

ABSTRACT

Background: An emerging body of research has reported high consumption of alcohol mixed with energy drinks (AmED) among young adults, particularly college students, however, little is known about adolescents' AmED use. The purpose of this study was to determine the prevalence of AmED consumption and examine its correlates among Canadian high school students.

Methods: We used nationally representative sample of 36,155 Canadian students in grades 7 to 12 who participated in the 2010-2011 Youth Smoking Survey.

Results: Approximately 20% of Canadian high school students reported using AmED in the last year, with considerable variation across provinces. Multivariate logistic regression analyses revealed that the odds of AmED use were higher among students in younger grades (grade 7 and grade 8) and who identified as Black and 'other'. AmED was positively associated with substance use behaviours (current smoking, past year heavy drinking, marijuana use), school truancy, participation in school team sports, and having more weekly spending money. Similarly, students who feel more connected to school, and had academic marks 70 and higher were less likely to consume AmED.

Interpretation: The consumption of AmED is an emerging public health concern that has, to date, received limited attention. AmED use is substantial among Canadian high school students, with many potential harms, both acute, such as injury, and long-term (i.e. increased alcohol dependence). Our findings highlight the need for further research into the long-term effects of AmED amongst young people, as well as the development of interventions aimed at reducing energy drink mixing.

INTRODUCTION

The consumption of energy drinks, beverages that contain moderate to high concentrations of caffeine as well as taurine, herbal supplements, and sugar or sweeteners, has risen steadily in the last decade,¹ with North American sales surpassing that of many other non-alcohol beverages.² Under brand names such as “Red Bull”, “Monster”, “Rockstar” and “Full Throttle”, these beverages have become particularly popular amongst youth and young adults, due to their purported stimulant effects, ability to increase alertness, and enhance mental and physical energy.³ Clinical studies have shown that the consumption of energy drinks increases stimulation, attention and memory, decreases reaction times and mental fatigue, while also improving performance on some physical activities.⁴ At the same time, these beverages have been associated with negative health effects, including those typically associated with excess caffeine consumption, such as irritability, arrhythmia, nervousness, nausea, and seizures.⁵

Despite warnings to the contrary, a popular practice among energy drink consumers is to mix them with alcohol (AmED).⁶ The combined effects of alcohol mixed with caffeine produce varied results on cognitive and motor performance. Due to increased feelings of alertness produced by caffeine, subjective estimates of alcohol impairment are typically underestimated, while the perceived rewarding aspects of drinking are enhanced.^{7,8} As such, AmED has been associated with greater risk-taking, impaired driving, higher volumes of alcohol consumption per sitting, increased injury susceptibility, and higher rates of alcohol dependence.⁹ Other detrimental health consequences of AmED include cardiac arrest and sexual assault,¹⁰ one study has found AmED to reduce risk-taking relative to the use of alcohol alone.¹¹

Largely absent from the literature are studies reporting on the prevalence of AmED and key individual and social correlates. A handful of non-representative, small-sample studies from

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3 Canada, the United States, Turkey, and Italy, report on AmED consumption amongst college
4 students, and note that between 15% and 85% of energy drinks users mix them with
5 alcohol.^{12,13,14,15,16,17} Similarly, O'Brien and colleagues note that in the past 30 days nearly one-
6 quarter of college students who drank alcohol had mixed it with an energy drink.¹⁸ In terms of
7 social factors, the propensity to AmED appears highest in youth and young adults, those who are
8 white, unmarried, and of higher income, and those involved in sport.^{19,20} To date, we lack
9 understanding of AmED use prevalence, related individual and social correlates of use, and the
10 associated health and social burden, as no nationally representative studies have been completed.
11 Additionally, AmED use has not been examined among those most vulnerable - youth and
12 adolescents. The current study addresses these gaps by reporting on the prevalence and
13 correlates of AmED use in a nationally representative sample of Canadian junior and senior high
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32 **METHODS**

33 **Data**

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36 We used nationally representative data from 36,155 Canadian students in grades 6 to 12 from the
37 2010-2011 Youth Smoking Survey (YSS). A detailed description about the design and procedure
38 of the YSS has been documented elsewhere.²¹ Briefly, the YSS is a cross sectional, biennial
39 classroom-based survey that primarily contains information on tobacco-related behaviours
40 among students in the ten Canadian provinces. The survey excludes those living in institutions,
41 First Nations reserves, Yukon, Nunavut and Northwest Territories, attending special schools or
42 schools on military bases. The province of New Brunswick did not participate in the 2010-2011
43 YSS cycle. In this study, data for students in grades 7 to 12 are used because information on our
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3 outcome variable, AmED use, was not collected for those in grade 6. The total response rate for
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5 the 2010-2011 YSS at the school board level was 82%, it was 56% for schools and 73% for
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7 students. All protocol and materials of the YSS received ethics approval from the University of
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9 Waterloo (the principal coordinator of the YSS), Health Canada and institutions of consortium
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11 members where required. Ethics approval for this research project was obtained from the
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13 Dalhousie University.
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17 18 **Measures**

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21 *Dependent variable.* To determine AmED use, respondents were asked whether they had mixed
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23 or pre-mixed alcohol with an energy drink during the past 12 months. We created a dichotomous
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25 indicator for AmED status, (one if the response was “yes”, zero if “no”).
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30 *Independent variables.* Consistent with previous related studies^(Berger, Woolsey) a number of factors
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32 were included in the analysis. These covariates included the following: gender (1=male); school
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34 grade level (7, 8, 9, 10, 11, and 12); risk taking behaviours, including being a current smoker
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36 (yes vs. no); past year heavy drinking (reported drinking ≥ 5 on one occasion at least 12 times in
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38 the last year, compared to drank ≥ 5 on one occasion fewer than 12 times in the last year, and no
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40 drinking in past year); past year marijuana use (used marijuana in the last year vs. no marijuana
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42 use); academic mark (grade average $\geq 70\%$ vs. $\leq 69\%$). School connectedness was measured
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44 according to how students’ strongly agreed or disagreed with six statements (scale score range, 6
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46 to 24, with higher score indicating greater school connectedness, Cronbach’s alpha =0.82), such
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48 as “I feel close to people in my school” and “I feel I am part of my school”; absence from school
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50 (3 days or more, 1 or 2 days, no absence from school); participation in one or more school team
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52 sports; weekly spending money (\$40 or more, unknown, less than \$40); race (Asian, Aboriginal,
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3 Black, other (Hispanic or mixed-race), White); and province of residence (Newfoundland &
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5 Labrador, Prince Edward Island, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British
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7 Columbia, and Nova Scotia).
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10 11 **Statistical analysis**

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14 Multivariate logistic regression analysis was used to examine the cross-sectional associations
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16 between the prevalence of AmED use in the last year and risk-taking behaviours, individual
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18 school-related factors, weekly spending money, race, and province of residence. Survey weights
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20 were used in all analyses to produce population estimates and adjust for unequal probabilities of
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22 selection. All analyses were carried out using Stata 12.²²
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27 **RESULTS**

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30 Table 1 presents weighted demographic sample characteristics. Of the 36,155 students included
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32 in this study, half were female and there were approximately equal proportions of grade levels.
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34 About 10% of the males and 7% of the females identified themselves as smokers while 21% of
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36 the males and 17% of females reported heavy drinking in the last year. Almost one-fifth of all
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38 students used marijuana in the last year (22% males and 18% females). More than two-thirds
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40 were white.
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46 The prevalence of AmED use in the last year by selected characteristics (gender, grade, race and
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48 province of residence) is shown in Figures 1 and 2. About 20% of Canadian high school
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50 students reported using AmED in the last year. The prevalence of AmED use was higher among
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52 Aboriginals (33.8%) and Black youth (25%), and those in British Columbia (25.8%) and Nova
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54 Scotia (25.6%). AmED use was higher for those in higher grades and in those who were older.
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Multivariate logistic regression analysis revealed that students who: were in grade 7 (odds ratio [OR] 1.64, 95% confidence interval [CI] 1.22-2.20, Model 2) and grade 8 (OR 1.53, 95% CI 1.15-2.02), currently smoked (OR 1.52, 95% CI 1.19-1.95), were involved in past year heavy drinking (OR 3.41, 95% CI 2.84-4.09, used marijuana in the past year (OR 2.29, 95% CI 1.90-2.76), skipped school (3days or more: OR 2.05 95% CI 1.60-2.64; 1or 2days: OR 1.25 95% CI 1.04-1.52), participated in school team sports (OR 1.16 95% CI 1.01-1.34), and who had \$40 or more weekly spending money (OR 1.51 95% CI 1.27-1.80), were more likely to consume AmED in the previous year (see Table 2). Similarly, students who feel more connected to school (OR 0.96, 95% CI 0.93-0.98), and who had academic marks $\geq 70\%$ (OR 0.80, 95% CI 0.68-0.94) were less likely to consume AmED. The results also confirmed provincial differences in AmED use prevalence; those in Newfoundland & Labrador (OR 0.82, 95% CI 0.71-0.95), Prince Edward Island, Quebec (OR 0.66, 95% CI 0.56-0.78), Ontario (OR 0.86, 95% CI 0.75-0.99), Manitoba (OR 0.65, 95% CI 0.56-0.76), and Saskatchewan (OR 0.64, 95% CI 0.52-0.78) were less likely to consume AmED than those in Nova Scotia. Gender was not associated with AmED use.

INTERPRETATION

We carried out an analysis of a nationally representative sample of Canadian junior and senior high school youth to determine the prevalence and social determinants of AmED use. Among 36,155 youth in grades 7 to 12 in Canada, approximately 1 in 5 had used AmED in the previous year (21.5% of males and 18.5% of females). These findings are in keeping with previous evidence drawn from studies of college students in Canada, the United States and other jurisdiction, where it was reported that mixing alcohol beverages with energy drinks was common.^{14;18} We found considerable provincial variation in the prevalence of AmED. Respondents in Nova Scotia and British Columbia reported the highest rates of AmED use, with

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3 lower rates observed in Prince Edward Island, Manitoba, and Ontario. It is not apparent,
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5 however, whether there are systematic variations in terms of energy drink availability, product
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7 price, or provincial taxes.
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11 The risk of consuming AmED also varied considerably for certain subgroups of students.
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13 AmED was increased for students who: were younger, had used psychoactive substances, were
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15 frequently truant from school, were involved in sports, and had more spending money. Protective
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17 factors included performing well in school and reporting stronger feelings of school
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19 connectedness. That other risk behaviours, including smoking, drinking (including heavy
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21 drinking) and marijuana use were strongly associated with AmED is not surprising. Risk
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23 behaviours are known to cluster in Canadian youth,²³ and policies and programs which address
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25 only one concern (such as AmED) may not be successful if underlying issues are not addressed.
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31 As seen here, school-related issues, including school connectedness, academic performance and
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33 school truancy, were strongly related to AmED. Among these, school connectedness, which is
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35 also related to smoking, marijuana use and heavy drinking^{24,25} is perhaps most amenable to
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37 change. A study of elementary schools in Seattle, Washington showed that teacher training in
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39 classroom management to enhance school bonding, parent training to promote family and school
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41 bonding, and student training in social competency, positively affected students' attitudes
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43 towards school and increased levels of measures of school attachment, while reducing substance
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45 use and related risk behaviours.²⁶ Such an approach can be implemented by schools themselves,
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47 who can develop and tailor the conditions that would most enhance their environment.
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53 Participation in sports is often believed, perhaps incorrectly, to be preventive of risk-taking
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55 among young people; ^{27,28} however, we found that participation in school sports increased the
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3 risk of the consumption of AmED. This association has also been observed in a study of
4 students from ten universities in North Carolina. Of note, this study found associations of
5 AmED with intramural athletes, but not varsity athletes, suggesting that there may be two kinds
6 of athletes, the 'jock' who participates in a limited number of sports which emphasize contact,
7 high performance, and traditional notions of masculinity, and the more prosocial student 'athlete'
8 with serious academic intentions.¹⁸ We were not able to make such a distinction, but it is clear
9 that school athletic directors and coaches should be aware of the potential for AmED among
10 those who participate in school sports.
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23 Finally, the prevalence of AmED increased with increasing age; yet, after adjusting for other risk
24 factors AmED use was highest for students in younger grades. This finding reflects differences
25 in observed rates of drinking for students of different ages. A lower percentage of younger
26 students (grade 7) drink alcohol (10%) compared to students in grades 11 (65%) and 12(69%),
27 yet a higher proportion of these young drinkers mix alcohol with energy drinks. More
28 concerning, however, is that while there exists no minimum age for the purchase and
29 consumption of energy drinks in Canada, for the great majority of students participating in the
30 survey, the use of alcohol is illegal. While we may set our sights on addressing the practice of
31 mixing alcohol with energy drinks, the fundamental concern remains underage drinking. Trend
32 data from Ontario²⁹ indicate that the prevalence of past year alcohol consumption among
33 students has decreased from 70% in the late 1970's, to 50% in the early 1990's, where it has
34 remained for the next 20 years. This stability exists despite the presence of considerable
35 programs, interventions, and other resources, in the school and the community, directed at
36 reducing underage drinking.
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LIMITATIONS

Our study is limited in several ways. First, it is cross-sectional, so that only claims of association, but not causation, can be made about the observed relationships between AmED and other risk behaviour. Second, the survey does not include key social determinants, including appropriate measures of socioeconomic status (i.e. family income or relative wealth) and family structure, as well as key confounders, such as depression, impulsivity, and poor mental health.^{30,31} The survey also did not include measures of energy drink use alone and frequency of AmED consumption. Therefore, we were unable to provide a rate of overall energy drink consumption as well as examining the intensity at which AmED was consumed. Finally, the province of New Brunswick was not involved in the current survey, which has a marginal impact on the overall generalizability of results. Of note, previous cycles of the YSS with complete data did not have information on AmED.

POLICY IMPLICATIONS & FUTURE RESEARCH

This is the first study to report on the prevalence of AmED in a large, nationally representative sample, and the first such study to report on use among school-aged youth. The finding that 20% of Canadian high school students had used AmED in the previous year raises a number of important questions as to how best to move forward. Given that individuals who use AmED, relative to alcohol alone, are less able to recognize the symptoms of intoxication, and report greater risk taking, higher susceptibility to injury, and increased alcohol consumption, in the short-term, along with neurological and cardiac complications, and higher alcohol dependence,⁹ opportunities to intervene by health policy makers, clinicians, and programmers responsible for youth are necessary. Health Canada, along with the U.S. Food and Drug Administration (FDA),

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3 warn against the mixing of energy drinks with alcohol and the FDA has recently banned
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5 'premixed' beverage sales, yet self-mixing remains widespread.^{32.33.34} Given that youth
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7 continue to drink despite its illegal status suggest that alternative strategies may be more
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9 effective than top-down, abstinence based programs. At the policy level, this may take the form
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11 of a flat tax on energy drinks, or a variable tax reflective of caffeine content, similar to what is
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13 done with alcohol in certain jurisdictions (i.e. Saskatchewan).³⁵ Conversely, schools and
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15 community services may adopt innovative harm reduction approaches, assisted by social media,
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17 which encourage youth not to mix, without directly focusing on the use of either substance, per
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19 se. Schools and clinicians need to be aware of the extent of AmED use among Canadian youth,
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21 and play a major role in educating and directing young people away from this potentially
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23 dangerous practice. We encourage further research on the consumption pattern of AmED among
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25 adolescents and its long-term impact on health, and also research is needed to explore the
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27 provincial variation of AmED use in Canada.
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Table 1: Weighted sample characteristics

Variable	Total, % n=36,155	Male, % n=17,439	Female, % n=18,716
Grade level			
7	15.3	15.2	15.5
8	16.0	16.0	16.0
9	16.9	17.0	16.9
10	17.5	17.8	17.2
11	17.6	17.5	17.7
12	16.6	16.5	16.7
Race			
White	68.9	69.2	68.6
Asian	12.3	11.9	12.6
Aboriginal	3.3	3.5	3.2
Black	3.1	3.3	2.9
Other	12.4	12.1	12.7
Risk taking behaviours			
Smoker	8.1	9.5	6.8
Nonsmoker	91.9	90.5	93.2
Heavy drinking	18.7	20.5	16.9
Less heavy drinking	29.8	28.8	30.7
No drinking	51.5	50.6	52.4
Marijuana	20.4	22.3	18.4
No Marijuana	79.6	77.7	81.6
Individual School measure			
Academic marks 70 & above	75.4	70.9	80.0
Academic marks below 70	24.6	29.1	20.0
School connectedness ^a	19.1	19.1	19.1
Absence from school 3 days or more	10.2	10.4	10.1
Absence from school 1 or 2 days	14.9	14.2	15.6
No absence from school	74.7	75.3	74.1
School team sports	48.5	52.9	43.9
No school team sports	51.5	47.1	56.1
Weekly spending money			

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\$40 or more	19.6	19.9	19.3
Below \$40	68.0	69.2	66.7
Unknown	12.4	10.9	13.9
Province of residence			
Newfoundland	1.5	1.3	1.6
Prince Edward Island	0.5	0.5	0.5
Nova Scotia	2.7	2.7	2.8
Quebec	19.9	20.1	19.7
Ontario	43.2	43.4	43.0
Manitoba	3.9	3.9	4.0
Saskatchewan	3.2	3.1	3.2
Alberta	12.1	11.9	12.4
British Columbia	13.0	13.1	12.8

^a School connectedness is a continuous variable, the value represents the mean score.

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Table 2: Logistic regression of the prevalence of AmED among Canadian high school students during the past year

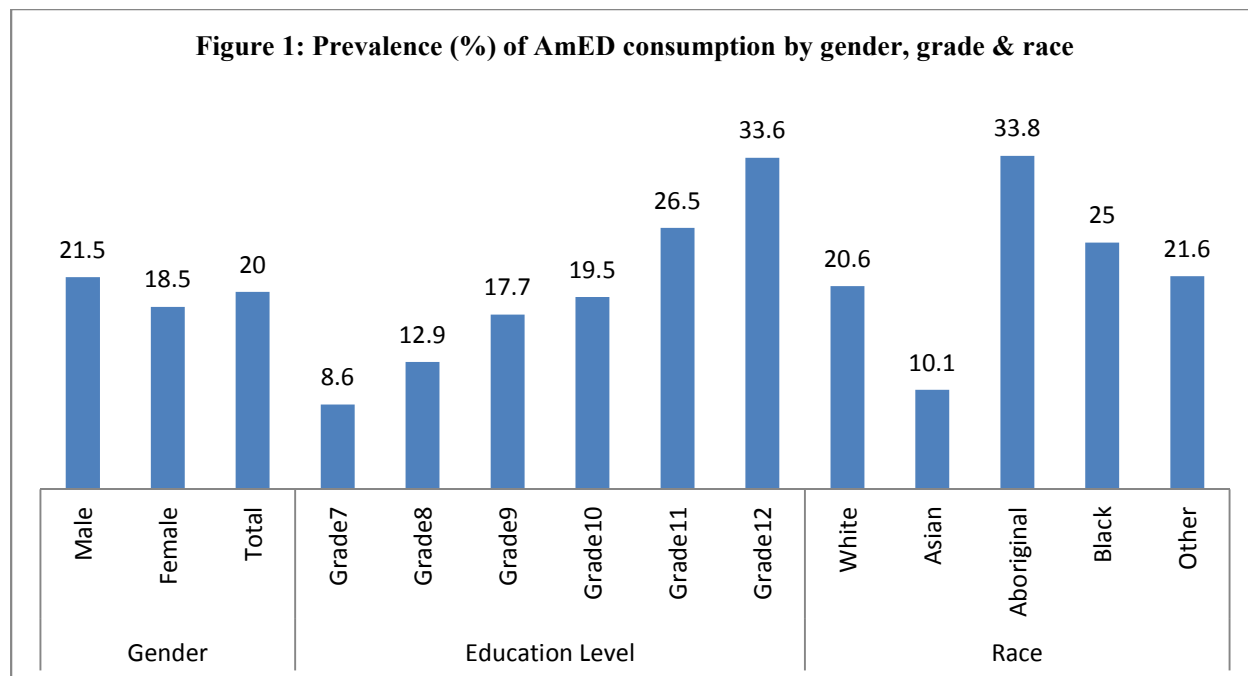
Variable	Model 1, AOR (95% CI)	Model 2, AOR (95% CI)
Gender		
Male	1.08 (0.94 – 1.25)	1.09 (0.945 – 1.248)
Female	1	1
Grade level		
7	1.50*** (1.11 – 2.02)	1.64*** (1.22 – 2.20)
8	1.41** (1.07 – 1.85)	1.53*** (1.15 – 2.02)
9	1.15 (0.88 – 1.48)	1.24* (0.96 – 1.60)
10	0.84 (0.66 – 1.07)	0.89 (0.70 – 1.14)
11	0.86 (0.68 – 1.08)	0.90 (0.72 – 1.14)
12	1	1
Race		
Asian	0.89 (0.63 – 1.27)	0.89 (0.62 – 1.27)
Aboriginal	1.29 (0.94 – 1.77)	1.25 (0.91 – 1.73)
Black	1.49* (0.93 – 2.38)	1.49* (0.93 – 2.36)
Other	1.38*** (1.10 – 1.72)	1.35*** (1.08 – 1.69)
White	1	1
Risk taking behaviours		
Current smoker	1.51*** (1.18 – 1.93)	1.52*** (1.19 – 1.95)
Nonsmoker	1	1
Heavy drinking	3.40*** (2.84 – 4.08)	3.41*** (2.84 – 4.09)
No drink	0.26*** (0.21 – 0.31)	0.25*** (0.21 – 0.30)
Light drinking	1	1
Marijuana	2.30*** (1.91 – 2.77)	2.29*** (1.90 – 2.76)
No marijuana	1	1

Individual school measures

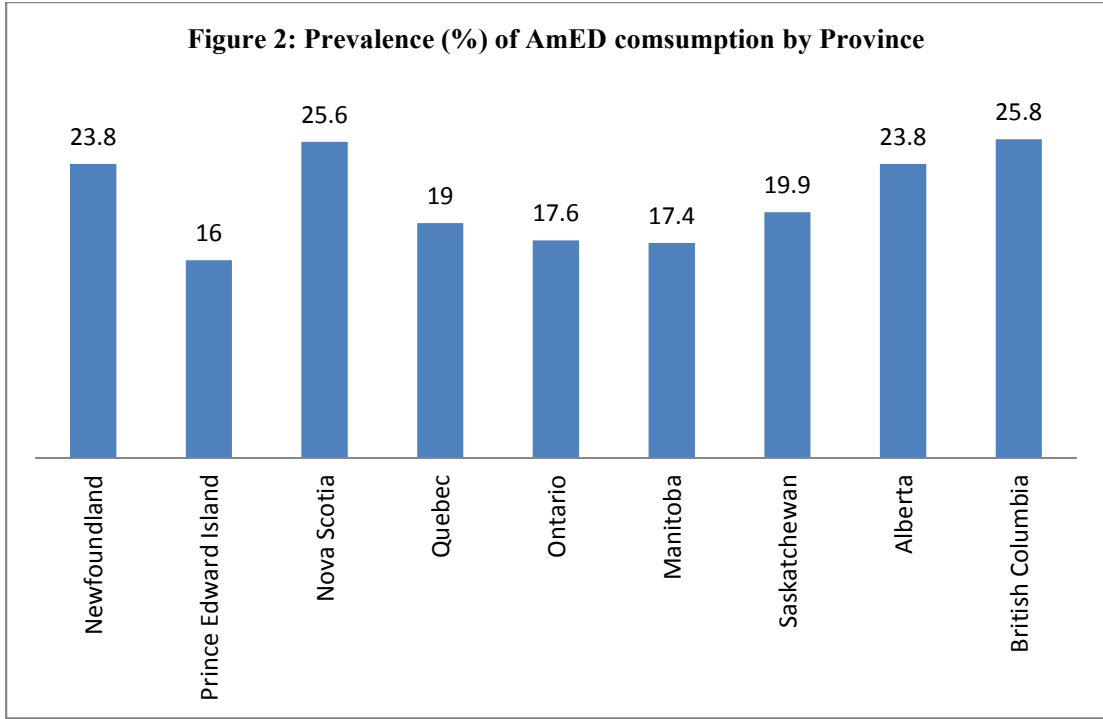
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Academic marks 70 & above	0.79*** (0.67 – 0.93)	0.80*** (0.68 – 0.94)
Academic marks below 70	1	1
School connectedness	0.95*** (0.93 – 0.97)	0.96*** (0.93 – 0.98)
Absence from school 3days or more	1.99*** (1.55 – 2.56)	2.05*** (1.60 – 2.64)
Absence from school 1 or 2 days	1.24** (1.03 – 1.50)	1.25** (1.04 – 1.52)
No absence from school	1	1
School team sports	1.16** (1.01 – 1.35)	1.16** (1.01 – 1.34)
No school team sports	1	1
Weekly spending money, \$		
40 or more	1.51*** (1.26 – 1.80)	1.51*** (1.27 – 1.80)
Unknown	1.07 (0.85 – 1.35)	1.06 (0.84 – 1.34)
Below 40	1	1
Province of residence		
Newfoundland		0.82*** (0.71 – 0.95)
Prince Edward Island		0.66*** (0.56 – 0.78)
Quebec		0.70*** (0.57 – 0.86)
Ontario		0.86** (0.75 – 0.99)
Manitoba		0.65*** (0.56 – 0.76)
Saskatchewan		0.64*** (0.52 – 0.78)
Alberta		0.97 (0.78 – 1.22)
British Columbia		0.96 (0.80 – 1.15)
Nova Scotia		1
Observations	36,155	36,155

AOR = adjusted odds ratio; CI = confidence interval; *** p<0.01, ** p<0.05, * p<0.1



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