Cannabis-Related Emergency Department Visits by Ontario Youths and their Outcomes: Repeated Cross-Sectional Study

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Funding Statement

This research was funded by a contract from the Public Health Agency of Canada (PHAC). The researchers are independent from the funder, with the exception of Melissa Baker, who is employed by PHAC. This study was also supported by ICES, which is funded by an annual grant from the Ontario Ministry of Health and Long-Term Care (MOHLTC). ICES reviewed the plan for creating the data set and analyzing the data. Other than author Isac Lima, who was then an ICES employee, ICES played no role in the management, analysis, and

interpretation of the data; or the preparation or review of the manuscript. Author Paul Kurdyak was the ICES Scientist on this project, and he reviewed the manuscript to ensure that it complied with ICES and provincial data privacy laws and regulations. Otherwise, the funders had no role in the design and conduct of the study; the collection, management, analysis, and interpretation of the data; the preparation, review, or approval of the manuscript; or the decision to submit the manuscript for publication.

Competing Interests

All authors declare: no support from any other organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, and no other relationships or activities that could appear to have influenced the submitted work.

Keywords: Adolescents, Emergency Departments, Cannabis, Population Health, Substance Misuse

ABSTRACT

Background: Cannabis use can have chronic and acute health consequences resulting in the use of hospital emergency services. We examined trends in health administrative data on cannabis-related Emergency Department (ED) visits among youth in Ontario, Canada, from 2003-2017.

Methods: Participants were youth aged 10-24 years who presented to an Ontario ED. Cannabis-related visits were identified among 14,697,778 ED visits using ICD-10 codes T407 and F12. Nurses assigned Canadian Triage and Acuity Scale at triage; we categorized presentations as "Less Severe" ('Non-Urgent' or 'Less Urgent') versus "More Severe" ('Urgent', 'Emergent', or 'Resuscitation').

Results: Cannabis-related visits increased from 3.8/10,000 youths (95%CI 3.5-4.0) in 2003 to 17.9 (95%CI 17.4-18.4) in 2017, a 4.8-fold increase (95%CI 4.4-5.1). Rates increased for both sexes and each age group. Males were more likely to have a visit than females (Rate ratios [RR] $\geq$ 1.5 in 2003 and 2017). Among 19-24 year-olds, 25.0/10,000 (95%CI 24.0-25.9) had cannabis visits in 2017, compared to 21.9/10,000 (95%CI 20.9-22.9) for 13-18 year-olds, and 0.8/10,000 (95%CI 0.5-1.0) for 10-12 year-olds. In 2017, 88.2% (95%CI 87.3%-89.0%) of cannabis visits were triaged as "more severe", compared to 58.1% (58.0%, 58.2%) of non-cannabis visits; RR = 1.52 (1.50, 1.53). Similarly, in 2017 19.0% (95%CI 18.0-20.1) of cannabis visits were admitted to hospital, compared to 5.8% (95%CI 5.7-5.8) of non-cannabis visits; RR = 3.3 (95%CI 3.1-3.5.

Interpretation: Cannabis-related ED visit rates by 10-24 year-olds increased almost five-fold from 2003 to 2017 in Ontario. The triage severity and rate of hospital admissions of cannabis-related ED presentations also increased.

INTRODUCTION

Cannabis use can have chronic and acute health consequences resulting in the use of hospital emergency services. Patients may present to the Emergency Department (ED) with agitation, psychosis, anxiety, or emesis following cannabis use (1). Younger children seen in the ED following ingestion of cannabis may present with unexplained lethargy, ataxia, tachycardia, mydriasis, or hypotonia (2,3). Cannabis exposure in children may require intubation or admission to the intensive care unit (2). Cannabis exposure, particularly in youth under 18 years, is also associated with an increased risk of psychosis and long-term cognitive problems (4,5).

The nonspecific presenting symptoms of cannabis use can pose a diagnostic challenge for ED physicians, particularly if the patient does not disclose recent cannabis use or if ingestion was unknown to the child's caregivers or bystanders. Such patients may undergo costly diagnostic tests, including bloodwork, electrocardiograms, and neuroimaging (6). By quantifying the trends of cannabis-related visits, physicians can be furnished with information to encourage maintenance of a high index of suspicion for cannabis use, which may result in improved management of cannabis-related ED visits among youths. The ED is also an important entry point for youths to the mental health and substance use care systems, so understanding trends in cannabis-related ED visits is important for health system planning and the organization of connected care systems.

Therefore, the objectives of our study were to present annual rates of cannabis-related ED visits, and the severity of such visits, among 10-24 year-olds in Ontario from 2003-2017. We studied these trends as a function of youths' age and sex because these differences in drug use are well-established (7,8).

METHODS

Study design, setting, and participants

This was a repeated cross-sectional study, approved by the Research Ethics Board of the Children's Hospital of Eastern Ontario. We examined all visits to Ontario EDs from 2003 to 2017 by youth aged 10-24 years with an Ontario Health Insurance Plan number. This age range captures the highest risk groups for cannabis-related ED visits (9,10).

Data sources

Data on ED visits were obtained from the Canadian National Ambulatory Care Reporting System (NACRS). The variables collected from the NACRS database included International Classification of Diseases, 10th Revision (ICD-10) diagnostic codes (11), Canadian Triage and Acuity Scale (CTAS) (12–14), year of ED presentation, sex, and age. The Registered Person Database (RPDB) was used to link ED youth records with rural status and neighborhood income quintile. The Ontario population counts by year, age, and sex were obtained from population estimates by Statistics Canada held by the Ontario Ministry of Health and Long-Term Care and were linked using encoded identifiers at ICES.

Measurements

Cannabis visits

Cannabis visits were identified using the International Classification of Diseases, 10th Revision (ICD-10) codes T407 "(Poisoning by narcotics and psychodysleptics [hallucinogens]: cannabis [derivatives])" (15) and F12 "(Mental and behavioural disorders due to use of cannabinoids)" (16). ICD-10 codes have not been validated for cannabis-related ED visits. However, studies of opioid poisoning in routinely-collected health records (17) and alcohol intoxication in ED records (18) suggest that these codes have moderate validity.

Visit Severity

Triage nurses assign the CTAS to patients on entry to the ED. We grouped the five CTAS levels as Less Severe ('Non-Urgent' or 'Less Urgent') versus More Severe ('Urgent', 'Emergent', or 'Resuscitation'). We also recorded whether ED patients were admitted to hospital.

Demographic variables

Data were gathered on patients' age (grouped as 10-13, 14-18, and 19-24 years), sex, whether they lived in a rural census area, and the patient's census area's income quintile.

Statistical methods

To describe changes in ED visits, we calculated the rates of cannabis-related visits/10,000 ED visits in 2003 and 2017. Some youths had more than one cannabis-related visit in a given year. To eliminate the clustering of visits among youths, our primary analyses examined counts of youths with at least one cannabis-related visit in a year. We divided these counts by the Ontario youth population during each year (19) to report rates of youths with at least one cannabis visit/10,000. We plotted these rates from 2003 to 2017 with loess-smoothed curves with 95% confidence intervals. (A Poisson regression analysis is in an online supplement.)

Rate ratios (RRs) were used to capture the association between cannabis-related ED visits and demographics. Given our large *N*s, we reported RRs with 95% confidence intervals (95%CI) and omitted significance tests. Statistics were calculated using R Version 4.0.3 (20).

RESULTS

Participants

[Table 1 about here.]

There were 14,697,778 ED visits by eligible patients between 2003 and 2017. Table 1 reports patient demographics and cannabis-related ED visit counts in 2003 and 2017.

Cannabis-Related Visits/10,000 ED Visits

For patients aged 10-24 years, cannabis visits increased from 11.0 (95%CI 10.3-11.7) to 51.7 visits/10,000 ED visits (95%CI 50.3-53.1) a 4.7-fold increase (95%CI 4.4-5.0. Cannabis-related ED visits increased between 2003 and 2017 for both sexes and all age groups (Table 1). In 2017, rates of cannabis visits were higher for males, 69.7 visits/10,000 visits (95%CI 67.3-72.1) than females 36.6 (95%CI 35.0-38.2); RR = 1.9 (95%CI 1.8-2.0). Rates were higher for 19-24 year-old youths, 63.9 visits/10,000 ED visits (95%CI 61.7-66.1) and 14-18 year-old youths, 61.6 (95%CI 58.9-64.3) than for 10-13 year-olds, 2.7 (95%CI 2.0-3.4). The RRs were more than twenty-fold greater in both older groups, compared to the younger age group. Rates in 2017 were higher for youths residing in areas in the lowest income quintile) 57.8 visits/10,000 visits (95%CI 54.7-60.8) compared to those living in the highest quintile, 47.3 (95%CI 44.1-50.4); RR = 1.2 (95%CI 1.1-1.3). Finally, youths who resided in a non-rural census area had 55.8 visits/10,000 visits (95%CI 54.2-57.4) versus those living in a rural area, 31.7 (95%CI 29.1-34.3); RR = 1.8 (95%CI 1.6-1.9).

Rates of Youths with at least one Cannabis Visit/10,000 Youths

[Figure 1 and Table 2 about here.]

Figure 1 presents the trends between 2003 and 2017 in rates of youths with at least one cannabis visit/10,000 Ontario youths. Table 2 contrasts the rates in 2003 and 2017. Figure 1 Panel A presents the rates for all youths, which increased from 3.8 youths/10,000 (95%CI 3.5-4.0) in 2003 to 17.9 (95%CI 17.4-18.4) in 2017; RR = 4.8 (95%CI 4.4-5.1). Youths with cannabis visits/10,000 increased between 2003 and 2017 for both sexes (Panel B), each age group (Panel C), and each age × sex subgroup (Panel D). Males had higher rates than females throughout the time period, with RRs ≥ 1.5 in both 2003 and 2017. Panel C shows increases in youths with cannabis visits/10,000 between 2003 and 2017 among 19-24 year-olds, RR = 5.7 (95%CI 5.2-6.3), and 14-18 year-olds, RR = 3.8 (95%CI 3.4-4.2). The increases in the two older groups were non-linear, with accelerating growth over time. In 2017, the rate was 25.0/10,000 youths (95%CI 24.0-25.9) for 19-24 year-olds, compared to 0.8 (95%CI 0.5-1.0) for 10-13 years olds; RR = 33.0 (95%CI 24.8-43.7). Finally, Panel D and Table 2 show that the sex difference in youths/10,000 occurred among the 19-24 and 13-17 year-old groups, where the rates for males were ≥ 1.3 times greater than for females in 2003 and 2017. The RRs for males versus females among 10-12 year-olds, however, were not statistically different from 1.0.

Triaged Visit Severity and Admissions from the ED to the Hospital

[Figure 2 and Table 3 about here.]

Figure 2, Panel A shows that cannabis-related visits were more likely to be triaged as severe than non-cannabis visits. In 2003, 65.7% (95%CI 62.8%-68.7%) of cannabis visits were severe, compared to 31.0% (95%CI 30.9%-31.1%) of non-cannabis visits; RR = 2.1 (95%CI 2.0-

2.2) (Table 3). In 2017, 88.2% (95%CI 87.3%-89.0%) of cannabis visits were severe, compared to 58.1% (95%CI 58.0%-58.2%) of non-cannabis visits; RR = 1.52 (95%CI 1.50-1.53). The severity of both types of visits grew over time: RR = 1.3 (95%CI 1.3-1.4) for cannabis and 1.9 (95%CI 1.9-1.9) for non-cannabis visits. Panel B shows that cannabis visits were more likely to result in hospital admissions. In 2003, 9.0% (95%CI 7.2%-10.8%) of cannabis visits were admitted, compared to 5.0% (95%CI 5.0%-5.1%) of non-cannabis visits; RR = 1.8 (95%CI 1.5-2.2) (Table 3). In 2017, 19.0% (95%CI 18.0%-20.1%) of cannabis visits were admitted, compared to 5.8% (95%CI 5.7-5.8) of non-cannabis visits; RR = 3.3 (95%CI 3.1-3.5). Admissions increased from 2003 to 2017 for both types of visits: RR = 2.1 (95%CI 1.7-2.6) for cannabis and 1.2 (95%CI 1.1-1.2) for non-cannabis visits.

DISCUSSION

In 2017, 4,612 Ontario youths aged 10-24 years had ED visits for cannabis exposure, nearly five times the number in 2003. Even though this was a small absolute increase in visit rates, from 0.1% to 0.5% of all visits, the increase in rates of ED visits for cannabis exposure accelerated over time, and the rapid increase raises concern about the impact of cannabis on youth.

Cannabis-related ED visits were more common among males, although rates increased for both sexes. Cannabis visits were more common and increased more quickly among 14-18 and 19-24 year-olds than among 10-13 year-olds. Similar increases in cannabis-related visits for youths have been reported in other jurisdictions, including the US (10,21), Colorado (22), Washington state (23), and France (24). Cannabis visits were more severe at presentation than visits for other conditions, and the proportion of cannabis visits triaged as severe increased between 2003 and 2017. A patient with a cannabis visit was twice as likely to be admitted to

hospital in 2017 compared to 2013, and in 2017 they were more than three times as likely to be admitted to hospital compared to those with non-cannabis visits. We have not found previous studies of trends in the severity of cannabis-related ED visits.

Why have cannabis-related ED visits been increasing? It is possible that cannabis use in the adolescent population has been increasing. However, the Canadian Tobacco, Alcohol and Drugs Survey (CTADS) reported no increase from 2015 to 2017 in past-year cannabis use for youth aged 15 to 24 years (25). The Ontario Student Drug Use and Health Survey (OSDUHS) found significant self-reported *decreases* in cannabis use amongst Ontario high school students, from 28.0% in 1999 to 19.0% in 2017 (26). Note that ED visits could increase even when cannabis use in the general youth population decreased if use increased in a small but high-risk subset of the population. Many of these youths may have concurrent mental health problems, and ED visits for these problems have increased during the same period (27). However, it is unclear whether this increase is a result of increased prevalence of mental health disorders or increased help-seeking for these disorders (28). An alternative explanation is that as cannabis has become increasingly accepted, prevalent, and legalized for Canadian adults, cannabis surveillance has increased within EDs. If so, the increase in cannabis-related ED visits could reflect a greater propensity for clinicians to diagnose a visit as cannabis-related.

Cannabis-related ED visits may also have increased because cannabis users are increasingly exposed to potent cannabis products or efficient modes of drug administration. Chandra *et al*. (29) report that the tetrahydrocannabinol (THC) concentrations in cannabis preparations seized in the US nearly doubled from 2008 to 2017. THC concentrations in European samples likewise doubled from 2006 to 2016 (30); potency increases have also been reported by French police (24) and Dutch retailers. Synthetic cannabinoids are of particular

concern; patients may present to the ED with agitation or somnolence, emesis, tachycardia, and hypertension (31). Cannabis vaping can deliver high doses of THC and has been increasing among US adolescents (32–34). We speculate that potent preparations and modes of drug administration may also explain the increasing acuity of presentation noted in our study (35,36). The long-term effects of these novel products and consumption patterns are not currently known.

With more potent cannabis formulations and ingestion methods, youths may present to the ED in a way that is difficult to distinguish from a primary psychotic disorder. The agitation of acute paranoia would be scored higher on CTAS (e.g., these individuals may require physical or chemical restraint). They may also require hospitalization if discriminating between cannabis toxicity and psychosis requires too much time for a typical ED visit, which may explain the increase in admission rates over time.

Awareness of cannabis-related ED visits is relevant in Canada following the Cannabis Act on October 17, 2018 (37), which legalized recreational use for persons 18 years and older. Colorado's legalization was followed by increases in cannabis-related ED visits, calls to poison control centers, and hospitalizations.(38,39) This suggests that Canadian rates of cannabis-related ED visits may continue to rise.

We recommend that ED clinicians maintain a high index of suspicion for cannabis exposure in young people presenting with non-specific somnolence or psychomotor agitation. Asking about possible cannabis exposure early in the clinical encounter may help avoid unnecessary diagnostic testing. Parents and youth should be counselled about the acute and chronic risks of cannabis exposure, including the possible impacts on mental health and safety of prolonged use or of products with high THC concentrations (4,5,40).

Limitations

Our study was observational and used administrative data. Administrative records are subject to several forms of error, including inaccurate or incomplete documentation of problems by clinicians and errors in coding and abstraction of data from clinical records. Gibson and her colleagues (41) studied the quality of NACRS data by carrying out re-abstractions of charts at several Ontario EDs and found agreement rates for ICD-10 codes that ranged from 86-90%. DeYoung and colleagues (42) noted excellent sensitivity and specificity by using the same ICD10 codes to identify cannabis-related ED visits, and several other studies have used the same codes to identify such visits (40,43–47). However, other studies suggest that using health administrative data to identify substance use presentations has low sensitivity but high specificity (48). Therefore, our results likely underestimate the rates of cannabis-related ED visits. Since NACRS records have limited information, our understanding of the presenting features, treatments, and discharge planning for these patients is limited. Also, our data lacked information about the cannabis preparation, how the youth consumed the drug, or whether the youth was a chronic user. Finally, our study uses data from a single Canadian province and may have limited generalizability.

Conclusion

Cannabis-related ED visits increased in Ontario from 2003 to 2017 for youths 14 to 24 years of age. Moreover, these visits were increasingly likely to be triaged as severe and to result in hospitalizations. Research is needed to identify the health and social consequences of cannabis-related visits for these youth. Further studies of the complex and multifactorial predictors and causes of cannabis-related ED presentations will help guide preventive efforts.

Research is also needed on the follow-up care patients receive after discharge from the ED or hospital following a cannabis-related visit.

Transparency Declaration

The lead/corresponding author (the manuscript's guarantor) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

Contributions and Acknowledgments

Melanie Bechard, Roger Zemek, Mina Salamatmanesh, Maala Bhatt, Sinthuja Suntharalingam, Paul Kurdyak, and Melissa Baker contributed to the conception or design of the work, analysis and interpretation of the data, to the drafting of the manuscript, and the revision of critical content. Isac Lima contributed to the analysis and interpretation of the data, to the drafting of the manuscript, and the revision of critical content. Paula Cloutier and William Gardner contributed to the conception or design of the work, acquisition of the data, analysis and interpretation of the data, to the drafting of the manuscript, the revision of critical content, and to securing the funding for the research. All authors approved the final version of the manuscript and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. No one else fulfils the criteria for participation as an author.

This study was supported by ICES, which is funded by an annual grant from the Ontario Ministry of Health and Long-Term Care (MOHLTC). ICES is an independent, non-profit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze health care and demographic data, without consent, for health system evaluation and improvement. The opinions, results and conclusions reported in this paper are those of the authors and are independent from the funding sources. No endorsement by ICES or

the MOHLTC is intended or should be inferred. Parts of this material are based on data and/or information compiled and provided by the Canadian Institute of Health Information (CIHI). However, the analyses, conclusions, opinions and statements expressed in the material are those of the author(s), and not necessarily those of CIHI.

The dataset from this study is held securely in coded form at ICES. While data sharing agreements prohibit ICES from making the dataset publicly available, access may be granted to those who meet pre-specified criteria for confidential access, available at www.ices.on.ca/DAS. The full dataset creation plan and underlying analytic code are available from the authors upon request, understanding that the computer programs may rely upon coding templates or macros that are unique to ICES and are therefore either inaccessible or may require modification.

Access to Data and Data Analysis

Isac Lima had full access to all the data in the study and carried out the preliminary analyses to calculate the annual ED visit counts and demographic statistics analyzed in this article. William Gardner carried out the analyses of the visit counts. Gardner and Lima take responsibility for the integrity of the data and the accuracy of the data analysis. R code is available from the corresponding author.

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Table 1. Cannabis Visits/10,000 ED Visits, 2003 and 2017

Factor		*2003*				*2017*				*Increase 2003-2017 (95% CI)*
		Non-Cannabis Visits	*Cannabis Visits*	*Cannabis Visits/10,000 ED Visits (95% CI)*	*RR (95% CI)*	*Non-Cannabis Visits*	*Cannabis Visits*	*Cannabis Visits/10,000 ED Visits (95% CI)*	*RR (95% CI)*	
All Visits		900,256	992	11.0 (10.3-11.7)	-	1,004,909	5,224	51.7 (50.3-53.1)	-	4.7 (4.4-5.0)
Sex	Male	449,828	650	14.4 (13.3-15.5)	1.9 (1.7-2.2)	458,291	3,215	69.7 (67.3-72.1)	1.9 (1.8-2.0)	4.8 (4.4-5.3)
	Female	450,428	342	7.6 (6.8-8.4)	-	546,618	2,009	36.6 (35.0-38.2)	-	4.8 (4.3-5.4)
Age	19-24 Years	401,511	449	11.2 (10.1-12.2)	6.7 (4.7-9.5)	495,218	3,186	63.9 (61.7-66.1)	23.7 (18.0-31.3)	5.7 (5.2-6.3)
	14-18 Years	308,047	511	16.6 (15.1-18.0)	9.9 (6.9-14.1)	320,522	1,987	61.6 (58.9-64.3)	22.9 (17.3-30.2)	3.7 (3.4-4.1)
	10-13 Years	190,698	32	1.7 (1.1-2.3)	-	189,169	51	2.7 (2.0-3.4)	-	1.6 (1.0-2.5)
Income	Quintile 1	203,770	262	12.8 (11.3-14.4)	1.5 (1.2-1.9)	240,088	1,395	57.8 (54.7-60.8)	1.2 (1.1-1.3)	4.5 (3.9-5.1)
	Quintile 2	184,854	219	11.8 (10.3-13.4)	1.4 (1.1-1.7)	197,856	1,042	52.4 (49.2-55.6)	1.1 (1.0-1.2)	4.4 (3.8-5.1)
	Quintile 3	176,001	197	11.2 (9.6-12.7)	1.3 (1.1-1.6)	194,966	932	47.6 (44.5-50.6)	1.0 (0.9-1.1)	4.3 (3.6-5.0)

Factor		*2003*				*2017*				*Increase 2003-2017 (95% CI)*
		Non-Cannabis Visits	*Cannabis Visits*	*Cannabis Visits/10,000 ED Visits (95% CI)*	*RR (95% CI)*	*Non-Cannabis Visits*	*Cannabis Visits*	*Cannabis Visits/10,000 ED Visits (95% CI)*	*RR (95% CI)*	
	Quintile 4	171,713	174	10.1 (8.6-11.6)	1.2 (1.0-1.5)	187,129	951	50.6 (47.4-53.8)	1.1 (1.0-1.2)	5.0 (4.3-5.9)
	Quintile 5	157,796	134	8.5 (7.0-9.9)	-	180,877	859	47.3 (44.1-50.4)	-	5.6 (4.6-6.7)
Rural Status	Non-Rural	668,154	866	12.9 (12.1-13.8)	2.4 (2.0-3.0)	820,631	4,607	55.8 (54.2-57.4)	1.8 (1.6-1.9)	4.3 (4.0-4.6)
	Rural	230,609	122	5.3 (4.3-6.2)	-	180,651	574	31.7 (29.1-34.3)	-	6.0 (4.9-7.3)

Note. Cannabis Visits/10,000 ED Visits = 10,000 × (Cannabis Visits)/(Non-Cannabis Visits + Cannabis Visits). RR is the ratio of the rates of Cannabis Visits/10,000 youths by category. The last category is the reference category. Increase 2003-2017 = (Cannabis Visits/10,000 in 2017)/(Cannabis Visits/10,000 in 2003). Income Quintile and Rural Status had < 1% missing data. CI = confidence interval.

Table 2. Youths with Cannabis Visits/10,000 Ontario Youths by Age and Sex

Factor		*2003*				*2017*				*Increase, 2003-2017 (95% CI)*
		Youths with Cannabis Visits	*Ontario Population*	*Cannabis Visits/10,000 Youths (95% CI)*	*RR (95% CI)*	*Youths with Cannabis Visits*	*Ontario Population*	*Cannabis Visits/10,000 Youths (95% CI)*	*RR (95% CI)*	
All	-	947	2,514,869	3.8 (3.5-4.0)	-	4,612	2,573,692	17.9 (17.4-18.4)	-	4.8 (4.4-5.1)
Sex	Male	611	1,285,110	4.8 (4.4-5.1)	1.7 (1.5-2.0)	2,834	1,319,346	21.5 (20.7-22.3)	1.5 (1.4-1.6)	4.5 (4.1-4.9)
	Female	336	1,229,759	2.7 (2.4-3.0)	-	1,778	1,254,346	14.2 (13.5-14.8)	-	5.2 (4.6-5.8)
Age	19-24	424	969,310	4.4 (4.0-4.8)	9.6 (6.7-13.7)	2,776	1,111,515	25.0 (24.0-25.9)	33.0 (24.8-43.7)	5.7 (5.2-6.3)
	14-18	491	844,430	5.8 (5.3-6.3)	12.7 (8.9-18.2)	1,787	815,590	21.9 (20.9-22.9)	28.9 (21.8-38.4)	3.8 (3.4-4.2)
	10-13	32	701,129	0.5 (0.3-0.6)	-	49	646,587	0.8 (0.5-1.0)	-	1.7 (1.1-2.6)
Age 19-24	Male	305	491,595	6.2 (5.5-6.9)	2.5 (2.0-3.1)	1,782	568,668	31.3 (29.9-32.8)	1.7 (1.6-1.8)	5.1 (4.5-5.7)
	Female	119	477,715	2.5 (2.0-2.9)	-	994	542,847	18.3 (17.2-19.4)	-	7.4 (6.1-8.9)
Age 14-18	Male	287	433,667	6.6 (5.9-7.4)	1.3 (1.1-1.6)	1,026	418,657	24.5 (23.0-26.0)	1.3 (1.2-1.4)	3.7 (3.2-4.2)

Factor		*2003*				*2017*				*Increase, 2003-2017 (95% CI)*
		Youths with Cannabis Visits	*Ontario Population*	*Cannabis Visits/10,000 Youths (95% CI)*	*RR (95% CI)*	*Youths with Cannabis Visits*	*Ontario Population*	*Cannabis Visits/10,000 Youths (95% CI)*	*RR (95% CI)*	
Age 10-13	Female	204	410,763	5.0 (4.3-5.6)	-	761	396,933	19.2 (17.8-20.5)	-	3.9 (3.3-4.5)
	Male	19	359,848	0.5 (0.3-0.8)	1.4 (0.7-2.8)	26	332,021	0.8 (0.5-1.1)	1.1 (0.6-1.9)	1.5 (0.8-2.7)
	Female	13	341,281	0.4 (0.2-0.6)	-	23	314,566	0.7 (0.4-1.0)	-	1.9 (1.0-3.8)

Note. RR is the ratio of the rates of Cannabis Visits/10,000 youths by category. The last category is the reference category. Relative Increase, 2003 to 2017 = (Cannabis Visits/10,000 Youths in 2017)/(Cannabis Visits/10,000 Youths in 2003). CI = confidence interval.

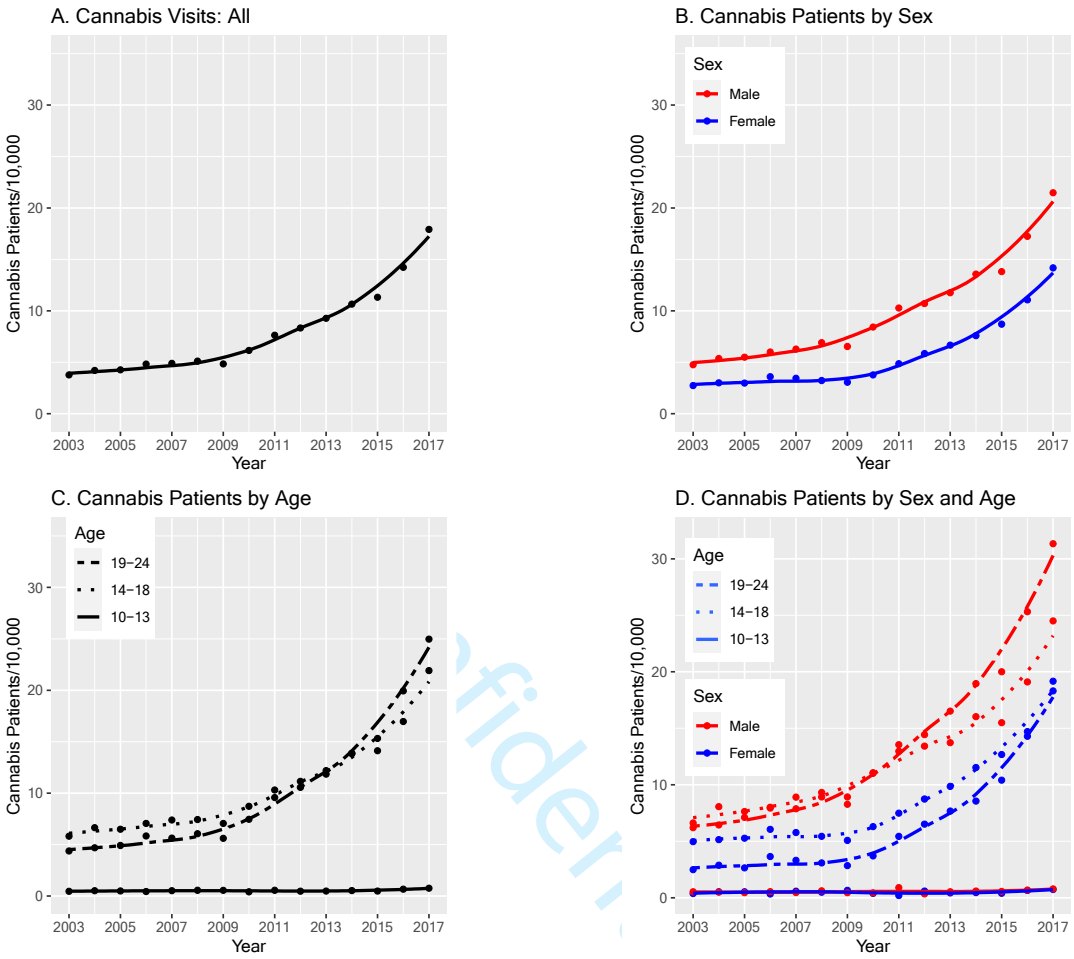
Table 3. Severe ED Visits and Transfers-Hospital by Cannabis vs Non-Cannabis Visit, 2003 and 2017

	2003			*2017*			
			Visits Coded Resuscitation, Emergent, or Urgent				
Visit Type	*N of Severe Visits*	*% Severe Visits (95% CI)*	*RR (95% CI)*	*N of Severe Visits*	*% Severe Visits (95% CI)*	*RR (95% CI)*	*Increase 2003-2017 (95% CI)*
Cannabis	652	65.7 (62.8-68.7)	2.1 (2.0-2.2)	4,606	88.2 (87.3-89.0)	1.52 (1.50-1.53)	1.3 (1.3-1.4)
Non-Cannabis	279,253	31.0 (30.9-31.1)		583,799	58.1 (58.0-58.2)		1.9 (1.9-1.9)
			ED Visits Transferred-Hospital				
Visit Type	*N of Transfers*	*% Transfers (95% CI)*	*RR (95% CI)*	*N of Transfers*	*% Transfers (95% CI)*	*RR (95% CI)*	*Increase 2003-2017 (95% CI)*
Cannabis	89	9.0 (7.2-10.8)	1.8 (1.5-2.2)	995	19.0 (18.0-20.1)	3.3 (3.1-3.5)	2.1 (1.7-2.6)
Non-Cannabis	45,172	5.0 (5.0-5.1)		58,022	5.8 (5.7-5.8)		1.2 (1.1-1.2)

Note. There were N = 992 cannabis and N = 900,256 non-cannabis ED visits in 2003. There were N = 5,224 cannabis and N = 1,004,909 non-cannabis ED visits in 2017. RR = (% of Cannabis Visits)/(% of Non-Cannabis Visits). Increase 2003-2017 = (% of Visits in 2017)/(% of Visits in 2003). Severity, which was the CTAS collapsed to 'Visits Coded Resuscitation, Emergent, or Urgent', had less than 1% missing data.

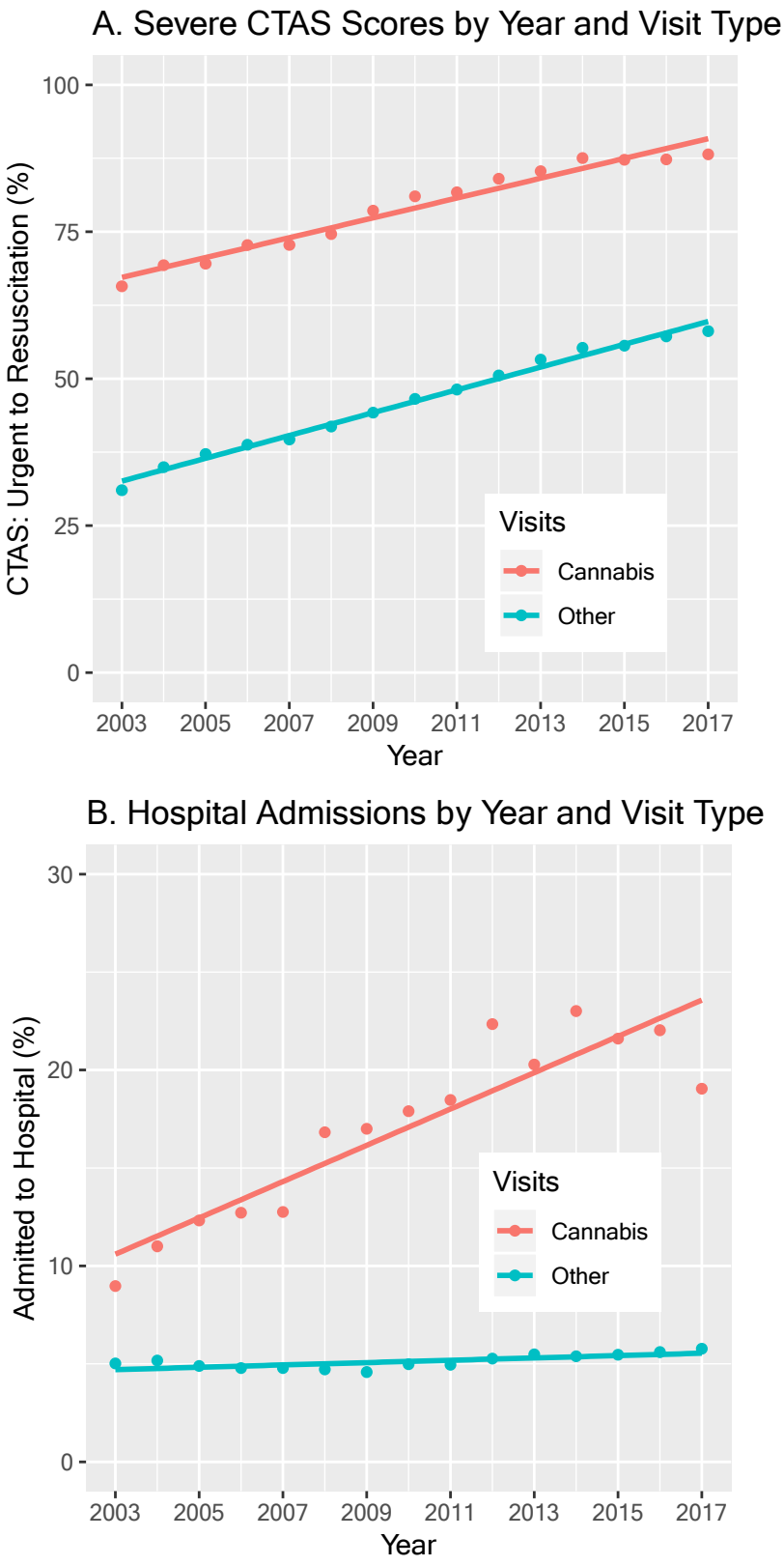
CI = confidence interval.

Figure 1. Trends in Youths with Cannabis Visits/10,000 Ontario Youths



Note. These graphs present trends in the rates of patients with cannabis-related ED visits. Smoothed curves with 95% confidence bands were fit to the rates using the loess method.

Figure 2. Trends in Severity of ED Visits and Hospital Admissions by Visit Type



Note. Lines are ordinary least-squares fits with 95% confidence intervals.

Supplement to 'Cannabis-Related Emergency Department Visits by Ontario Youths and their Outcomes: Repeated Cross-Sectional Study'

Objective

This supplement presents a Poisson regression analysis of the trends in the rates of youths with cannabis-related ED visits, and how those trends vary by age and sex.

Statistical Methods

We defined several variables for time and for sex and age differences. We let $c(t) = t - 2009.5$ for year t. $c(t)$ centered time at the midpoint of the year 2009, halfway between the beginning of 2003 and the end of 2017. $c(t)^2$ and $c(t)^3$ are the square and the cube of centered time. $M = 1$ if the youth was male and 0 if the youth was female. Two variables were created to capture age differences. We defined $A_1 = 1$ if a youth was ≥ 13 years old and $A_1 = -2$ for the youngest youths. $A_2 = 1$ for youths who were 19-24 years old, $A_2 = -1$ for youths who were 13 to 17 years old, and $A_2 = 0$ for 10-13 year-old youths. Thus A_1 contrasts the two older groups with the youngest youths, and A_2 contrasts the oldest youths with the 14-18 year-old youths.

Results

First we determined what order of polynomial best fit the curvature of the time trend seen in Figure 1 Panel A. Let $Y_a(t)$ be the count of all youths with cannabis-related visits in year t. Then our generalized linear model for the trend was

$$\mathrm{E}[Y_a(t)] = B_0 + B_1\, c(t) + B_2 c(t)^2 + B_3 c(t)^3.$$

We fit this model using the R function glm. We used the Ontario youth population in the year t as an offset, so that we modelled the annual rate of visits, rather than the counts.

Poisson Regression Model for Rates of All Youths with Cannabis Visits

Table S.1 Poisson Regression Model for Rates of Visits by All Youths

Variable	*B*	*95% CI*
Intercept	-7.31836	-7.33649 to -7.30022
c(t)	0.10830	0.10130 to 0.11530
$c(t)^2$	0.00567	0.00497 to 0.00637
$c(t)^3$	0.00009	-0.00010 to 0.00028

Note. *c(t)* is centered time, that is, *c(t) = Year* – 2009.5. $c(t)^2$ and $c(t)^3$ are the square and the cube of centered time.

In Table S.1, the 95% confidence interval for the coefficient for $c(t)^3$ included zero, so we concluded that the curvature of the trend was adequately captured by a model with linear and quadratic terms. The Durbin-Watson statistic for the residuals of this model was 1.48 (p = 0.29), indicating that there was no substantial serial correlation in the residuals.

Poisson Regression Model for Age and Sex Differences in Rates of Youths with Cannabis Visits

To model the age and sex differences in trends of rates of youths with cannabis visits, we built a Poisson regression model with linear and quadratic terms for time, as well as terms for age, sex, and all two-way interactions among time, sex, and age terms. We did not include possible three-way interactions because such terms are difficult to interpret. The resulting regression model was as follows. Let $Y_{as}(t)$ be the count of cannabis visits in year t for youths in age group a and sex s. Then

$$\begin{aligned}\mathrm{E}[Y_{as}(t)] = \quad & B_0 + B_1 c(t) + B_2 c(t)^2 + B_m M + B_{A_1} A_1 + B_{A_2} A_2 + B_{M\times A_1} M A_1 + \\ & B_{M\times A_2} M A_2 + B_{c\times M}\, c(t) M + B_{c\times A_1}\, c(t) A_1 + B_{c\times A_2}\, c(t) A_2 + \\ & B_{c^2\times M}\, c(t)^2 M + B_{c^2\times A_1}\, c(t)^2 A_1 + B_{c^2\times A_2}\, c(t)^2 A_2.\end{aligned}$$

We were concerned that a model with fourteen terms might be at risk of overfitting the data, so we used a LASSO procedure (1) to determine whether all terms were necessary. Perhaps because of the large number of observations, the LASSO procedure suggested that all time, age, and sex terms, and their two-way interactions were appropriate to keep in the model. Table S.2 reports the estimated regression coefficients from the above model.

Table S.2 Poisson Regression Model for Rates of Visits by Age and Sex

Variable	*B*	*95% CI*
Intercept	-8.32661	-8.38718 to -8.26603
c(t)	0.09325	0.08557 to 0.10094
$c(t)^2$	0.00827	0.00629 to 0.01026
M	0.53720	0.47017 to 0.60424
A_1	0.85677	0.80078 to 0.91275
A_2	-0.19467	-0.21919 to -0.17015
M x A_1	0.15628	0.09766 to 0.21491
M x A_2	0.20642	0.18226 to 0.23058
c(t) x *M*	-0.02066	-0.02642 to -0.01491
c(t) x A_1	0.02941	0.02275 to 0.03607
c(t) x A_2	0.01894	0.01614 to 0.02173
$c(t)^2$ *x M*	-0.00515	-0.00663 to -0.00367
$c(t)^2$ x A_1	0.00088	-0.00084 to 0.00260
$c(t)^2$ x A_2	0.00074	0.00003 to 0.00146

Note. *c(t)* is centered time, that is, *c(t) = Year* – 2009.5. $c(t)^2$ and $c(t)^3$ are the square and the cube of centered time. *M* is a dummy variable for male youths. A_1 is a contrast variable comparing the 19-24 year-old and the 14-18 year-old youths against the 10-13 year olds. A_2 contrasts the 19-24 year-old against the 14-18 year-old youths. The remaining variables code the two-way interactions among these variables. For example, M *x* A_1 picks up sex differences in the contrast between 19-24 year-old and the 14-18 year-old youths versus the 10-13 year olds.

In Table S.2, the estimates for $c(t)$ and $c(t)^2$ are similar to those in Table S.1. $B_m > 0$ reflects the consistently higher rates of cannabis visits among males. $A_1 > 0$ means that expected visit rates were higher for 14-18 year-old and 19-24 year-old youths at the midpoint of the period, compared to the 10-13 year olds. $A_2 < 0$ means that visit rates were higher for 14-18 year-old than 19-24 year-old youths at that time. $B_{M \times A_1} > 0$ and $B_{M \times A_2} > 0$ implies that the age effects for males were greater than for females. $B_{c(t) \times M} < 0$ says that the linear component of the trend was smaller for males, but this was counterbalanced by $B_{c(t)^2 \times M} > 0$, which indicated that the quadratic trend was greater for males than for females. $B_{c(t) \times A_1} > 0$ means that rates of youths with visits increased over time faster among the 14-18 year-old and 19-24 year-old youths compared to the 10-13 year olds, as seen in Figure 1 Panel C. Finally, $B_{c(t) \times A_2} > 0$ and $B_{c(t)^2 \times A_2} > 0$, which means that the rates of youths with cannabis visits increased more quickly among 19-24 year-old compared to 14-18 year-olds. This is consistent with the crossover of the trends for these two groups, visible in Figure 1.

Interpretation

The Poisson regression analysis of the trends data support the conclusions apparent in Figure 1 and Table 2. The most important findings were that rates of youths with visits increased faster than linearly between 2003 and 2017. Rates were higher among males. Rates were higher and increased faster for 14-18 year-old and 19-24 year-old youths compared to the 10-13 year olds.

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