

# Use of caffeinated energy drinks among secondary school students in Ontario: Prevalence and correlates of using energy drinks and mixing with alcohol

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## ABSTRACT

**OBJECTIVES:** Caffeinated energy drinks have become increasingly popular among young people, raising concern about possible adverse effects, including increased alcohol consumption and related risk behaviours. The current study examined consumption of caffeinated energy drinks and use of energy drinks with alcohol, as well as associations with socio-demographic and behavioural characteristics, among a sample of secondary school students in Ontario.

**METHODS:** Survey data from 23,610 grade 9–12 students at 43 purposefully sampled Ontario secondary schools participating in the baseline wave (2012/13) of the COMPASS study were analyzed using generalized linear mixed-effects models. Outcomes were any energy drink use, frequency of use, and use of alcohol mixed with energy drinks; covariates were age, sex, race, spending money, body mass index (BMI), weight-related efforts and alcohol use. Two-way interactions between sex and other covariates were tested.

**RESULTS:** Nearly one in five students (18.2%) reported consuming energy drinks in a usual week. Use of energy drinks was associated ( $p < 0.01$ ) with all socio-demographic variables examined and was more common among students who were male, off-reserve Aboriginal, had some spending money, had a BMI outside of “healthy” range, were trying to lose weight, and/or reported a higher intensity of alcohol use. Interactions with sex were observed for age, spending money and weight-related efforts. Use of energy drinks mixed with alcohol in the previous 12 months was reported by 17.3% of the sample, and was associated with race, spending money, and more frequent binge drinking.

**CONCLUSION:** Regular use of energy drinks was common among this sample of students and strongly linked to alcohol consumption.

**KEY WORDS:** Adolescent; energy drinks; caffeine; health behaviour

La traduction du résumé se trouve à la fin de l'article.

*Can J Public Health* 2015;106(3):e101–e108  
doi: 10.17269/CJPH.106.4684

Caffeinated energy drinks (CEDs) are one of the fastest-growing segments of the beverage industry. Energy drinks typically contain caffeine levels ranging from 70 to 180 mg, as well as other ingredients, including vitamins, herbs, and stimulants such as taurine, ginseng, guarana, green tea, L-carnitine and yerba mate.<sup>1–3</sup> Sales and consumption of CEDs have increased dramatically in recent years, particularly among young people.<sup>3–5</sup> Evidence from a European study conducted in 2012 and including 16 countries found that 68% of adolescents had consumed energy drinks in the previous year, as compared with 30% of adults and 18% of children.<sup>6</sup> Few published studies exist on energy drink consumption among Canadian youth. However, a 2012 survey in the Atlantic provinces found that 62% of students in grades 7 to 12 reported CED use at least once in the previous year,<sup>7</sup> and in New Brunswick 8% of students aged 11 to 19 had used CEDs more than twice a month.<sup>8</sup> Findings from the 2013 Ontario Student Drug Use and Health Survey indicated that among students in grade 7 to 12, 40% reported past year use of CEDs, and prevalence increased with grade, to 50% in grade 12.<sup>9</sup>

The increasing popularity of energy drinks has raised concerns about the potential health effects of elevated caffeine consumption among children and youth.<sup>10</sup> Health Canada currently suggests that adolescents limit caffeine consumption

to 2.5 mg/kg per day.<sup>11</sup> Excessive caffeine consumption among youth can lead to side effects such as irritability, nervousness, anxiety, dizziness, dehydration, gastrointestinal disturbances, insomnia and sleep disorders.<sup>2,4,12,13</sup> High caffeine consumption may also lead to more serious side effects, such as detrimental effects on bone mineralization, arrhythmia, tachycardia, seizures, haemorrhage, hallucinations and even death in rare cases.<sup>2,12</sup> In the US, an estimated 11% of emergency room visits linked with energy drink consumption involved youth aged 12 to 17, and 75% of those visits involved only energy drinks.<sup>14</sup>

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**Acknowledgements:** The COMPASS study was supported by a bridge grant from the Canadian Institutes of Health Research (CIHR) Institute of Nutrition, Metabolism and Diabetes through the “Obesity – Interventions to Prevent or Treat” priority funding awards (OOP-110788; grant awarded to Scott Leatherdale) and an operating grant from the CIHR Institute of Population and Public Health (MOP-114875; grant awarded to Scott Leatherdale). Additional support was provided to David Hammond by a CIHR New Investigator Award and a Canadian Cancer Society Research Institute Junior Investigator Award.

**Conflict of Interest:** None to declare.

The use of alcohol mixed with energy drinks (AmEDs) is an increasingly common practice among youth and young adults.<sup>15,16</sup> AmEDs can be found in different forms, including pre-mixed alcoholic energy drinks or drinks mixed by consumers or bartenders. Reasons for consuming AmEDs include “partying longer”, consistent with themes portrayed in marketing for CEDs and pre-mixed AmEDs.<sup>17</sup> Alcohol consumption tends to be greater when combined with energy drinks,<sup>18</sup> which can produce feelings of increased alertness and energy.<sup>15,19,20</sup> Consumption of AmEDs has been associated with binge drinking and a range of risk behaviours, including driving while intoxicated, alcohol dependence, increased risk of physical injury and personal harms (such as being taken advantage of sexually).<sup>16,21,22</sup>

A high prevalence of drinking AmEDs among college-age and post-secondary students has been reported, with some studies indicating rates above 50%.<sup>13,20,21,23,24</sup> Recent studies of Canadian university students have found that 76% had ever consumed AmEDs<sup>24</sup> and one quarter of past-month alcohol drinkers had consumed AmEDs in that time.<sup>20</sup> Few studies have assessed AmED use in younger age groups. A national survey conducted in 2010 found that 5% of youth aged 15 to 17 who had reported using alcohol in the previous 30 days also reported using AmEDs.<sup>25</sup> Findings from the 2012–13 Youth Smoking Survey (YSS), another nationally representative survey of students in grades 7 to 12, indicated that close to a quarter of students reported AmED use in the preceding year.<sup>26</sup>

The current study sought to examine the prevalence of energy drink consumption and use of energy drinks with alcohol among a large sample of secondary students in Ontario, as well as differences in use by socio-demographic and behavioural characteristics. Existing Canadian studies on CED use have primarily examined “past year” or “past month” use, whereas the current study assessed both “any usual weekly” and weekly frequency of use. The current study also examined use of AmEDs, which has been associated with increased risk behaviour and negative outcomes from CED use in studies conducted outside of Canada,<sup>27</sup> as well as the association of AmEDs with binge drinking, for which there is limited Canadian evidence.<sup>22</sup>

## METHODS

COMPASS is a prospective cohort study designed to collect longitudinal data from a sample of grade 9–12 secondary school students in Ontario and Alberta.<sup>28</sup> The current paper reports findings from the Year 1 data collection that was conducted in 43 Ontario secondary schools during the 2012/2013 school year. A full description of the design and methods of the COMPASS study is available elsewhere<sup>28</sup> and online at [www.compass.uwaterloo.ca](http://www.compass.uwaterloo.ca).

### Participants and recruitment

Ontario school boards and schools were purposefully selected. All English-speaking school boards that had secondary schools operating in a standard school/classroom setting with grades 9 through 12 and at least 100 students per grade, and that permitted the use of active-information passive-consent parental permission protocols, were determined eligible and were approached for participation ( $n = 40$ ; 17 were recruited). A total

of 88 eligible schools in those boards, plus an additional 23 private schools, were approached. Of these, 49 schools (44%) were recruited for the study, although 6 did not complete data collection.

Parents/guardians of eligible students were mailed information letters and asked to contact the COMPASS coordinator using the toll-free phone number or e-mail address provided in the letter if they did not want their child to participate; all other students were deemed eligible and could decline to participate at any time. The COMPASS study was reviewed by and received ethics clearance from the University of Waterloo Office of Research Ethics and appropriate school board review panels.

A final sample of 43 Ontario secondary schools, with a total of 30,147 students enrolled, participated in the Year 1 survey. Overall, 80.2% of eligible students ( $n = 24,173$ ) completed the student questionnaire. Non-response resulted from absenteeism on the survey date (18.8%), student refusal (0.1%) and parental refusal (0.9%). An additional 563 students were deleted from the sample because of missing data for grade, age, sex, or energy drink use, resulting in a final sample of 23,610 respondents.

### Measures

The student-level questionnaire for COMPASS, designed for self-completion during class time, assesses multiple behavioural domains (e.g., alcohol use, tobacco use, obesity, physical activity, eating behaviour), as well as correlates and demographic characteristics. The measures were based on existing national standards or surveillance tools where possible; questionnaire details and psychometric properties for some measures are available elsewhere.<sup>28–30</sup>

#### Energy Drink Use

Students were asked, “In a *usual* school week (*Monday to Friday*), on how many days do you do the following? ...Drink high-energy drinks (Red Bull, Monster, Rock Star, etc.) (none, 1 day, 2 days, 3 days, 4 days, 5 days).” The same question was repeated for a “*usual* weekend (*Saturday and Sunday*)”. Responses to the usual week and weekend questions were added to get *weekly frequency of energy drink use* (range: 0–7 days) and recoded into *any weekly energy drink use* (0 = no days; 1 = 1–7 days). Alcohol mixed with energy drink (*AmED*) use in the past year was assessed using an item consistent with the YSS that asks, “In the last 12 months, have you had alcohol mixed or pre-mixed with an energy drink such as Red Bull, Monster, Rock Star, or another brand?” with responses “I have never done this”, “I did not do this in the last 12 months”, “Yes” and “I do not know”, recoded as 0 = Never/Not in last 12 months/Don’t know; 1 = Yes.

#### Alcohol Use

*Current alcohol use* was assessed as it is in the national YSS survey by asking, “In the last 12 months, how often did you have a drink of alcohol that was more than just a sip?” Participants were defined as *non-users* if they reported “I have never drunk alcohol”, “I did not drink alcohol in the last 12 months” or “I have only had a sip of alcohol”. *Alcohol users* were defined as those who reported any frequency of drinking more than a sip in the previous 12 months. *Binge drinking* was assessed by asking: “In the last 12 months, how often did you have 5 drinks of

alcohol or more on one occasion?" Responses were coded as 0 = none ("I have never done this", "I did not have 5 or more drinks on one occasion in the last 12 months"); 1 = occasional binge drinker ("Less than once a month"); 2 = monthly ("Once a month", "2 or 3 times a month"); or 3 = weekly or more ("Once a week", "2 to 5 times a week", "Daily or almost daily"). The two alcohol measures were combined to form *intensity of alcohol use*: 0 = no drinking; 1 = alcohol use, no binge drinking; 2 = alcohol use, occasional binge drinking; 3 = alcohol use, monthly binge drinking; or 4 = alcohol use, weekly binge drinking.

#### Socio-demographic Variables

Individual-level socio-demographic variables were *age* ("13 years or younger" to "18 years or older"), *sex* and *race* (recoded into 1 = White only, non-Aboriginal, 2 = Black only, non-Aboriginal, 3 = Asian only, non-Aboriginal, 4 = Off-reserve Aboriginal, 5 = Hispanic only, non-Aboriginal, 6 = Mixed/other, non-Aboriginal/Not stated). Previous research suggests racial inequalities in a number of health behaviours, including a higher prevalence of risk behaviours associated with energy drink use among visible minorities.<sup>7,31</sup> Energy drink consumption has also been shown to vary by age and sex.<sup>7,9</sup> Grade was not included in the analysis because of a high correlation (0.91) with age.

Previous evidence suggests that energy drink consumption can account for a significant proportion of caloric intake: a national survey of US students in grades 9 to 12 found that energy drinks represented almost 9% of sugar-sweetened beverage consumption.<sup>32</sup> Body mass index (*BMI*) was calculated from self-reported height and weight, and coded into four categories (underweight, healthy weight, overweight, obese) using age- and sex-specific cut-offs based on World Health Organization reference values.<sup>33</sup> Further, anecdotal evidence suggests that energy drinks may be used to increase or maintain energy levels while dieting, so weight-related efforts were explored. *Weight-related efforts* were assessed with the question, "Which of the following are you trying to do about your weight? Lose weight, Gain weight, Stay the same weight, I am not trying to do anything about my weight". *Spending money*, associated with AmED use in a previous Canadian study,<sup>22</sup> presumably because the higher cost of these drinks may serve as a barrier to some youth, was assessed using the question, "About how much money do you usually get each week to spend on yourself or to save?" with responses recoded as 0 = \$0, 1 = \$1–\$20, 2 = \$21–\$100, 3 = >\$100, and 4 = Not stated (Missing/Don't know).

#### Statistical analyses

Analyses were conducted in 2013 and 2014 using SAS version 9.3. Separate generalized linear mixed-effects models (GLMMs) were fit to examine correlates of each of three outcomes: 1) *any weekly energy drink use*, 2) *weekly frequency of energy drink use* and 3) *AmED use in past year*; specifically, PROC GLIMMIX using Adaptive Gaussian Quadrature was used to estimate a logistic GLMM for outcomes 1 and 3, and a Poisson GLMM for outcome 2. Covariates were *age*, *sex*, *race*, *spending money*, *BMI*, *weight-related efforts* and *intensity of alcohol use*. The analysis of *AmED use in past year* included only respondents who had used alcohol in the previous 12 months, and *intensity of alcohol use* was replaced with *binge drinking*. Models accounted for students

clustered within schools by including a random intercept at the school level. For covariates significantly associated with the outcome, all pair-wise comparisons between levels were estimated using Bonferroni correction for multiple comparisons. To test for variation by sex, two-way interactions between sex and the other covariates were tested by adding the interaction terms one at a time to the models. Students were excluded from models on a case-wise basis if data were missing for the outcome or covariates. Statistical significance was set at  $\alpha = 0.01$  due to the large sample size.

## RESULTS

### Sample

Table 1 shows the socio-demographic and behavioural characteristics of the 23,610 respondents in the current study.

**Table 1.** Characteristics of the sample of grade 9–12 students in Year 1 of COMPASS (Ontario), 2012/13 ( $n = 23,610$ )

Characteristic	% (n)
Mean age (SD)	15.66 (1.25)
Grade	
Grade 9	26.2% (6196)
Grade 10	25.7% (6073)
Grade 11	24.5% (5780)
Grade 12	23.6% (5561)
Sex	
Female	49.8% (11,769)
Male	50.2% (11,841)
Race	
White only, non-Aboriginal	71.4% (16,849)
Black only, non-Aboriginal	4.4% (1040)
Asian only, non-Aboriginal	5.9% (1381)
Off-reserve Aboriginal	5.3% (1257)
Hispanic only, non-Aboriginal	2.3% (536)
Mixed/other, non-Aboriginal/Not stated	10.8% (2547)
Spending money (weekly)	
\$0	15.7% (3699)
\$1–20	30.5% (7203)
\$21–100	27.0% (6371)
>\$100	14.1% (3321)
Not stated	12.9% (3037)
Body mass index category	
Underweight	1.4% (338)
Healthy weight	57.1% (13,498)
Overweight	13.9% (3277)
Obese	6.3% (1478)
Not stated	21.3% (5040)
Weight-related efforts	
Lose weight	42.1% (9860)
Gain weight	18.6% (4350)
Stay the same weight	18.4% (4305)
Not trying to do anything	20.9% (4905)
Alcohol use (past 12-month frequency)	
None	44.3% (10,237)
Occasional (<once/month)	19.7% (4545)
Monthly (1–3 times/month)	24.6% (5688)
Weekly or more ( $\geq$ once/week)	11.4% (2620)
Binge drinking (past 12-month frequency)	
None/Not applicable	60.6% (14,247)
Occasional (<once/month)	16.0% (3750)
Monthly (1–3 times/month)	17.3% (4070)
Weekly or more ( $\geq$ once/week)	6.2% (1446)
Intensity of alcohol use	
No alcohol use	44.6% (10,270)
Alcohol use, no binge drinking	15.2% (3513)
Alcohol use with occasional binge drinking	16.3% (3750)
Alcohol use with monthly binge drinking	17.7% (4070)
Alcohol use with weekly binge drinking	6.3% (1446)

**Table 2.** Use of energy drinks among grade 9–12 students ( $n = 23,610$ ) and use of alcohol mixed with energy drinks among current alcohol users ( $n = 12,794$ ), by socio-demographic and behavioural variables, in the Year 1 COMPASS cohort (Ontario), 2012/13

	Any CED use (usual weekly), %	Frequency of CED use (days/week), mean (SD)	Any AmED use (past year), %
Age (years)			
≤13	18.1	0.70 (1.82)	10.2
14	18.3	0.48 (1.25)	9.1
15	17.6	0.43 (1.18)	12.7
16	18.1	0.47 (1.25)	20.5
17	17.5	0.46 (1.25)	24.1
≥18	22.1	0.63 (1.50)	26.8
Sex			
Female	12.9	0.32 (1.02)	26.7
Male	23.4	0.63 (1.44)	31.3
Race			
White only, non-Aboriginal	17.4	0.44 (1.19)	27.7
Black only, non-Aboriginal	21.6	0.66 (1.59)	37.0
Asian only, non-Aboriginal	12.2	0.33 (1.10)	30.7
Off-reserve Aboriginal	30.5	0.87 (1.70)	34.3
Hispanic only, non-Aboriginal	19.8	0.51 (1.32)	31.8
Mixed/other, non-Aboriginal/Not stated	18.3	0.50 (1.33)	31.9
Body mass index category			
Underweight	24.3	0.55 (1.23)	27.7
Healthy weight	15.9	0.40 (1.14)	28.7
Overweight	19.0	0.48 (1.23)	29.7
Obese	24.4	0.64 (1.46)	28.4
Not stated	21.4	0.61 (1.48)	29.5
Weight-related efforts			
Trying to lose weight	17.4	0.44 (1.20)	28.7
Trying to gain weight	23.5	0.65 (1.51)	33.3
Trying to maintain weight	16.9	0.43 (1.18)	25.7
Not doing anything	15.9	0.41 (1.17)	27.7
Spending money (weekly)			
\$0	13.2	0.33 (1.08)	23.6
\$1–20	17.1	0.42 (1.17)	24.3
\$21–100	19.5	0.49 (1.25)	30.1
>\$100	25.3	0.75 (1.61)	35.9
Not stated	16.0	0.43 (1.23)	29.3
Intensity of alcohol use			
No alcohol use	11.4	0.28 (0.99)	–
Alcohol use, no binge drinking	15.2	0.36 (1.07)	10.0
Alcohol use with occasional binge drinking	17.0	0.39 (1.09)	22.5
Alcohol use with monthly binge drinking	28.3	0.72 (1.47)	39.3
Alcohol use with weekly binge drinking	42.5	1.41 (2.15)	62.7

CED, caffeinated energy drink; AmED, alcohol mixed with energy drink.

### Use of energy drinks

Overall, 18.2% of the sample reported “usually” consuming energy drinks at least one day a week: 6.5% one day, 4.8% two days, 2.4% three days, 1.5% four days, 1.2% five days, 0.7% six days, and 1.1% seven days. Table 2 shows the proportion of students

reporting any usual use of energy drinks by socio-demographic and behavioural characteristics.

### Any Energy Drink Use

In the GLMM for any energy drink use, all covariates were significantly associated with the outcome: *age* ( $F_{(1, 22,779)} = 102.6, p < 0.0001$ ), *sex* ( $F_{(1, 22,779)} = 298.0, p < 0.0001$ ), *race* ( $F_{(5, 22,779)} = 14.8, p < 0.0001$ ), *money* ( $F_{(4, 22,779)} = 12.6, p < 0.0001$ ), *BMI* ( $F_{(4, 22,779)} = 31.0, p < 0.0001$ ), *weight-related efforts* ( $F_{(3, 22,779)} = 4.5, p = 0.004$ ) and *intensity of alcohol use* ( $F_{(4, 22,779)} = 237.7, p < 0.0001$ ). Table 3 presents all pairwise comparisons between levels of the covariates. The odds of using energy drinks were significantly greater in the following socio-demographic groups: males (vs. females); off-reserve Aboriginal students (vs. “White, non-Aboriginal”, “Asian” or “Mixed/other, non-Aboriginal/Not stated”); students reporting some spending money (\$1–20, \$21–100, >\$100) compared with reporting \$0, and reporting >\$100 compared with \$21–100 or not stated. In addition, students with a “healthy” BMI were less likely to use energy drinks than those who were underweight, obese or not stated; overweight students were less likely to use than underweight or not stated. Students who reported trying to lose weight were more likely to use than those not trying to do anything about their weight. Intensity of alcohol use was strongly associated with energy drink use: students reporting any level of alcohol use were more likely to use than those who did not drink at all, and the odds increased with increasing intensity of alcohol use.

When two-way interactions between sex and the other covariates were tested (individually) in the model for any use of energy drinks, several interactions were significant: sex with age ( $F_{(1, 22,778)} = 14.4, p = 0.0001$ ), spending money ( $F_{(4, 22,775)} = 4.2, p = 0.002$ ) and weight efforts ( $F_{(3, 22,776)} = 9.3, p \leq 0.0001$ ), and the interaction of sex and race was of borderline significance ( $F_{(5, 22,774)} = 2.9, p = 0.012$ ). While any use of CEDs increased consistently with age among males, a contrasting pattern was observed among females: use was highest among the youngest students and decreased with age up until age 17; those aged 18 and older also had high use. Although the same general pattern of increasing CED use by amount of spending money was observed for both males and females, differences were more pronounced and significant only among males. There was little difference in CED use by weight-related efforts among males, but a difference was observed among females, with particularly high use among those trying to gain weight. Rates of CED use among males were around twice those of females in most racial/ethnic groups, except among Aboriginal and Black students, among whom females’ use was higher (closer to males’). For all estimates of CED use by sex and other covariates, see [Supplementary Table](#).

### Frequency of Energy Drink Use

In the GLMM for usual weekly *frequency of energy drink use*, all covariates were significantly associated with the outcome: *age* ( $F_{(1, 22,779)} = 245.1, p < 0.0001$ ), *sex* ( $F_{(1, 22,779)} = 693.2, p < 0.0001$ ), *race* ( $F_{(5, 22,779)} = 49.0, p < 0.0001$ ), *money* ( $F_{(4, 22,779)} = 43.2, p < 0.0001$ ), *BMI* ( $F_{(4, 22,779)} = 110.6, p < 0.0001$ ), *weight-related efforts* ( $F_{(3, 22,779)} = 10.6, p < 0.0001$ ) and *intensity of alcohol use* ( $F_{(4, 22,779)} = 706.9, p < 0.0001$ ). The socio-demographic patterns for pairwise comparisons (Table 3) were similar to those for any energy drink

**Table 3.** Estimates for all pair-wise comparisons from the models\* for any energy drink use and frequency of energy drink use among grade 9–12 students in Year 1 of COMPASS (Ontario), 2012/13 ( $n = 22,844$ )

Variable	Any energy drink use			Frequency of use (days/week)		
	Odds ratio	99% CI <sup>†</sup>	Adjusted $p$ value <sup>‡</sup>	exp (estimate) <sup>‡</sup>	99% CI <sup>†</sup>	Adjusted $p$ value <sup>‡</sup>
Age	<b>0.85<sup>‡</sup></b>	<b>(0.81–0.88)</b>	<b>&lt;0.0001</b>	<b>0.87</b>	<b>(0.85–0.89)</b>	<b>&lt;0.0001</b>
Sex						
Male vs. female	<b>2.10</b>	<b>(1.88–2.35)</b>	<b>&lt;0.0001</b>	<b>1.86</b>	<b>(1.75–1.98)</b>	<b>&lt;0.0001</b>
Race						
Black, non-Aboriginal (NA) vs. White, NA	1.33	(0.97–1.81)	0.03	<b>1.42</b>	<b>(1.22–1.65)</b>	<b>&lt;0.0001</b>
Asian, NA vs. White, NA	0.92	(0.67–1.27)	1.00	1.03	(0.87–1.23)	1.00
Aboriginal vs. White, NA	<b>1.80</b>	<b>(1.40–2.31)</b>	<b>&lt;0.0001</b>	<b>1.65</b>	<b>(1.46–1.86)</b>	<b>&lt;0.0001</b>
Hispanic, NA vs. White, NA	1.17	(0.77–1.76)	1.00	1.14	(0.92–1.42)	0.61
Mixed/other, NA/Not stated vs. White, NA	1.13	(0.92–1.40)	0.60	<b>1.17</b>	<b>(1.05–1.31)</b>	<b>&lt;0.0001</b>
Black, NA vs. Asian, NA	1.43	(0.94–2.18)	0.05	<b>1.38</b>	<b>(1.11–1.71)</b>	<b>&lt;0.0001</b>
Black, NA vs. Aboriginal	0.74	(0.50–1.09)	0.12	0.86	(0.72–1.04)	0.10
Black, NA vs. Hispanic, NA	1.14	(0.69–1.87)	1.00	1.25	(0.96–1.61)	0.05
Black, NA vs. Mixed/other, NA/Not stated	1.17	(0.82–1.66)	1.00	<b>1.21</b>	<b>(1.02–1.44)</b>	<b>0.002</b>
Aboriginal vs. Asian, NA	<b>1.95</b>	<b>(1.31–2.88)</b>	<b>&lt;0.0001</b>	<b>1.60</b>	<b>(1.30–1.96)</b>	<b>&lt;0.0001</b>
Aboriginal vs. Hispanic, NA	1.54	(0.96–2.47)	0.03	<b>1.45</b>	<b>(1.13–1.85)</b>	<b>&lt;0.0001</b>
Aboriginal vs. Mixed/other, NA/Not stated	<b>1.58</b>	<b>(1.16–2.16)</b>	<b>&lt;0.0001</b>	<b>1.41</b>	<b>(1.21–1.64)</b>	<b>&lt;0.0001</b>
Asian, NA vs. Hispanic, NA	0.79	(0.48–1.31)	1.00	0.91	(0.69–1.19)	1.00
Asian, NA vs. Mixed/other, NA/Not stated	0.81	(0.57–1.16)	0.75	0.88	(0.73–1.07)	0.41
Hispanic, NA vs. Mixed/other, NA/Not stated	1.03	(0.66–1.60)	1.00	0.97	(0.77–1.23)	1.00
Spending money						
\$1–20 vs. \$0	<b>1.34</b>	<b>(1.09–1.64)</b>	<b>&lt;0.0001</b>	<b>1.23</b>	<b>(1.09–1.38)</b>	<b>&lt;0.0001</b>
21–100 vs. \$0	<b>1.35</b>	<b>(1.09–1.66)</b>	<b>&lt;0.0001</b>	<b>1.25</b>	<b>(1.11–1.40)</b>	<b>&lt;0.0001</b>
>\$100 vs. \$0	<b>1.62</b>	<b>(1.29–2.05)</b>	<b>&lt;0.0001</b>	<b>1.60</b>	<b>(1.41–1.81)</b>	<b>&lt;0.0001</b>
Not stated vs. \$0	1.20	(0.93–1.53)	0.17	<b>1.22</b>	<b>(1.06–1.39)</b>	<b>&lt;0.0001</b>
\$21–100 vs. \$1–20	1.00	(0.85–1.18)	1.00	1.01	(0.93–1.11)	0.63
>\$100 vs. \$1–20	1.21	(1.00–1.47)	0.01	<b>1.30</b>	<b>(1.18–1.44)</b>	<b>&lt;0.0001</b>
\$1–20 vs. Not stated	1.12	(0.91–1.38)	0.72	1.01	(0.90–1.13)	0.76
>\$100 vs. \$21–100	<b>1.21</b>	<b>(1.00–1.45)</b>	<b>0.009</b>	<b>1.29</b>	<b>(1.17–1.41)</b>	<b>&lt;0.0001</b>
\$21–100 vs. Not stated	1.13	(0.91–1.39)	0.64	1.02	(0.91–1.15)	0.50
>\$100 vs. Not stated	<b>1.36</b>	<b>(1.08–1.71)</b>	<b>0.0001</b>	<b>1.32</b>	<b>(1.18–1.48)</b>	<b>&lt;0.0001</b>
Body mass index category						
Underweight vs. Healthy	<b>2.06</b>	<b>(1.30–3.26)</b>	<b>&lt;0.0001</b>	<b>1.54</b>	<b>(1.20–1.97)</b>	<b>&lt;0.0001</b>
Overweight vs. Healthy	1.07	(0.89–1.29)	1.00	1.05	(0.95–1.17)	0.85
Obese vs. Healthy	<b>1.32</b>	<b>(1.03–1.69)</b>	<b>0.002</b>	<b>1.29</b>	<b>(1.14–1.47)</b>	<b>&lt;0.0001</b>
Not stated vs. Healthy	<b>1.60</b>	<b>(1.37–1.87)</b>	<b>&lt;0.0001</b>	<b>1.63</b>	<b>(1.51–1.77)</b>	<b>&lt;0.0001</b>
Underweight vs. Overweight	<b>1.93</b>	<b>(1.19–3.12)</b>	<b>&lt;0.0001</b>	<b>1.46</b>	<b>(1.12–1.90)</b>	<b>&lt;0.0001</b>
Obese vs. Overweight	1.23	(0.94–1.62)	0.10	<b>1.22</b>	<b>(1.06–1.41)</b>	<b>&lt;0.0001</b>
Not stated vs. Overweight	<b>1.50</b>	<b>(1.22–1.84)</b>	<b>&lt;0.0001</b>	<b>1.55</b>	<b>(1.39–1.73)</b>	<b>&lt;0.0001</b>
Not stated vs. Obese	1.22	(0.94–1.57)	0.13	<b>1.27</b>	<b>(1.11–1.44)</b>	<b>&lt;0.0001</b>
Underweight vs. Not stated	1.28	(0.80–2.06)	0.80	0.94	(0.73–1.22)	1.00
Underweight vs. Obese	1.56	(0.94–2.60)	0.04	1.19	(0.90–1.57)	0.37
Weight-related efforts						
Trying to lose weight vs. Nothing	<b>1.21</b>	<b>(1.01–1.43)</b>	<b>0.007</b>	<b>1.13</b>	<b>(1.03–1.24)</b>	<b>0.003</b>
Trying to gain weight vs. Nothing	1.17	(0.97–1.41)	0.04	<b>1.18</b>	<b>(1.07–1.30)</b>	<b>&lt;0.0001</b>
Trying to maintain weight vs. Nothing	1.12	(0.93–1.35)	0.52	1.08	(0.98–1.20)	0.10
Trying to gain vs. Maintain weight	1.05	(0.87–1.26)	1.00	1.09	(0.99–1.20)	0.04
Trying to gain vs. Lose weight	0.97	(0.81–1.16)	1.00	1.05	(0.96–1.15)	0.68
Trying to lose vs. Maintain weight	1.08	(0.91–1.28)	1.00	1.04	(0.95–1.14)	1.00
Intensity of alcohol use						
Alcohol use, no binge drinking vs. No alcohol	<b>1.60</b>	<b>(1.32–1.94)</b>	<b>&lt;0.0001</b>	<b>1.43</b>	<b>(1.27–1.60)</b>	<b>&lt;0.0001</b>
Occasional binge drinking vs. No alcohol use	<b>1.90</b>	<b>(1.57–2.30)</b>	<b>&lt;0.0001</b>	<b>1.58</b>	<b>(1.42–1.77)</b>	<b>&lt;0.0001</b>
Monthly binge drinking vs. No alcohol use	<b>3.55</b>	<b>(2.99–4.23)</b>	<b>&lt;0.0001</b>	<b>2.74</b>	<b>(2.50–3.02)</b>	<b>&lt;0.0001</b>
Weekly binge drinking vs. No alcohol use	<b>6.45</b>	<b>(5.14–8.09)</b>	<b>&lt;0.0001</b>	<b>4.94</b>	<b>(4.45–5.49)</b>	<b>&lt;0.0001</b>
Occasional vs. Alcohol use, no binge drinking	1.19	(0.96–1.48)	0.08	1.11	(0.98–1.26)	0.07
Monthly vs. Alcohol use, no binge drinking	<b>2.22</b>	<b>(1.82–2.72)</b>	<b>&lt;0.0001</b>	<b>1.92</b>	<b>(1.72–2.15)</b>	<b>&lt;0.0001</b>
Weekly vs. Alcohol use, no binge drinking	<b>4.03</b>	<b>(3.15–5.17)</b>	<b>&lt;0.0001</b>	<b>3.46</b>	<b>(3.06–3.92)</b>	<b>&lt;0.0001</b>
Monthly vs. Occasional binge drinking	<b>1.87</b>	<b>(1.54–2.26)</b>	<b>&lt;0.0001</b>	<b>1.73</b>	<b>(1.56–1.93)</b>	<b>&lt;0.0001</b>
Weekly vs. Occasional binge drinking	<b>3.39</b>	<b>(2.67–4.29)</b>	<b>&lt;0.0001</b>	<b>3.12</b>	<b>(2.78–3.50)</b>	<b>&lt;0.0001</b>
Weekly vs. Monthly binge drinking	<b>1.81</b>	<b>(1.46–2.26)</b>	<b>&lt;0.0001</b>	<b>1.80</b>	<b>(1.63–1.98)</b>	<b>&lt;0.0001</b>

Figures in **bold** indicate statistically significant associations.

\*Separate generalized linear mixed-effects models for each outcome, with covariates grade, sex, race, spending money, body mass index, weight-related efforts, and intensity of alcohol use; school included as a random intercept.

<sup>†</sup>Adjusted for multiple comparisons (Bonferroni),  $\alpha = 0.01$ .

<sup>‡</sup>(exp)estimate represents the difference between the two groups in the expected count of the number of days per week of usual energy drink use, controlling for all other variables in model (e.g., an exp(estimate) of 1.19 for group A vs. group B would correspond to an expected 19% greater number of days per week for group A over group B, controlling for all other variables in the model).

use, with few exceptions. In general, the differences were that estimates of similar magnitude were significant when the more nuanced frequency variable was used, rather than the dichotomous “any use” outcome. In particular, a number of race comparisons were significant when the frequency outcome was

used: Black and Aboriginal students used more energy drinks than other racial/ethnic groups. The two-way interactions of sex with age ( $F_{(1, 22,778)} = 10.0, p = 0.002$ ), race ( $F_{(5, 22,774)} = 8.0, p \leq 0.0001$ ), spending money ( $F_{(4, 22,775)} = 3.8, p = 0.005$ ), weight efforts ( $F_{(3, 22,776)} = 37.5, p \leq 0.0001$ ) and intensity of alcohol use

( $F_{(4, 22,775)} = 29.6, p \leq 0.0001$ ) were significant, with patterns similar to those discussed above for the “any use” outcome. The interaction of sex with intensity of alcohol use indicated that males used CEDs more frequently than females at all levels of alcohol use, although the magnitude of this sex difference narrowed from around double for occasional or non-drinkers to more comparable levels for students who reported binge drinking at least weekly.

#### *Use of Alcohol Mixed With Energy Drinks*

Overall, 17.3% of the sample ( $n = 4,016$ ) reported using alcohol mixed with energy drinks in the previous 12 months; 71.6% ( $n = 16,892$ ) reported “never” doing this, 6.4% ( $n = 1,502$ ) reported that they “did not do this in the last 12 months”, and 3.7% ( $n = 871$ ) said “I do not know” (a further 329 had no response and were excluded from further analysis). Of the 55.7% of students ( $n = 12,843$ ) who reported using alcohol in the previous 12 months, 28.9% reported having used AmED. An additional 262 students (2.6%) who reported not having had more than a sip of alcohol in the previous 12 months also reported having used AmED. Table 2 shows the proportion of past-year alcohol users who reported any use of AmEDs in the previous year, by socio-demographic and behavioural characteristics.

In the GLMM for *any energy drink use mixed with alcohol* among past 12-month drinkers, of the covariates *age, sex, race, money, BMI, weight-related efforts* and *binge drinking*, only race ( $F_{(5, 12,587)} = 5.1, p = 0.0001$ ), spending money ( $F_{(4, 12,587)} = 4.0, p = 0.003$ ), and binge drinking ( $F_{(3, 12,587)} = 436.0, p < 0.0001$ ) were significantly associated with using AmED.

White students were less likely to use AmED than those who identified as “Black, non-Aboriginal” (odds ratio [OR] = 0.72, 99% confidence interval [CI]: 0.53–0.98), “Asian, non-Aboriginal” (OR = 0.69, 99% CI: 0.51–0.93) or “Mixed/other, non-Aboriginal/Not stated” (OR = 0.81, 99% CI: 0.67–0.98), but these differences were not significant once all 15 possible pairwise comparisons had been adjusted for. Students reporting having more than \$100 per week in spending money were more likely to use AmED than those reporting \$1–20 (adjusted OR = 1.26, 99% CI: 1.02–1.57). Binge drinking had the strongest association with using AmED: students reporting less than monthly (adjusted OR = 2.63, 99% CI: 2.11–3.27), monthly (adjusted OR = 5.90, 99% CI: 4.78–7.29) or weekly (adjusted OR = 14.73, 99% CI: 11.40–19.05) binge drinking were more likely to use AmED than those who did not binge drink. In addition, monthly (adjusted OR = 2.25, 99% CI: 1.91–2.64) and weekly (adjusted OR = 5.61, 99% CI: 4.51–6.97) binge drinkers were more likely to use AmED than less than monthly binge drinkers, and weekly binge drinkers were more likely to use AmED than monthly binge drinkers (adjusted OR = 2.50, 99% CI: 2.04–3.06).

Two-way interactions between sex and the other covariates were tested, but none were significant, indicating that the relationships between AmED use and the covariates were consistent across sexes.

## DISCUSSION

The current study indicates that nearly one in five Ontario secondary school students participating in COMPASS reported consuming energy drinks at least once a week. Of those

reporting use, the majority consumed energy drinks on one or two days a week, although 1 in 10 reported use on 6 or 7 days a week. Relatively little historical data exist in Canada with which to compare the current estimates. A recent survey of Ontario students in grades 7 to 12 reported past-year use of energy drinks at 40%.<sup>9</sup> Although the weekly use rates reported in the current study are difficult to compare with past year estimates, these studies are consistent in demonstrating a very high prevalence of use among young people in Ontario.

Weekly use of energy drinks in the current study was much higher among males, with nearly twice the proportion of male students reporting use in the previous week compared with females. This is consistent with previous research<sup>4,7,9</sup> and fits with popular approaches to marketing energy drinks, which prominently feature themes of masculinity and risk-taking.<sup>31</sup> Among males, energy drink use increased with age, while the opposite pattern was observed among females. Other Canadian and US studies have also found higher use among younger adolescents.<sup>7,27</sup>

Energy drink use was particularly high among off-reserve Aboriginal respondents, consistent with previous research indicating markedly higher prevalence of alcohol and energy drink consumption<sup>22</sup> and risky health behaviour among off-reserve Aboriginal peoples in Canada.<sup>34,35</sup> The findings also suggest intriguing associations between energy drink consumption and diet. Students who were underweight, obese or overweight were more likely to report consuming energy drinks than students with healthy weights, as determined by BMI. Similarly, students who reported trying to lose weight were more likely to use than those not trying to do anything about their weight.

The current study adds to evidence demonstrating a strong association between alcohol and energy drink use among youth. Students reporting any level of alcohol use were more likely to consume energy drinks, and the odds of consumption increased with greater intensity of alcohol use. This is consistent with previous research involving young people in other countries, which has identified strong relationships between alcohol consumption and/or binge drinking and energy drink consumption.<sup>6,36–38</sup>

In addition, binge drinking was the strongest predictor of using alcohol mixed with energy drinks: more than 60% of youth who reported binge drinking in the previous week also reported consuming AmEDs. The current study is among the first in Canada to examine binge drinking and AmEDs, and extends previous Canadian data indicating an increase in AmED consumption among youth who have ever tried alcohol.<sup>22</sup> The current study did not assess the potential negative consequences associated with alcohol use or AmEDs; however, previous studies have identified a range of health risks associated with consuming AmEDs among young adults.<sup>20–22</sup> The consequences of alcohol and energy drink use among youth should be a priority for future research.

## Limitations

The current study has several limitations common to survey research. First, the study relies on self-reports of energy drink and alcohol use. Although the survey included concrete examples of

energy drinks (“Red Bull, Monster, Rock Star, etc.”), it is nevertheless possible that some respondents may have over-reported as a result of confusion with other beverage categories, such as sports drinks. Although respondents were reassured that survey responses would be anonymous, the self-reported nature of the data may have underestimated actual levels of energy drink and alcohol consumption. In some cases, survey responses yielded conflicting data. For example, preliminary analyses identified 262 students who reported not having had more than a sip of alcohol in the previous 12 months but also reported having used alcohol mixed with an energy drink. These respondents were excluded from the analysis; however, it remains unclear whether this pattern reflects reporting error or indicates that some youth omit reporting AmEDs as alcohol consumption. In addition, the current survey did not include a probability-based sample of Ontario schools. However, it included a large number of schools and students, and had a robust response rate within participating schools. Finally, the data reported here are cross-sectional in nature, which limits any causal inferences. Given that COMPASS data are collected longitudinally, future research may examine the temporal nature of the associations identified.

## CONCLUSIONS

The current study highlights the increasing use of energy drinks among youth. Given the potential health effects of excessive caffeine consumption among youth, future studies should assess the quantity of energy drink consumption in addition to frequency of use. There is also a need to examine the contexts in which energy drinks are used. Most importantly, the findings underscore the strong association between energy drinks and binge drinking among under-age youth. Collectively, these findings highlight the importance of evaluating existing energy drink policies with respect to consumption among youth.

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Received: July 14, 2014

Accepted: January 11, 2015

## RÉSUMÉ

**OBJECTIFS :** Les boissons énergisantes deviennent de plus en plus populaires auprès des jeunes et suscitent des inquiétudes sur leurs effets secondaires possibles, y compris l'augmentation de la consommation d'alcool et des comportements à risques. Nous avons examiné la

consommation de boissons énergisantes et la consommation simultanée de boissons énergisantes et d'alcool, ainsi que leurs associations avec des caractéristiques sociodémographiques et comportementales, dans un échantillon d'élèves des écoles secondaires de l'Ontario.

**MÉTHODES :** Les données d'enquête de 23 610 élèves de la 9<sup>e</sup> à la 12<sup>e</sup> année, fréquentant 43 écoles secondaires de l'Ontario sélectionnées par échantillonnage dirigé et ayant participé à la phase de référence (2012-2013) de l'étude COMPASS, ont été analysées avec des modèles linéaires généralisés à effets mixtes. Les résultats comptabilisés étaient l'utilisation quelconque de boissons énergisantes, la fréquence d'utilisation, et la consommation de boissons énergisantes en combinaison avec l'alcool; les covariables étaient l'âge, le sexe, l'ethnicité, l'argent de poche, l'indice de masse corporelle (IMC), les efforts liés au poids et la consommation d'alcool. Les interactions entre le sexe et d'autres covariables ont été testées.

**RÉSULTATS :** Près d'un élève sur cinq (18,2 %) a déclaré consommer des boissons énergisantes au cours d'une semaine habituelle. L'utilisation de boissons énergisantes était associée ( $p < 0,01$ ) avec toutes les données sociodémographiques examinées et était plus fréquente chez les élèves de sexe masculin, les Autochtones hors réserve, les élèves qui avaient de l'argent de poche, ceux qui avaient un IMC hors de la zone des « poids santé », ceux qui tentaient de perdre du poids et/ou ceux ayant déclaré une consommation d'alcool élevée. Des interactions avec le sexe ont été observées pour l'âge, l'argent de poche et les efforts liés au poids. La consommation simultanée de boissons énergisantes et d'alcool au cours des 12 mois précédents a été déclarée par 17,3 % de l'échantillon et était associée à l'ethnicité, à l'argent de poche et aux excès occasionnels d'alcool plus fréquents.

**CONCLUSION :** L'utilisation habituelle de boissons énergisantes était courante dans cet échantillon d'élèves, et fortement liée à la consommation d'alcool.

**MOTS CLÉS :** adolescent; boissons énergisantes; caféine; comportement sanitaire