TITLE: Substance use and related harms among adolescents**with and without traumatic brain injury****AUTHORS NAMES AND AFFILIATIONS:**Gabriela Ilie, PhD^{1,4}, Robert E. Mann², PhD, Hayley Hamilton, PhD², Edward M. Adlaf,PhD², Angela Boak, MA,² Mark Asbridge, PhD³, Jürgen Rehm, PhD², Michael D.Cusimano, MD, PhD^{1,4}¹- St. Michael's Hospital, Division of Neurosurgery, 30 Bond St., Toronto, M5B 1W8,

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23 Manuscript: 4,031 words (excluding Title Page, Abstract, References, and Tables);

Abstract: 207 words.

26 ***Acknowledgements:***

27 Funding: This work was financially supported by a STAIR Team Grant from the
28 Canadian Institutes of Health Research (# TIR-103946) and by the Ontario Neurotrauma
29 Foundation. Additional funding was obtained from a grant from AUTO21, a member of
30 the Networks of Centres of Excellence program that is administered and funded by the
31 Natural Sciences and Engineering Research Council, the Social Sciences and Humanities
32 Research Council, in partnership with Industry Canada, and ongoing funding support
33 from the Ontario Ministry of Health and Long-Term Care.

34 The authors gratefully acknowledge the participation of schools and students and the
35 dedicated work of the data collection team from the Institute for Social Research.

36

37 ***Conflict of interest disclosures:*** The funding agencies had no role in design and conduct
38 of the study, the collection, management, analysis and interpretation of the data, or the
39 preparation, review or approval of the manuscript. All authors are independent from the
40 funding agencies. All authors declare: no competing interests exist; no support from any
41 organization for the submitted work; no financial relationships with any organizations
42 that might have an interest in the submitted work in the previous three years, no other
43 relationships or activities that could appear to have influenced the submitted work.

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ABSTRACT

49 **Objective:** The relationship between self-reported lifetime traumatic brain injury (TBI)
50 and drug and alcohol use and associated harms was examined using an epidemiological
51 sample of Canadian adolescents.

52 **Settings and design:** Data were derived from a 2011 population-based cross-sectional
53 school survey, which included 6383 Ontario 9th–12th graders who self-completed
54 anonymous self-administered questionnaires in classrooms. TBI was defined as loss of
55 consciousness for at least 5 minutes or a minimum one-night hospital stay due to
56 symptoms.

57 **Results:** Relative to high schoolers without a history of TBI, those who acknowledged
58 having a TBI in their lifetime had odds 2 times greater for binge drinking (5+ drinks per
59 occasion in the past 4 weeks), 2.5 times greater for daily cigarette smoking, 2.9 times
60 greater for use of non-medical use of prescription drugs, and 2.7 times greater for
61 consuming illegal drug in the past 12 months. Adolescents with a history of TBI had
62 greater odds for experiencing hazardous/harmful drinking (aOR = 2.3), cannabis
63 problems (aOR = 2.4) and drug problems (aOR = 2.1), compared with adolescents who
64 were never injured.

65 **Conclusion:** There are strong and demographically stable associations between TBI and
66 substance use. These associations may not only increase the odds of injury, but may
67 impair the quality of post-injury recovery.

68 **Keywords:** traumatic brain injury; concussion; substance use; adolescents; alcohol use;
69 drugs; smoking

INTRODUCTION

Traumatic brain injury (TBI) is a major cause of disability, morbidity and mortality among individuals under age 45, and it is responsible for a significant proportion of all traumatic deaths.¹⁻⁴ Between 1994-1995 and 2003-2004, the highest percentage of admission to hospital due to TBI in Canada (30%) were among those aged 19 and under.⁵ Between 2001-2010 in US adolescents aged 15 to 19 had the second highest combined rates of TBI-related emergency department visits, incidences of hospitalizations and deaths, compared to all other age groups.⁶ Furthermore, existing TBI estimates are likely understated as most are based on hospitalized events many or most of which go unreported.⁷ The high costs associated with TBI and TBI-related disability in Canada (over \$7 billion), US (over \$60 billion), and worldwide have increased the interest in its prevention.⁸⁻¹⁴

Traumatic brain injuries represent hits, blows or trauma to the head that cause damage to the brain.^{1,5,6} Most TBIs among youth occur during sports.^{2,3,4,14} The Centre for Disease Control and Prevention (CDCP) in the US reports that between 2001 and 2009 the number of head injuries during sports among youth has risen by 57%.¹⁵ In recent years, CDCP has termed TBI among youth a “silent epidemic”, as most incidences of sports related TBI among teens, go unreported.¹⁶ TBI concerns stem from its persisting effects and burdens that range from cognitive dysfunction, substance use, anxiety, depression, and suicidality, to poor academic performance and social impairments that contribute to the development of dysfunctional relationships.¹⁷⁻²³

One area worthy of more investigation is the co-occurrence of TBI and substance use. Indeed, both, TBI and substance use, are risk behaviours or the consequence of risk

behaviours that surface during adolescence. Moreover, substance use is a behaviour that has both pre- (by increasing the risk of injury) and post- (by influencing the length and quality of recovery) TBI influences. More notably, there is some direct evidence on the association between substance use and TBI among adolescents.⁷ One cohort study showed that moderate to severe forms of TBI in early childhood were related to subsequent alcohol and drug use later on in adolescence,²³ while another showed the onset of substance use disorders three years post injury during adolescence.²³ Population studies have shown that between 40% to 66% of adults with TBI report having a history of chronic alcohol-related problems.¹⁷ Substance use (including alcohol) has been identified as a risk factor for reoccurring head injuries in early adulthood.^{18,23-26} Population-based studies are needed not only to describe and track the epidemiological pattern of injury, but also to examine the relationship between TBIs and substance use problems in adolescence, to inform injury prevention and educational efforts, as well as clinical recovery and rehabilitation strategies. Thus, the aim of our study is to describe population-based estimates of the prevalence of TBI and the associations between TBI and substance misuse among a nonclinical population of adolescents. These data not only describe current estimates of TBI from a jurisdiction without such prior data, but also investigates a wide range of substance types, and, unlike many epidemiological studies, also investigate substance misuse as measured by standard screeners.

METHODS

We examined the relationship between substance use, related harms and traumatic brain injury in a sample of high school students (grades 9-12). This sample was derived

from the 2011 cycle of the Ontario Student Drug Use and Health Survey (OSDUHS), a cross-sectional repeated survey of Ontario students enrolled in grades 7 through 12 enrolled in middle and high schools in Ontario. The 2011 OSDUHS employed a stratified (region, school type and grade), two-stage (school, class) cluster sample design. Within each region x school type stratum, schools were selected with probability-proportionate-to-size and within selected schools, classes, stratified by grade, were selected with equal probability (one class per grade). Of 255 selected schools, 181 participated (71%); within participating classes, 9288 of 15,005 enrolled students provided useable questionnaires (62%), a response rate above average for a student survey using active consent procedures.²⁷ The survey was administered by field-trained staff from the Institute for Social Research (ISR), York University. The Research Review Committees of CAMH, York University, public and Catholic school boards approved the study. All participants provided signed assent/consent; and those younger than 18 additionally required signed active parental consent. A complete description of the sampling plan, procedures and the questionnaires used is available online at the OSDUHS webpage.²⁸ The electronic report provides prevalence estimates of the outcomes, and trend analyses over the life of the study.

Since use of most of the substances reported here is not initiated until grade 9 or later, we restricted the current sample to students in grades 9-12.²⁵ We used two subsamples in this analysis. First, a subsample of 6383 high school students in grades 9-12 who individually completed the paper and pencil survey (approximately 30 minutes long), in their classroom. The estimated mean age of this sample was 15.8 years (age range: 13-20; 52% were male). These students provided information on substance use.

Within this subsample, a random subsample of 3358 of these high schoolers also completed screening instruments (see AUDIT, CRAFFT and SDS-C, below) for substance-related problems (field staff randomly distributed one of two versions of the questionnaire to each student, one of which contained the screening instruments). The surveys The mean age of this subsample was 15.8 years (age range: 13-20; 51% were male).

Measures

Traumatic brain injury (TBI)

The TBI question was prefaced with a description of frequently used TBI criteria of a minimum of at least a five-minute period of unconsciousness or at least one overnight hospital stay due to symptoms that resulted from the injury to the head. The question asked: “*We are interested in any head injuries that resulted in you being unconscious (knocked out) for at least 5 minutes, or you had to stay in the hospital for at least 1 night because of it.*” Students were then asked, “*Did you have this type of head injury in your life?*” Responses included “(1) *Yes, I’ve had a head injury like this in the last 12 months,* (2) *Yes, I’ve had a head injury like this in my life, but not in the last 12 months, or (3) No, I’ve never had a head injury like this in my life.*” To reduce data sparseness and improve our modelling, responses 1 and 2 were combined to represent lifetime prevalence and were binary coded 1 (history of TBI) or 0 (no history of TBI) otherwise. This question with an item response of 98%, is similar to those employed in recent studies of self-reported TBI²⁹⁻³⁴ and is an operational definition used in several classification systems including DSM-IV.³⁵⁻⁴⁰ Although we have no external data to validate our TBI measure, we do have concurrent items that provide correlational evidence of validity. One such

item asked students if they had any medically treated injuries in the past year. When correlating these two items, a significantly positive relationship emerged (Cramer's $V = 0.21, P < .001$). This correlation was both positive and significant, although we expect a modest correlation because since the criterion includes injuries not related to TBI.

Cigarette use

The prevalence of daily cigarette use in the past 12 months was assessed with the question, "*In the last 12 months, how often did you smoke cigarettes?*" The question and its responses are accessible on line.²⁸ Responses were combined to classify those not smoking daily, from those that do (binary coded as 1/0).

Alcohol use

The OSDUHS assessed alcohol use in the past 12 months and binge drinking (5+ drinks of alcohol on the same occasion at least once in the past 4 weeks).²⁸

Other drug use

The past-year prevalence of nine substances – cannabis, LSD, hallucinogens, cocaine, ecstasy, methamphetamine or crystal methamphetamine, and 3 psychotherapeutics taken without medical direction—sedatives (e.g., Xanax) without one's own prescription, ADHD drugs (e.g., Ritalin) without one's own prescription, and opioid pain medication (e.g., Percocet) without one's own prescription – were contrasted by TBI status.

Drug related harms subsample

Among the students who completed the survey, 3332 provided measures of alcohol, drug and cannabis related harms. The first measure was *hazardous/harmful drinking* and it was assessed using the *Alcohol Use Disorders Identification Test* (AUDIT) classification, developed by the World Health Organization (WHO).⁴⁰ This 10-item screen, designed to

detect problem drinkers at the less severe end of the spectrum of alcohol disorders, assesses *hazardous drinking* - an established pattern of drinking that increases the likelihood of future medical and physical problems (e.g., liver disease), - and *harmful drinking*, a pattern of drinking that is already causing damage to one's health or social relations (e.g., depression, injuries). A binary variable was created by summing up the responses from the 10-items and using the WHO's the recommended cut score of 8 or more of a maximum 40 (binary coded as 1 and 0 otherwise) to classify those displaying a *hazardous/harmful drinking* pattern.⁴¹⁻⁴²

The second measure was *drug use problems* experienced by adolescents during the past year and used the 6 yes/no items of the *CRAFT* screener ([1] *use drugs to relax, feel better about self*; [2] *used drugs while alone*; [3] *forgot things you did while using drugs*; [4] *gotten into trouble while using drugs*; [5] *family/friends told you to cut down*; [6] *used drugs when driving*).⁴³ A total count of two or more problems, binary coded as 1, classifies adolescents as having a drug use problem and may be in need of treatment.⁴³

The internal consistency (α) of these six items is 0.78. The third drug-related harm measure assessed cannabis use problems through the *Severity of Dependence Scale for Cannabis* (SDS-C) classification,⁴⁴ which is a validated 5-item scale used to screen for past three-month dependence in adolescent and other populations ([1] *thought of missing a smoke causes anxiety/worry*; [2] *use out of control*; [3] *worry about their cannabis use*; [4] *wish to stop using*; and [5] *difficult to stop using or go without*). Each item was scored on a 4-point scale (0-3) and then summed. A total score of ≥ 4 (of 15) classifies students as being cannabis dependent (binary coded as 1 or 0 otherwise). The internal consistency (α) for these 5 items was 0.77.

While we could not compare students who returned a signed consent form with those who did not, we were able to compare TBI prevalence in classes in which the class rate was below 70% ($<70\%$; $n=323$ classes) with classes in which the class response was 70% or higher ($\geq 70\%$; $n=258$ classes). If students who did not return consent forms were indeed “high-risk” youth, then we would expect classes with low participation rates to have lower prevalence estimates (less likely) of TBI compared with high-participation classes. No difference in the prevalence of TBI occurred between students in lower and higher responding school classes (19.8% vs. 19.6%, $t_{579}=-0.189$, $p=0.850$). Thus, we found no appreciable evidence of TBI non-response bias in our data. We also compared demographics and substance use among low ($<70\%$) versus high ($\geq 70\%$) response rate. We found no significant differences between classes with low and high participation rates regarding demographics. Our assessment of nonresponse bias in the drug use items showed that for the substance use measures compared in the full study, only 3 of 28 comparisons showed significant differences (see page 11, of our on-line data report).²⁸ This suggests that students who participated in the surveys were not dominantly “low-risk” youth.

Analyses

To accommodate our clustered, stratified, and weighted survey data, we employed pseudo-maximum likelihood estimation in estimating point estimates (because some key assumptions of standard maximum likelihood estimation are violated in the presence of complex survey data) and Taylor-Series-Linearization (a robust variance estimator) in

estimating variances. Both these techniques of analysis are implemented in the Complex Sample module and were examined using the SPSS statistical software version 20.0.⁴⁵ Our analysis was based on an unconditional subclass selection⁴⁶⁻⁴⁷ of high schoolers resulting in a subsample with 9 strata (region), 103 primary sampling units (high-schools) containing 6288 students. The need for unconditional subclass selection is that the design-based estimation must recognize all of the original strata/PSU codes, which would be removed with conventional subclass selection (e.g., if schooltype=2), a procedure if naively used would also remove the PSU/strata information of excluded observations, which are necessary for estimation.

We modeled two sets of binary logistic regressions, one based on the sample of 6288 high school students, regressing each substance use variable (daily-smoking, and past-year alcohol, binge drinking, illegal and legal drug use) on the predictors (a history of TBI [yes/no] with grade and sex as covariates) and the other based on the *subsample* of 3332 high schoolers (drawn from the total 6288 sample) who also completed the AUDIT, CRAFFT and SDS, regressing the outcomes of drug-related harms (AUDIT, CRAFFT and SDS) on the set of 3 covariates noted earlier. For all regressions the three predictors were entered together.

With listwise deletion, the estimation samples were reduced to 6288 (from 6383) for the *prevalence subsample*, and to 3332 (from 3358) for the *harms subsample*. Finally, as noted earlier, all analyses were weighted based on sampling probabilities and nonresponse and post stratification adjustments.

254

255 **RESULTS**

256 An estimated 20.3% (95% CI: 17.7, 23.2) of Ontario 9th to 12th graders, representing
257 some 147,800 high-schoolers, acquired a TBI in their lifetime (not tabled). The odds of
258 history of TBI was 1.38 times higher among males than females ($P < 0.01$; not tabled).

259

260 As seen in Table 1, for 12 of 12 substances the covariate-adjusted (for sex and grade)
261 odds of substance use were significantly greater for students who had a history of TBI
262 than those with no history of TBI (all TBI confidence intervals exclude 1). Moreover, the
263 TBI adjusted odds ratios, which range from 1.9 to 3.8, average a 2-fold increase in the
264 odds of substance use.

265

266 The prevalence shows that just over 9% of students with a history of TBI smoked
267 cigarettes daily in the past year, compared with about 4% of non-injured students. When
268 accommodating the survey data and holding constant values of sex and grade, the
269 estimated odds of daily smoking were 2.5 times greater for brain-injured over that of non-
270 injured students. For alcohol use, the adjusted odds of past year drinking and binge
271 drinking increase by a factor of 2 for students with a history of TBI over that of non-
272 injured students. Similarly, past year use of illegal drugs (i.e., cannabis, LSD,
273 hallucinogens, cocaine, ecstasy, methamphetamine) and nonmedical use of prescription
274 drugs including sedatives, ADHD drugs, and opioid pain relievers was significantly
275 higher among students with a history of TBI than those without. Again the adjusted odds
276 of past-year illegal drug use and nonmedical prescription drug use ranged from 2-4 times

greater for students who reported a history of TBI than those who did not report a history of TBI.

Table 2 presents the prevalence and adjusted odds of substance use harms according to history of TBI status (harms subsample). The unadjusted prevalence of hazardous/harmful drinking (AUDIT) for students who reported a history of TBI is 36.2% compared with 20.5% for students who did not report a history of TBI. The grade and sex adjusted odds of hazardous or harmful drinking was 2 times greater for students who reported a history of TBI in their lifetime than those who did not. The unadjusted prevalence of 25% of students who acquired a TBI was also classified with a drug use problem (CRAFFT) compared to 14% of their counterparts. The unadjusted prevalence of reports of a history of TBI with a drug use problem (CRAFFT) was 25%, compared to 14% among those not reporting a history of TBI in their lifetime. The adjusted odds ratio of a drug use problem among students who reported a history of TBI were twice that of those who did not report a history of TBI in their lifetime. The unadjusted prevalence of cannabis dependence (SDS) was significantly higher among TBI than non-TBI students (5% versus 2%). The adjusted odds of cannabis dependence increased by a factor of 2 for students with a history of TBI, over that of students without a history of TBI in their lifetime

DISCUSSION

One-in-five high-school students reported a TBI in their lifetime. Among students who reported a history of TBI, odds were between 2 and 4 times higher for past-year

substance use compared with students without a history of TBI, even when sex and grade were held constant. This estimate is closely related to the estimate of the larger sample from which these data were derived (20.2%) showing significant associations between TBI and alcohol and cannabis use and poorer grades in school.¹⁴ The results of this study extend our initial report by providing a closer look at the associations between TBI and substance use and problems. The results from our investigation corroborate associations reported previously in the adult literature that point to the negative synergistic effects between substance use, TBI, negative life trajectories as well as the consequences these associations precipitate.⁴⁸ For example, research indicates that about 20% of individuals who experience a TBI also report the onset of a substance use problem after their injury.^{17,49-50} However, as indicated by some studies, substance use can also precede TBI and constitute a risk factor for TBI.^{17,51-52} Past research shows that among large samples of TBI-injured adults as many as 40% to 66% of these individuals also had a history of problem alcohol use or illegal drugs prior to the head injury.^{17,51-52} Links between risk-taking behaviours and TBI among youth have been previously reported in two other studies outside North America.²⁵⁻²⁶ Our results show adolescents who reported a history of TBI in their lifetime have higher rates of substance abuse than those who did not report a history of TBI. Heavy substance use and substance related problems in adolescents are known risk factors for difficulties later in life.⁵³⁻⁵⁴ Their co-occurrence with TBI suggests a particularly toxic combination and may have similar long term adverse effects.⁵⁵⁻⁵⁸

These data underscore a need for injury prevention action in schools. School guidance counsellors, parents and medical professionals should be vigilant and screen for history of

TBI when students present substance misuse problems. Use of substances post TBI may create additional challenges for youth and may lead to slower recovery from brain injury, further brain damage, increased frequency of aggressive or antisocial-behaviours, failure in school projects, poorer grades, or problems with parents, family members and/or peers.^{23,55-58} Good identification, management and education efforts early on may prevent the development of other set of difficulties brought on by the use of substances, (in addition to those stemming from the TBI) and, subsequently, improve outcomes.

Our definition of TBI excluded blows, hits, or trauma to the head that did not result in loss of consciousness for at least 5 minutes (or at least one overnight hospitalization due to symptoms associated with the injury). Therefore, it is likely that the TBI prevalence estimates we report here are underestimates of concussions, in this population. Concussions are mild forms of traumatic brain injury that alter brain functioning.^{4,8,15} Loss of consciousness may or may not occur following a concussion but headaches, sensory problems (e.g., irritation with lights, high pitched sounds) and problems with concentration, memory, and/or balance and coordination are usual symptoms for this type of TBI.^{4,8,15,59} Concussions are often interpreted by teens, parents, coaches and media to mean a less alarming injury than “mild traumatic brain injury” but this interpretation is incorrect as concussions are considered a subset of mild traumatic brain injury and they are associated with important clinical outcomes.^{59,60} Thus it is important to caution parent, coaches, media and medical professionals from being tempted to minimize the seriousness of a brain injury inappropriately by using terminology to wrongly justify lack of injury severity.^{59,60}

Effective TBI preventive programs among youth should be initiated to help

reduce the incidence of TBI and with it the development of substance misuse problems that may develop post TBI. In our view, reducing the burden of adolescent TBI will require a three-pronged approach. First, good management of TBI will likely improve outcomes. Current preventive programs aimed at identification and management of TBI (e.g., Heads Up: Concussion in High School Sports) should continue to be used to educate parents, youth and coaches on the harms of TBI. Educating parents and coaches on the substance abuse problems that may develop post TBI, their impediments to TBI recovery, as well as their leading to worse outcomes from TBI should also be implemented in existing TBI prevention and management programs. Such addition to existing programs could help improve outcomes and prevent complications from the potential use of substances in the recovery process.⁶¹⁻⁶² Second, intervention and treatment to reduce substance abuse among adolescents is also needed. Research has shown that among TBI hospitalized patients a significant number (adults and youth) have histories of substance misuse (especially alcohol related).^{17,63,64} Adolescence is not only a turbulent period in human development, but an important stage in which harms experienced through the combination of TBI and heavy substance use could negatively impact an individual's life trajectory in late adolescence and adulthood. We know that in 2013 in Ontario, 50% of all students surveyed (irrespective of whether or not they indicated that they have a history of TBI) grades 7 through 12 consume alcohol, 20% of students binge drink, and 16% engage in hazardous/harmful drinking.⁶⁵ Studies in the US since 1985 show that between 40% to 60% of individuals with substance abuse problems also incur at least one traumatic brain injury.⁶⁶ The associations between TBI and substance use we report here could be reduced by drug and substance use prevention

efforts that target youth's beliefs and attitudes about drugs, especially the risk of physical harms and injuries that occur from use. Third, given that rehabilitation efforts following TBI for cognitive and behavioural effects could be confounded by drug use, it may be important for clinicians, school guidance counsellors, sports coaches and parents to be cognizant of the possibility that these youth may also be using drugs that interfere with their treatment. Therefore, a prevention approach aimed at returning to activity and school after TBI that include education about substance abuse may lead to better TBI outcomes.

Interpretation of the results of this study must keep in mind important limitations. Although population surveys are particularly useful for estimating the prevalence of a health condition in a large population of adolescents and for identifying associated risk factors and at-risk subtypes, possible bias related to self-report procedures may limit such results.^{46,47} This study included only youth who were in school and not those who may not be in school due to the severity of TBI-related disability. Our sample also excluded groups at potentially high-risk for TBI such as institutionalized adolescents, and although we did not see appreciable evidence of bias²⁸, we cannot conclude that such bias is trivial.⁶⁷⁻⁶⁹ The cross-section design used cannot establish casual order (e.g., whether TBI causes drug use, or whether drug use causes TBI). Finally, while respondents were able to attend school and participate in normal activities, we cannot rule out the possibility of cognitive impairments affecting responses of TBI-injured students.

Our results suggest several important areas for future research. First, epidemiological

population based surveys should continue to examine TBI prevalence in the adolescent population and its various subgroups, identify correlates, and monitor change over time. Second, future population studies should examine how severity of TBI affects relationships with adverse correlates. As well, age at first injury and age of onset for TBI correlates should be investigated to assess temporal ordering. Third, person-centered analytic methods such as latent class analysis may provide a valuable insight into this condition and its comorbid linkages. For example, definable and replicable classes/clusters might be identified that could have important distinguishing clinical features. Finally, longitudinal studies are necessary to clarify the temporal pathways between substance use and TBI so that causal relationships can be resolved.

Despite the stated limitations, we believe this study points out important issues for TBI survivors, TBI rehabilitation, and TBI prevention efforts. This is the first investigation examining substance use associations with a history of TBI among youth using a cross-sectional population based sample of high school students. The results presented here point to important opportunities for TBI and substance misuse prevention.

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Table 1. Tobacco, alcohol and other drug use by history of TBI, Ontario high school students, 2011 OSDUHS (n=6288)

Drug use prevalence	No history of TBI % (95% CI) (n=5073)	History of TBI % (95% CI) (n=1215)	aOR	95% CI
<i>Tobacco use</i>				
Not used ^a	96.1 (95.0,97.0)	90.8 (85.6,94.2)	1.0 (Reference)	
Smoked 1+ cigarettes daily ^a	3.9 (3.0,5.0)	9.2 (5.8,14.4)	2.48**	1.45,4.25
<i>Alcohol use</i>				
Not used ^a	36.3 (33.7,39.0)	23.0 (19.2,27.2)	1.0 (Reference)	
Alcohol ^a	63.7 (61.0,66.3)	77.0 (72.8,80.8)	2.01***	1.52,2.67
No binge drinking ^b	73.6 (71.7,75.4)	60.7 (55.9,65.4)	1.0 (Reference)	
Binge drinking 5+ drinks ^b	26.4 (24.6,28.3)	39.3 (34.6,44.1)	1.87***	1.49,2.35
<i>Illegal drugs use</i>				
Not used ^a	74.8 (72.5, 76.9)	60.5 (55.1,65.7)	1.0 (Reference)	
Cannabis ^a	25.2 (23.1,27.5)	39.5 (34.3,44.9)	2.00***	1.60,2.50
Not used ^a	98.9 (98.3,99.3)	97.0 (94.8,98.3)	1.0 (Reference)	
LSD ^a	1.1 (0.7,1.7)	3.0 (1.7,5.2)	2.56**	1.45,4.52
Not used ^a	96.2 (95.2,97.1)	90.4 (86.5,93.3)	1.0 (Reference)	
Hallucinogens ^a	3.8 (2.9,4.8)	9.6 6.7,13.5)	2.64***	1.73,4.04
Not used ^a	98.1 (97.6,98.5)	95.4 (93.6,96.7)	1.0 (Reference)	
Cocaine ^a	1.9 (1.5,2.4)	4.6 (3.3,6.4)	2.49***	1.75,3.54
Not used ^a	96.7 (95.7,97.4)	91.3 (87.3,94.1)	1.0 (Reference)	
Ecstasy ^a	3.3 (2.6,4.3)	8.7 (5.9,12.7)	2.82***	1.73,4.58

Not used ^a	99.2 (98.8,99.5)	97.1 (94.8,98.4)	1.0 (Reference)
Methamphet./crystal meth ^a	0.8 (0.5,1.2)	2.9 (1.6,5.2)	3.77*** 2.21,6.41
<i>Use of medical drug^c</i>			
Not used ^a	98.4 (97.9,98.7)	94.1 (91.9,95.7)	1.0 (Reference)
Sedatives/tranq. ^{a,c}	1.6 (1.3,2.1)	5.9 (4.3,8.1)	3.83*** 2.67,5.51
Not used ^a	99.0 (98.5,99.3)	97.9 (96.9,98.7)	1.0 (Reference)
ADHD drugs ^{a,c}	1.0 (0.7,1.5)	2.1 (1.3,3.1)	2.07* 1.18,3.61
Not used ^a	87.4 (85.7,89.0)	72.8 (68.2,77.0)	1.0 (Reference)
Opioid pain reliever ^{a,c}	12.6 (11.0,14.3)	27.2 (23.0,31.8)	2.69*** 2.02,3.60

Notes: Adjusted odds ratios (aOR) based on logistic regression with grade and sex covariates; model n's

vary from 6256 to 6282; *** odds ratios significant at $P < 0.001$, 2 tailed-test; ** adjusted odds ratios

significant at $P < 0.01$, 2 tailed-test; * odds ratios significant at $P < 0.05$, 2 tailed-test; ^a past 12 months; ^b

past 4 weeks; ^c non-medically prescribed

Table 2. AUDIT, CRAFFT and Cannabis Severity of Dependence Scale (SDS) by history of TBI, Ontario high school students. 2011 OSDUHS (n=3332)

	No TBI history % (95% CI) (n=2722)	History of TBI % (95% CI) (n=610)	aOR	95% CI
AUDIT (8+) – hazardous/harmful drinking	20.5 (17.5,24.0)	36.2 (30.6,42.3)	2.33***	1.78, 3.05
CRAFFT (2+) – drug use problem	13.9 (11.3,16.9)	24.7 (19.2,31.3)	2.07***	1.60, 2.69
SDS - cannabis use problems	2.1 (1.2,3.9)	5 (3.0,8.3)	2.35*	1.08, 5.12

Notes: Adjusted odds ratios (aOR) based on logistic regression with grade and sex covariates; models were

based on the following samples, n=3227 (AUDIT), n=3328 (CRAFFT) and n=3309 (SDS)

*** odds ratios are significant at $P < 0.001$, 2 tailed-test; * adjusted odds ratios are significant at $P < 0.05$, 2 tailed-test