS-KEY (("built environment" OR "social environment" OR "natural environment" OR "outdoor space" OR greenspace OR "green space" OR brownfield OR "public space" OR "open space" OR "recreational space" OR playground OR school) AND ("physical activity" OR exercise OR "outdoor play" OR "outdoor activity" OR "physical health" OR "social cohesion" OR "social interaction" OR "social capital" OR (social AND (connect*)) OR "mental health" OR wellbeing OR well-being OR wellness)) AND TITLE-ABS-KEY (infant OR toddler OR child OR children OR childhood OR adolescent OR teen OR teenager OR youth)) AND TITLE-ABS-KEY (review AND (rapid OR scoping OR systematic OR "of reviews" OR literature))
Web of Science	(TS=(children OR adolescents OR youth) AND TS=("physical activity" OR "mental health" OR wellbeing OR well-being OR "social capital" OR "social cohesion" OR "social connection" OR "social connectedness")) AND (TS=(greenspace OR "green space" OR "outdoor space" OR park OR "public space" OR brownfield OR "open space"))

In the second stage of the search process, five independent reviewers manually searched the results sections of these 298 systematic reviews and meta-analyses for studies on interventions in outdoor spaces with populations aged 19 years or less, from Australia, Canada, Europe, New Zealand or the USA, that had at least one outcome measure for physical activity or social connectedness. As stated earlier, we defined outdoor spaces as including all natural, water, sporting, playground and hardscaped public open spaces.

This stage of the search yielded 104 unique intervention studies. We report on 70 (67%) that we determined to be of sufficient quality and impact for inclusion in the review (Figure 1).

Selection criteria

The selection criteria—age, setting (outdoor spaces), location and outcome measure (physical activity and social connectedness)—were developed with public health practitioners based on their research and policy needs.

We adopted the World Health Organization's *Global Strategy on Diet, Physical Activity and Health* definition of physical activity as bodily movement that occurs as part of structured exercise, play, work, mobility or recreation.² We considered social connectedness as encapsulating the presence, quantity and quality of social interaction between people.¹⁹ These definitions were used to make scoping decisions and synthesize the evidence base.

Scoping, screening and quality assessment

We developed a quality assessment tool to determine the internal reliability and external validity of each intervention study. Scoping, screening and quality assessment decisions were completed by at least two reviewers, working independently. Disagreements were resolved through consensus after discussion with a third team member.

We assessed the research design and reporting of each study to determine the validity of its findings. This approach was inspired by other standardized quality assessment protocols. However, given the design of our review methodology, the lack of quality assessment tools in this subject area and the broad variation in methodological design and outcome measures of each intervention study, our approach is not a traditional marker of study quality.²⁵ Rather, our bespoke quality assessment uses an approach rooted in the core principles of quality appraisal to retrieve studies demonstrating interventions that effectively increase physical activity and/or social connectedness in children and youth.²⁵

We assessed the quality of studies based on four types of validity. Internal validity was assessed by examining the reporting of limitations in the study. Construct validity was assessed by comparing the composition of the sample to the expected population and by appraising the reporting of the intervention's implementation. External validity was assessed by appraising the suitability of a study's methodological approach compared to its conclusions.

Statistical conclusion validity was assessed by accounting for the study's sample size and reported effect sizes.

We excluded any study that at least two reviewers independently assessed as having one or more major flaws in internal, construct, external or statistical conclusion validity. As such, our review is a distillation of intervention-type studies that could be used to inform the development of future interventions, and in particular, the evaluations of these interventions to build a more robust evidence base.

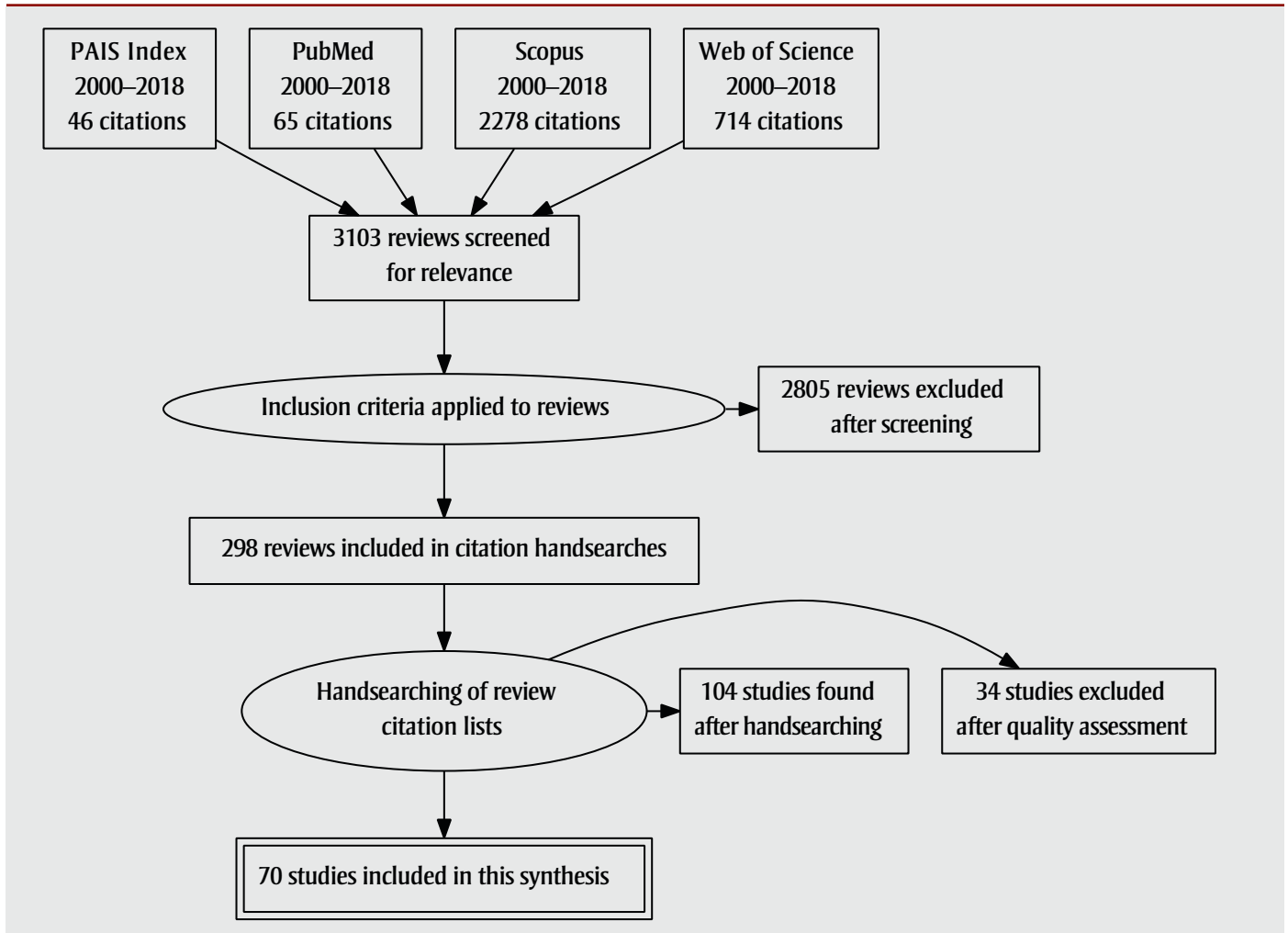
Data extraction and synthesis

At least two reviewers, working independently, extracted bibliographic details and information about the population, intervention, context, outcome, timing and setting for each study determined to be relevant and of sufficient quality according to its research design, confidence intervals and reported strengths and limitations. Disagreements were resolved through discussion until consensus was reached. Results were synthesized based on their common thematic elements as determined by public health practitioner interest.

Results

The quality assessment rendered 70 unique intervention studies for this critical narrative synthesis. The bulk of the interventions focussed on physical activity outcomes ($n = 55$); a few explored social connectedness ($n = 10$) or both outcomes together ($n = 5$). Play ($n = 47$) and contact with nature ($n = 25$) were dominant

FIGURE 1
Rapid review search process diagram



themes across interventions, with most taking place in a school ($n = 48$) or public park ($n = 11$). The majority ($n = 64$) of studies worked with preschool or elementary school-aged children (< 13 years), with a few ($n = 20$) interventions engaging with secondary school-age populations (13–19 years). Effect sizes (Cohen's d) in Tables 2, 3 and 4 are reported at the 95% confidence level using information (i.e. means, standard deviations, sample size) described in the associated manuscript.

Physical activity

We found 55 interventions that had a physical activity outcome, including 8 in Australia and New Zealand, 3 in Canada, 15 in Europe (including Turkey) and 29 in USA (Table 2). The most popular form of intervention involved modifying the built environment or providing additional equipment and supports for moderate-to-vigorous

physical activity.²⁶⁻⁴³ Other interventions deployed programming⁴⁴⁻⁵³ or curriculum changes involving outdoor space⁵⁴⁻⁶³ to promote physical activity. The concept of fostering spontaneous play in school and community-based settings was often an underlying component of these interventions.

Technology was sometimes used as a delivery mechanism for the intervention. In addition, some interventions leveraged active travel as a way to increase physical activity through walking school buses or improved cycling supports.⁶⁴⁻⁷⁵ An emerging area for population-level intervention research is the use of smartphone and remote sensing technology to deliver interventions to children and youth.⁷⁶⁻⁸⁰ In short, physical activity interventions often combine environmental supports and programming with a play-based approach to reduce knowledge and contextual barriers to participation.

Social connectedness

We found 10 interventions with outcomes related to social connectedness, from across Australia and New Zealand ($n = 1$), Europe ($n = 4$) and the USA ($n = 5$) (Table 3). Many interventions identified increasing exposure to nature as a pathway to increasing social connectedness.⁸¹⁻⁸⁵ In addition, some interventions modified features of the built and social environment to increase opportunities for social interaction.⁸⁶⁻⁹⁰ These opportunities were rooted in promoting spontaneous and organized play; sometimes they leveraged technology to connect participants. Effective interventions that increase social connectedness appear to rely on creating supportive environments with high exposure to natural elements.

Joint outcomes

We identified five interventions in Europe ($n = 4$) and the USA ($n = 1$) that had

TABLE 2
Summary of interventions with physical activity outcomes

Ref.	Effect (95% CI)	Sample size (n)	Intervention	Design	Age group	Setting
(47) USA	3.28 (2.32, 4.24)	54	Education and support groups	CCT	Primary	Parks
(58) USA	0.66 (0.52, 0.80)	1849	Education and support groups	RCT	Primary Teen	Education
(60) EU	1.10 (1.01, 1.19)	19	Naturalized outdoor spaces	ITS	Primary	Education
(61) USA	0.87 (0.65, 1.11)	211	Naturalized outdoor spaces	CCT	Primary	Education
(78) USA	0.75 (0.34, 1.16)	152	Active and safe routes to school	RCT	Primary	Community
(49) USA	2.04 (1.71, 2.37)	147	Naturalized outdoor spaces	CCT	Primary	Parks
(63) AN	2.00 (1.99, 2.01)	2965	Education and support groups	RCT	Primary	Education
(57) EU	0.02 (-0.66, 0.70)	2287	Recess programs and supervision	RCT	Primary	Education
(79) EU	0.46 (0.36, 0.56)	2840	Recess programs and supervision	RCT	Primary Teen	Education
(33) AN	1.55 (1.47, 1.63)	102	Naturalized outdoor spaces	ITS	Primary	Education
(59) EU	0.88 (-11.9, 13.7)	19	Naturalized outdoor spaces	ITS	Primary	Education
(77) EU	1.29 (1.07, 1.51)	1793	Education and support groups	ITS	Primary Teen	Education
(54) AN	3.99 (-52.3, 60.3)	97	Education and support groups	ITS	Primary	Education
(68) EU	0.99 (0.89, 1.10)	3336	Active and safe routes to school	CCT	Primary	Community
(71) USA	3.33 (3.21, 3.45)	653	Active and safe routes to school	ITS	Primary	Education
(69) USA	2.97 (2.33, 3.61)	324	Active and safe routes to school	CCT	Primary	Education
(72) USA	0.30 (-1.18, 1.78)	149	Active and safe routes to school	ITS	Primary	Education
(45) AN	-0.26 (-1.00, 0.48)	480	Recess programs and supervision	ITS	Primary	Education
(30) CA	Improvement	400	Naturalized outdoor spaces	Q	Primary	Education
(43) EU	0.18 (-2.65, 3.01)	235	Play equipment	CCT	Primary	Education
(70) USA	0.09 (0.01, 0.17)	3315	Active and safe routes to school	CCT	Primary	Education
(40) USA	Improvement	5	Built environment modification	Q	Primary	Parks
(28) USA	0.95 (0.89, 1.01)	56	Naturalized outdoor spaces	ITS	Pre-school	Education
(26) EU	0.01 (-0.88, 1.07)	412	Play equipment	CCT	Primary	Education
(27) USA	1.42 (1.40, 1.44)	9407	Naturalized outdoor spaces	CCT	Primary	Education
(29) USA	0.73 (0.57, 0.89)	377	Play equipment	ITS	Teen	Community

Continued on the following page

outcomes for both physical activity and social connectedness (Table 4). These interventions typically involved modifying the built or natural environment to create opportunities for physical activity and social connection.⁹¹⁻⁹³ Alternatively, interventions used physical activity as an opportunity to promote social connection.^{94,95} These multifaceted interventions seem to provide the most impactful solutions, as they can improve both physical activity and social connectedness among children and youth.

Discussion

The broad concern about activity levels and socialization among children and youth^{8,9} provides the impetus for further studies that can identify interventions that get children and youth outdoors. All three levels of government in Canada have made moves to better support public use of outdoor spaces through funding, programming and staff training. Therefore, it is ideal to evaluate work that either captures the effects of ongoing interventions in local communities or develops new interventions for the Canadian context that are informed by international evidence.

Contact with nature is recognized as an integral part of health and well-being in all populations. The interventions included in our review suggest opportunities for both physical activity and social connection among children and youth often occur in natural and play-encouraging outdoor spaces. Many of the physical activity-related studies reviewed identified the presence of nature as a moderator of the intervention's effect on physical activity.^{30,36,38} Naturalized environments were noted as being a clear determinant of social connection between children and youth.⁸¹⁻⁸⁵ Given Canada's high rate of naturalized space per capita for over 90% of households,⁹⁶ nature should be viewed as a fundamental component of any intervention with a physical activity or social connectedness outcome.

Play is an important element of most physical activity interventions. Interventions from France²⁶ and the United Kingdom⁴¹ provide excellent examples of how to easily increase participation in moderate-to-vigorous physical activity through playground markings and with proactive supervision by staff who promote children's games and movement. Play equipment is a common feature of many public

TABLE 2 (continued)
Summary of interventions with physical activity outcomes

Ref.	Effect (95% CI)	Sample size (n)	Intervention	Design	Age group	Setting
(67) USA	1.60 (1.38, 1.82)	2207	Built environment modification	ITS	Primary Teen	Community
(36) USA	1.03 (0.86, 1.19)	2712	Naturalized outdoor spaces	Obs.	Pre-school Primary Teen	Parks
(32) USA	8.33 (8.04, 8.62)	64	Play equipment	ITS	Pre-school	Education
(38) USA	2.13 (0.80, 3.46)	107	Naturalized outdoor spaces	ITS	Pre-school	Education
(73) USA	4.37 (-13.4, 22.2)	20	Active and safe routes to school	ITS	Teen	Community
(41) EU	0.61 (-3.92, 5.14)	60	Play equipment	CCT	Primary	Education
(34) USA	1.79 (1.38, 2.20)	309	Play equipment	Obs.	Primary	Education
(75) EU	0.72 (-8.13, 9.57)	313	Active and safe routes to school	ITS	Primary	Education
(65) EU	0.82 (0.39, 1.25)	126	Regulatory changes	ITS	Primary	Community
(44) USA	2.00 (1.94, 2.06)	710	Recess programs and supervision	CCT	Primary	Community
(50) CA	1.22 (1.18, 1.26)	5200	Education and support groups	CCT	Primary	Education
(46) USA	0.74 (-0.01, 1.49)	262	Recess programs and supervision	RCT	Primary	Education
(48) AN	5.80 (2.00, 9.60)	497	Built environment modification	Obs.	Primary Teen	Parks
(53) USA	0.32 (0.19, 0.45)	227	Naturalized outdoor spaces	CCT	Primary	Education
(51) USA	1.6 (0.00, 3.33)	8727	Naturalized outdoor spaces	RCT	Primary Teen	Education
(56) AN	1.8 (0.50, 3.10)	221	Recess programs and supervision	RCT	Primary	Education
(55) USA	0.58 (0.51, 0.65)	1582	Education and support groups	RCT	Primary	Education
(66) EU	1.41 (1.15, 1.67)	1359	Active and safe routes to school	CCT	Primary Teen	Education
(62) EU	0.16 (-1.58, 1.90)	797	Recess programs and supervision	RCT	Primary	Education
(42) EU	2.00 (1.67, 2.33)	128	Built environment modification	ITS	Primary	Education
(52) USA	0.48 (-2.16, 3.12)	21	Recess programs and supervision	CCT	Primary	Education
(35) AN	1.08 (0.94, 1.22)	459	Education and support groups	ITS	Pre-school	Education
(31) USA	0.57 (0.38, 0.76)	1206	Recess programs and supervision	RCT	Primary	Education
(39) AN	12.5 (-13.0, 38.0)	1582	Built environment modification	RCT	Primary Teen	Education
(76) USA	2.24 (0.19, 4.29)	442	Recess programs and supervision	Obs.	Primary	Education

Continued on the following page

outdoor spaces in Canada. However, much of this equipment consists of traditional playground structures (i.e. slides, swings, jungle gyms) that do not typically foster high levels of moderate-to-vigorous physical activity.¹⁰ Riskier play may incentivize higher physical activity and improve social connectedness, but the studies reviewed do not include data on injuries and other consequences from these types of interventions.⁹⁷ Youth could be engaged with outdoor spaces through access to free game equipment or if they had digital challenges to compete in against friends.^{43,98}

Technology is an emerging area of interest.^{54,76,79,80} Given the high adoption rate of mobile devices, plus the myriad sensors and devices being placed in Canadian urban environments, technologies could be used to deliver and track the effects of health interventions with a view to preventing chronic disease.⁹⁹ A few of the interventions reviewed included technological elements, with some gamifying simple physical activities like walking to school or running around a track.^{79,80} Future Canadian-specific interventions could apply a technological element to the delivery or monitoring element of existing interventions to improve data collection efficiency and encourage higher uptake of the intervention among children and youth. For example, traditional observational methods for collecting data on the use of playground equipment^{26,34,41,76} could be replaced with anonymized pattern-recognition camera technology to detect when children are engaging in moderate-to-vigorous physical activity. Moreover, compared to traditional email and paper-based techniques,^{54,78} a GPS-enabled mobile phone application could deliver recommendations about activities and outdoor spaces to visit when in geographical proximity to these spaces. Such a user-friendly approach explicitly provides opportunities for physical activity and chance social encounters among youth.

Strengths and limitations

This rapid review encapsulates the available literature on the connections between physical activity, social connectedness, outdoor spaces and population-level health interventions. As part of the review, expert reviewers undertook a systematic search and clearly documented the review process. This methodological approach ensures reproducibility and transparency.

TABLE 2 (continued)
Summary of interventions with physical activity outcomes

Ref.	Effect (95% CI)	Sample size (n)	Intervention	Design	Age group	Setting
(37) EU	0.79 (-58.2, 59.8)	247	Recess programs and supervision	RCT	Primary	Education
(80) CA	3.21 (3.12, 3.30)	3817	Active and safe routes to school	ITS	Primary	Community
(64) USA	1.30 (0.20, 2.30)	104	Regulatory changes	CCT	Primary Teen	Community
(74) USA	2.86 (2.77, 2.95)	187	Active and safe routes to school	Obs.	Primary	Community

Abbreviations: AN, Australia & New Zealand; CA, Canada; CCT, case-control trial; CI, confidence interval; EU, Europe; ITS, Interrupted time series; Obs., observational; Q, Qualitative; RCT, randomized controlled trial; USA, United States of America.

However, the use of a rapid review approach could limit the comprehensiveness of the interventions captured in this report. In addition, the lack of a formal standardized quality assessment tool for rapid reviews could limit the generalizability of our findings. Our review is further limited by excluding evidence that was not published in English or was from outside of Australia, Canada, Europe, New Zealand and the USA. The exclusion of interventions by population age could also limit finding interventions for adults that could translate to potential interventions for children and youth.

Conclusion

Our review found a wide range of evidence about interventions that could effectively increase physical activity and improve social connectedness among children and youth. The evidence base aligns with policies at all levels of government in Canada and could be used to guide implementation of detailed interventions at the local level. Moreover, the findings of our review align with other recent evidence syntheses of this topic, particularly on incorporating nature into interventions that improve physical activity and social

connectedness outcomes.^{100,101} However, the lack of Canadian-specific research may hamper the overall applicability of our findings to Canada's many diverse and vibrant communities.

Further, the results of this review are high-level in nature; this limits their transferability across populations and contexts. Many of the interventions reviewed in this study were only tested and/or shown to be effective in one demographic group and contextual setting, which should not be construed as an evidence-based finding that the intervention works in all contexts with all children and youth populations. There is a clear need for more studies that replicate existing interventions in new contexts and with different populations.

Implications

The interventions identified in this review should be used to inform interventions made by all levels of government, school boards and community actors to create outdoor spaces that contribute to increasing physical activity and social connectedness in children and youth. Policy makers and program delivery staff should reach out to researchers in advance of implementing changes to the built environment or implementing changes to regulatory systems to allow high-quality pre-post studies of the effects of the intervention. In addition, researchers should make their knowledge, expertise and willingness to collaborate known to policy makers and program delivery staff to ensure interventions are of strong methodological design and contribute to the broader evidence base. This collaborative approach would maximize the impact of public funds, advance research-policy partnerships and create a more robust understanding of physical activity and social connectedness interventions. Further, given the underrepresentation of youth across the evidence base, there is a clear need for policy makers and researchers to work collaboratively with youth populations in Canada in both research and practice.¹⁰²

Future research

While there is a large body of international evidence about interventions for increasing physical activity and social connectedness among children and youth, there is a lack of Canadian-specific research. Our review originally captured 104 studies, but only 7 included a Canadian population;

TABLE 3
Summary of interventions with social connectedness outcomes

Ref.	Effect (CI 95%)	Sample (n)	Intervention	Study design	Age group	Setting
(83) EU	1.29 (-2.45, 5.03)	8	Naturalized outdoor spaces	ITS	Primary	Parks
(85) USA	3.77 (2.88, 4.66)	598	Naturalized outdoor spaces	CCT	Primary	Education
(86) AN	0.55 (-0.08, 1.19)	20	Play equipment	ITS	Primary	Parks
(87) USA	Improvement	50	Naturalized outdoor spaces	Q	Primary Teen	Parks
(90) EU	Improvement	18	Built environment modification	Q	Preschool Primary Teen	Parks
(81) EU	0.09 (0.00, 0.17)	223	Naturalized outdoor spaces	CCT	Teen	Education
(82) USA	0.48 (0.02, 0.94)	112	Naturalized outdoor spaces	ITS	Teen	Education
(89) USA	0.32 (0.16, 0.48)	27	Recess programs and supervision	ITS	Preschool	Education
(84) USA	3.12 (-1.68, 7.92)	24	Education and support groups	ITS	Primary Teen	Parks
(88) EU	4.49 (1.93, 10.44)	1 347	Built environment modification	CCT	Teen	Education

Abbreviations: AN, Australia & New Zealand; CA, Canada; CCT, case-control trial; CI, confidence interval; EU, Europe; ITS, interrupted time series; Obs., observational; Q, qualitative; RCT, randomized controlled trial; USA, United States of America.

TABLE 4
Summary of interventions with outcomes for both physical activity and social connectedness

Ref.	Effect (CI 95%)	Sample (n)	Intervention	Design	Age	Setting
(94) EU	0.42 (-2.4, 10.1)	38	Education and support groups	RCT	Teen	Education
(93) USA	1.58 (1.37, 1.79)	112	Built environment modifications	CCT	Primary Teen	Parks
(91) USA	0.62 (0.76, 0.90)	27	Naturalized outdoor spaces	ITS	Preschool	Education
(95) USA	3.14 (1.82, 4.46)	27	Recess programs and supervision	CCT	Primary	Education
(92) USA	2.39 (2.27, 2.51)	58	Active and safe routes to school	CCT	Primary	Community

Abbreviations: AN, Australia & New Zealand; CCT, case-control trial; CA, Canada; CI, confidence interval; EU, Europe; ITS, interrupted time series; Obs., observational; Q, qualitative; RCT, randomized controlled trial; USA, United States of America.

of these, only 2 were determined to be of sufficient quality using our quality assessment process. This is not due to a lack of action by governments and civil society to improve the physical activity and social connectedness of children and youth in Canada. Rather, these interventions are not adequately tracked and reported through easily searchable sources. Research practices that can rapidly respond to outdoor space interventions using controlled study designs should be emphasized, and international studies should be replicated in many different Canadian contexts.

The lack of evidence for interventions that could increase physical activity or social connection in secondary school-age populations compared to the volume of evidence available on interventions for preschool and elementary school populations is of concern. Because of concerns about Canadian youth populations disengaging from public life and outdoor spaces,¹⁰³ future research should focus on exploring the unique enablers and barriers to youth participation in physical activity and creating social connections. This research could involve blending technology into outdoor spaces as well as determining the built and natural features that attract youth to outdoor spaces.

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Authors' contributions and statement

AW: design and conceptualization of the work, acquisition and interpretation of the data, drafting the manuscript, revising the manuscript; GM: acquisition and interpretation of the data, drafting the manuscript, revising the manuscript; EO: acquisition and interpretation of the data, revising the manuscript; AM: acquisition and interpretation of the data, revising the manuscript; ML: acquisition and interpretation of the data, revising the manuscript; KR: revising the manuscript; JG: design and conceptualization of the work and revising the manuscript. All authors were responsible for approval of the final manuscript for submission.

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Conflict of interest

The authors have no conflicts of interest.

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Evidence synthesis

Preferred modalities for delivering continuing education to the public health workforce: a scoping review

Anya Archer, MPH; Isha Berry, MSc; Uttam Bajwa, PhD; Robyn Kalda, MES; Erica Di Ruggiero, PhD

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Abstract

Introduction: Continuing education (CE) can help public health professionals maintain and further develop their knowledge and skills to adapt to the changing public health landscape. This scoping review aims to identify the preferred modalities for delivering CE to public health professionals and to determine how equity has been incorporated into public health training.

Methods: Using the PRISMA extension for Scoping Reviews as a guide, we searched four databases for peer-reviewed primary research studies that evaluated public health workforce CE modalities.

Results: The review included 33 studies published between 1 January 2000 and 6 August 2019 from over 11 countries. Most articles broadly described their training audience as public health professionals employed by government or non-governmental organizations. Delivery methods included online, in-person or blended learning (combining online and in-person instruction). Learners strongly preferred self-directed approaches. Organizational support, including protected time for professional development during work hours, was an important enabler of training completion. Commonly cited barriers included course duration and a high number of contact hours.

Conclusion: Findings suggest that there is no single preferred training modality. We identified three elements that influence modality preference: design, delivery and organizational support. Modality should be determined by participants' location, needs and previous experiences to ensure the content is relevant and delivered in a way that equips learners to apply the knowledge gained.

Keywords: *public health, continuing education, training, capacity building, health human resources, professional development, scoping review*

Introduction

The Ottawa Charter for Health Promotion describes the purpose of public health as improving population health while enabling individuals' increased control over their own health.¹ This requires the public health workforce to stay responsive to changing health needs while considering the social, cultural, environmental and economic contexts for good health.² As a result, it is important that public health professionals at all levels—frontline staff

as well as middle and senior management—have the resources and organizational supports necessary to keep abreast of new developments in the field.

These resources and supports can be delivered in part through continuing education (CE) courses.³ In Canada, for example, reviews of the public health system in the early 2000s called for a renewed commitment to public health at federal, provincial and territorial levels to strengthen

Highlights

- It is important that the public health workforce has continuing education (CE) opportunities relevant to the context of their daily work and overarching organizational priorities.
- CE opportunities should be equitably accessible.
- Training that takes into account the context in which it will be delivered helps to create practical content. Such CE increases learners' knowledge retention and their ability to apply new knowledge and skills in their professional settings.
- Specific enablers of completion of CE programs are leadership support and protected time to participate in training.

core functions and prepare for the challenges of the 21st century.⁴

While training is one way to stay current and meet these challenges, organizations that employ public health professionals are not always able to prioritize training due to resource and time constraints.⁵ These factors must be taken into consideration during the planning and designing phases of training development.

Although public health professionals assume a variety of roles and responsibilities, the entire workforce requires a foundational understanding of population health and the social and ecological determinants of health.⁶ The workforce must also be equipped with the competencies needed to collect and analyze population health

Author reference:

Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, Canada

Correspondence: Anya Archer, Dalla Lana School of Public Health, 155 College Street, Toronto, ON M5T 1P8; Email: anya.archer@alum.utoronto.ca

data and evaluate interventions, particularly ones that reduce and eliminate health inequities.⁶ These competencies include undertaking evidence-informed practice, using surveillance data and communicating information on risks to various audiences.⁷

Public health professionals also need to understand and appreciate the sociopolitical and economic context in which they are working to ensure they do not exacerbate inequities.⁸ As a result, equity-focussed training is a crucial priority.⁶ Equity-focussed content refers to considering and presenting on how certain practices and ways of thinking in all types of public health work can amplify inequities, from collecting data to designing and evaluating interventions.⁶ Training that incorporates concepts of equity questions the status quo to ensure diversity and inclusion are considered in all work.

CE can be delivered in a number of different ways—online, in-person and as a combination of the two, which is known as blended learning.⁹ CE continues to evolve as technologies allow for more interaction with content and peers outside of a traditional classroom setting. CE should be delivered equitably, meaning that developers adopt an inclusive approach that reduces barriers to participation, for example, by offering training at times and places that are convenient.¹⁰ This approach requires adapting to the audience’s accessibility needs.¹¹

We undertook a scoping review to assess the current state of literature on public health CE and to better understand which modalities professionals prefer when receiving CE on population health topics and approaches. The specific objectives of this scoping review were to identify

preferred modalities to provide CE to public health professionals; identify the enablers and barriers to training; and determine how equity has been incorporated into public health training, including both equity as a training topic and its equitable delivery.

Methods

We developed a research question based on a preliminary review of the academic literature and consultation with public health workforce training experts. Our research question was as follows: “What are preferred delivery methods for training the public health workforce in population health topics and approaches?”

Using a scoping review methodology, we mapped concepts broadly, identified key sources and evaluated the types of evidence available in the public health field.^{12,13} We used the PRISMA-ScR (PRISMA extension for Scoping Reviews) to guide reporting.¹³

Data sources and searches

We searched four databases—MEDLINE (Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE®); Embase (Embase Classic + Embase); CINAHL Plus with Full Text; and ERIC (ProQuest)—to identify all peer-reviewed primary research articles published between 1 January 2000 and 6 August 2019. The literature search was first performed on 17 August 2018 and repeated on 6 August 2019 to ensure inclusion of relevant articles published in the year since the original search. The search start date was chosen to best capture the changing context and scope of public health and the growing number of academic training programs.

We included original research (i.e. empirical research) that evaluated modalities, meaning the method for delivering training content. Furthermore, information and communication technologies have evolved rapidly in the 21st century, with Internet access expanding the ways CE programs can be delivered.¹⁴ To ensure that the review was comprehensive, public health experts were consulted to identify additional articles.¹² The experts included public health professionals and academics with experience in developing CE; all were provided with our research question.

Search strategy

A focussed search strategy using a set of key search terms guided the scoping review. Table 1 lists the search terms used for MEDLINE and Embase. The search strategies for the other databases were similar, with formatting adaptations made based on their respective requirements (details available upon request). In keeping with scoping review methodology, search terms as well as inclusion and exclusion criteria were iteratively developed as the reviewers examined the literature.¹²

Search terms fell into four key domains: public health (the context); the public health workforce (the population); the training activity; and delivery method.

Study selection and eligibility criteria

The results were exported into Covidence, a literature review management software program. Two reviewers (AA and IB) independently screened titles and abstracts and then screened full texts of the relevant articles. Differences between the reviewers were resolved through discussion until a consensus was reached.

TABLE 1
Search terms used in MEDLINE and Embase

		Search term
Context	Public health	(Health ADJ1 promotion) OR (Population ADJ1 health) OR (public ADJ1 health)
Population	Public health workforce	(public health workforce) OR (Practitioner*) OR (Health personnel) OR (Health professional*) OR (Front#line public health practitioner*) OR (Community#health worker*) OR (Employee*) OR (Human resource*) OR (Staff) OR (Adult learner*)
Activity	Training	(training) OR (Professional ADJ2 development) OR (Continuing ADJ2 education) OR (Capacity ADJ2 building) OR (Competency#based ADJ2 education) OR (Education) OR (Technical ADJ2 assistance) OR (Staff ADJ2 development) OR (continuing#professional#development)
Focus	Delivery method	(delivery method*) OR (MOOC*) OR (Massive Open Online Course) OR (Online platform*) OR (Webinar*) OR (Workshop*) OR (Course*) OR (Module*) OR (online#learning*) OR (Institute*) OR (Community of practice) OR (peer#learning) OR (train#the#trainer) OR (study#groups) OR (hybrid ADJ1 learning)

We reviewed the full texts of studies that evaluated CE training programs delivered to the public health workforce. The populations of interest also included the medical and nursing sectors, non-governmental organizations and government departments. Articles were included if they were written in English and explicitly evaluated training delivery methods. Articles were excluded if they focussed on university-level education and training (i.e. courses for undergraduate or graduate degree programs); were literature reviews; or did not explicitly evaluate the modes of delivering training content (Table 2). The search was not restricted by geography.

Data charting process

In an abstraction form co-developed by all authors, three reviewers (AA, IB and RK) charted article characteristics (e.g. study funder, objectives); numbers of individuals completing the training; training populations (e.g. country, organization); development and delivery of training; topics and modalities of trainings (including contact hours); equity (whether considered in both delivery and content); evaluation methods and outcomes for training; and recommendations for future practice.

All authors piloted the extraction form by each charting data from one article, which informed the final version of the form. This descriptive-analytical method assisted the analysis and reporting of results by identifying standard information from each study for extraction.¹² Differences in abstraction were resolved through discussion. Consistent with the proposed scoping

review methodology,¹⁵ risk of bias for individual studies was not assessed.

Results

Of the 4251 articles identified through our search, 143 were selected for full-text screening, including 20 identified by the consulted experts. Of the 143 full-text articles identified, 33 met our inclusion criteria and were included in this review for evidence synthesis (Figure 1).

Public health training program characteristics

We identified public health training programs delivered in over 11 countries: Australia,^{10,16,17} Bolivia,¹⁸ Brazil,¹⁹ Canada,²⁰⁻²² Greece,²³ the Islamic Republic of Iran,²⁴ Mexico,²⁵ Rwanda,^{26,27} Uganda,²⁸ the United Kingdom²⁹ and the United States of America (USA).³⁰⁻⁴⁵ One program offered trainings in over 77 countries,⁴⁶ and another trained participants in Austria, Lithuania and the Netherlands.⁹ Within the past 7 years, 19 of these articles were published.^{9,16,18-21,23,25-29,34,39,40,43-46}

A number of organizations developed non-degree public health training programs: universities/academic institutions, such as the University of North Carolina; non-profit organizations, such as the USA-based group Management Sciences for Health; and government agencies, such as the Public Health Agency of Canada. Organizations that developed training programs also often delivered the content to the intended audiences. We found that 36% (12/33) of the articles reported using

frameworks and competencies; most of these used frameworks developed by governmental organizations such as the Centers for Disease Control and Prevention (USA) and the Public Health Agency of Canada (Canada) to inform the design and content of the trainings.

Online training included on-demand and live webinars, tele- or videoconferencing and course modules (a few short segments of the course offered at a time). In-person training included traditional didactic lectures, facilitated discussions and case studies (Table 3).

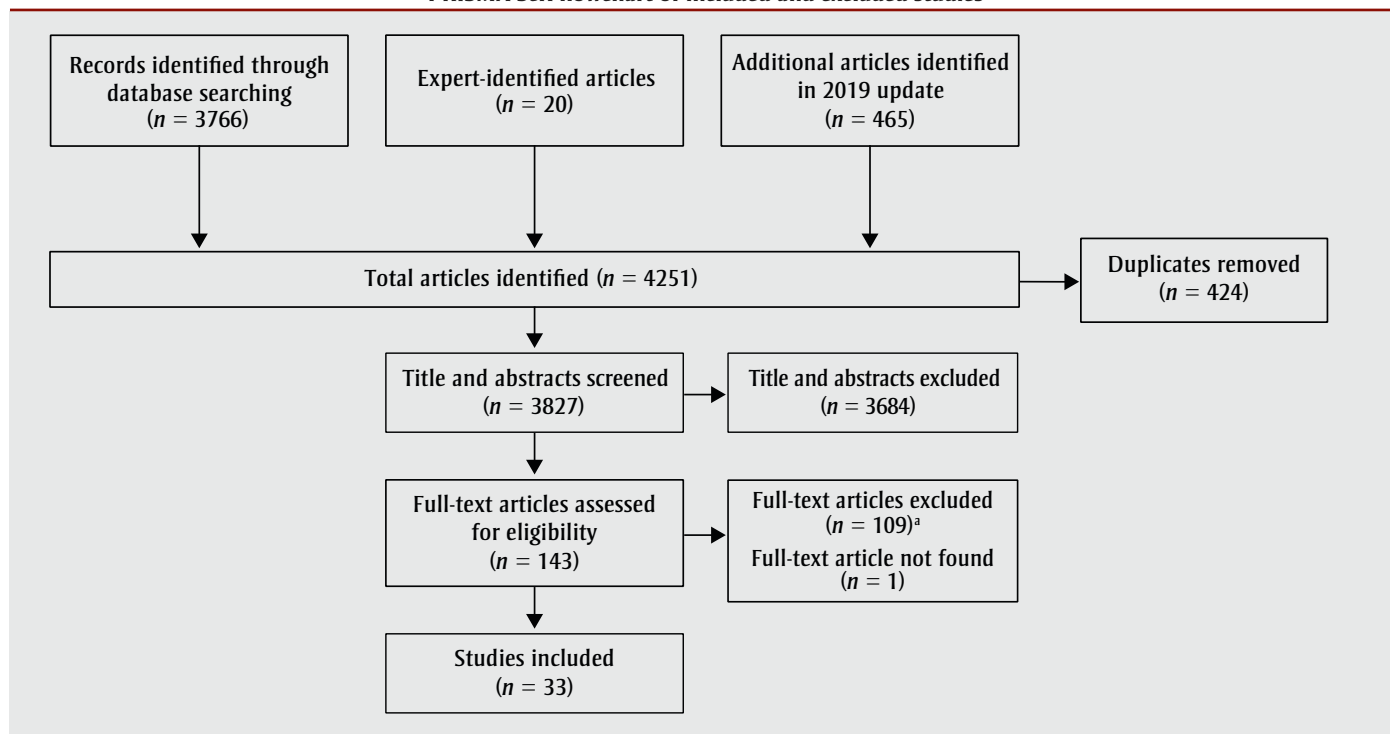
Online modalities tended to be shorter, from 20 minutes to 20 hours per module. In-person trainings were generally described as workshops and occurred over a full day or multiple days, often over a number of weeks and occasionally over the course of a year. Blended training programs included various components of these modalities, with the most common being online tutorials complemented by in-person facilitated group sessions. Individuals could choose between participating online or in-person.^{23,40,42} The number of individuals being trained varied, with the smallest programs reaching 12 participants^{17,36} and the largest delivered to over 4000 participants.⁴⁶

Only six studies explicitly considered ways to deliver their training equitably. These six addressed equity by offering training at no cost to participants;³⁸ providing multiple methods of engaging with the material to allow participants with poor Internet connectivity to participate;^{25,46}

TABLE 2
Inclusion and exclusion criteria for study articles

	Inclusion criteria	Exclusion criteria
Title/abstract screening	<ul style="list-style-type: none"> Related to public health training Published in English Peer-reviewed primary research articles 	<ul style="list-style-type: none"> Not related to public health training Focussed on university-level education and training, i.e. courses for degree programs Not published in English Not peer reviewed Literature reviews
Full text screening	<ul style="list-style-type: none"> Related to public health training Evaluated modes of delivering training Evaluated the uptake, reach, participant feedback, training objectives reached and any external evaluations of the training 	<ul style="list-style-type: none"> Focussed on university-level education and training, i.e. courses for degree programs No discussion of the evaluation of modes of delivering training materials/content in sufficient detail Not relevant Full-text was not found/not available

FIGURE 1
PRISMA-ScR flowchart of included and excluded studies



^a Full-text excluded: Did not discuss evaluation of models of delivering training materials/content in sufficient detail ($n = 76$); not peer reviewed ($n = 9$); not original research ($n = 1$); focussed on university-level education and training ($n = 6$); not English ($n = 4$); not relevant to training the public health workforce ($n = 12$); article retracted ($n = 1$).

donating resources (e.g. computers) to participating sites to overcome technical barriers to participation;¹⁹ or ensuring that content was adapted to reflect the local context and the participants' level of literacy.^{20,27} The other 27 studies did not specify whether equity was a consideration in designing the training programs. Only eight studies included trainings where issues around equity, diversity and inclusion were part of the course content.^{10,16,18,23,24,35-37} Topics included reducing health inequities and instruction related to conducting research with vulnerable populations.

Evaluation of trainings

The objectives of and the methods used to gather evaluations varied across studies. Approaches to evaluation included surveys;^{26,27,38,42,43} pre/post questionnaires;^{30,31,33,41} participant completion statistics;¹⁹ interviews;^{28,45} and mixed methods (a combination of either focus groups or interviews and surveys or questionnaires with participants).^{9,10,16-18,20-25,29,32,34-36,39,40,44}

Evaluations after participation captured participants' demographic information, subject knowledge before and after training, satisfaction with and post-training use of their newly gained knowledge.

Post-training evaluations were administered anywhere from immediately after the training concluded—the majority of evaluations—to 6-months post-training.⁴¹ Two studies did not describe their evaluation approach in detail.^{37,46}

Although the 33 included studies evaluated different aspects of their programs, we identified common enabling factors as well as barriers to completing training (Table 4). Where measured, participants generally rated high satisfaction with the training and noted increases in knowledge, perceived skill and self-efficacy. Self-efficacy was commonly defined by evaluators as increasing confidence in one's ability to perform specific behaviours.³⁶

Enablers to completing public health training

Participants generally preferred a hands-on, interactive, “learning by doing” approach^{18,27,31,40,41} that included time for the practical application of content on projects relevant to participants' roles within their organization.^{22,36,46} When training did not take a practical approach, participants said the content was too focussed on theory and that they were not ready to apply the content in their workplace.^{16,24,43}

A commonly cited enabler to engaging with training content was the opportunity to meet colleagues within and outside of their organizations to discuss training materials.^{17,18,22,24,36,46} Networking was perceived as a strong benefit of trainings that used this collaborative approach.

For online training programs, participants highly rated the opportunity to engage in training at a self-directed pace.^{18,32,40,46} Participants also noted the convenience of online training²⁹ and onsite training,¹⁷ with both decreasing travel time. Other factors that increased accessibility to public health professionals included content adapted to the context of the community in which the learners work^{20,27,45} and when a variety of modalities was used to deliver the content.⁹ One study noted participants' preference for a formally certified course.²⁴ Employer support, for instance by providing tools such as computers and designated time to complete the training, was an essential factor in facilitating program completion.^{10,19,20,22,25,44,45}

Barriers to completing public health training

In the context of online training, technological challenges such as sound quality and network issues were cited as one of

TABLE 3
Public health training program characteristics

	Articles, <i>n</i> (%)	Reference
Year study published		
2000–2005	7 (21.0)	10, 32, 36-38, 41, 42
2006–2011	7 (21.0)	17, 22, 24, 30, 31, 33, 35
2012–2019	19 (58.0)	9, 16, 18-21, 23, 25-29, 34, 39, 40, 43-46
Organizations responsible for training development		
Universities/academic institutions	13 (40.0)	9, 10, 24, 26, 29, 31, 32, 34-36, 38, 41, 43
Non-profit organizations	1 (3.0)	46
Government agencies	12 (36.0)	17, 19-22, 25, 27, 28, 33, 37, 42, 45
Universities and government agencies together	7 (21.0)	16, 18, 23, 30, 39, 40, 44
Use of frameworks and competencies		
Yes	12 (36.0)	9, 20, 23, 27, 28, 30, 31, 35, 38, 40, 44, 45
No	21 (64.0)	10, 16-19, 21, 22, 24-26, 29, 32-34, 36, 37, 39, 41-43, 46
Intended training audience		
Public health professionals employed by governments or health non-governmental organizations	25 (76.0)	10, 17, 20, 22, 23, 25-29, 31, 33-46
Health educators	2 (6.0)	9, 18
Public health nurses	1 (3.0)	30
Medical professionals	1 (3.0)	19
A combination of the health professions listed above	4 (12.0)	16, 21, 24, 32
Training modalities		
Online	9 (27.3)	17, 21, 25, 32, 33, 35-38
In-person	8 (24.2)	10, 16, 22, 24, 27, 28, 43, 44
Blended learning	13 (39.4)	9, 18-20, 26, 29-31, 34, 39, 41, 45, 46
Participant choice	3 (9.1)	23, 40, 42
Training topics		
Public health approaches	11 (33.3)	10, 16, 23, 32, 33, 35, 39, 40, 43-45
Epidemiological methods	8 (24.2)	17, 20, 21, 30, 31, 36, 37, 42
Management and leadership	4 (12.1)	9, 24, 29, 46
Research principles	2 (6.1)	22, 41
Specific topics (injury prevention, emergency preparedness, global health, ethics, quality improvement, health and safety in hospitals)	8 (24.2)	18, 19, 25-28, 34, 38
Equity (in delivery of training)		
Yes	6 (18.0)	19, 20, 25, 27, 38, 46
No	27 (82.0)	9, 10, 16-18, 21-24, 26, 28-37, 39-45
Equity (in topic)		
Yes	8 (24.0)	10, 16, 18, 23, 24, 35-37
No	25 (76.0)	9, 17, 19-22, 25-34, 38-46

largest barriers to completing training,^{18,20,32} especially in rural locations.^{17,26} In one study, some training participants did not use computers in their daily work so they were not familiar with the technologies used for the course, which resulted in poor uptake.¹⁹

The lack of time to work on modules or assignments while working full-time was another commonly reported barrier,^{18,20,39,41,45}

especially when planning group work.²² This concern cut across the literature. Some participants found it difficult to continually engage with material during long training programs.^{10,16,37} One study noted that a year-long course had a high dropout rate.²⁸ Another study noted that participants preferred courses that were divided into shorter units.²⁹ A lack of employer funding to register for courses also inhibited participation.^{16,39}

Recommended practices

Most studies concluded with recommendations (i.e. lessons learned or best practices) for designing training based on their evaluation findings (Table 5). Recommendations included designing interactive sessions to facilitate collaboration between participants from different organizations; gaining employer support for staff participation; and adapting content to local

TABLE 4
Enablers and barriers to participating in and completing training identified across studies

Enablers to completing training	Barriers to completing training
Interactive, hands-on training	Technological challenges associated with online learning
Opportunity to collaborate and network with colleagues from other organizations	Scheduling time to complete course work
Self-directed online courses that allow for varying learning paces	Courses that lasted a year or longer
Locally adapted content	Lack of funding from organization to participate in training
Choice between various modalities	
Certification upon completion	
Organizational support (i.e. resources to complete training)	

contexts. In addition, studies recommended that training be delivered in short, easily digestible segments with support from technical specialists and be regularly evaluated for revisions and improvements. Other studies identified online learning as being the most flexible for participants and also recommended “train-the-trainer” approaches as preferred delivery methods within the public health workforce.

Discussion

We conducted a scoping review to identify the preferred delivery modes of training the public health workforce and the extent to which equity is considered in training content and delivery. Our findings indicate that while there is no single preferred delivery method for training public health professionals, online content allows for increased access to the material and opportunity to collaborate with individuals across organizations. We found that most of the training programs did not

consider equity, but some paid attention to the equitable delivery of content. We also analyzed the enablers and barriers to completing the training to better understand what types of factors affect learners’ preference of training modality. From this analysis, we identified three elements that influence overall preference: design, delivery and organizational support.

Design

Although only one study mentioned the importance of conducting a needs assessment,²⁰ literature not included in the scoping review suggests that before designing a CE course, developers should conduct a comprehensive needs assessment to identify suitable modes of delivery.^{47,48} This process helps gauge participant readiness and ability to engage and assess issues to do with computer literacy and organizations’ technological capacities.^{47,48} With this information, appropriate and accessible considerations can be built into training

upfront, rather than adapting delivery mode content after the fact.

Role of competencies in training design

Over one-third of the studies indicated that competencies were used when designing training. Many of these studies illustrated that anchoring content in existing competencies helped participants understand how their new skills and knowledge can be applied in their work.^{23,30,31} Implementing common competencies across organizations helps to create a shared language and develops transferrable skills that are valued by employers.⁴⁹ By integrating these concepts and standards into CE, participants can be more confident in their increased ability to fulfill their agency’s goals and mandates.

Built-in feedback mechanisms

Our scoping review found that participants appreciated having their learning needs and feedback iteratively incorporated

TABLE 5
Recommended practices based on evaluation results

Recommended practice	Number of mentions	Reference
Gaining employer support for staff to participate in training	11	10, 16, 19, 20, 22, 25, 38, 39, 41, 44, 45
Using interactive learning strategies with an opportunity for application throughout the training	6	18, 22, 27, 28, 34, 40
Adapting training content and delivery method to local context	5	20, 23, 24, 27, 45
Building teams or hosting collaborative training sessions across organizations	4	16, 18, 35, 39
Employing blended learning techniques where multiple modalities are used to deliver the content	4	9, 26, 30, 46
Dedicating a technical support person or providing pre-training course on how to access and use the online platform	4	17, 27, 35, 45
Shorter, just-in-time modules to better meet the evolving needs of public health professionals	3	10, 36, 37
Ongoing evaluation to revise and improve training	2	24, 40
Posting content online to provide participants with flexibility to complete the work when most convenient	1	18
Train-the-trainer approach as an effective delivery method to train the public health workforce	1	23

into the training as the course progressed. Having dedicated support allowed individuals to actively participate, highlighting the need for training programs that incorporate ongoing mechanisms for evaluation and continuous quality improvement.⁴⁰

Participatory approach

Reviewed studies highlighted problem-based learning as beneficial for applying the knowledge post training. Participants considered it highly desirable to develop tangible skills that are directly applicable in the workplace.^{10,18,24,28,36,39,43} Using current, relevant issues or dilemmas that a professional might encounter allows them to engage with the training material in more depth and better understand how to apply the skills in their daily public health practice.⁴⁷

Participants preferred participatory approaches, including facilitating team-building and learning through collaboration with other health professionals. Some studies suggested that teams of two or three individuals from an agency should attend a course together, creating a “critical mass” of trained staff who subsequently disseminate the knowledge.^{36,39,46} This approach enhances the likelihood of the skills being implemented and adopted throughout the organization.³⁶ Team learning also strengthens relationships between colleagues as they work towards a common goal.⁴⁶

Other trainings created teams of individuals across participating organizations to complete the training as a group. This method encourages resource sharing (e.g. of finances and staff time), especially for agencies with limited resources.⁵⁰ The development of interorganizational teams facilitates improved knowledge management and strengthens strategies for addressing population health across geographies.⁴⁸ Team-based learning that integrates a collaborative approach is essential to public health work and provides opportunities for the practical application of the skills learned in CE programs.

Equity

Equity should be an overarching objective for public health programs, not an independent component.⁵¹ Our literature search did not identify many training programs that focussed on equity as a consideration in the design and delivery of training

initiatives. There should be a stronger emphasis on incorporating equity into the assessment of participants’ needs. This can help guide the development and delivery of training content, as well as the evaluation of this work, so that best practices can be shared within the public health community. Incorporating equity into the delivery of training includes ensuring the participation of a diverse cross-section of the public health workforce, providing content in multiple languages as well as addressing potential barriers to people’s participation, particularly the engagement of underrepresented groups.^{30,31,36}

Delivery

Online training with a complementary in-person component was the most popular modality based on evaluation results. Options for engaging with online content have vastly expanded in recent years. The emphasis is on courses that are user-friendly and engaging.⁴⁰ Interactive exercises provide immediate feedback, assisting with knowledge retention.⁵² Combining online content with in-person approaches allows participants to ask questions, collaborate and understand the content better than in more passive engagement (e.g. reading static content on a screen).^{9,26,30,46}

It is crucial that trainers adapt the delivery modality to the type and complexity of content while being mindful of the skills, goals and experiences of their intended audience.^{18,20} Modality should be chosen based on content, participant capacity and resource availability. When learners have the autonomy to choose when and how to engage with material, known as self-directed learning, they are able to tailor their learning to their own professional goals and motivations.⁵³ This is an important aspect of adult-learning that allows individuals to decide their level of self-direction based on their own experiences, time constraints and learning goals.⁴⁷

Technological support

The availability of technological support to facilitate the timely resolution of technology-related challenges is important.³⁵ Before starting the course, participants should be familiar with the training modality, for instance via a website,³⁶ to minimize technical issues. In general, programs and the platforms need to be accessible and easy to use. When issues do arise, there should be an obvious way for

individuals to obtain technical assistance.^{17,18,20,35,37} Developers must ensure that the chosen delivery method is compatible with the technology available to potential participants wherever they are completing the training.

Organizational-level support

The design and delivery of a course is only as effective as the way in which it is promoted in the workplace. Based on our findings, managerial support, such as time to complete training during work hours and use of office equipment, enables staff to complete training.^{10,16,19,20,22} In order to successfully recruit participants, those offering training programs must ensure that potential participants and their managers see the purpose and benefits of training. Certification (only mentioned in one study¹⁰) can incentivize completion for both participants and their managers when ideally aligned with competencies.⁸ As shorter courses were generally more manageable for full-time staff to complete,^{10,22,28,36,37,41} course developers should consider how much time is needed for participants to become certified in a specific topic.⁸ Communicating incentives like certification early on can increase buy-in from all stakeholders.

Connected to managerial support, research on capacity building conducted by Joffres et al.⁵⁴ found that organizational-level support can promote the ability of participants to incorporate knowledge and skills gained into their daily work. An organization’s strategic direction begins at the senior management level, signalling to staff where priorities lie.⁵⁰ Organizational cultures that support the development of staff skills are essential for addressing emerging public health challenges in the face of rapidly changing contexts. As those in senior management positions are the stewards of systems-level change, their promotion of CE courses can help align the training offerings with organizational priorities so that training can be framed as part of existing work responsibilities, rather than as additional and new tasks that may burden an employee.⁵⁴ This approach to communicating the benefits of training also reflects an understanding of the context in which CE courses are offered and the value of using competencies to design relevant content. Senior and middle managers should work together towards a culture of professional development and organizational competence,

motivating, incentivizing and supporting the public health workforce to engage in meaningful CE.⁵⁰

Limitations

We did not extend our search to grey literature despite that agencies that offer public health workforce training do not always publish in the peer-reviewed literature. Given our specific focus on training programs that were explicitly evaluated afterwards, we considered that a review of the peer-reviewed literature was appropriate.

Having restricted our search to start in the year 2000, we may be missing further training courses offered before this date.

In addition, we only included programs with evaluations. Although we may have missed some innovative programs that have yet to be evaluated, this inclusion criterion allowed us to capture participant-preferred modalities and better understand lessons learned and best practices identified.

Finally, this being a scoping review, we did not assess the methodological quality of evaluation findings within the individual studies.¹² Rather, we used the evaluations across the studies to assess the commonly reported results, both positive and negative, of the various ways of delivering CE content.

Conclusion

The aim of this scoping review was to identify preferred modalities used to deliver CE to the public health workforce while examining how equity (in the form of inclusive approaches to training and health equity as a content area) has been incorporated in training. Our findings suggest that while there is no preferred modality, using both in-person and online engagement strategies, when possible, is highly beneficial for learner knowledge retention and application of content. Adult-learning principles should be used to design training and engage public health professionals.⁵³ This includes preparing the course with the understanding that adult-learners are motivated by the desire to solve problems and know why they are learning before undertaking training.⁴⁷ Similarly, CE should be developed with special consideration for participants' needs, previous experiences and technological and financial resources.⁴⁷

Only a few studies detailed strategies for delivering training equitably or teaching health equity as a content area. This highlights the need for greater emphasis to be placed on incorporating health equity into the design and delivery of CE material for this audience. Future research assessing the quality of literature on evaluating modalities employed would be beneficial to further understand the landscape of CE within the public health sector.

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Authors' contributions and statement

Conceptualization and design: AA, IB, UB, RK, EDR; acquisition of data: AA, IB; pilot of data charting: AA, IB, UB, RK, EDR; data charting: AA, IB, RK; formal analysis and interpretation of data: AA, IB; writing – original draft: AA, IB; writing – review and editing: AA, IB, UB, RK, EDR; writing – journal revisions: AA, IB, UB, RK, EDR; final approval: AA, IB, UB, RK, EDR; project administration: AA.

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At-a-glance

Injuries and poisonings associated with methamphetamine use: sentinel surveillance, the electronic Canadian Hospitals Injury Reporting and Prevention Program (eCHIRPP), 2011–2019

Steven R. McFaull, MSc; André Champagne, MPH; Wendy Thompson, MSc; Felix Bang, MPH

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Abstract

Information from emergency department (ED) visits for methamphetamine-related injuries and poisonings between 1 April 2011 and 9 August 2019 were captured from 19 sentinel sites across Canada for all ages.

Overall, 1093 cases (97.6/100 000 eCHIRPP cases) were identified (59.4% male), with female patients experiencing more poisonings (71% vs 57.4% for males). Unintentional injuries and poisoning accounted for 14.8% of ED presentations. Self-harm (while or as a result of consuming methamphetamine) accounted for 11.4% of cases. The circumstances surrounding injuries and poisonings associated with methamphetamine are varied and include self-harm, fall-related brain injuries, mental illness, criminal activity and other circumstances. These domains should be taken into account when developing mitigation strategies.

Keywords: *methamphetamine, poisoning, injury, surveillance, eCHIRPP*

Introduction

Methamphetamine is a highly addictive stimulant that acts on the central nervous system. Also known as “meth,” “blue,” “ice,” “crystal,” “crank,” “peanut” and others, methamphetamine takes the form of an odourless, bitter-tasting white crystalline powder that dissolves in water or alcohol. Methamphetamine was developed in the 1930s from its parent drug, amphetamine. It was used originally in nasal decongestants and bronchial inhalers.^{1,2,3}

Like amphetamine, methamphetamine use decreases appetite and increases alertness and energy, euphoria, physical activity, talkativeness, disinhibition and confidence. Chronic use may lead to psychotic symptoms such as hallucinations, paranoia and anxiety.⁴

Methamphetamine differs from amphetamine in that, at similar doses, larger amounts of the drug get into the brain, making it a more potent psychostimulant.⁵ It also has longer-lasting and more harmful effects on the central nervous system.⁶ Methamphetamine can be easily manufactured from readily available precursor substances.⁴ These characteristics make it a drug with high potential for abuse.

There are many physical, physiological and psychological harms associated with methamphetamine use and manufacture.^{4,7,8,9-11} There are also sex differences in the harms associated with methamphetamine use.¹²

The purpose of this study is to describe the circumstances of emergency department (ED) visits for injuries and poisonings associated with methamphetamine use or manufacture.

Highlights

- 1093 methamphetamine-related injury and poisoning cases presented to participating emergency departments (EDs).
- 71.4% of patients aged 10–14 years were female; of those aged 15–19 years, 63.7% were female.
- 70.4% of the patients aged 20 years plus were male.
- Of the 689 cases that also involved other substances (63%), 40.9% involved two or more other substances. Alcohol (24.4%), cannabis (10.7%), cocaine (7.7%), heroin (5.4%), opiates (3.6%) and other substances (7.3%) were involved when only one substance other than methamphetamine was used.
- Compared to males, females had more poisonings, while males more frequently had multiple injuries.
- Self-harm accounted for 11.4% of cases

Methods

Data source

The Electronic Canadian Hospitals Injury Reporting and Prevention Program (eCHIRPP) is an injury and poisoning sentinel surveillance system operating in 11 pediatric and 8 general hospitals across Canada. eCHIRPP is managed by the Centre for Surveillance and Applied Research at the Public Health Agency of Canada. The eCHIRPP captures detailed information via text fields, which allows

Author reference:

Public Health Agency of Canada, Ottawa, Ontario, Canada

Correspondence: Steven R. McFaull, Injury Section, Centre for Surveillance and Applied Research, Public Health Agency of Canada, 785 Carling Avenue, Ottawa, ON K1A 0K9; Tel: 613-404-1881; Email: steven.mcfauill@canada.ca

more detailed coding of circumstances and mechanisms.¹³ In contrast, administrative data coding using *International Classification of Diseases, 10th Revision (ICD-10-CA)*¹⁴ lacks the specificity to identify methamphetamine-related cases and does not provide details surrounding the circumstances of the incident.

Extraction of cases

We searched the eCHIRPP database for cases (all ages) of methamphetamine-related injuries and poisonings in the system as of 9 August 2019. Cases were included if the injured/poisoned person was a consumer and/or a manufacturer of methamphetamine or if the patient was injured by a person under the influence of and/or manufacturing methamphetamine (including infants born to addicted mothers and child bystanders). Since people could be injured (as opposed to poisoned), we used a broad, bilingual (English and French) text search to identify records using the eCHIRPP *narrative* and *substance ID* fields. A detailed list of 83 terms in both official languages (available upon request) was used in the initial search. Ultimately, the majority of cases (82.1%) were identified with four keywords/strings: “meth,” “crystal meth,” “speed” and “ice.” The data were cleaned by mining the narrative fields using Practical Extraction and Report Language (PERL) regular expressions¹⁵ in SAS version 9.4 (SAS Institute Inc., Cary, NC, USA), and all irrelevant expressions (e.g. “speed bumps,” “speeding”) were excluded.

The clean dataset was manually reviewed and coded with further circumstantial details (police involvement, use of other substances, self-harm, “on a bender,” presented with an unintentional injury, etc.).

Statistical analyses were conducted using SAS version 9.4, Epi Info 7.2.0.1 (CDC, Atlanta, GA, USA) and Microsoft Excel (2013).

Results

Overview

Overall, 1093 patients (97.6/100,000 eCHIRPP cases) were identified for the period between 1 April 2011 and 9 August 2019; of these, 59.4% (n = 649) were male. Among those aged 10–14 and 15–19 years, females accounted for 71.4% and 63.7%, respectively. Of those aged 20 years and older,

males predominated at 70.4% (see Figure 1 for the normalized age and sex distribution).

Location

The location where the injury occurred was specified in 420 cases (38.4%). Of those, 30.2% occurred in the patient’s own home and 16.9% in another private home. About one-quarter (26.4%) of the incidents happened outside, on a road or in an alley or public park. The injury occurred in a group home in 7.1% of cases. The remaining incidents (approximately 20%) occurred in hospitals, bars, hotels and numerous other locations, with each type of location contributing only a few per cent overall.

Circumstances

At 14.8%, unintentional injuries (aside from the toxic effects of the substances) were the most frequent circumstances surrounding the ED presentation (see Table 1). Of these unintentional injuries, 30.2% were falls. Self-harm, including attempted suicide, accounted for 11.4% of cases. People aged 15–29 years accounted for the highest percentage of self-harm (data not shown). Of the self-harm cases aged 10–19 years, 75% were female;

among those aged 20–49 years, 66.7% were male. Of the 1093 identified patients, 10.8% involved police or criminal activity and 9.4% involved violence (family and other).

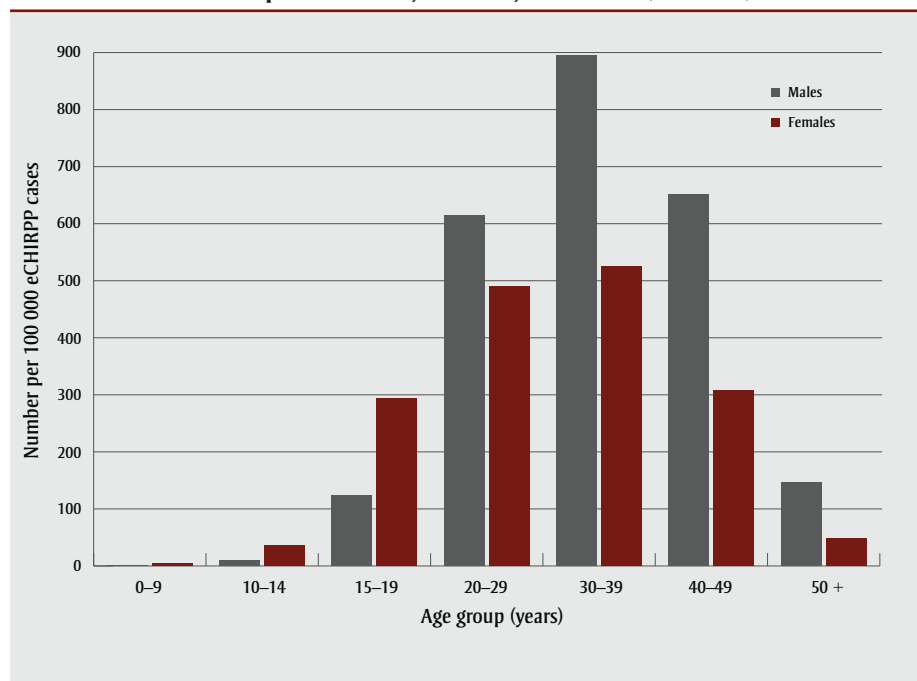
Use of other substances

Of the 1093 identified patients, 404 (37%) involved methamphetamine use alone. Of the remaining 689 cases, 40.9% involved polysubstance use (i.e. the simultaneous use of two or more substances in addition to methamphetamine). When only one other substance was involved, the following distribution was observed: alcohol (24.4%), cannabis (10.7%), cocaine (7.7%), heroin (5.4%), opiates (3.6%) and other substances (e.g. LSD, ecstasy, psychoactive medications) (7.3%).

Injuries and poisonings – sex differences

The 1093 patients had a total of 1389 injuries and poisonings, as 27.1% had multiple injuries. The sex differences in the injury and poisoning patterns were as follows: male patients had multiple injuries more frequently (32.8% vs. 18.7% for females; $p < .001$); female patients had more poisonings (71% vs. 57.4% for males; $p < .001$). Also, male patients had a

FIGURE 1
Normalized^a age and sex distribution of emergency department visits associated with methamphetamine use, eCHIRPP, 2011–2019 (N = 1093)



Abbreviation: eCHIRPP, electronic Canadian Hospitals Injury Reporting and Prevention Program.

^a Expressed as a proportion of all eCHIRPP cases in the given age group ($\times 100\,000$).

TABLE 1
Circumstances leading to an emergency department visit associated with methamphetamine use, eCHIRPP, 2011–2019 (N = 1093)

Circumstances ^a leading to ED visit	Number	
	Frequency (n)	Per cent (%)
Unintentional injury	162	14.8
Fall	49	4.5
Motor vehicle collision	32	2.9
Bicyclist, pedestrian	22	2.0
Other unintentional injury ^b	59	5.4
Self-harm, suicide	125	11.4
Police involvement/criminal activity ^c	118	10.8
Known ^d addict/abuser	108	9.9
On a binge/bender ^e	106	9.7
Violence	103	9.4
Other violence ^f	77	7.0
Family violence	26	2.4
Found having a seizure/unresponsive	82	7.5
Found wandering, homeless	62	5.7
Depression, anxiety, mentally ill	59	5.4
Partying (including at a rave)	37	3.4
Asking for help	9	0.8
Other person injected or “slipped” pill ^g	8	0.7
Undergoing meth withdrawal ^h	7	0.6
Bad batch/“different from usual”	6	0.5
Took meth, NFS	93	8.5
Other ⁱ	8	0.7
Total	1093	100.0

Abbreviations: eCHIRPP, electronic Canadian Hospitals Injury Reporting and Prevention Program; ED, emergency department; NFS, not further specified.

^a Each case was coded into only one category based on information in the patient’s narrative.

^b Includes burns, work-related, struck by/against, poisoning, needle stick.

^c Includes police chases, break and enter, rowdiness, running into traffic.

^d Patient was known to ED staff.

^e Over a period of days; including in “trap houses, flop houses.”

^f Assaulted; in a fight; sexual assault.

^g Patient was injected with or ingested methamphetamine unwillingly.

^h Includes infants born to addicted mothers.

ⁱ Includes injury in fire (related to use) and during manufacture/“cooking”; pregnant; in chronic pain; took to help study; at safe injection site.

higher proportion of fractures (21.5% vs 11.1%; $p < .005$) and females had a higher proportion of bruises and abrasions (16.3% vs. 7.9%; $p < .005$). After evaluation in EDs, females more frequently had a diagnosis of “no injury detected” (11.8% vs. 4.4% for males; $p < .005$). Males had a higher proportion of traumatic brain injuries (9.8% vs. 5.2% for females), but due to the low counts, this was statistically not significant ($p = .06$). Thirteen patients had frostbite due to prolonged exposure to cold (“found outside unresponsive”). Males accounted for 11 of these 13 cases, but due to low

counts the difference was not statistically significant ($p = .21$).

Treatment in the emergency department

Overall, 17.7% of male cases and 10.8% of female cases ($p < .001$) who presented to the ED were admitted. A further 2.9% of cases were admitted for reasons other than injury (e.g. addiction treatment).

Discussion

The physical and psychological harms to users as well as to families and society

can be considerable, making methamphetamine use a serious public health concern.^{7,16}

The opioid crisis in Canada has shown that various factors contribute to substance abuse increasing rapidly in populations.¹⁷ Thus continued surveillance is necessary to detect changes and implement mitigation strategies.

The eCHIRPP narratives allow contextual information and further circumstantial details can be gleaned, for example, involvement of police/criminal activity, family violence, psychological state, self-harm, homelessness and other situations. This information can be used in health promotion and injury mitigation efforts. The eCHIRPP database has been previously used in the same way to describe suspected opioid-related poisonings.¹⁸

We observed sex differences with respect to poisonings, injuries and self-harm. Such sex differences (which have been previously reported¹²) should be kept in mind when developing prevention initiatives.

Strengths and limitations

The eCHIRPP does not capture all the incidents in Canada, but only those presenting to the participating EDs. Because most of the eCHIRPP hospitals are pediatric (and usually located in major cities), certain populations are underrepresented, for example, rural inhabitants (including some Indigenous peoples), older teens and adults.

While eCHIRPP captures people who are dead-on-arrival, those who died at the scene or later in hospital are not included. Patients who bypass the ED registration desk for immediate treatment may also not be captured as is the case for those who do not complete an Injury/Poisoning Reporting form.

In the case of polysubstance use, it is not possible to determine the effects of the individual substances on the outcome. In addition, sex differences in use behaviors and drug responses may result in a bias of those presenting to the ED.^{12,19}

Conclusion

The circumstances, sex and age differences to do with injuries and poisonings associated with methamphetamine use and

manufacture should be taken into account when developing mitigation strategies.

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Conflicts of interest

The authors declare no conflicts of interest.

Authors' contributions and statement

SRM: conceptualization, analysis, methodology, writing – original draft; AC: writing – review and editing; WT: writing – review and editing; FB: writing – review and editing.

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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At-a-glance

Trends in emergency department visits for acetaminophen-related poisonings: 2011–2019

Jaskiran Kaur, MSc; Steven R. McFaull, MSc; Felix Bang, MPH

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Abstract

We examined trends in emergency department (ED) presentation rates for acetaminophen-related poisonings across Canada. A total of 27 123 cases of poisoning were seen in the electronic Canadian Hospitals Injury Reporting and Prevention Program (eCHIRPP) sentinel sites between April 2011 and February 2019; of these, 13.7% were related to acetaminophen use. A significant decreasing trend for both sexes was observed for unintentional poisonings (males: –10.3%; females: –8.0%). For intentional poisonings, there was a significant decrease among females only (–5.9%). Females have consistently displayed higher rates of ED presentations for both unintentional and intentional poisoning.

Keywords: acetaminophen, Tylenol, paracetamol, poisoning, CHIRPP

Introduction

Acetaminophen, also known as paracetamol, APAP¹ or Tylenol, is a common medication used for reducing pain and fever. It is widely available on the market in many over-the-counter and prescription medicines. It can be found as an individual product containing acetaminophen only (e.g. Tylenol); as over-the-counter cold remedies (e.g. DayQuil/NyQuil); or in combination with an opiate (e.g. Percocet). Due to its widespread availability, acetaminophen is a common cause of both unintentional and intentional ingestions.

Research from Canada and the United States has shown that, if taken in excessive amounts, acetaminophen is the leading cause of acute liver failure.¹⁻⁴ Approximately 4500 hospitalizations due to acetaminophen overdose are reported each year in Canada. About 6% of patients hospitalized for overdose develop liver conditions including acute liver failure that may lead to death.²

The purpose of this brief report is to describe the pattern of cases of acetaminophen

ingestions reporting to Canadian emergency departments.

Methods

The Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP)⁵ is a sentinel injury and poisoning surveillance system administered by the Public Health Agency of Canada. CHIRPP collects data from emergency departments (ED) in 11 pediatric and 8 general hospitals across Canada (19 sites altogether). We searched the electronic (eCHIRPP) database for ED visit records for acetaminophen-related poisonings between 1 April 2011 and 23 February 2019 ($N = 1\,037\,843$). Cases were included if the following criteria were met:

i. Description of injury

- The direct cause of injury, or contributing factors, was coded as “Acetaminophen, INCL Tylenol – alone” (eCHIRPP code 753F) or “Acetaminophen, INCL Tylenol – with other substance, INCL Tylenol with codeine” (eCHIRPP code 754F)

Highlights

- A total of 27 123 cases of poisoning were captured in the eCHIRPP database, of which 3721 cases (13.7%) were acetaminophen related.
- About 50.3% of the poisonings were unintentional, 48.6% were intentional and 1.1% were of undetermined intent.
- There was a significant decreasing trend in acetaminophen poisonings, among all unintentional poisonings, for both males (–10.3%) and females (–8.0%).
- Among all intentional poisonings, there was a significant decrease for acetaminophen poisonings among females (–5.9%) but not among males.
- Compared to males, females had consistently higher rates of emergency department presentations for both unintentional and intentional acetaminophen-related poisonings.

or “Allergy/cold/cough medications, INCL containing ASA or acetaminophen” (eCHIRPP code 755F), or

- The narrative text included the following French and English key words/strings: “ACETA,” “ACÉTA,” “TYLENOL,” “TYLÉN,” “PARACETA,” “PARACÉTA”
- ii. Nature of injury and external cause.
 - The nature of injury code indicated poisoning or toxic effect (eCHIRPP code 50NI) or the external cause contained the code 301EC (301EC: Poisoning INCL street and

Author reference:

Public Health Agency of Canada, Ottawa, Ontario, Canada

Correspondence: Jaskiran Kaur, Centre for Surveillance and Applied Research, Public Health Agency of Canada, Rm 629A4, 785 Carling Avenue, Ottawa, ON K1A 0K9; Tel: 613-668-7254; Email: jaskiran.kaur@canada.ca

prescription drugs, alcohol, solvents, gases, corrosives and pesticides/fertilizers).

In instances where only one of the three criteria was met, an analyst adjudicated the case manually. Cases ($n = 98$) were excluded from the present analysis when it was uncertain which drug had been taken.

Time trends for 2011 to 2018 were analyzed using Joinpoint Regression Program version 4.6.0.0 (SEERStat, NCI, Bethesda, MD, USA), which outputs the average annual per cent change (AAPC) or the annual per cent change (APC).⁶ Data for 2019 are incomplete and therefore excluded from the trends analysis. All statistical analyses were performed using Enterprise Guide, version 5.1 (SAS Institute Inc., Cary, NC, USA).

Results

From 1 April 2011 to 23 February 2019, a total of 27123 cases of poisoning were seen at the eCHIRPP sentinel sites, of which 3721 (13.7%) cases were related to acetaminophen. This represented 13719/100000 eCHIRPP cases of all types of poisoning. About 50.3% of the poisonings were classified as unintentional, while 48.6% were intentional and 1.1% of the cases were of undetermined intent.

The median age was 14.0 years (interquartile range [IQR]: 2.0–16.0). Females accounted for two-thirds ($n = 2513$; 67.5%) of the ED visits for acetaminophen-related poisoning, representing 19.9% of all female poisoning cases from 2001 to 2019. Those aged 15–19 years accounted for one-third (35%) of acetaminophen-related poisoning cases in eCHIRPP, while those aged 2–4 years accounted for 22.9% of acetaminophen-related poisoning cases.

Acetaminophen-related intentional poisonings were significantly higher in those aged 15–19 years (28.2%; $p < .0001$) and in females (42.2%; $p < .0001$). The majority of the cases ($n = 2597$; 69.8%) involved products containing acetaminophen alone (e.g. Tylenol), while 15.9% ($n = 590$) involved acetaminophen combined with other substances (e.g. Tylenol with codeine) and 14.4% ($n = 534$) involved allergy/cold/cough medication containing acetaminophen. Acetaminophen-related intentional poisonings predominated

in both sexes from the age of 10 years and older.

Figure 1 shows the results of the Joinpoint analysis by intent and sex from 2011 to 2018 (data for 2019 are incomplete and therefore excluded from the trends analysis). No inflection points were found and overall trends were represented by APC. As a proportion of all unintentional poisonings, there was a significant decreasing trend for both males (–10.3%; 95% CI: –17.2 to –3.0) and females (–8.0%; 95% CI: –12.5 to –3.2). For the intentional acetaminophen poisonings, there was a significant decrease among females (–5.9%; 95% CI: –10.7 to –1.0) but not males.

Figure 2 summarizes the results for both sexes by age and by intent. Females were older, with a median age of 14.0 years

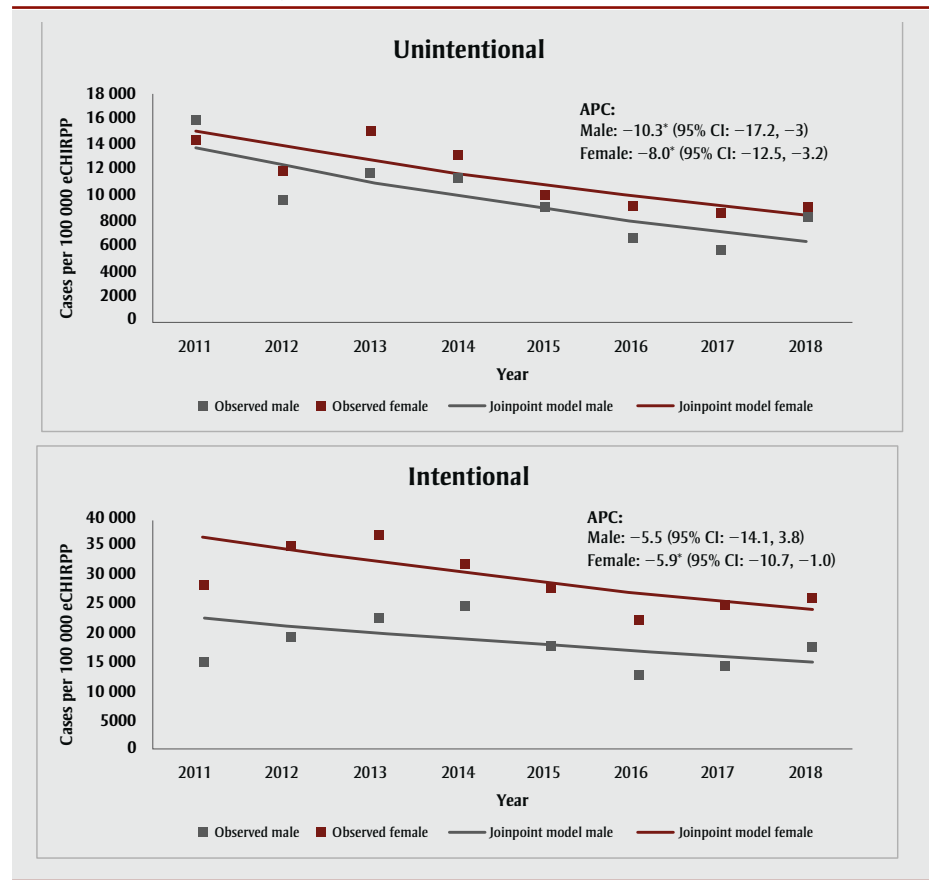
(IQR: 9.0–16.0) compared to a median age of 3.0 years for males (IQR: 2.0–15.0). Females have consistently displayed higher rates of ED presentations for both unintentional and intentional acetaminophen-related poisoning than males. At almost six times that of males in the same age group, females aged 10–19 years have a disproportionately high rate of unintentional poisoning ($n = 1390$; 31512 per 100000 eCHIRPP cases).

The number of patients presenting to EDs for acetaminophen-related poisoning decreased in older age groups (≥ 20 years) for both sexes.

Discussion

From 2011 to 2019, 3721 acetaminophen-related poisoning cases presented to EDs

FIGURE 1
Evolution of normalized^a emergency department presentation rates associated with intentional and unintentional acetaminophen poisonings, by intent and sex, eCHIRPP, 2001–2018^b



Abbreviations: APC, annual per cent change; CI, confidence interval; eCHIRPP, electronic Canadian Hospitals Injury Reporting and Prevention Program.

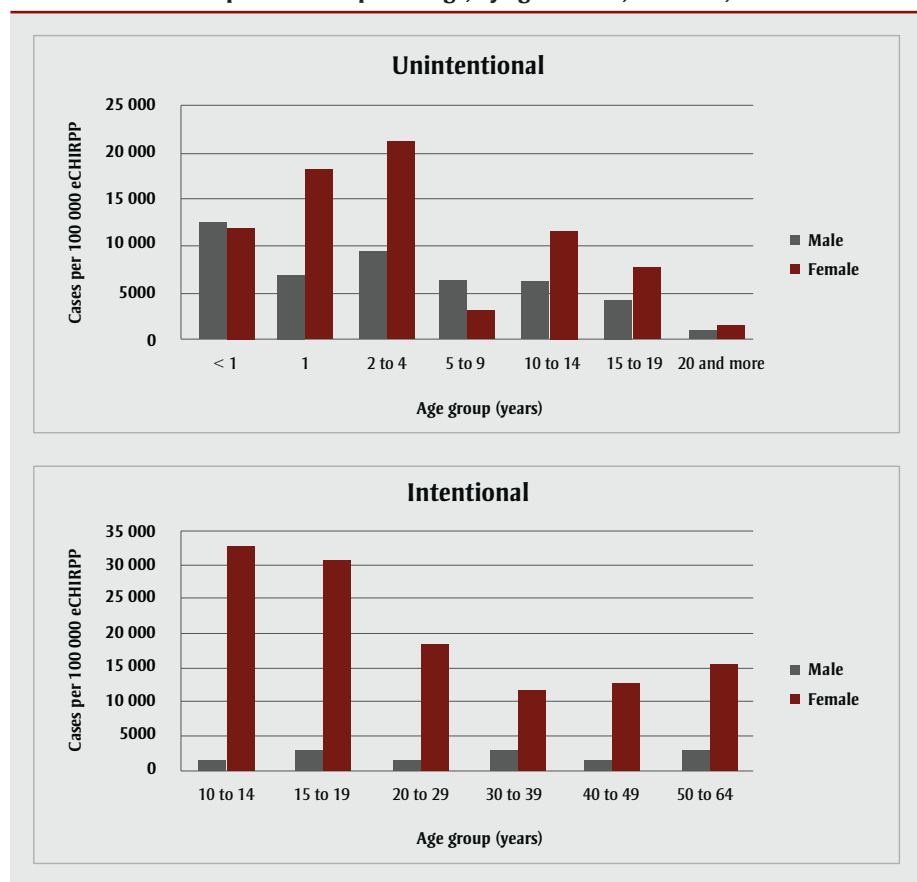
Note: Undetermined intent was excluded from the analysis due to the low number of cases.

^a Proportion of all eCHIRPP cases for a given year ($\times 100\,000$).

^b Because data are incomplete for 2019, only 2011 to 2018 data were included in the Joinpoint analysis.

*Indicates that APC is significantly different from zero at the $\alpha = 0.05$ level.

FIGURE 2
Normalized^a distribution of emergency department presentations
for acetaminophen-related poisonings, by age and sex, eCHIRPP, 2001–2019



Abbreviation: eCHIRPP, electronic Canadian Hospitals Injury Reporting and Prevention Program.

Note: Due to non-stable data, the <10-year and >65-year age groups were not included in the analysis for intentional poisoning.

^a Proportion of all eCHIRPP cases for a given year ($\times 100\,000$).

across Canada; these accounted for 13.7% of all poisoning cases in eCHIRPP. Consistent with other studies,^{7,8} there were far more acetaminophen-related poisoning cases among females than males. This is consistent with data that show poisoning to be a primary method of suicide among females.^{9,10}

Overall, ED presentations due to acetaminophen overdose appeared to decline between 2011 and 2018. As a proportion of all unintentional poisonings, a significant decreasing trend was observed for both males and females; in the case of intentional acetaminophen poisonings, a significant decrease was noted among females but not males.

We found that children aged 0–4 years had more acetaminophen-related accidental poisonings compared to other age groups. Accidental poisonings predominated in females in all ages groups except among neonates and infants aged less

than one year. It is possible that these accidental overdoses were caused by miscalculation or incorrect measurement of doses by parents/guardians. On the other hand, intentional poisoning by acetaminophen was more common among adolescents aged 10–19 years, with higher prevalence among females. Studies have shown that self-poisoning is the most common method of attempting suicide among adolescents^{11,12} and that over-the-counter medications are the most commonly used means.¹³ Acetaminophen-related mortality is higher in countries where unlimited quantities can be obtained.¹⁴ However, it is important to note that the use of acetaminophen for self-poisoning is not merely related to its accessibility but also to its popularity and the availability of other methods.

In 2009, Health Canada finalized the *Acetaminophen Labelling Standard*, which led to the inclusion of stronger warnings on the risk of liver damage.¹⁵ The labelling

standard was revised in 2016 based on the outcome of Health Canada’s 2014 review.¹⁶ These recommendations include, but are not limited to, a stronger warning to do with concomitant alcohol consumption; more safety information about the product’s contents on the label; and a drug facts table providing instructions and warnings in an easy-to-read format. A dosing device has also been included to help parents/caregivers administer children’s liquid acetaminophen products.

All acetaminophen products have been expected to comply with the new labelling standard since March 2018. As such, the improved labelling standard may have been implemented too recently to have had an obvious effect. Consequently, ongoing surveillance of acetaminophen-related poisoning is necessary to assess the effect of the improved labelling standard and to support the implementation of safety measures to reduce the risk of harm from this regularly used and widely accessible medication.

Strengths and limitations

This study provides the most up-to-date analysis of pan-Canadian trends in ED presentations of acetaminophen poisoning. However, our sample was not fully representative of the Canadian population as only some hospitals participate in the CHIRPP. Because CHIRPP sites are mostly pediatric hospitals located in major cities, older teens, adults, some Indigenous peoples and rural inhabitants are under-represented.

While eCHIRPP captures cases who are dead-on-arrival, fatalities are under-represented because ED data do not capture those who died before they could be taken to hospital or those who died after being admitted. Patients who bypass the ED registration desk for immediate treatment may also not be captured. The same is true of those who do not complete the Injury/Poisoning Reporting form.

Finally, the narratives are largely dependent on patients/caregivers as they are based solely on the information they provide at the time of the injury. Patients who do not have good knowledge of drugs may confuse acetaminophen with other drugs. Further, the intent of the poisoning could also be potentially flawed from omissions as patients may not want to report this due to the sensitive nature of the topic.

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Conflicts of interest

None.

Authors' contributions and statement

JK conducted the data analysis and wrote the paper. FB performed Joinpoint analysis. SRM and FB helped revise the paper.

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