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Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-046171
Article Type:	Original research
Date Submitted by the Author:	21-Oct-2020
Complete List of Authors:	Doggett, Amanda; University of Waterloo, Godin, Katelyn; Public Health Agency of Canada Schell, Olena; Public Health Agency of Canada Wong, Suzy; Public Health Agency of Canada Jiang, Ying; Public Health Agency of Canada, Applied Research Division Leatherdale, Scott ; University of Waterloo
Keywords:	EPIDEMIOLOGY, PUBLIC HEALTH, Substance misuse < PSYCHIATRY

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Assessing the impact of sports and recreation facility density within school neighbourhoods on Canadian adolescents' substance use behaviours: COMPASS study, 2015 to 2018

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Abstract:

Objectives: There has been relatively little exploration to date of potential protective effects within school neighbourhoods, such as those conferred by facilities that seek to promote health, with respect to substance use and related harms. This study examined how density of sports and recreation facilities in the school neighbourhood is associated with the likelihood of binge drinking, e-cigarette use, cigarette smoking, and cannabis use among Canadian secondary school students.

Design: Longitudinal data from the COMPASS study on Canadian youth health behaviours from 2015/16 to 2017/18 was linked with school neighbourhood data capturing the number of sports and recreation facilities within a 1500-meter radius of schools.

Setting: Secondary schools and school neighborhoods in Alberta, British Columbia, Ontario and Quebec who participated in the COMPASS study

Participants: 16,471 youth who participated in the COMPASS study over three school years (2015/16 to 2017/18)

Primary and secondary outcome measures: Binge drinking, e-cigarette use, cigarette use, cannabis use

Results: Logistic regression models using generalized estimating equations identified that greater density of sports and recreation facilities within the school neighbourhood was significantly associated with lower likelihood of binge drinking and e-cigarette use, but was not associated with cigarette smoking or cannabis use.

Conclusions: This research can help to support evidence-informed school community-based efforts to prevent substance-related harms among youth.

Strengths and Limitations of this study:

- This study adds to limited existing literature examining impact of protective built environment features in the school neighborhood on youth substance use
- This study links multiple high-quality data sources, including youth behaviour data from the COMPASS study, neighborhood information from the Statistics Canada census, and built environment features from the DMTI EPOI database
- The COMPASS study data are drawn from a convenience sample and are therefore not generalizable
- The COMPASS data are self-reported and as such may be subject to biases
- The COMPASS study uses an active information passive-consent protocol which increases sample size and reduces potential self-selection bias

Word count: 4257

Keywords: youth; substance use; built environment; neighbourhood; sports; recreation; binge drinking; e-cigarettes; smoking; cannabis

1. Introduction

Youth substance use is subject to considerable public health attention within Canada. Though many youth who use substances may do so without experiencing significant or long-lasting harms, research demonstrates that initiation of substance use at an earlier age during adolescence has been associated with future problematic substance use behaviours, as well as increased propensity for certain chronic diseases later in life [1–4]. Substance use during adolescence, particularly high frequency use, may also have negative impacts on mental wellbeing [5–8], as well as educational outcomes and aspirations [8–11]. Nationally-representative data from the 2018/19 school year show that 23% of Canadian students in grades 7-12 report engaged in binge drinking, while 18% report cannabis consumption within the past year [12]. These data also suggest that the prevalence of current cigarette smoking among Canadian youth is low (3%); however, 20% of students reported current e-cigarette use, reflecting an all-time high [12]. Though there are a variety of factors that can impact propensity for substance use during adolescence, youth substance use is largely moderated by peer influence and social norms, particularly in the context of binge drinking [13–15]. The relatively high rates of youth substance use, coupled with the potential health impacts, illustrate the need to identify population-level opportunities to prevent substance-related harms among Canadian youth.

The school and community environments have an important influence on youth health behaviours, particularly during adolescence when individuals increasingly spend time outside of the home. The school can play an important part in moderating youth substance use through school culture, policies and prevention programs [16–19]. This influence extends beyond these aspects of the school itself and to the broader school neighbourhood. For example, previous research indicates that density of tobacco retailers surrounding a school is positively associated with the likelihood of smoking initiation among students [20]. Similarly, e-cigarette retailer density is associated with greater likelihood of e-cigarette use in the United States [21], although similar Canadian research found no association [22]. Research has also suggested that alcohol retailer density surrounding schools can influence students' perceived availability of substances, which in turn is related to likelihood of future substance use [23].

Current literature focuses on risk factors within the school neighborhood related to youth substance use (e.g., tobacco and alcohol retailer density), with little exploration of potential protective effects, such as those conferred by facilities that seek to promote health. One of the most robust and internationally celebrated primary prevention approaches for youth substance use is the Icelandic Model for Preventing Adolescent Substance Use developed by the Icelandic Centre for Social Research & Analysis (ICSRA), which supports youth health through focus on leveraging protective factors within the school and community environments [24]. ICSRA identified that one key protective factor in Icelandic communities was increased accessibility to physical activity, sports, and leisure activities. The researchers leveraged

the influence of this protective factor through ongoing multifaceted school- and community-based efforts, including free access to sports and leisure facilities for youth and collaborating with schools to encourage student participation in extracurricular activities [25]. ISCRA researchers assert that the positive impact of these community-level interventions stems from youths' increased opportunity to develop life skills and form healthy, supportive relationships with adults, which builds social capital within the community [26]. Iceland has witnessed substantial reductions in youth substance use over the past few decades as a result of this model, which has since been adopted in other jurisdictions internationally [27].

In the Canadian context, many of the population-level, built environment-focused public health interventions to date have focused on increasing individuals' physical activity. Examples of these interventions include efforts to improve neighbourhood walkability, neighbourhood attractiveness, and access to green spaces or recreation facilities [28]. There is also a wealth of evidence suggesting that physical activity can be a protective factor for youth substance use and support positive mental wellbeing [29,30]. However, many studies have also identified sport participation as a risk factor for binge drinking among adolescents [31–34], and a potential risk factor for cannabis use, although results are mixed [32,35,36]. Interestingly, one study found that participation in team sports was a risk factor for binge drinking, while participation in endurance sports (e.g. running, swimming, etc.) was protective [36]; the authors posit that this may be related to the unique social contexts found within team sports which normalize alcohol use [37]. Although many studies have examined the relationships between individual-level physical activity, sports participation, and youth substance use, there has been a lack of consideration of broader environmental factors within the school and community that can impact substance use behaviours, such as those that were part of ISCRA's approach in Iceland.

This research aims to fill a gap in the youth substance use and school neighborhood literature, as most of the Canadian literature examining school neighborhood characteristics focuses on risk factors rather than protective factors. By using a three-year linked longitudinal sample of youth in Canada at the individual-level, and corresponding built environment data at the school neighbourhood-level, this research examined the effect that density of sports and recreation facilities (e.g. sport clubs, instructional exercise facilities, skating rinks, swimming pools, etc.) in the school community may have on youth substance use. Based on existing research, including evidence from evaluations of the Icelandic Model, we hypothesize that greater density of sports and recreation facilities in the school neighbourhood may be associated with decreased propensity for substance use among youth.

2. Methods

COMPASS is a prospective cohort study that collects data longitudinally from secondary school students and the school that they attend in four Canadian provinces: Ontario, Alberta, British Columbia, and Quebec [38]. The student-level data collected are self-reported via an anonymous paper-based questionnaire administered during class time. The questionnaire includes items on multiple domains including physical activity, diet and substance use, as well as potential correlates of these behaviours and demographic information. COMPASS uses an active information passive-consent protocol [38]. A full description of COMPASS methods can be found in print [38] or online (www.compass.uwaterloo.ca).

2.1 Sample

This study uses linked longitudinal COMPASS data collected over three consecutive school years (2015/16, 2016/17, 2017/18), hereout referred to as Year 1 (Y1), Year 2 (Y2), and Year 3 (Y3). To be eligible for inclusion in this study, participants needed to complete the COMPASS student questionnaire at baseline (Y1) as grade 9, 10, or secondary I or II students (secondary I and II pertains to Quebec, where the school system structure differs from other provinces; this is equivalent to grades 7 or 8), and again in least one follow-up year (i.e., Y2 and/or Y3). A total of 16,471 participants met these criteria. The primary reason for non-participation in the COMPASS study in any year is students being absent or on a spare period during the time of data collection. The procedure for linking participants' data over time is described elsewhere [39]. Secondary data on the types of facilities surrounding the schools were derived from Desktop Mapping Technology Inc (DMTI)'s enhanced points of interest (EPOI) database, which categorizes types of area and facilities using the Standard Industrial Classification (SIC) codes system [40]. EPOI data from 2017 were linked with COMPASS data by school postal code, in order to obtain the number of facilities within the neighbourhood of participating schools [38]. Socioeconomic status and urbanicity of the school neighbourhood was obtained from Statistics Canada Census 2016 data and similarly linked to participating COMPASS schools.

2.2 Dependent Variables

Four substance use behaviours: binge drinking, e-cigarette use, cigarette smoking, and cannabis use were examined in this research, and each of the substance use variables were dichotomized into a binary outcome. Binge drinking was examined through the question "In the last 12 months, how often did you have 5 drinks of alcohol or more on one occasion?" where the response included "I have never done this", "I did not have 5 or more drinks on one occasion in the last 12 months", "Less than once a month", "Once a month", "2 to 3 times a month", "Once a week", "2 to 5 times a week", and "Daily or almost daily". E-cigarette use was examined through the question "On how many of the last 30 days did you use an e-cigarette?" where the response option included "None", "1 day", "2 to 3 days", "4 to 5 days", "6 to 10 days", "11 to 20 days", "21 to 29 days", "30 days (*every day*)". Cigarette smoking was examined through the question "On how many of the last 30 days did you smoke one or more cigarettes?" where the

response options included “None”, “1 day”, “2 to 3 days”, “4 to 5 days”, “6 to 10 days”, “11 to 20 days”, “21 to 29 days”, “30 days (*every day*)”. Cannabis use was examined through the question “In the last 12 months, how often did you use marijuana or cannabis? (a joint, pot, weed, hash)” where the response options included “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 week,” “4 to 6 times a week,” and “Every day.”

2.3 Independent Variables

2.3.1 Individual Level Demographic Variables and Control Variables

Consistent with other literature, the following covariates (with their response options in brackets) were included in all analyses to address potential confounding effects: grade (9,10,11,12, secondary I and II), sex (male, female), ethnicity (White, Black, Asian, Aboriginal, Latin American/Hispanic, Other), and personal spending money (zero, \$1 to \$5, \$6 to \$10, \$11 to \$20, \$21 to \$40, \$41 to \$100, More than \$100, I do not know how much money I get each week). Participants were also asked to separately indicate their moderate and vigorous physical activity per week in hours (0,1,2,3,4) and minutes (0,15,30,45). Examples of what constitutes each activity were given in the questionnaire alongside the question. The measure of physical activity is an average of moderate to vigorous physical activity (MVPA) per day and was included in all analyses as a covariate.

2.3.2 School Neighbourhood Level Variables

2.3.2.1 Neighbourhood Sports and Recreation Facilities

The number of neighbourhood sports and recreation facilities within a 1500-meter radius of secondary schools that participated in the COMPASS study were obtained from DMTI’s Enhanced Points of Interest Database (EPOI). School-based research has previous used a radius between 1000m and 2000m to constitute the school neighborhood [41–44] – a radius of 1500 meters was chosen for this study. The categories of interest for this project based on the Standard Industrial Classification System (SIC) [45] were: Physical Fitness Facilities (SIC:7991), Membership Sports and Recreation Clubs (SIC:7997), and Amusement and Recreation Services, not elsewhere classified (SIC:7999). Notably, the latter category was selected for inclusion because it encompasses several sports and recreation-focused items of interest not included in the former two, including swimming, gymnastics, and yoga instruction. All three SIC categories were collapsed into one overall indicator of the number of neighbourhood sports and recreation facilities. A full list of the included facilities in each SIC category can be found by referring to the SIC Major Group 79: Amusement and Recreation Services [45]. Consistent with previous research [20,22,23], the term ‘density’ of school neighborhood sports and recreation facilities is used hereout in reference to the number of sports and recreation facilities within the aforementioned 1500m radius of a school.

2.3.2.2 Alcohol and Tobacco Retailers

The models created for each of binge drinking and cigarette smoking controlled for the number of alcohol and tobacco retailers in the school neighbourhood, since existing research has demonstrated that a greater number of retail facilities is associated with higher rates of substance use among youth [20,23]. The DMTI EPOI for these facilities were: Liquor Stores (SIC:5921) and Tobacco Stores and Stands (SIC:5993) within a 1500-meter radius of participating COMPASS schools.

2.3.2.3 Urbanicity and Median Income

The models adjusted for potential neighbourhood-level confounders, including measures of urbanicity and income. Urbanicity data was obtained from Statistics Canada census data (2016), using GeoSearch lookup on city name [46]. Areas were classified into 'Large Urban', 'Medium Urban', 'Small Urban', and 'Rural' categories based on national standards [47]. Median household income data for the areas where schools were located was obtained from 2016 Statistics Canada Census Profile [48].

2.4 Analysis

Descriptive statistics were used to characterize the student and school-level variables examined. Four logistic regression models were developed: one for each substance use behaviour. All models used the same 3-year linked longitudinal sample of COMPASS youth and adjusted for the same individual-level covariates. The number of alcohol retailers was included in the binge drinking model, and the number of tobacco retailers was included in the cigarette smoking model. Data related to cannabis and e-cigarettes retailers were not included in the corresponding models for those substance use behaviours, as data are not yet available on these locations in DMTI's EPOI database. Since youth often use multiple substances, all models adjusted for the other substance use behaviours (e.g. in the binge drinking model, the other three substance use behaviours (cannabis use, cigarette smoking and e-cigarette use) were included as predictors).

Generalized estimating equations (GEE) – a semiparametric method which models population average effects – were used for all logistic regression analyses via PROC GENMOD specifying exchangeable working correlation [49]. All models accounted for the longitudinal nature of the data (within-subject correlation), as well as the clustering of students within schools (between-subject correlation). GEE is the preferred method when the aim of the research is to estimate overall effect of a particular variable, rather than individual-specific effects [50]. The GEE approach ignores missing observations, but all available pairs are used in the estimation of the working correlation matrix [51]. The longitudinal effect of the main variable of interest (density of school neighbourhood sports and recreation facilities) was tested through

an interaction term between that variable and time for all models. All analyses were conducted using SAS 9.4 (SAS Institute, Cary NC).

3. Results

Table 1 presents school neighbourhood-level characteristics of the sample. The mean density of sports and recreation facilities within a 1500 m radius of schools was 3.01, although this varied considerably between schools and ranged from 0 to 29. At baseline, 46.17% (n=7586) of the sample were in grade 9, 46.22% (n=7008) were in grade 10, and 11.17% (1835) were in secondary I or II. Of the baseline sample, 52.85% (n=8655) reported their sex as female, and 47.15% (n=7721) reported their sex as male. 73.72% (12090) of the sample reported their ethnicity as white, while 26.28% (4311) reported an ethnicity other than white. Figure 1 presents the prevalence of each substance use behaviour across each study sample year. Item non-response for the outcome variables was low (In Y1, 49,282,119, and 246 students were missing responses for binge drinking, e-cigarette use, cigarette use, and cannabis use, respectively).

Table 1: Characteristics of school neighbourhoods (2016/17) in the sample population

	Percent of Schools (N) N=78
Urbanicity	
Rural	8.97(7)
Small Urban	35.90 (28)
Medium Urban	14.10 (11)
Large Urban	43.59 (34)
Mean (SD)	
Median Income	69014.26 (18726.60)
Sports and Recreation Facilities	3.01 (4.64)
Alcohol Retailers	1.61 (2.45)
Tobacco Retailers	0.48 (1.37)

[FIGURE 1 HERE]

Figure 1: Percent of participants who reported each substance use behaviour in the sample population (Y1:2015/16, Y2:2016/17, Y3:2017/18)

Results of the four logistic regression models are presented in Table 2. For all models, time (i.e. participants increasing in age/grade) was significantly associated with likelihood of engaging in current substance use. The main variable of interest (i.e., density of sports and recreation facilities) was significantly associated with lower likelihood of binge drinking and e-cigarette use but was not associated with either cigarette smoking or cannabis use. For binge drinking and e-cigarette use, a greater number of sports and recreation facilities within a school neighbourhood decreased likelihood of respective substance use by 3% for each additional facility. Physical activity levels were significantly associated with increased likelihood of binge drinking and e-cigarette use but were not associated with cigarette smoking or cannabis use. Interaction terms between time and each of the school neighbourhood sports and recreation facilities measures were used to test for the presence of longitudinal effects [52] but are not presented as effect sizes were not large enough to meaningfully interpret.

Table 2: Results of binary logistic regression models of four youth substance use behaviours (2015/16 - 2017/18)

Variable	Odds Ratio (95% Confidence Interval)			
	N=16471			
	Model 1: Binge drinking	Model 2: E-cigarette use	Model 3: Cigarette Smoking	Model 4: Cannabis use
Time	1.26 (1.21-1.31)***	2.11 (2.04-2.19)***	0.79 (0.75-0.84)***	1.31 (1.25-1.37)***
School Variables				
Sports and Recreation Facilities	0.97 (0.96-0.99)***	0.97 (0.97-0.98)***	0.99 (0.97-1.00)	1.01 (1.00-1.02)
Rural	1	1	1	1
Small Urban	0.74 (0.64-0.87)***	0.71(0.61-0.83)***	0.83 (0.68-1.02)	1.13 (0.93-1.38)
Medium Urban	0.65 (0.55-0.78)***	0.70 (0.59-0.82)***	0.66 (0.53-0.83)***	1.48 (1.19-1.83)***
Large Urban	0.52 (0.45-0.61)***	0.66 (0.57-0.77)***	0.37 (0.30-0.46)***	1.31 (1.08-1.59)**
Income	0.99 (0.99-0.99)***	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.01)*

Alcohol Retailers	1.04 (1.01-1.07)**			
Tobacco Retailers			1.05 (1.00-1.10)	
Individual Variables ¹				
Physical Activity Level (hours MVPA/day)	1.11 (1.09-1.14)***	1.06 (1.04-1.08)***	1.03 (1.00-1.07)	1.00 (0.98-1.03)
Binge Drinking		3.85 (3.59-4.13)***	2.77 (2.51-3.07)***	3.37 (3.11-3.65)***
E-cigarette Use	3.89 (3.62-4.17)***		4.17 (3.74-4.64)***	3.85 (3.55-4.18)***
Cigarette Smoking	2.60 (2.35-2.87)***	3.66 (3.30-4.07)***		5.65 (5.11 -6.24)***
Cannabis Use	3.32 (3.06-3.60)***	3.71 (3.42- 4.03)***	5.99 (5.41-6.64)***	

¹ In addition to all variables shown in the table, all models also controlled for time-invariant covariates (measured at baseline): sex, ethnicity, grade at baseline, as well as spending money as a time-varying covariate. Odds ratios are rounded to two decimals.

*p<0.05 **p<0.01 ***p<0.001

4. Discussion

To our knowledge, this is the first study to examine the potential impact of density of school neighbourhood sports and recreation facilities on youth substance use in Canada. Our findings indicate that density of these facilities within the school neighborhood may have a protective effect against youth binge drinking and e-cigarette use, but is not associated with youths' cigarette smoking or cannabis use.

4.1 Patterns of Substance Use Behaviours

E-cigarette use was the most common substance use behaviour reported by participants, followed by binge drinking and cannabis use, and then cigarette smoking. The prevalence of these different substance use behaviours align with expectations based on previous Canadian and US research [12,22,53]. Likewise, consistent with previous research [54,55], this study observed increased likelihood of substance use over time in regression models as well as descriptive analyses, which showed increases in substance use prevalence rates between baseline Y1 and follow up by Y3. The increase in e-cigarette use between Y1 and follow-up Y3 is particularly drastic compared to the other substances, and is consistent with previous research having identified spikes in youth e-cigarette use in recent years [12,56].

4.2 Density of School Neighbourhood Sports and Recreation Facilities

Greater density of school neighbourhood sports and recreation facilities was significantly associated with a decreased likelihood of binge drinking and e-cigarette use among this sample of adolescents. The confidence that these findings do directly reflect the effects of density of these facilities, as opposed to some proxy of larger effects (e.g. neighborhood urbanicity, individual physical activity, etc.) is

strengthened due to the inclusion of several potential school- and individual-level confounders in the models.

Previous Canadian research identifies that a key aspect of community sports and recreation facilities that promotes health is their ability to foster social connection and support [28]. Sports and recreation facilities can provide youth with opportunities for social connections through a variety of mechanisms, including sports and club participation, as well as volunteer and work opportunities. This type of social engagement in the community is a part of the foundation for the Iceland Prevention Model. Research has demonstrated that greater accessibility to sports and leisure for youth in Iceland was protective against substance use behaviours through greater community interaction and strengthened social capital [25,57].

However, the density of school neighbourhood sports and recreation facilities did not produce a protective effect against all four substance use behaviours examined. This disparity may be partially explained by differences in the social contexts in which substances are typically used by adolescents (e.g., using substances alone versus with peers, motivations for using substances, etc.). Among youth, it is known that substance use behaviours are strongly influenced by social norms [58,59]. As discussed below, the unique social contexts of different substance use behaviours may have a bearing on the likelihood for sports and recreation activities to impact substance use behaviours.

4.2.1. Binge Drinking and E-Cigarette Use

Research indicates that, among young people, binge drinking most often occurs in social contexts (e.g. parties) [14,60]. It may be reasonable to suggest that accessing school neighbourhood sports and recreation facilities can reduce some social motivators for binge drinking; some of the students' need for social engagement could be met through involvement with these facilities, and they may therefore be less inclined to binge drink for social reasons. Moreover, boredom is a known predictor of binge drinking [61,62], and a neighborhood with higher density of sports and recreation facilities offers more opportunities for extra-curricular activities in which youth can participate, and therefore may decrease the likelihood that youth will engage in binge drinking out of boredom. While the overall effect of sports and recreation facility density was protective against binge drinking in this research, aforementioned research has highlighted that team sports specifically can be a risk factor for binge drinking, so there are likely unique social contexts depending on the type of sports in which youth participate [31,36]. The complex nature of the associations between sports, recreation and binge drinking indicate that prevention efforts likely require a combination of population-level and targeted approaches.

Similar to binge drinking, youth primarily report social reasons for engaging in e-cigarette use, including the need to be perceived as 'cool' by their peers [63,64]. The large presence of online marketing of novel e-cigarette products which target youth have also likely contributed to these shifts in perception and

normalization of e-cigarette use [65,66]. This study demonstrated protective effects of school neighbourhood sports and recreation facilities density against youth e-cigarette use, as well as binge drinking. These findings may indicate that greater access to opportunities for social connection may displace some social motivation to engage in these substance use behaviours.

4.2.2. Tobacco and Cannabis Use

In contrast, there is evidence that cigarette smoking and cannabis use may be less socially motivated behaviours, compared to binge drinking and e-cigarette use. While smoking has inherent ties to social factors, such as peer group and family opinions on smoking [67,68], opinions towards smoking have shifted and continue to shift in Canada to be increasingly unfavourable. Research has found that Canadian youth are altering their perceptions away from smoking being a ‘cool’ behaviour and instead considering it a negative and less socially acceptable behaviour, in part due to better knowledge of associated adverse health outcomes [69]. These changing social norms among Canadian youth may have contributed to steadily decreasing smoking rates in recent years [70], and may explain why density of sports and recreation facilities showed no protective effects for this substance use behaviour.

The social context of cannabis use among Canadian youth appears to be more complex; while many youth report that a main motivator for cannabis use is to ‘fit-in’, there are many reported motivators that are not necessarily social in nature, such as improved physical or mental health, sleep, or concentration [71]. Particularly relevant to the present study, Canadian youth have reported that being busy with extra-curricular activities is not necessary an impedance to cannabis use, and instead sometimes can be used as a “cover” to hide use from parents [71]. Therefore, while existing research suggests that youth have some social motivators for youth cannabis use, it remains distinct from other substance use behaviours. This may partly explain the findings presented here that school neighbourhood sports and recreation facilities had no effect on cannabis use while showing significant protective effects for other substances. Notably, the present research as well as the referenced literature was conducted prior to non-medical cannabis legalization for adults. Although cannabis remains an illegal substance for youth, it is unclear what effects legalization may have on youths’ perceptions and norms around cannabis.

4.3 Implications

The present findings suggest a protective effect of school neighbourhood sports and recreation facilities, even after controlling for potential neighbourhood risk factors, including the presence of alcohol and tobacco retailers. This lends support for initiatives similar to the Iceland Prevention Model’s comprehensive approach to addressing youth substance use, which focused on leveraging community-level resources and engagement [27]. The relatively small effect sizes in this research are to be expected, and reflect that neighbourhood sports and recreation facilities represent only a single aspect of the built

environment. The built environment components of the school neighbourhood consist of many overarching elements that may influence health behaviours, including the density of sports and recreation facilities examined in the present research, as well as other types of facilities, walkability, green space, transit, and many others. The number and various types of factors that influence youth health and well-being underscores the importance of multipronged, comprehensive efforts to prevent substance-related harms, and that there is no “silver bullet” for addressing this complex public health problem. The present research, supported by the existing literature, illustrates the importance of considering all aspects of the school community for youth health. Understanding the impact of the school neighbourhood sports and recreation facilities also illustrates potential opportunities to leverage partnerships and services between schools and community organizations toward the shared goal of supporting youth health.

4.4 Limitations

There are several limitations to note with respect to the present study. First, this research only measured associations between the built environment and individual health behaviours, and as such it was not possible to fully understand the mechanism behind these associations. Future research should consider measuring social context of substance use alongside frequency, in order to further understand the potential connection between school neighbourhood sports and recreation facilities, social connection, and substance use. Second, this research relied on existing DMTI database categorizations as representations of the built environment, and therefore were imperfect representations of sports and recreation centres in which youth might engage. As such our research could only measure density, rather than accessibility, of the school neighbourhood sports and recreation facilities; unmeasured characteristics of the individual facilities (e.g. cost, activities offered, age restrictions, etc.) would affect ability for youth to use these facilities. In particular, cost barriers to participation may disproportionality impact school communities in lower income areas, and therefore future research should consider collecting this data and examining accessibility of these facilities. The COMPASS study uses convenience sampling and as such the results of this research may not be generalizable outside the study population. This study has many strengths; to our knowledge, this is the first study to examine the impact of school neighbourhood sports and recreation facilities on youth substance use in Canada, and is one of few studies in the literature that focus on potential protective factors of the built environment. Furthermore, the longitudinal nature of this research combined with the large sample size allowed for robust examination of how aspects of the school neighbourhood impact likelihood of substance use. Lastly, the use of a passive consent protocol was an important feature for a study examining substance use behaviours since it helps to limit response and self-selection biases [72,73].

5. Conclusions

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This study identified a negative association between density of school neighbourhood sports and recreation facilities and likelihood of youth binge drinking and e-cigarette use, which suggests that these facilities may have the potential to displace some substance use behaviours among youth. These findings lend support to population-level interventions aiming to prevent substance-related harms among youth through built environment features, such as sports and recreation facilities in school neighbourhoods. Potential directions for future research include examining the influence of sports and recreation facility density within school neighbourhoods on youth substance use in other study samples, as well as exploring other features of the built environment that may have protective effects on youth substance use behaviours.

Contributors: AD, KG, OS, SW and YJ contributed to project conceptualization. AD planned the methodology, conducted the formal analysis, and did the original draft preparation. SL acquired funding, managed resources, and provided supervision for the host study and corresponding data in this manuscript. AD, KG, OS, SW, YJ, and SL reviewed and edited the manuscript for critical content. All authors have read and agreed to the published version of the manuscript.

Funding: The COMPASS study has been supported by a bridge grant from the CIHR Institute of Nutrition, Metabolism and Diabetes (INMD) through the “Obesity – Interventions to Prevent or Treat” priority funding awards (OOP-110788; awarded to Scott T. Leatherdale), an operating grant from the CIHR Institute of Population and Public Health (IPPH) (MOP-114875; awarded to Scott T. Leatherdale), a CIHR project grant (PJT-148562; awarded to Scott T. Leatherdale), a CIHR bridge grant (PJT-149092; awarded to Karen Patte/Scott T. Leatherdale), a CIHR project grant (PJT-159693; awarded to Karen Patte), and by a research funding arrangement with Health Canada (#1617-HQ-000012; contract awarded to Scott T. Leatherdale). The creation of this manuscript was funded by the Research Affiliate Program from the Public Health Agency of Canada, Applied Research Branch.

Competing interests: None declared

Data sharing statement: COMPASS data are available for researchers upon successful completion and approval of the COMPASS data usage application (<https://uwaterloo.ca/compass-system/information-researchers>). Technical reports detailing COMPASS study methods are available online (<https://uwaterloo.ca/compass-system/publications#technical>).

Patient and Public Involvement Statement: Youth participating in the COMPASS study were not involved in the study design. Some of the COMPASS student questionnaire measures are based off of previously validated questions among youth, and as such in some cases youth may have been involved in the

design. COMPASS disseminates results to stakeholders in a variety of ways including school and provincial level reports prepared yearly. More information about the COMPASS study can be found at <https://uwaterloo.ca/compass-system/>.

Research Ethics Approval: The COMPASS Study received ethics approval from the University of Waterloo Office of Research Ethics as well as participating school boards (ORE #: 30118).

For peer review only

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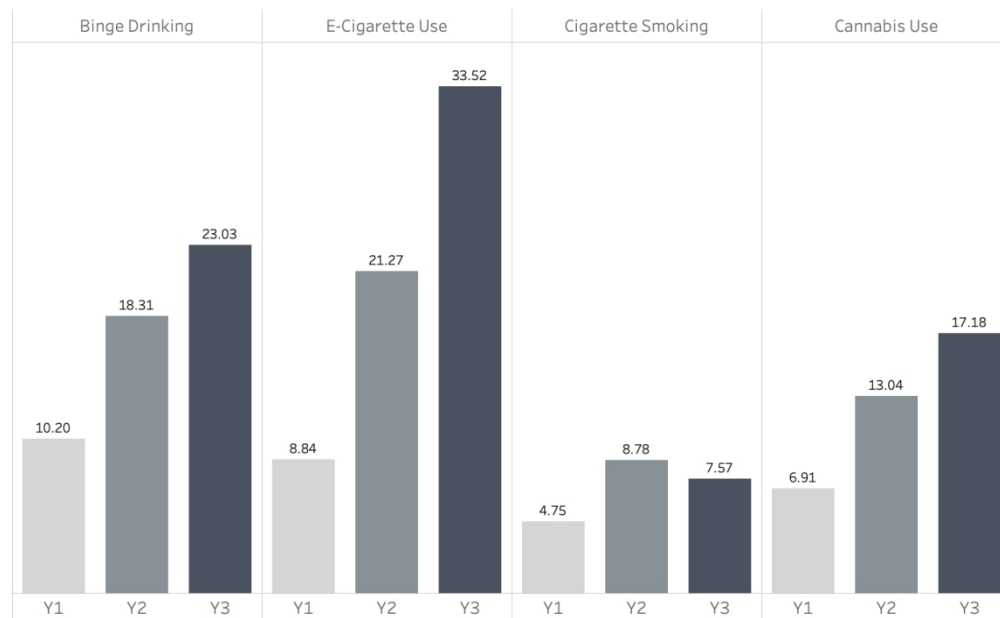


Figure 1: Percent of participants who reported each substance use behaviour in the sample population (Y1:2015/16, Y2:2016/17, Y3:2017/18)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of cohort studies

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study’s design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	3
		(b) For matched studies, give matching criteria and number of exposed and unexposed	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3,4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	3,4
Bias	9	Describe any efforts to address potential sources of bias	3
Study size	10	Explain how the study size was arrived at	3
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4,5
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	4,5
		(b) Describe any methods used to examine subgroups and interactions	5
		(c) Explain how missing data were addressed	3,5
		(d) If applicable, explain how loss to follow-up was addressed	3
		(e) Describe any sensitivity analyses	N/A
Results			N/A

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	3
		(b) Give reasons for non-participation at each stage	3
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5
		(b) Indicate number of participants with missing data for each variable of interest	5
		(c) Summarise follow-up time (eg, average and total amount)	3
Outcome data	15*	Report numbers of outcome events or summary measures over time	5
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6
		(b) Report category boundaries when continuous variables were categorized	N/A
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	5,6,7
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	6,7,8,9
Generalisability	21	Discuss the generalisability (external validity) of the study results	9
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	9

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Assessing the impact of sports and recreation facility density within school neighbourhoods on Canadian adolescents' substance use behaviours: quasi-experimental evidence from the COMPASS study, 2015 to 2018

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-046171.R1
Article Type:	Original research
Date Submitted by the Author:	27-Apr-2021
Complete List of Authors:	Doggett, Amanda; University of Waterloo, Godin, Katelyn; Public Health Agency of Canada Schell, Olena; Public Health Agency of Canada Wong, Suzy; Public Health Agency of Canada Jiang, Ying; Public Health Agency of Canada, Applied Research Division Leatherdale, Scott ; University of Waterloo
Primary Subject Heading:	Public health
Secondary Subject Heading:	Epidemiology
Keywords:	EPIDEMIOLOGY, PUBLIC HEALTH, Substance misuse < PSYCHIATRY

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Assessing the impact of sports and recreation facility density within school neighbourhoods on Canadian adolescents' substance use behaviours: quasi-experimental evidence from the COMPASS study, 2015 to 2018

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Abstract:

Objectives: There has been relatively little exploration to date of potential protective effects within school neighbourhoods, such as those conferred by facilities that seek to promote health with respect to substance use and related harms. This study examined how the density of sports and recreation facilities in the school neighbourhood is associated with the likelihood of binge drinking, e-cigarette use, cigarette smoking, and cannabis use among Canadian secondary school students.

Design: Longitudinal data from the COMPASS study on Canadian youth health behaviours from 2015/16 to 2017/18 was linked with school neighbourhood data capturing the number of sports and recreation facilities within a 1500-meter radius of schools.

Setting: Secondary schools and school neighbourhoods in Alberta, British Columbia, Ontario and Quebec who participated in the COMPASS study

Participants: 16,471 youth who participated in the COMPASS study over three school years (2015/16 to 2017/18)

Primary and secondary outcome measures: Binge drinking, e-cigarette use, cigarette use, cannabis use

Results: Logistic regression models using generalized estimating equations identified that greater density of sports and recreation facilities within the school neighbourhood was significantly associated with lower likelihood of binge drinking and e-cigarette use but was not associated with cigarette smoking or cannabis use.

Conclusions: This research can help to support evidence-informed school community-based efforts to prevent substance-related harms among youth.

Strengths and Limitations of this study:

- This study links multiple high-quality data sources, including youth behaviour data from the COMPASS study, neighbourhood information from the Statistics Canada census, and built environment features from the DMTI EPOI database
- The COMPASS study data are drawn from a convenience sample and are therefore not generalizable
- The COMPASS data are self-reported and as such may be subject to biases
- The COMPASS study uses an active information passive-consent protocol which increases sample size and reduces potential self-selection bias

Word count: 4800

Keywords: youth; substance use; built environment; neighbourhood; sports; recreation; binge drinking; e-cigarettes; smoking; cannabis

1. Introduction

Youth substance use is subject to considerable public health attention within Canada. Though many youth who use substances may do so without experiencing significant or long-lasting harms, research demonstrates that initiation of substance use at an earlier age during adolescence has been associated with future problematic substance use behaviours, as well as increased propensity for certain chronic diseases later in life (1–4). Substance use during adolescence, particularly high-frequency use, may also have negative impacts on mental wellbeing (5–8), as well as educational outcomes and aspirations (8–11). Nationally representative data from the 2018/19 school year show that 23% of Canadian students in grades 7–12 report engaging in binge drinking, while 18% report cannabis consumption within the past year (12). These data also suggest that the prevalence of current cigarette smoking among Canadian youth is low (3%); however, 20% of students reported current e-cigarette use, reflecting an all-time high (12). Though there are a variety of factors that can impact propensity for substance use during adolescence, youth substance use is largely moderated by peer influence and social norms, particularly in the context of binge drinking (13–15). The relatively high rates of youth substance use, coupled with the potential health impacts, illustrate the need to identify population-level opportunities to prevent substance-related harms among Canadian youth.

The school and community environments have an important influence on youth health behaviours, particularly during adolescence when individuals increasingly spend time outside of the home. The school can play an important part in moderating youth substance use through school culture, policies and prevention programs (16–19). This influence extends beyond these aspects of the school itself and to the broader school neighbourhood. For example, previous research indicates that the density of tobacco retailers surrounding a school is positively associated with the likelihood of smoking initiation among students (20). Similarly, e-cigarette retailer density is associated with greater likelihood of e-cigarette use in the United States (21), although similar Canadian research found no association (22). Research has also suggested that alcohol retailer density surrounding schools can influence students' perceived availability of substances, which in turn is related to likelihood of future substance use (23).

Current literature focuses on risk factors within the school neighbourhood related to youth substance use (e.g., tobacco and alcohol retailer density), with little exploration of potential protective effects, such as those conferred by facilities that seek to promote health. One of the most robust and internationally celebrated primary prevention approaches for youth substance use is the Icelandic Model for Preventing Adolescent Substance Use developed by the Icelandic Centre for Social Research & Analysis (ICSRA), which supports youth health through focusing on leveraging protective factors within the school and community environments (24). ICSRA identified that one key protective factor in Icelandic communities was increased access to physical activity, sports, and leisure activities. The researchers leveraged the

influence of this protective factor through ongoing, multifaceted school- and community-based efforts, including free access to sports and leisure facilities for youth and collaborating with schools to encourage student participation in extracurricular activities (25). ICSRA researchers assert that the positive impact of these community-level interventions stems from youths' increased opportunity to develop life skills and form healthy, supportive relationships with adults, which builds social capital within the community (26). Iceland has witnessed substantial reductions in youth substance use over the past few decades as a result of this model, which has since been adopted in other jurisdictions internationally (27).

In the Canadian context, many of the population-level, built environment-focused public health interventions to date have focused on increasing individuals' physical activity. Examples of these interventions include efforts to improve neighbourhood walkability, neighbourhood attractiveness, and access to green spaces or recreation facilities (28). There is a wealth of evidence suggesting that physical activity can be a protective factor for youth substance use and support positive mental wellbeing (29,30). However, many studies have also identified sport participation as a risk factor for binge drinking among adolescents (31–34) and a potential risk factor for cannabis use, although results are mixed (32,35,36). Research surrounding physical activity/sports and cigarette/e-cigarette use is less established, although some studies have found observed inverse associations (37–40)

The wide range of contexts for sports and recreation activities (e.g., inside vs. outside of the school recreation, varsity vs. intramural sports) can differentially impact youth substance use (41,42). However, in general, engagement in these activities is seen as a positive for youth development (43). Notably, the concept of sports participation being beneficial for youth extends beyond physiological impact, as social and psychological factors also play a substantial role in how these activities can be health-promoting (44). Moreover, although much of the literature focuses on potential protective effects of physical activity and sports, there is substantial rationale to support that leisure more broadly is health-promoting. Leisure plays a large role in how individuals find life purpose and meaningfully engage with life (45,46), and leisure activities have been shown to promote youth health and protect against behaviours such as substance use (47). As such, availability of community resources that offer spaces for youth to engage in recreation and leisure may promote health in a variety of ways, including being protective against substance use behaviours.

Although many studies have examined the relationships between individual-level physical activity, sports participation, and youth substance use, there has been a lack of research surrounding broader environmental factors within the school and community that can impact substance use behaviours, such as the sports and leisure facilities that were part of ICSRA's approach in Iceland. This study aims to fill a gap in the youth substance use and school neighbourhood literature, as most of the Canadian literature examining school neighbourhood characteristics focuses on risk factors rather than protective factors. By

using a three-year linked longitudinal sample of youth in Canada at the individual-level, and corresponding built environment data at the school neighbourhood-level, this study examined the effect that density of sports and recreation facilities (e.g. sports clubs, instructional exercise facilities, skating rinks, swimming pools, etc.) in the school community may have on youth substance use. Based on existing research, including evidence from evaluations of the Icelandic Model, we hypothesize that greater density of sports and recreation facilities in the school neighbourhood may be associated with decreased propensity for substance use among youth.

2. Methods

COMPASS is a prospective cohort study that collects data longitudinally from secondary school students and the school that they attend in four Canadian provinces: Ontario, Alberta, British Columbia, and Quebec (48). The student-level data collected are self-reported via an anonymous paper-based questionnaire administered during class time. The questionnaire includes items on multiple domains, including physical activity, diet and substance use, as well as potential correlates of these behaviours and demographic information. COMPASS uses an active information passive-consent protocol (48). A full description of COMPASS methods can be found in print (48) or online (www.compass.uwaterloo.ca).

2.1 Sample

This study uses linked longitudinal COMPASS data collected over three consecutive school years (2015/16, 2016/17, 2017/18), hereout referred to as Year 1 (Y1), Year 2 (Y2), and Year 3 (Y3). To be eligible for inclusion in this study, participants needed to complete the COMPASS student questionnaire at baseline (Y1) as grade 9, 10, or secondary I or II students (secondary I and II pertains to Quebec, where the school system structure differs from other provinces; this is equivalent to grades 7 or 8), and again in at least one follow-up year (i.e., Y2 and/or Y3). A total of 16,471 participants met these criteria. The primary reason for non-participation in the COMPASS study in any year is students being absent or on a spare period during the time of data collection. Student questionnaires were linked across years without the need for identifying information by generating a consistent but unique code from a series of questions on the front page of the questionnaire. The full procedure for linking participants' data over time is described elsewhere (49). Secondary data on the types of facilities surrounding the schools were derived from Desktop Mapping Technology Inc (DMTI)'s enhanced points of interest (EPOI) database, which categorizes types of area and facilities using the Standard Industrial Classification (SIC) codes system (50). EPOI data from 2017 were linked with COMPASS data by school postal code in order to obtain the number of facilities within the neighbourhood of participating schools (48). Socioeconomic status and urbanicity of the school neighbourhood were obtained from Statistics Canada Census 2016 data and similarly linked to participating COMPASS schools.

2.2 Dependent Variables

Four substance use behaviours: binge drinking, e-cigarette use, cigarette smoking, and cannabis use, were examined in this study, and each of the substance use variables was dichotomized into a binary outcome. Consistent with existing research measures (12,51,52), binge drinking was examined through the question “In the last 12 months, how often did you have 5 drinks of alcohol or more on one occasion?” where the response included “I have never done this”, “I did not have 5 or more drinks on one occasion in the last 12 months”, “Less than once a month”, “Once a month”, “2 to 3 times a month”, “Once a week”, “2 to 5 times a week”, and “Daily or almost daily”. Binge drinking was examined in this study as opposed to alcohol consumption in general because it represents the more high-risk substance use behaviour. E-cigarette use was examined through the question “On how many of the last 30 days did you use an e-cigarette?” where the response option included “None”, “1 day”, “2 to 3 days”, “4 to 5 days”, “6 to 10 days”, “11 to 20 days”, “21 to 29 days”, “30 days (*every day*)”. Cigarette smoking was examined through the question “On how many of the last 30 days did you smoke one or more cigarettes?” where the response options included “None”, “1 day”, “2 to 3 days”, “4 to 5 days”, “6 to 10 days”, “11 to 20 days”, “21 to 29 days”, “30 days (*every day*)”. Cannabis use was examined through the question “In the last 12 months, how often did you use marijuana or cannabis? (a joint, pot, weed, hash)” where the response options included “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 week,” “4 to 6 times a week,” and “Every day.” For comparability, all four substance use measures were dichotomized into current and non-current use, where current use was defined as engaging in the respective behaviour at least once in the past month.

2.3 Independent Variables

2.3.1 Individual Level Demographic Variables and Control Variables

The following control variables (with their response options in brackets) were included in all analyses to address potential confounding effects: grade (9,10,11,12, secondary I and II), sex (male, female), ethno-racial identity (select all that apply: White, Black, Asian, Aboriginal, Latin American/Hispanic, Other). Personal spending money (zero, \$1 to \$5, \$6 to \$10, \$11 to \$20, \$21 to \$40, \$41 to \$100, More than \$100, I do not know how much money I get each week) was also included as an important control which may influence the propensity for substance use behaviours (53–55). Participants were also asked to separately indicate their moderate and vigorous physical activity per week in hours (0,1,2,3,4) and minutes (0,15,30,45). Examples of what constitutes each activity were given in the questionnaire alongside the question. The measure of physical activity is an average of moderate to vigorous physical activity (MVPA) per day and was included in all analyses as a covariate to allow for separation of individual physical activity levels from any potential effects of sports and recreation facility density.

2.3.2 School Neighbourhood Level Variables

2.3.2.1 Neighbourhood Sports and Recreation Facilities

The number of neighbourhood sports and recreation facilities within a 1500-meter radius of secondary schools that participated in the COMPASS study were obtained from DMTI's Enhanced Points of Interest Database (EPOI). School-based research has previously used a radius between 1000m and 2000m to constitute the school neighbourhood (56–59) – a radius of 1500 meters was chosen for this study. The categories of interest for this project based on the Standard Industrial Classification System (SIC) (60) were: Physical Fitness Facilities (SIC:7991), Membership Sports and Recreation Clubs (SIC:7997), and Amusement and Recreation Services, not elsewhere classified (SIC:7999). Notably, the latter category was selected for inclusion because it encompasses several sports and recreation-focused items of interest not included in the former two, including swimming, gymnastics, and yoga instruction. All three SIC categories were collapsed into one overall indicator of the number of neighbourhood sports and recreation facilities. A full list of the included facilities in each SIC category can be found by referring to the SIC Major Group 79: Amusement and Recreation Services (60). Consistent with previous research (20,22,23), the term 'density' of school neighbourhood sports and recreation facilities is used hereout in reference to the number of sports and recreation facilities within the aforementioned 1500m radius of a school.

2.3.2.2 Alcohol and Tobacco Retailers

The models created for each of binge drinking and cigarette smoking controlled for the number of alcohol and tobacco retailers in the school neighbourhood, since existing research has demonstrated that a greater number of retail facilities is associated with higher rates of substance use among youth (20,23). The DMTI EPOI for these facilities were: Liquor Stores (SIC:5921) and Tobacco Stores and Stands (SIC:5993) within a 1500-meter radius of participating COMPASS schools. The number of alcohol retailers was included in the binge drinking model, and the number of tobacco retailers was included in the cigarette smoking model. Data related to cannabis and e-cigarettes retailers were not included in the corresponding models for those substance use behaviours, as data are not yet available on these locations in DMTI's EPOI database.

2.3.2.3 Urbanicity and Median Income

The models adjusted measures of urbanicity and income as potential neighbourhood-level confounders of youth substance use (61,62). Urbanicity data were obtained from Statistics Canada census data (2016), using GeoSearch lookup on city name (63). Areas were classified into 'Large Urban', 'Medium Urban', 'Small Urban', and 'Rural' categories based on national standards (64). Median household income data

for the areas where schools were located was obtained from the 2016 Statistics Canada Census Profile (65).

2.4 Analysis

Descriptive statistics were used to characterize the student and school-level variables examined. Four logistic regression models were developed: one for each substance use behaviour. All models used the same 3-year linked longitudinal sample of COMPASS youth and adjusted for the same individual-level covariates. Models were categorized into “A” and “B” series. The A series of models focused only on the substance use examined in the outcome, while the B series of models included adjustments for the other substance use behaviours (e.g. in the binge drinking model, the other three substance use behaviours (cannabis use, cigarette smoking and e-cigarette use) were included as predictors).

Generalized estimating equations (GEE) – a semiparametric method that models population average effects – were used for all logistic regression analyses via PROC GENMOD specifying exchangeable working correlation (66). All models accounted for the longitudinal nature of the data (within-subject correlation), as well as the clustering of students within schools (between-subject correlation). GEE is the preferred method when the aim of the research is to estimate the overall effect of a particular variable, rather than individual-specific effects (67). The GEE approach ignores missing observations, but all available pairs are used in the estimation of the working correlation matrix (68). The longitudinal effect of the main variable of interest (density of school neighbourhood sports and recreation facilities) was tested through an interaction term between that variable and time for all models. All analyses were conducted using SAS 9.4 (SAS Institute, Cary NC).

3. Results

Table 1 presents school neighbourhood-level characteristics of the sample. The mean density of sports and recreation facilities within a 1500 m radius of schools was 3.01, although this varied considerably between schools and ranged from 0 to 29. At baseline, 46.17% (n=7586) of the sample were in grade 9, 46.22% (n=7008) were in grade 10, and 11.17% (1835) were in secondary I or II. Of the baseline sample, 52.85% (n=8655) reported their sex as female, and 47.15% (n=7721) reported their sex as male. 73.72% (12090) of the sample reported their ethno-racial identity as white, while 26.28% (4311) reported an ethno-racial identity other than white. Figure 1 presents the prevalence of each substance use behaviour across each study sample year. Item non-response for the outcome variables was low (In Y1, 49,282,119, and 246 students were missing responses for binge drinking, e-cigarette use, cigarette use, and cannabis use, respectively).

Table 1: Characteristics of school neighbourhoods (2016/17) in the sample population

	Percent of Schools (N) N=78
Urbanicity	
Rural	8.97(7)
Small Urban	35.90 (28)
Medium Urban	14.10 (11)
Large Urban	43.59 (34)
Mean (SD)	
Median Income	69014.26 (18726.60)
Sports and Recreation Facilities	3.01 (4.64)
Alcohol Retailers	1.61 (2.45)
Tobacco Retailers	0.48 (1.37)

[FIGURE 1 HERE]

Figure 1: Percent of participants who reported each substance use behaviour in the sample population (Y1:2015/16, Y2:2016/17, Y3:2017/18)

Results of the logistic regression models are presented in Table 2. For all models, time (i.e. participants increasing in age/grade) was significantly associated with likelihood of engaging in current substance use, with the exception of Model 3B, where the likelihood of smoking decreased over time. The main variable of interest (i.e., density of sports and recreation facilities) was significantly associated with lower likelihood of binge drinking and e-cigarette use but was not associated with either cigarette smoking or cannabis use. For binge drinking and e-cigarette use, a greater number of sports and recreation facilities within a school neighbourhood decreased likelihood of respective substance use by 3% for each additional facility. The results pertaining to sports and recreation facilities remained consistent between the A and B series models. In the B series models, physical activity levels were significantly associated with an increased likelihood of binge drinking and e-cigarette use but were not associated with cigarette smoking or cannabis use. Interaction terms between time and each of the school neighbourhood sports and recreation facilities measures were used to test for the presence of longitudinal effects (69) but are not

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presented as effect sizes were not large enough to meaningfully interpret. Models which did not include substance use retailers were also tested, but effect size and significance for sports and recreation facilities remained stable compared to the models presented.

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Table 2: Results of binary logistic regression models of four youth substance use behaviours (2015/16 - 2017/18)

Odds Ratio (95% Confidence Interval)								
N=16471								
Variables ¹	Binge Drinking		E-cigarette Use		Cigarette Smoking		Cannabis Use	
	Model 1A	Model 1B:	Model 2A	Model 2B	Model 3A	Model 3B	Model 4A	Model 4B
Time	1.65 (1.60, 1.70)***	1.26 (1.21-1.31)***	2.25 (2.18, 2.31) ***	2.11 (2.04-2.19)***	1.35 (1.29, 1.41)***	0.79 (0.75-0.84)***	1.71 (1.66, 1.77) ***	1.31 (1.25-1.37)***
School Variables								
Sports and Recreation Facilities	0.97 (0.96, 0.99) ***	0.97 (0.96-0.99)***	0.97 (0.97, 0.98) ***	0.97 (0.97-0.98)***	0.98 (0.97, 1.00)	0.99 (0.97-1.00)	0.99 (0.99, 1.00)	1.01 (1.00-1.02)
Rural	1	1	1	1	1	1	1	1
Small Urban	0.65 (0.56, 0.75) ***	0.74 (0.64-0.87)***	0.65 (0.56, 0.75) ***	0.71(0.61-0.83)***	0.67 (0.56, 0.80) ***	0.83 (0.68-1.02)	0.80 (0.67, 0.95)	1.13 (0.93-1.38)
Medium Urban	0.59 (0.50, 0.70) ***	0.65 (0.55-0.78)***	0.63 (0.54, 0.74) ***	0.70 (0.59-0.82)***	0.58 (0.47, 0.71) ***	0.66 (0.53-0.83)***	0.91 (0.75, 1.10)	1.48 (1.19-1.83)***
Large Urban	0.42 (0.36, 0.48) ***	0.52 (0.45-0.61)***	0.50 (0.43, 0.57) ***	0.66 (0.57-0.77)***	0.30 (0.25, 0.36) ***	0.37 (0.30-0.46)***	0.66 (0.55, 0.78) ***	1.31 (1.08-1.59)**
Alcohol Retailers	1.02 (0.99, 1.05)	1.04 (1.01-1.07)**						
Tobacco Retailers					1.05 (1.00-1.10)			
Individual Variables								
Physical Activity Level (hours MVPA/day)	1.11 (1.09, 1.13) ***	1.11 (1.09-1.14)***	1.08 (1.06, 1.10) ***	1.06 (1.04-1.08)***	1.08 (1.05, 1.11) ***	1.03 (1.00-1.07)	1.05 (1.03, 1.08) ***	1.00 (0.98-1.03)

Binge Drinking			3.85 (3.59-4.13)***		2.77 (2.51-3.07)***		3.37 (3.11-3.65)***
E-cigarette Use		3.89 (3.62-4.17)***			4.17 (3.74-4.64)***		3.85 (3.55-4.18)***
Cigarette Smoking		2.60 (2.35-2.87)***		3.66 (3.30-4.07)***			5.65 (5.11 -6.24)***
Cannabis Use		3.32 (3.06-3.60)***		3.71 (3.42- 4.03)***		5.99 (5.41-6.64)***	

¹ In addition to all variables shown in the table, all models also controlled for time-invariant covariates (measured at baseline): neighbourhood income, sex, ethno-racial identity, grade at baseline, as well as spending money as a time-varying covariate. Odds ratios are rounded to two decimals.

*p<0.05 **p<0.01 ***p<0.00

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4. Discussion

To our knowledge, this is the first study to examine the potential impact of density of school neighbourhood sports and recreation facilities on youth substance use in Canada. Our findings indicate that the density of these facilities within the school neighbourhood may have a protective effect against youth binge drinking and e-cigarette use but is not associated with youths' cigarette smoking or cannabis use.

4.1 Patterns of Substance Use Behaviours

E-cigarette use was the most common substance use behaviour reported by participants, followed by binge drinking and cannabis use, and then cigarette smoking. The prevalence of these different substance use behaviours aligns with expectations based on previous Canadian and US research (12,22,70). Likewise, consistent with previous research (71,72), this study observed increased likelihood of substance use over time (except for smoking, which decreased over time) in regression models as well as descriptive analyses, which showed increases in substance use prevalence rates between baseline Y1 and follow-up by Y3. The increase in e-cigarette use between Y1 and follow-up Y3 is particularly drastic compared to the other substances and is consistent with previous research having identified spikes in youth e-cigarette use in recent years (12,73).

4.2 Density of School Neighbourhood Sports and Recreation Facilities

Greater density of school neighbourhood sports and recreation facilities was significantly associated with a decreased likelihood of binge drinking and e-cigarette use among this sample of adolescents. The confidence that these findings do directly reflect the effects of density of these facilities, as opposed to some proxy of larger effects (e.g., neighbourhood urbanicity, individual physical activity, etc.) is strengthened due to the inclusion of several potential school- and individual-level confounders in the models.

Previous Canadian research identifies that a key aspect of community sports and recreation facilities that promotes health is their ability to foster social connection and support (28). Sports and recreation facilities can provide youth with opportunities for social connections through a variety of mechanisms, including sports and club participation, as well as volunteer and work opportunities. This type of social engagement in the community is a part of the foundation for the Iceland Prevention Model (24). Research has demonstrated that greater accessibility to sports and leisure for youth in Iceland was protective against substance use behaviours through greater community interaction and strengthened social capital (25,74).

However, the density of school neighbourhood sports and recreation facilities did not produce a protective effect against all four substance use behaviours examined. This disparity may be partially explained by

differences in the social contexts in which substances are typically used by adolescents (e.g., using substances alone versus with peers, motivations for using substances, etc.)(15). Among youth, it is known that substance use behaviours are strongly influenced by social norms (75,76). As discussed below, the unique social contexts of different substance use behaviours may have a bearing on the likelihood for sports and recreation activities to impact substance use behaviours.

4.2.1. Binge Drinking and E-Cigarette Use

Research indicates that, among young people, binge drinking most often occurs in social contexts (e.g. parties) (14,77). It may be reasonable to suggest that accessing school neighbourhood sports and recreation facilities can reduce some social motivators for binge drinking; some of the students' need for social engagement could be met through involvement with these facilities, and they may therefore be less inclined to binge drink for social reasons. Moreover, boredom is a known predictor of binge drinking (78,79), and a neighbourhood with a higher density of sports and recreation facilities offers more opportunities for extracurricular activities in which youth can participate, and therefore may decrease the likelihood that youth will engage in binge drinking out of boredom. While the overall effect of sports and recreation facility density was protective against binge drinking in this study, aforementioned research has highlighted that team sports specifically can be a risk factor for binge drinking, so there are likely unique social contexts depending on the type of sports in which youth participate (31,36). The complex nature of the associations between sports, recreation and binge drinking indicate that prevention efforts likely require a combination of population-level and targeted approaches.

Similar to binge drinking, youth primarily report social reasons for engaging in e-cigarette use, including the need to be perceived as 'cool' by their peers (80,81). The large presence of online marketing of novel e-cigarette products that target youth has also likely contributed to these shifts in perception and normalization of e-cigarette use (82,83). This study demonstrated protective effects of school neighbourhood sports and recreation facilities density against youth e-cigarette use, as well as binge drinking. These findings may indicate that greater access to opportunities for social connection may displace some social motivation to engage in these substance use behaviours.

4.2.2. Tobacco and Cannabis Use

In contrast, there is evidence that cigarette smoking and cannabis use may be less socially motivated behaviours, compared to binge drinking and e-cigarette use. While smoking has inherent ties to social factors, such as peer group and family opinions on smoking (84,85), opinions towards smoking have shifted and continue to shift in Canada to be increasingly unfavourable (86). This can be observed even over the short time period of the present study, as smoking was the only substance use behaviour that showed decreased likelihood over time. Research has found that Canadian youth are altering their

perceptions away from smoking being a 'cool' behaviour and instead considering it a negative and less socially acceptable behaviour, in part due to better knowledge of associated adverse health outcomes (86). These changing social norms among Canadian youth may have contributed to steadily decreasing smoking rates in recent years (87) and may explain why the density of sports and recreation facilities showed no protective effects for this substance use behaviour.

The social context of cannabis use among Canadian youth appears to be more complex; while many youth report that a main motivator for cannabis use is to 'fit-in', there are many reported motivators that are not necessarily social in nature, such as improved physical or mental health, sleep, or concentration (88). Particularly relevant to the present study, Canadian youth have reported that being busy with extracurricular activities is not necessary an impediment to cannabis use, and instead sometimes can be used as a "cover" to hide use from parents (88). Therefore, while existing research suggests that youth have some social motivators for youth cannabis use, it remains distinct from other substance use behaviours. This may partly explain the findings presented here that school neighbourhood sports and recreation facilities had no effect on cannabis use while showing significant protective effects for other substances. Notably, the present study, as well as the referenced literature, was conducted prior to non-medical cannabis legalization for adults. Although cannabis remains an illegal substance for youth, it is unclear what effects legalization may have on youths' perceptions and norms around cannabis.

4.3 Implications

The present findings suggest a protective effect of school neighbourhood sports and recreation facilities, even after controlling for potential neighbourhood risk factors, including the presence of alcohol and tobacco retailers. This lends support for initiatives similar to the Iceland Prevention Model's comprehensive approach to addressing youth substance use, which focused on leveraging community-level resources and engagement (27). The relatively small effect sizes in this study are to be expected and reflect that neighbourhood sports and recreation facilities represent only a single aspect of the built environment. The built environment components of the school neighbourhood consist of many overarching elements that may influence health behaviours, including the density of sports and recreation facilities examined in the present study, as well as other types of facilities, walkability, green space, transit, and many others. The number and various types of factors that influence youth health and wellbeing underscore the importance of multipronged, comprehensive efforts to prevent substance-related harms and that there is no "silver bullet" for addressing this complex public health problem. The present study, supported by the existing literature, illustrates the importance of considering all aspects of the school community for youth health. Understanding the impact of the school neighbourhood sports and recreation facilities also illustrates potential opportunities to leverage partnerships and services between schools and community organizations toward the shared goal of supporting youth health.

4.4 Limitations

There are several limitations to note with respect to the present study. First, this study only measured associations between the built environment and individual health behaviours, and as such, it was not possible to fully understand the mechanism behind these associations. Future research should consider measuring the social context of substance use alongside frequency in order to further understand the potential connection between school neighbourhood sports and recreation facilities, social connection, and substance use. Second, this study relied on existing DMTI database categorizations as representations of the built environment and therefore were imperfect representations of sports and recreation centres in which youth might engage. As such, our study could only measure density, rather than accessibility, of the school neighbourhood sports and recreation facilities; unmeasured characteristics of the individual facilities (e.g. cost, activities offered, age restrictions, etc.) would affect ability for youth to use these facilities. In particular, cost barriers to participation may disproportionality impact school communities in lower-income areas, and therefore future research should consider collecting this data and examining the accessibility of these facilities. Moreover, family-related indicators such as parental income or education may be associated with youth substance use but were not collected in this study, and as such, may confound results. Lastly, the COMPASS study uses convenience sampling and as such, the results of this study may not be generalizable outside the study population. This study has many strengths; to our knowledge, this is the first study to examine the impact of school neighbourhood sports and recreation facilities on youth substance use in Canada and is one of few studies in the literature that focus on potential protective factors of the built environment. Furthermore, the longitudinal nature of this study, combined with the large sample size, allowed for robust examination of how aspects of the school neighbourhood impact likelihood of substance use. Lastly, the use of a passive consent protocol was an important feature for a study examining substance use behaviours since it helps to limit response and self-selection biases (89,90).

5. Conclusions

This study identified a negative association between the density of school neighbourhood sports and recreation facilities and likelihood of youth binge drinking and e-cigarette use, which suggests that these facilities may have the potential to displace some substance use behaviours among youth. These findings lend support to population-level interventions aiming to prevent substance-related harms among youth through built environment features, such as sports and recreation facilities in school neighbourhoods. Potential directions for future research include examining the influence of sports and recreation facility density within school neighbourhoods on youth substance use in other study samples, as well as exploring other features of the built environment that may have protective effects on youth substance use behaviours.

Contributors: AD, KG, OS, SW and YJ contributed to project conceptualization. AD planned the methodology, conducted the formal analysis, and did the original draft preparation. SL acquired funding, managed resources, and provided supervision for the host study and corresponding data in this manuscript. AD, KG, OS, SW, YJ, and SL reviewed and edited the manuscript for critical content. All authors have read and agreed to the published version of the manuscript.

Funding: The COMPASS study has been supported by a bridge grant from the CIHR Institute of Nutrition, Metabolism and Diabetes (INMD) through the “Obesity – Interventions to Prevent or Treat” priority funding awards (OOP-110788; awarded to Scott T. Leatherdale), an operating grant from the CIHR Institute of Population and Public Health (IPPH) (MOP-114875; awarded to Scott T. Leatherdale), a CIHR project grant (PJT-148562; awarded to Scott T. Leatherdale), a CIHR bridge grant (PJT-149092; awarded to Karen Patte/Scott T. Leatherdale), a CIHR project grant (PJT-159693; awarded to Karen Patte), and by a research funding arrangement with Health Canada (#1617-HQ-000012; contract awarded to Scott T. Leatherdale). The creation of this manuscript was funded by the Research Affiliate Program from the Public Health Agency of Canada, Applied Research Branch.

Competing interests: None declared

Data sharing statement: COMPASS data are available for researchers upon successful completion and approval of the COMPASS data usage application (<https://uwaterloo.ca/compass-system/information-researchers>). Technical reports detailing COMPASS study methods are available online (<https://uwaterloo.ca/compass-system/publications#technical>).

Patient and Public Involvement Statement: Youth participating in the COMPASS study were not involved in the study design. Some of the COMPASS student questionnaire measures are based off of previously validated questions among youth, and as such in some cases youth may have been involved in the design. COMPASS disseminates results to stakeholders in a variety of ways including school and provincial level reports prepared yearly. More information about the COMPASS study can be found at <https://uwaterloo.ca/compass-system/>.

Research Ethics Approval: The COMPASS Study received ethics approval from the University of Waterloo Office of Research Ethics as well as participating school boards (ORE #: 30118).

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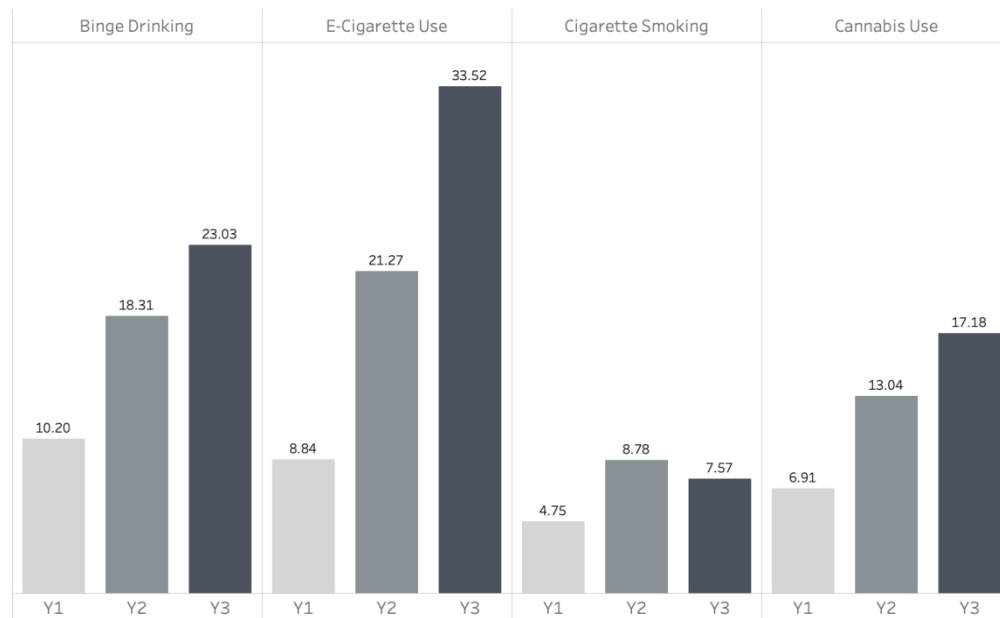


Figure 1: Percent of participants who reported each substance use behaviour in the sample population (Y1:2015/16, Y2:2016/17, Y3:2017/18)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of cohort studies

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study’s design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	3
		(b) For matched studies, give matching criteria and number of exposed and unexposed	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3,4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	3,4
Bias	9	Describe any efforts to address potential sources of bias	3
Study size	10	Explain how the study size was arrived at	3
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4,5
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	4,5
		(b) Describe any methods used to examine subgroups and interactions	5
		(c) Explain how missing data were addressed	3,5
		(d) If applicable, explain how loss to follow-up was addressed	3
		(e) Describe any sensitivity analyses	N/A
Results			N/A

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	3
		(b) Give reasons for non-participation at each stage	3
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5
		(b) Indicate number of participants with missing data for each variable of interest	5
		(c) Summarise follow-up time (eg, average and total amount)	3
Outcome data	15*	Report numbers of outcome events or summary measures over time	5
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6
		(b) Report category boundaries when continuous variables were categorized	N/A
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	5,6,7
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	6,7,8,9
Generalisability	21	Discuss the generalisability (external validity) of the study results	9
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	9

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.