



Neighbourhood crime and adolescent cannabis use in Canadian adolescents



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ABSTRACT

Background: Although neighbourhood factors have been proposed as determinants of adolescent behaviour, few studies document their relative etiological importance. We investigated the relationship between neighbourhood crime and cannabis use in a nationally representative sample of Canadian adolescents.

Methods: Data from the 2009/10 Canadian Health Behaviour in School-aged Children (HBSC) survey ($n = 9134$ 14- and 15-year-olds) were combined with area-level data on crime and socioeconomic status of the neighbourhood surrounding the schools ($n = 218$).

Results: Multilevel logistic regression analyses showed that after individual and contextual differences were held constant, neighbourhood crime related to cannabis use (OR 1.29, CI 1.12–1.47 per 1.0 SD increase in crime). This association was not moderated by parental support nor having cannabis-using friends. The amount of explained variance at the neighbourhood level was 19%.

Conclusions: Neighbourhood crime is an important factor to consider when designing interventions aimed at reducing adolescent cannabis use. Interventional research should examine the effectiveness of community-based interventions that target adolescents through parents and peers.

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1. Introduction

Canadian adolescents report amongst the highest rates of cannabis use in the world. In 2010, 33% of Canadian 15-year olds reported having ever used cannabis, as compared to an international (Western) average of 17% (Currie et al., 2012). Although adolescent cannabis use declined between 2002 and 2010 in most Western countries, including Canada (Ter Bogt et al., 2013), cannabis remains the most commonly used illicit drug among 15-year olds (Johnston et al., 2014; Hibell et al., 2012).

Although few health effects of experimental or occasional cannabis use among adolescents are known, early and frequent use relate to a wide range of psychosocial and health prob-

lems, including cannabis dependence and the use of other illicit drugs (Fergusson et al., 2006; Hall, 2006; Hall and Degenhardt, 2009; MacLeod et al., 2004), cognitive impairment (Hall and Degenhardt, 2009), low educational attainment (MacLeod et al., 2004), memory and learning deficiencies (Solowij et al., 2011), problems at school and school drop-out (Hall, 2006; Hall and Degenhardt, 2009), increased risk of accidents and injuries (Hall and Degenhardt, 2009), externalizing problems such as delinquent and aggressive behaviours (Monshouwer et al., 2006), internalizing problems such as depression, anxiety and suicidal thoughts (Moore et al., 2007), and increased risks for psychotic disorders such as schizophrenia (Hall, 2006; Hall and Degenhardt, 2009; Moore et al., 2007). It is therefore a public health priority, particularly in Canada, to identify individual and contextual determinants of frequent cannabis use among adolescents. Such information will help inform the development of effective, targeted prevention programmes.

Although the residential neighbourhood is an important domain for adolescent development and behaviour (Bronfenbrenner,

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1979), neighbourhood factors have been understudied in relation to adolescent cannabis use, relative to family and peer contexts (Lambert et al., 2004). Social disorganization theory (Shaw and McKay, 1942) suggests that neighbourhood disadvantage may increase cannabis use through adolescents' exposure to deviant individuals and greater access to cannabis (Ter Bogt et al., 2006, 2013), environmentally induced stress, and less social control and monitoring (Sampson et al., 2002). Consistent with this theory, studies have found a relation between adolescent cannabis use and neighbourhood socioeconomic deprivation, residential instability, and racial and ethnic diversity (Bernburg et al., 2009; Brooks-Gunn et al., 1993; Fite et al., 2009; Furr-Holden et al., 2011; Jang and Johnson, 2001; Lambert et al., 2004; Leventhal and Brooks-Gunn, 2000; Mason and Mennis, 2010; Tucker et al., 2013). In addition, they have shown that perceived (disapproving) social norms relate to lower rates of adolescent cannabis use (Keyes et al., 2011).

The association between adolescent cannabis use and objective measures of neighbourhood crime has not been investigated yet. This is surprising as neighbourhood crime is a strong indicator of neighbourhood disadvantage, placing young people at risk of being confronted with threatening situations, negative role models, and increased disorganization. Only one study (Mason and Mennis, 2010) examined objective measures of neighbourhood crime as a potential determinant. This study found that the likelihood of adolescent cannabis use decreased as the residential distance to robbery increased. However, the generalizability of this finding is limited because this study (1) only included the occurrence of robbery, (2) was geographically limited to one urban setting in the United States, and (3) was limited to a sample of adolescents who were in treatment for substance use problems. There is a need for further examination of the association between more comprehensive neighbourhood crime indices and cannabis use using representative, preferably national, samples of adolescents from other countries and a diversity of contextual settings.

Ecological systems theory (Bronfenbrenner, 1979; Bronfenbrenner and Evans, 2000) posits that nested environmental contexts (e.g., neighbourhood crime and parenting practices) may interact to influence various adolescent behaviours. This approach is supported by more contemporary population health theory (Health Canada, 1996), which states that health is influenced by combinations of individual and contextual factors. Building upon these theories, it is relevant to examine whether individual-level factors moderate the association between neighbourhood crime and adolescent cannabis use. Two of the strongest predictors of adolescent cannabis use at the individual level are parental support (Barnes et al., 2006; Chen et al., 2005; Freeman et al., 2011a) and cannabis use among peers (Connell et al., 2010; Creemers et al., 2010; Duan et al., 2009). While high parental support may have a protective role, cannabis-using peers may function as a risk factor by increasing the availability of cannabis and opportunities for use.

Using a unique combination of administrative crime data at the neighbourhood level and individual-level data on adolescent cannabis use, the present study investigated relations between neighbourhood crime and adolescent cannabis use in a nationally representative sample of 14- and 15-year olds in Canada. Our analysis addressed three research questions: (1) does crime in school neighbourhoods relate to cannabis use among adolescents? (2) are such relations stronger for adolescents who perceive less support from parents, compared to adolescents who perceive more support from their parents? (3) are such relations stronger in adolescents who have more friends who use cannabis, compared to adolescents who have few or no friends who use cannabis? The answers to these questions may facilitate identification of at-risk youth as well as protective factors that attenuate the potential influence of neighbourhood crime on adolescent cannabis use. Because targeting high-risk schools is less stigmatizing than

targeting high-risk individuals (Ennett et al., 1997), the present study may contribute to the development of interventions aiming to reduce adolescent cannabis use through neighbourhood, school and community projects.

2. Methods

2.1. Data sources

Relations between neighbourhood crime and adolescent cannabis use were examined using individual student-level data from the 2009/10 Canadian Health Behaviour in School-Aged Children (HBSC) survey (Freeman et al., 2011b), in combination with area-level geographic information system (GIS) measures of the socioeconomic status (SES; Statistics Canada, 2006) and crime rates (www.capindex.com) in the neighbourhoods surrounding the participating schools.

The HBSC study is a cross-national survey conducted in affiliation with the World Health Organization (Currie et al., 2012). The survey focuses on adolescent health, health behaviours, and the social context of health. The current analyses were limited to the most recent Canadian sample. This sample was designed using a variation of the international HBSC sampling protocol (Griebler et al., 2010; Roberts et al., 2009). The strategy followed a systematic multi-stage cluster technique, whereby individual students are nested in school classes that are nested within schools. The 2009/10 Canadian HBSC study included 26,078 students from 436 schools, with weighted distributions reflecting the distribution of Canadians in grades 6–10 (approximate age range 11–15 years). All provinces and territories in Canada participated with the exception of Prince Edward Island and New Brunswick. Students enrolled in private, special needs, or home schools, as well as incarcerated youth, were excluded; combined they constitute approximately 7% of the Canadian youth population. Consent was obtained and provided by school boards, individual schools, participants, and their parents/guardians. Consent was implicit or explicit depending on school board requirements. Response rates were 11/13 (84.6%) at the province/territorial level, 436/765 (57.0%) at the school level, and 26,078/33,868 (77.0%) at the student level. As questions on cannabis use were only asked to grade 9–10 students, grade 6–8 students were excluded from the analyses. This led to a sample of $N = 10,442$ adolescents. Of these, 9134 adolescents from 218 schools provided data on the question about cannabis use. Ethics approval was obtained from the General Research Ethics Board of Queen's University.

2.2. Measures

2.2.1. Individual characteristics.

2.2.1.1. Cannabis use. While lifetime use of cannabis can be considered normative to some extent (i.e., 33% of Canadian 15-year olds have used cannabis), frequent cannabis use is rare and considered an health risk behaviour (Ter Bogt et al., 2013). Students reported the frequency with which they had used cannabis in their lifetime on a scale that ranged from 1 to 7, with 1 = never, and 7 = 40 or more times. Students in the last category were characterized as *frequent lifetime users* and they were compared with those who reported never or less frequent lifetime use (as per Ter Bogt et al., 2006, 2013).

2.2.1.2. Parent–adolescent relationship. The parent–adolescent relationship scale was based on responses to the following statements: (a) My parents understand me; (b) I have a happy home life; (c) My parents expect too much of me; (d) My parents trust me; (e) I have a lot of arguments with my parents; (f) There are times I would like to leave home; (g) What my parents think of me is important; (h) My parents expect too much of me at school. Likert-like response options ranged from 1 = “strongly agree” to 5 = “strongly disagree”. The scale is internally consistent ($\alpha = 0.83$) and was constructed by taking the mean of the 8 items, after items c, e, f and h were reverse coded (as per Freeman et al., 2011a,b; Pepler et al., 2013).

2.2.1.3. Cannabis use among friends. Students reported to what extent the following statement applied to them: “Most of the friends in my group have used drugs to get stoned”. Response options were 1 = “rarely or never”, 2 = “sometimes”, 3 = “often”, and 4 = “I do not know” (adapted from Johnston et al., 1980). For correlation and regression analyses, the fourth category was treated as a missing value.

2.2.2. Neighbourhood characteristics.

2.2.2.1. Crime. Neighbourhood crime was measured by means of the overall crime index of the Crimecast dataset (CAP Index, Inc., 2012; www.capindex.com). This crime index consists of a computer modelled crime score for each Census dissemination area in Canada for the year 2011. The scores are modelled by combining criminology data (nation and local police reports, client loss reports, offender surveys, and victim surveys) and demographic data (education, economic, population mobility, housing data, population data). Crime scores represent the probability that a certain crime will be committed in a given location, relative to national averages. Scores range from 0 to 2000, with the average score for all dissemination areas being 100. Scores are created for 7 types of crime: homicide, sexual assault,

robbery, assault, breaking and entering, theft, and motor vehicle theft. The overall crime index is created based on the scores for these 7 types of crime. Using PCensus for Mappoint (Tetrad Computer Applications Inc., Vancouver, BC) software in combination with ArcGIS software version 10.2 (Esri, Redlands, CA), we aggregated the dissemination area crime scores within the 5 km radial buffer of each school to create neighbourhood-level crime scores for each of the participating schools.

2.2.2.2. Neighbourhood SES. Neighbourhood SES was captured from the 2011 Canadian Census data in PCensus for Mappoint (Tetrad Computer Applications Inc., Vancouver, BC) software in combination with ArcGIS software. To determine neighbourhood-level SES, two Census measures were considered within each buffer (also with a 5 km radius): average family income and education (% of adults with less than high school education). Based on these two standardized measures, a scale was created, as per Simpson et al. (2005) (Cronbach's alpha = .79).

2.2.3. Confounders. Covariates were chosen based on their demonstrated associations with adolescent cannabis use and their availability within the HBSC database (e.g., Currie et al., 2012; Leventhal and Brooks-Gunn, 2000). At the individual level, gender and family affluence were considered as potential covariates. The Family Affluence Scale (FAS) is a commonly used, valid and reliable HBSC measure of the material conditions of adolescents' household (number of cars, own bedroom, holiday frequency, number of computers; Currie et al., 2008). Responses were summed on a 0–9 point scale, with scores between 0 and 3 indicating low affluence, 4–5 indicating medium affluence, and 6–9 indicating high affluence.

At the neighbourhood-level, we included urban–rural geographic status of the school as a covariate. This was based on 2006 Canadian Census data using PCensus software (2006 Census of Canada Profile Data; Tetrad Computer Applications Inc, Bellingham, WA). Categories were (0) rural (population of 0–999), (1) small population centre (1000–29,999), (2) medium population centre (30,000–99,999), and (3) large population centre (>100,000).

2.3. Statistical analyses

Descriptive statistics were calculated using SPSS 20.0 to describe the study sample and neighbourhood-level characteristics. In addition, correlational analyses were conducted in SPSS for all the variables in our model at the aggregated level. Next, multilevel logistic regression analysis was conducted in Stata 13 and was used to examine relations between neighbourhood crime, each of the covariates, and adolescent cannabis use. Prior to the model building process, an empty (intercept only) model was fitted in order to calculate an intra-class correlation (ICC), which indicates the proportion of variance in cannabis use explained by neighbourhood differences (Diez, 2002). An ICC value of 0.19 was found, meaning that 19% of the total variance in adolescent cannabis use can be explained at the neighbourhood level. A series of two-level (individuals and schools/neighbourhoods) models were then developed. In Model 1, bivariate multilevel logistic regression models were run. Next, all individual-level variables were entered into a single model (Model 2). In Model 3, all neighbourhood-level variables were entered into a single model. Then, individual-level and neighbourhood-level predictors were entered in the same model (Model 4). In the last model (Model 5), interactions were added between neighbourhood crime and (a) parent–adolescent relationship and (b) cannabis using peers. The statistical significance of fixed and random effects was tested using Restrictive Iterative Generalised Least Squares (IGLS) procedures and second-order penalized quasi-likelihood (PQL2) estimation in order to provide accurate variance estimates when the ratio of low level units (e.g., number of individuals) to high level units (e.g., number of neighbourhoods) is high, as was the case in the HBSC study (Rasbash et al., 2009). Missing values, ranging from 0% (gender) to 5.5% (parent–adolescent relationship) were replaced by the mean.

3. Results

Individual characteristics of the 9134 adolescent participants are presented in Table 1. We found that 48% of the adolescents were male and the majority (63.1%) came from high FAS (more affluent) families. Most young people reported that they had a good relationship with their parents, and only a minority reported to have friends that often use cannabis.

Table 2 describes the features of the neighbourhoods of the 218 participating schools. About 55% of the schools were located in rural areas or in small population centres. Neighbourhood crime, as well as SES, varied considerably across schools. Yet, the average individual and composite crime scores in school neighbourhoods were considerably below national average crime scores of 100.

Table 3 summarizes the bivariate correlations between the variables in our model, at the aggregated school level. Most importantly, neighbourhood crime associated with adolescent cannabis use with $r = .14$ ($p < .01$). In addition, frequent cannabis use was

Table 1
Individual-level characteristics of study sample ($N = 9134$).

Adolescent characteristic	<i>n</i>	%
Gender		
Male	4380	48.0
Female	4754	52.0
Missing	0	.0
Family affluence		
Low	618	6.8
Medium	2276	24.9
High	5765	63.1
Missing	475	5.2
Parent–adolescent relationship		
Good	5932	64.9
Neutral or not good	2704	29.6
Missing	498	5.5
Friends use cannabis		
Rarely or never	5109	55.9
Sometimes	2096	22.9
Often	1253	13.7
Don't know	587	6.4
Missing	95	1.0
Frequent cannabis use		
Yes	842	9.2
No	8292	90.8
Missing	0	.0

more common among boys compared to girls, and among adolescents with low family affluence compared to adolescents with high family affluence. It was also more common among adolescents who did not have a good relationship with their parents and who had many cannabis-using friends. At the neighbourhood level, low SES and a more rural geographic status were related to frequent cannabis use.

Table 4 summarizes the results of the multilevel logistic regression analyses. In bivariate analyses (Model 1), all individual-level covariates related to adolescent cannabis use. Males and adolescents with more cannabis using friends were more likely to be frequent cannabis users. Frequent cannabis use negatively related to parental support and family affluence. All associations remained statistically significant ($p < .01$) when the individual-level variables were entered simultaneously in a single model (Model 2).

Furthermore, in the bivariate analyses, neighbourhood crime, SES, and urban–rural geographic status did not significantly relate to frequent cannabis use. When the three neighbourhood-level variables were entered simultaneously in a single model (Model 3), the association between crime and cannabis use became significant and positive ($OR = 1.40$). In addition, the association between

Table 2
School-level characteristics ($N = 218$ schools).

School characteristic	<i>M</i>	<i>SD</i>
Neighbourhood SES		
Adults with at least a high school diploma (%)	78.8	14.4
Income (\$ Canadian)	77,227	19,361
Urban–rural geographic status ^a	2.47	1.10
Crime in school neighbourhood ^b		
Homicide	48.9	36.9
Sexual assault	59.3	33.7
Robbery	48.0	36.8
Assault	45.5	39.7
Breaking and entering	64.4	43.0
Theft	55.5	49.0
Motor vehicle theft	58.9	43.3
Overall crime index score	52.8	34.7

^a Scale ranges from 1 (rural area; 0–999 inhabitants) to 4 (large population centre; >100,000 inhabitants).

^b Scores range from 0 to 2000, with the average score for all Canadian Census dissemination areas being 100.

Table 3

Correlations at the school level (individual level data were aggregated).

	Male gender	Family affluence	Parent–adolescent relationship	Substance using peers	Neighbourhood crime index	Neighbourhood SES	Urban–rural geographic status	Frequent cannabis use (ever, 40+)
Male gender	–							
Family affluence	–.01	–						
Parent–adolescent relationship	–.08**	+.16**	–					
Substance using peers	+.12**	–.14**	–.53**	–				
Neighbourhood crime	–.11**	–.34**	–.05**	+.11**	–			
Neighbourhood SES	–.12**	+.04**	+.10**	–.01	+.34**	–		
Urban–rural geographic status	–.04**	+.06**	–.06**	–.02*	+.51**	+.12**	–	
Frequent cannabis use (ever, 40+)	+.14**	–.24**	–.40**	+.77**	+.14**	–.06**	–.08**	–

* $p < .05$.** $p < .01$.**Table 4**Results of hierarchical regression analysis examining individual-level and school-level variables as possible determinants of adolescent frequent cannabis use in Canada ($n = 9134$).

Indicator	Model 1: bivariate associations		Model 2: individual level		Model 3: neighbourhood level		Model 4: individual + neighbourhood level	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Intercept	0.08	(0.07–0.10)	0.27	(0.16–0.46)	0.66	(0.47–0.93)	0.23	(0.13–0.40)
<i>Individual level variables</i>								
Male gender	1.49	(1.29–1.74)	1.78	(1.49–2.11)			1.78	(1.49–2.11)
Family affluence	0.85	(0.82–0.89)	0.89	(0.85–0.93)			0.89	(0.85–0.94)
Good parent–adolescent relationship	0.48	(0.44–0.53)	0.79	(0.70–0.89)			0.78	(0.69–0.88)
Substance using peers	8.32	(7.36–9.40)	7.91	(6.97–8.98)			7.89	(6.95–8.95)
<i>Neighbourhood level variables</i>								
Crime (overall index score) – per 1.0 SD	1.10	(0.92–1.32)			1.40	(1.18–1.66)	1.29	(1.12–1.47)
Socioeconomic status – per 1.0 SD	0.92	(0.79–1.07)			0.85	(0.74–0.98)	0.90	(0.79–1.01)
Urban–rural geographic status (ref. rural)								
Urban – small	0.85	(0.54–1.35)			0.97	(0.60–1.55)	0.93	(0.62–1.39)
Urban – medium	0.95	(0.54–1.70)			0.98	(0.55–1.74)	0.82	(0.50–1.32)
Urban – large	0.64	(0.38–1.08)			0.53	(0.32–0.89)	0.59	(0.38–0.92)
<i>Goodness of fit</i>								
AIC		5622.2		3871.0		5612.2		3864.5
BIC		5636.4		3913.7		5662.1		3942.8
Intraclass correlation	0.19	(0.14–0.27)	0.08	(0.05–0.12)	0.17	(0.12–0.22)	0.06	(0.04–0.11)

frequent cannabis use and (a) neighbourhood SES and (b) living in a large population centre became significant and negative.

When individual-level and neighbourhood-level factors were entered in a single model (Model 4), the results of Model 2 and 3 remained largely unchanged. A 1 SD increase in neighbourhood crime corresponded with a 29% increase in the likelihood of frequent cannabis use.

The ICCs of the four models are also reported in Table 4. In Model 4, the ICC was 0.06. With the ICC of the empty model being 0.19, this means that 68% (0.13/0.19) of the variance at the neighbourhood level (and 13% of the total variance) is explained by the variables in Model 4. About 11% (0.02/0.19) of the variance at the neighbourhood level is explained by crime, neighbourhood SES, and geographic status. The largest amount of variance (57%; 0.11/0.19) is explained by individual level variables. Importantly, however, it should be noted that the individual variable with the strongest association (substance using peers) to some extent is also indicative of social processes in the neighbourhood of the adolescent.

In Model 5 (not presented in Table 4), none of the hypothesized interaction effects were statistically significant (parental support and crime: OR = 1.00 [0.90–1.12]; substance using peers and crime: OR = 0.98 [0.87–1.11]).

4. Discussion

Our study provides a novel investigation as to whether neighbourhood-level crime relates to adolescent cannabis use. Two main findings emerged. First, crime rates in school neighbourhoods positively related to frequent cannabis use among adolescents. Second, the relation between neighbourhood crime and adolescent cannabis use was not modified by parental support nor by cannabis-using friends.

For each standard deviation increase in the neighbourhood crime score, the relative odds of an adolescent reporting frequent cannabis use increased by 29%. Thus, adolescents who attend a school that is a little above average (+1 SD) in crime would coincide with a relative odds that is about 60% higher than adolescents who attend a school that is a little below average (–1 SD) in crime. In the literature on area-level effects on adolescent behaviour, this is considered to be a strong effect (Leventhal and Brooks-Gunn, 2000). The effect is consistent with an ecological perspective on adolescent behaviour (i.e., the larger environment in which an adolescent is embedded influences the development of behaviour; Bronfenbrenner, 1979; Bronfenbrenner and Evans, 2000) and with the empirical literature on the effects of neighbourhood disadvantage on adolescent cannabis use (Bernburg et al., 2009;

Brooks-Gunn et al., 1993; Fite et al., 2009; Furr-Holden et al., 2011; Jang and Johnson, 2001; Lambert et al., 2004; Leventhal and Brooks-Gunn, 2000; Mason and Mennis, 2010; Tucker et al., 2013). High crime neighbourhoods may provide a model in which cannabis use behaviour is viewed as an acceptable behaviour (norms/collective efficacy model; Jencks and Mayer, 1990; Sampson, 2008). Living in high crime neighbourhoods also relates to fewer prosocial recreational activities and higher availability of substances, including cannabis (e.g., Lambert et al., 2004; Wallace and Muroff, 2002), thus increasing the likelihood of adolescent cannabis use.

The lack of interactions of neighbourhood crime with a supportive parent–adolescent relationship and with cannabis-using friends was unexpected. We hypothesized that the effect of neighbourhood crime would be smaller for adolescents who had a supportive relationship with their parents and for adolescents who did not have friends who used cannabis. Our findings demonstrate that parents have a protective role and substance using friends have a risk-enhancing role with respect to adolescent cannabis use, independent of whether adolescents attend schools in high versus low crime neighbourhoods. This finding is encouraging for parents. It is also relevant for the development of interventions; it may be fruitful to target parents and peers in school and community interventions aimed at reducing cannabis use among adolescents. Future intervention research should investigate whether such interventions are effective in practice.

Strengths of this study include the inclusion of both neighbourhood and individual-level variables in a single (multilevel) analysis, which reduces misspecification and overestimation of neighbourhood effects (Leventhal and Brooks-Gunn, 2000). Second, the use of a representative sample contributes to the study's external validity. Third, this study did not use data on subjective perceptions of crime, but rather objective administered crime data. The lack of the use of such data has been recognized as an important gap in the literature (Leventhal and Brooks-Gunn, 2000). Moreover, in contrast to previous studies (i.e., Mason and Mennis, 2010), this study includes a large range of different types of neighbourhood criminality.

This study also has a number of limitations. First, it is a cross-sectional survey study, which inherently limits our ability to draw conclusions on the causal nature of our findings. While social disorganization theory (Shaw and McKay, 1942) suggests that neighbourhood crime may affect adolescent cannabis use, an increase in adolescent cannabis use may also influence crime rates in the neighbourhood. In order to better capture the relevant social processes and influences, and to understand the direction(s) in which they influence each other, future studies based on direct observation and other qualitative methods may provide more insight.

Second, while family affluence, parental support, and cannabis-using peers were controlled for in our study, parental drug use and other potentially confounding factors were not considered, due to their unavailability in the HBSC dataset.

Third, our individual-level variables were based on adolescent self-report. We chose this method as it outweighed the limitations associated with alternative methodologies for simultaneously collecting large amounts of data. By stressing the anonymity of the study, including the fact that neither parents nor teachers would find out about respondents' individual answers, a bias due to self-reporting was limited (Brener et al., 2003). Yet, we cannot rule out that cannabis use may have been underreported, and relationships with neighbourhood, family and peer contexts may have been attenuated.

Fourth, although we used a rigorous sampling approach and our sample was largely representative of Canadian 15-year olds, two provinces did not participate in this study. While the provinces of

Prince Edward Island and New Brunswick combined only make up 2.7% of the Canadian population, the non-participation of these provinces is a limitation of our study. Furthermore, the response rate at the school-level was 57%. Each year, schools are requested to participate in a very large number of studies. Non-responding schools were replaced intentionally with like schools, which should not contribute to any systematic bias. Important to note is that the response rate at the student level was high (77%).

This study has implications for future research and interventions. Future research may address the limitations of the present study by investigating changes over time in neighbourhood crime and adolescent cannabis use, using a variety of advanced designs that have a longitudinal, repeated cross-sectional, and/or qualitative component. Such designs enable the examination of the likelihood that frequent cannabis use increases as a consequence of an increase in crime. Furthermore, as the amount of explained variance at the neighbourhood level was relatively high (i.e., 19%, compared to the typical 5–10% in this type of research; Leventhal and Brooks-Gunn, 2000), the neighbourhood and specifically neighbourhood crime appears to be an important factor to consider when designing interventions aimed at reducing adolescent cannabis use, in addition to individual and family level factors. Future intervention research should examine the effectiveness of community-based intervention programmes that target adolescents through parents and peers.

In conclusion, this study provides compelling evidence that, independent of neighbourhood socioeconomic deprivation and urban–rural geographic status, there is an association between high neighbourhood crime and adolescent cannabis use. This association exists independently of the parent–adolescent relationship and the number of cannabis-using peers. These findings may help to explain differences in adolescent substance use across neighbourhoods *within* Canada. However, given the relevance of neighbourhood affluence and crime, these findings seem paradoxical to Canada's #1 international ranking in Europe and North America in terms of adolescent cannabis use. Further international and comparative policy analysis is required to better interpret these findings at an international level. For instance, these findings are in line with a previous study that showed that perceived availability of cannabis at the country-level was associated with increased cannabis use among adolescents (Ter Bogt et al., 2006). In all, these results add to a growing body of evidence that shows that adolescent health and health behaviours may be powerfully shaped by sociocultural and socioeconomic contexts.

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Contributors

Margaretha de Looze, Ian Janssen, and William Pickett designed the study and wrote the protocol. Margaretha de Looze, Ian Janssen, Wendy Craig, and William Pickett managed the literature searches and summaries of previous related work. Frank J. Elgar, William Pickett and Margaretha de Looze undertook the statistical analysis. Margaretha de Looze and Ian Janssen wrote the first draft of the

manuscript. All authors contributed to and have approved the final manuscript.

Conflict of interest

No conflict declared.

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