



## Examining the impact of timing of alcohol use initiation on changes to body weight and weight status among students in the COMPASS study

Julianne Vermeer\*, Kate Battista, Scott T. Leatherdale

School of Public Health and Health Systems, University of Waterloo, Waterloo, Canada

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### ABSTRACT

Obesity rates among Canadian youth continue to be a concern, as weight issues during adolescence can transfer into adulthood, leading to long-term health problems. Current evidence lacks a consistent relationship between alcohol consumption and weight gain, and there remains a paucity of research examining the effect of alcohol intake on body weight and BMI over time. This study seeks to examine the effect of grade when students are first classified as “current drinker” and “current binge drinker” on weight and weight status (BMI) trajectories.

Two waves of 4-year linked longitudinal data (Y1:2012–13 to Y4:2015–16 and Y2:2013–14 to Y5:2016–17) collected from the COMPASS study (a large prospective cohort study examining health behaviours among Canadian high school students), were used to examine alcohol intake and weight gain among students in grade 9 at their respective baseline year (Y1,  $n = 1180$  or Y2,  $n = 1612$ ). A modest association between alcohol intake and increased body weight was seen in students who reported binge drinking and earlier onset of alcohol consumption (initiation in grade 10), compared to those who never became binge drinkers, or those who started drinking in grade 11 or grade 12. This additional increase was sustained in grade 11 in males but not females. In contrast, those categorized as “current drinkers” showed no significant increases in weight compared to non-drinkers regardless of grade of initiation. More research should investigate the association between binge drinking and weight gain in high school and beyond, specifically in relation to gender, to approach this issue comprehensively.

### 1. Introduction

Obesity rates among youth in Canada continue to be a concern, where data from the 2012/13 Canadian Health Measures Survey shows that one third of boys and slightly less than one third of girls, both groups aged 6–17 years old, are overweight or obese (Rao et al., 2016). While there are a number of short-term health issues for youth who are overweight or obese (e.g., sleep apnea, type 2 diabetes, bone and joint problems) (Government of Canada, 2019), weight issues can transfer into adulthood and lead to long-term health problems such as cardiovascular disease and certain forms of cancer (Engeland et al., 2004; Freedman et al., 2005). Much of research attributes excessive weight gain to a continuing imbalance of energy intake from diet and energy expenditure during physical activity and metabolic activities, with variability relating to individual characteristics (Martinez, 2000; Wright and Aronne, 2012). Only more recently have studies begun to address the issue of alcohol consumption and weight gain, however much of this research primarily focuses on the adult population.

Alcohol, as a component of diet, is an important variable to consider in the youth population, who are known to increase their intake of alcohol during their high school years (Public Health Agency of Canada, 2016). According to results from the 2016/17 cycle of the Canadian Student Tobacco, Alcohol and Drugs (CSTADS) survey, 44% of young Canadians in grades 7 to 12 consumed alcohol, where the mean age of initiation was 13.4 years old (Health Canada, 2017). Furthermore, 24.2% of these individuals drank five or more drinks on at least one occasion in the past 12 months (Health Canada, 2017). Considering the high prevalence of alcohol consumption throughout this stage of their life, added calories from alcohol might lead to added weight gain in youth. One study noted that in their sample of students, 27.2% of students who binge drank once per month would potentially be consuming between 6000 and 13 200 extra calories in one year, depending on the type of alcohol consumed (Battista and Leatherdale, 2017). Research also suggests that adolescence drinking patterns can predict alcohol habits into adulthood (Boden et al., 2019), and earlier stages of alcohol intake has been shown to lead to problems with drinking at

Abbreviation: MVN, multivariate normal

\* Corresponding author at: University of Waterloo, LHS 1618e, 200 University Avenue West, Waterloo, ON N2L 3G1, Canada.

E-mail addresses: [jvermeer@uwaterloo.ca](mailto:jvermeer@uwaterloo.ca) (J. Vermeer), [kbattista@uwaterloo.ca](mailto:kbattista@uwaterloo.ca) (K. Battista), [sleatherdale@uwaterloo.ca](mailto:sleatherdale@uwaterloo.ca) (S.T. Leatherdale).

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later stages in life (Dawson et al., 2008; DeWit, 2000). If alcohol does influence weight status, the relationship between age of onset and trajectories of alcohol consumption are important to consider.

A recent review examining alcohol consumption and obesity provided a summary of cross-sectional, longitudinal and experimental evidence across a range of ages, which indicated that there is no consistent relationship between alcohol consumption and weight gain (Traversy and Chaput, 2015). Variability in study results may depend on type of alcohol consumed, frequency of consumption, gender and age, among other factors (Traversy and Chaput, 2015). Additionally, there are few studies that look at weight status and weight trajectories related to alcohol consumption among the adolescent population (Berkey et al., 2008; Croezen et al., 2009; Oesterle et al., 2004; Pasch et al., 2008). Of this research, Berkey et al. (2008) showed that within a sample of females aged 14–21, those that consumed at least two alcoholic beverages per week gained more weight over one year than those in the category of 0–3 servings per month (Berkey et al., 2008). Trajectories of alcohol consumption were tracked among a sample of youth in the United States, where those that were considered chronic heavy drinkers had higher odds of overweight and obesity at age 24 (Oesterle et al., 2004).

The current study uses data from a sample of students that have participated in the COMPASS study (Leatherdale et al., 2014a) over a 4-year period in order to examine the longitudinal effect of the grade when students are first classified as “current drinker” and “current binge drinker” on body weight and weight status. More specifically, this study aims to explore whether earlier onset of alcohol consumption increases weight gain and weight status (Body Mass Index (BMI)) due to the impact of more years of drinking.

## 2. Methods

### 2.1. The COMPASS study

The COMPASS study is an ongoing prospective cohort study designed to examine longitudinal associations between the school environment and youth health behaviours, such as (physical activity, healthy eating, smoking, alcohol and marijuana use, and mental health (Leatherdale et al., 2014a). The COMPASS study collects hierarchical longitudinal data from a convenience sample of secondary schools across Canada and the grade 9 to 12 students attending these schools. The COMPASS questionnaire used to collect student-level data is a 12-page booklet completed in the classroom setting. The questionnaire was designed to be consistent with previous large-scale, school-based research (Bredin and Leatherdale, 2014; Leatherdale et al., 2005, 2014a; Leatherdale and Papadakis, 2011). Extensive details on the COMPASS host study, including sampling, data collection and linkage process, are available online ([www.compass.uwaterloo.ca](http://www.compass.uwaterloo.ca)).

### 2.2. Participants

The current study analyzed linked longitudinal student-level data from Year 1 (Y1: 2012–13) to Year 5 (Y5: 2016–17) of the COMPASS host study. Data were collected from 24,173 students (80.2% participation rate) in 43 Ontario schools in Y1, 45,298 students (80.1% participation rate) in 79 Ontario and 10 Alberta schools in Y2, 42,355 students (79.3% participation rate) in 78 Ontario and 9 Alberta schools in Y3, 40,436 students (79.9% participation rate) in 72 Ontario and 9 Alberta schools in Y4, and 37,060 students (76.0% participation rate) in 68 Ontario and 9 Alberta schools in Y5.

The convenience sample of schools recruited in the study were approached as they used active-information, passive consent parental permission protocols (Leatherdale et al., 2014a), which has been previously identified as an important method for collecting unbiased data within studies examining youth substance use (White et al., 2004). Data collections were completed annually and were scheduled to occur at the

same time each year, with few exceptions, to minimize seasonal bias. All students within a participating school were invited to complete the COMPASS student questionnaire (Cq) annually. Students could refuse to complete the study at any time. The vast majority of the non-response was due to scheduled spares or absenteeism at the time of the survey. The COMPASS study was approved by the Human Research Ethics Board at the University of Waterloo and participating school boards.

### 2.3. Measures

#### 2.3.1. Alcohol use and binge drinking

Consistent with national youth surveillance measures (Elton-Marshall et al., 2011) students were asked two questions on alcohol use and binge drinking. To assess alcohol use, students were asked, “In the last 12 months, how often did you have a drink of alcohol that was more than just a sip?” The response options ranged from “I have never drunk alcohol” to “Every day”. Students who indicated drinking alcohol “Once a month” or more frequently were classified as “current drinkers”, while students who answered never having drunk alcohol, or having drunk alcohol less than once a month were classified as “non-drinkers”.

To assess binge drinking, students were asked, “In the last 12 months, how often did you have 5 drinks of alcohol or more on one occasion?” The response options ranged from “I have never done this” to “Daily or almost daily”. Based on previous research (Fuller-Thomson et al., 2014; Miller et al., 2007), students who indicated having five or more drinks “Once a month” or more frequently were classified as “current binge drinkers”, while students who answered never having done this or having done this less than once a month were classified as “non-binge drinkers”. Students were then assessed on their grade of first alcohol use and binge drinking based on the first year in which they were classified as “current drinker” and “current binge drinker” respectively.

#### 2.3.2. Body weight and weight status (BMI)

Each year, students were asked to report their height and body weight. Self-reported height (in meters) and weight (in kilograms) were used to calculate BMI as a measure of weight status. Height and weight measures in COMPASS have been validated in a sample of grade 9 students and were found to be highly reliable and valid (Leatherdale and Laxer, 2013). In this report, weight and BMI were modeled as continuous variables.

### 2.4. Covariates

#### 2.4.1. Sociodemographic variables

Each year, students were also asked to indicate their grade, age in years, sex (male or female), ethnicity (White, Black, Asian, Aboriginal (First Nations, Métis, Inuit), Latin American/Hispanic or other), and weekly spending money. Weekly spending money is used as a proxy measure for socioeconomic status. Sex, ethnicity, and spending money were treated as static, and values at baseline were used in the analysis with values from subsequent years used in the case of missing data at baseline. Cohort was also included as a covariate.

#### 2.4.2. Physical activity variable

Two measures of physical activity were also used as control variables. Students reported time spent doing hard (e.g., jogging, team sports) and moderate (e.g., walking, biking to school) physical activity on each day in the previous seven days. Self-reported average daily moderate and vigorous physical activity (MVPA) in minutes was calculated as a continuous measure. Students were also asked the question, “On how many days in the last 7 days did you do exercises to strengthen or tone your muscles? (e.g., push-ups, sit-ups, or weight-training)?” Response options ranged from 0 to 7 days. This question was used as a continuous measure of strength training. The physical activity measures

in COMPASS were found to be both reliable and valid (Leatherdale et al., 2014b).

### 2.5. Analyses

Frequency statistics were calculated for the sample at baseline for all variables. Chi-square and t-test analyses were conducted to examine demographic differences between females and males.

Multivariate normal (MVN) linear models were used to examine the longitudinal effect of the grade when students are first classified as “current drinker” and “current binge drinker” on body weight and weight status trajectories over four years. MVN models are used to account for the clustering of students within schools, based on the assumption that students within the same school are more alike than students from different schools. Separate models were constructed for the effects of drinking and binge drinking initiation on body weight and weight status (BMI). All models adjusted for cohort, ethnicity, spending money, average daily MVPA, and days of strength training. Interaction terms between grade of onset and study year were used to examine the effect of grade of onset over time. The interaction terms represent the additional increase to body weight or BMI beyond that of the control group of never-initiators at each time point. To account for the potential differential impact of drinking or binge drinking on body weight and weight status (BMI) between females and males, interaction terms between sex, year, and grade of onset were included in the models. An exchangeable working correlation was used in all models, though MVN model estimates are robust to the misspecification of the covariance structure. Models were run using the GENMOD procedure. Predicted trajectories of body weight and weight status (BMI) were plotted to demonstrate effect sizes, given that the presence of interaction terms complicates the interpretation of individual model estimates. All analyses were conducted in SAS 9.4 (SAS Institute Inc., Cary, NC, USA).

## 3. Results

### 3.1. Descriptive statistics

The current study examined two waves of 4-year linked longitudinal data (Y1–Y4 and Y2–Y5) from students in grade 9 at their respective baseline year (Y1 or Y2). The study focused only on those students who were classified as “non-drinkers” at baseline. To examine trajectories, only students with complete baseline demographic and longitudinal alcohol use data in all four years were included, resulting in a final linked sample of 2792 grade 9 students in 64 Ontario and 4 Alberta schools (Y1–Y4, n = 1180 or Y2–Y5, n = 1612). Within this sample, 2229 students had complete longitudinal weight data and 2012 students had complete longitudinal weight status (BMI) data and were included in the respective models.

Table 1 contains baseline descriptive statistics for the 4-year linked sample of grade 9 students who were classified as non-drinkers at baseline. The sample is 54.6% female. Participants were 13–17 years old, with the majority being 14 or 15 years old, consistent with the typical age of a grade 9 student. The majority (81%) of students self-identified as white ethnicity, 8% identified as Asian, 4% as Black, 4% as Other/Mixed ethnicity, 2% as Off-Reserve Aboriginal, and 2% as Latin American/Hispanic. The majority (69%) of students received \$20 or less of spending money each week. Males had higher average daily MVPA than females with an average of 129.1 (SD ± 80.8) minutes compared to 110.8 (SD ± 71.9), respectively. Males also completed more days of strength training, with an average of 3.1 days per week compared to 2.8 days for females.

Nearly one-third of students who were non-drinkers at baseline (32%) continued to be non-drinkers for the following three years, while 30% started drinking in grade 10, 23% started drinking in grade 11, and 15% started drinking in grade 12. Males (36%) were more likely than females (30%) to be never-drinkers over the four years. 77% of students

**Table 1**

Baseline sample characteristics by sex among grade 9 students participating in the COMPASS study considered non-drinkers at their respective baseline years (Y1:2012–13; Y2:2013–14).

	Females N (%)	Males N (%)	Chi-square P value
Total	1525 (54.6)	1267 (45.4)	
<i>Cohort</i>			P = 0.0708
1	668 (42.3)	512 (43.8)	
2	857 (57.7)	755 (57.7)	
<i>Age</i>			p = 0.5031
13	62 (4.0)	41 (3.2)	
14	1203 (78.9)	997 (78.7)	
15	259 (17.0)	226 (17.8)	
16	1 (0.1)	2 (0.2)	
17	0 (0.0)	1 (0.1)	
<i>Ethnicity</i>			p = 0.5605
White	1241 (81.4)	1013 (80.0)	
Black	58 (3.8)	47 (3.7)	
Asian	122 (8.0)	96 (7.5)	
Off-Reserve Aboriginal	22 (1.4)	21 (1.7)	
Latin American/Hispanic	22 (1.4)	25 (2.0)	
Other/Mixed	60 (4.0)	65 (5.1)	
<i>Spending Money</i>			p = 0.0008
Zero	376 (24.7)	341 (26.9)	
\$1 to \$20	642 (42.1)	562 (44.4)	
\$21 to \$100	245 (16.1)	176 (13.9)	
More than \$100	16 (1.0)	31 (2.5)	
I do not know how much money I get each week	246 (16.1)	157 (12.4)	
<i>First “Current Drinker” Grade</i>			p = 0.0105
Never	456 (29.9)	451 (35.6)	
Grade 10	478 (31.3)	351 (27.7)	
Grade 11	358 (23.5)	272 (21.5)	
Grade 12	233 (15.3)	193 (15.2)	
<i>First “Current Binge Drinker” Grade</i>			p = 0.1728
Never	1192 (78.2)	952 (75.1)	
Grade 10	62 (4.1)	70 (5.5)	
Grade 11	123 (8.1)	115 (9.1)	
Grade 12	148 (9.7)	130 (10.3)	
	Females (Mean (SD))	Males (Mean (SD))	T-test
Average Daily MVPA (min)	110.8 (71.9)	129.1 (80.8)	p < 0.0001
Days of Strength Training	2.8 (2.1)	3.1 (2.2)	p = 0.0002
Body Weight (kg)	55.4 (11.3)	62.0 (14.6)	p < 0.0001
BMI (kg/m <sup>2</sup> )	20.9 (3.7)	21.1 (4.1)	p = 0.1955

remained non-binge drinkers over the 4-year period, while 5% began binge drinking in grade 10, 9% began in grade 11, and 10% began in grade 12. There was no statistically significant difference in binge drinking onset between males and females.

The average body weight at baseline was 55.4 kg (SD ± 11.3) for females and 62.0 kg (SD ± 14.6) for males. Average BMI at baseline was similar for females and males at 20.9 (SD ± 3.7) and 21.1 (SD ± 4.1) respectively.

### 3.2. Drinking and binge drinking trajectories

Fig. 1 shows body weight and BMI trajectories over the 4-year period by grade of alcohol use and binge drinking onset. All groups have similar body weight and BMI at baseline. Body weight and BMI increases over time for all groups, as expected. For onset of “current drinker” status, body weight and BMI trajectories are similar across groups, though BMI trajectory is slightly higher for students who began drinking in grade 10 compared to those who never began drinking or began drinking in grade 11 or 12.

For onset of “current binge drinker” status, body weight and BMI trajectories are higher for students who began binge drinking in grade 10 and 11 compared to those students who began binge drinking in

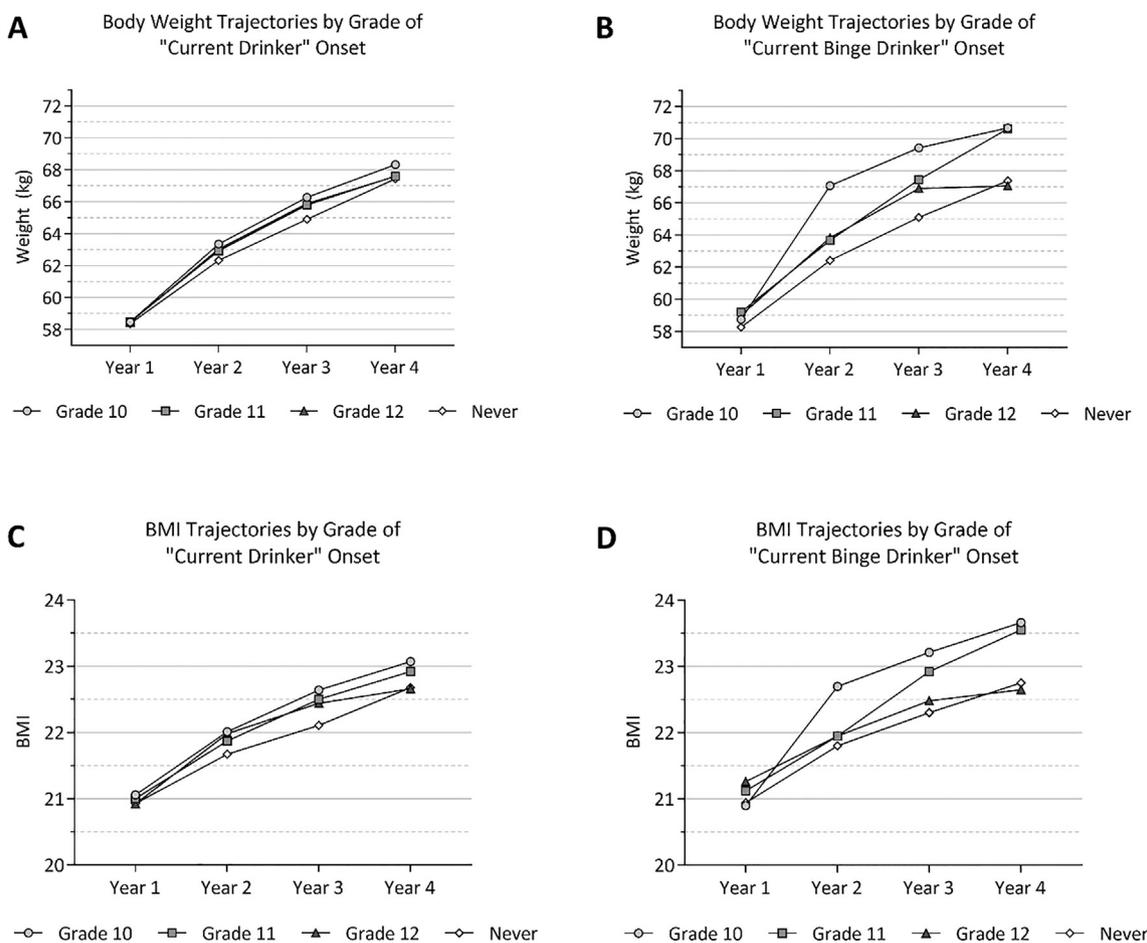


Fig. 1. Body weight and BMI trajectories over the 4-year period based on grade of drinking onset (A,C) and binge drinking onset (B,D) from linked longitudinal student-level data from Year 1 (Y1: 2012–13) to Year 5 (Y5: 2016–17) of the COMPASS study.

grade 12 or never began binge drinking. By grade 12, average body weight was 3.29 kg higher for students who began binge drinking in grade 10 and 3.24 kg higher for students who began binge drinking in grade 11 compared to those students who never began binge drinking, while average BMI was 0.91 and 0.80 units higher respectively.

### 3.3. Multivariate normal linear regression models

Table 2 shows the MVN linear model results for the additional increase to body weight and BMI for females and males with onset of “current drinker” and “current binge drinker” status in grades 10, 11, and 12 compared to those students who never became “current drinkers” or “current binge drinkers”. Fig. 2 shows predicted body weight and BMI trajectories for females and males by grade of onset. Males had additional increases to body weight and BMI over time beyond that of females, as evidenced by the significant year and sex interaction terms and the steeper slopes of male body weight trajectories. After adjusting for cohort, ethnicity, spending money, physical activity, and school-level clustering, there was no consistent statistically significant impact of earlier onset of drinking on body weight or BMI over time.

Both females and males who became “current binge drinkers” in grade 10 had increases to body weight in grade 10 beyond that of those who never became binge drinkers of 1.59 kg and 2.29 kg, respectively. This additional increase to body weight was sustained in grade 11 in males but not in females, consistent with the significant model interaction term. Neither sex had meaningful differences in body weight from never binge drinkers in grade 12, however females had an additional increase to BMI of 0.62 and males had an additional increase to BMI of 0.21. Both males and females who became “current binge

drinkers” in grade 11 showed additional increase in body weight and BMI in grade 12 over those who never became binge drinkers, though this increase was more pronounced for females than males (2.61 kg/0.97 BMI vs. 1.06 kg/0.19 BMI). Students who began binge drinking in grade 12 showed no meaningful additional increase in body weight or BMI over those who never began binge drinking.

### 4. Discussion

Findings from our study indicate that there is a modest association with weight gain in terms of the frequency of alcohol consumption, and year of first use. Students who were categorized as binge drinkers and started binge drinking in grade 10 and grade 11 had larger short-term body weight and BMI increases in comparison to those who never became binge drinkers, or those who started binge drinking in grade 12. However, students considered to be “current drinkers” but not necessarily “current binge drinkers” showed no significant increases in weight gain compared to those who did not start drinking in high school.

Based on this study’s findings, the amount of alcohol consumed per drinking occasion and the number of years of consumption may be factors when looking at adolescent weight changes in relation to alcohol intake. Those in grade 10 and grade 11 had additional years of drinking compared to those who had initiated binge drinking in grade 12 or those who have never drunk alcohol. A look at studies in the adult population suggest higher frequencies of alcohol intake over time have shown more positive associations with weight gain than low to moderate alcohol consumption (Sayon-Orea et al., 2011; Traversy and Chaput, 2015; Yeomans, 2010). There are few longitudinal studies that

**Table 2**  
Multivariate normal linear models of the impact of grade of alcohol Use and binge drinking onset on body weight and BMI.

	Current Drinker (est. [95% CI])		Current Binge Drinker (est. [95% CI])	
	Body Weight (kg)	BMI	Body Weight (kg)	BMI
Sex				
Male	5.86 (3.88,7.85) *	0.37 (-0.23,0.98)	5.70 (4.44,6.97) *	-0.03 (-0.41,0.35)
Female (ref)				
Year				
2	2.23 (1.31,3.14) *	0.71 (0.47,0.95) *	2.80 (2.32,3.29) *	0.76 (0.59,0.93) *
3	4.00 (2.99,5.01) *	1.07 (0.82,1.33) *	4.34 (3.84,4.84) *	1.12 (0.96,1.29) *
4	5.21 (4.11,6.32) *	1.4 (1.12,1.68) *	5.73 (5.12,6.35) *	1.43 (1.24,1.62) *
1 (ref)				
Grade of Onset				
10	0.26 (-1.41,1.92)	0.31 (-0.23,0.84)	1.08 (-1.26,3.41)	0.53 (-0.45,1.51)
11	0.45 (-1.29,2.19)	0.42 (-0.15,0.99)	-0.31 (-2.34,1.73)	-0.01 (-0.77,0.75)
12	0.14 (-1.80,2.08)	0.23 (-0.42,0.87)	-1.63 (-3.24,-0.02) *	-0.32 (-0.88,0.24)
Never (ref)				
Year * Grade 10 Onset				
2	0.90 (-0.46,2.27)	0.03 (-0.40,0.47)	1.59 (-0.92,4.11)	0.36 (-0.76,1.47)
3	0.37 (-0.89,1.64)	0.02 (-0.38,0.43)	-0.72 (-2.61,1.17)	0.00 (-0.86,0.86)
4	1.14 (-0.45,2.74)	0.21 (-0.27,0.69)	0.88 (-1.43,3.18)	0.62 (-0.28,1.52)
1 (ref)				
Year * Grade 11 Onset				
2	0.66 (-0.43,1.75)	-0.01 (-0.35,0.32)	-0.87 (-2.63,0.89)	-0.22 (-0.93,0.49)
3	0.88 (-0.33,2.08)	0.22 (-0.15,0.58)	0.02 (-1.85,1.89)	0.14 (-0.63,0.90)
4	1.29 (-0.13,2.71)	0.36 (-0.06,0.79)	2.61 (-0.64,5.86)	0.97 (-0.15,2.09)
1 (ref)				
Year * Grade 12 Onset				
2	1.62 (0.21,3.04) *	0.39 (-0.08,0.85)	1.35 (-1.05,3.74)	0.26 (-0.32,0.83)
3	0.33 (-1.04,1.71)	0.13 (-0.30,0.56)	0.63 (-0.66,1.93)	0.16 (-0.31,0.63)
4	0.89 (-0.97,2.74)	-0.03 (-0.51,0.44)	0.60 (-1.31,2.51)	0.27 (-0.22,0.76)
1 (ref)				
Year * Male				
2	3.55 (2.10,5.00) *	0.06 (-0.36,0.48)	2.97 (2.14,3.80) *	0.21 (-0.07,0.49)
3	5.29 (3.66,6.92) *	0.09 (-0.41,0.58)	5.45 (4.54,6.37) *	0.44 (0.14,0.74) *
4	7.45 (5.71,9.20) *	0.55 (0.05,1.06) *	7.07 (6.05,8.08) *	0.78 (0.47,1.10) *
1 (ref)				
Grade of Onset * Male				
10	1.15 (-1.55,3.85)	0.07 (-0.75,0.89)	-0.44 (-4.79,3.9)	-0.04 (-1.47,1.39)
11	0.10 (-2.93,3.13)	-0.70 (-1.62,0.23)	2.63 (-0.79,6.05)	0.78 (-0.32,1.87)
12	0.97 (-2.48,4.42)	-0.29 (-1.34,0.77)	3.88 (0.46,7.30) *	1.12 (0.02,2.23) *
9 (ref)				
Year * Grade 10 Onset * Male				
2	-0.59 (-2.53,1.35)	0.06 (-0.54,0.66)	0.69 (-3.18,4.57)	-0.15 (-1.37,1.07)
3	0.86 (-1.19,2.91)	0.55 (-0.11,1.22)	3.15 (0.09,6.21) *	0.40 (-0.72,1.52)
4	-0.62 (-2.95,1.70)	0.10 (-0.60,0.81)	-0.50 (-3.61,2.61)	-0.41 (-1.57,0.75)
1 (ref)				
Year * Grade 11 Onset * Male				
2	-0.20 (-2.21,1.80)	0.40 (-0.24,1.04)	0.72 (-1.57,3.01)	-0.02 (-0.91,0.86)
3	-0.08 (-2.39,2.23)	0.34 (-0.4,1.08)	0.32 (-2.32,2.97)	0.13 (-0.93,1.20)
4	-1.08 (-3.38,1.22)	0.01 (-0.72,0.74)	-1.55 (-5.37,2.27)	-0.78 (-2.07,0.52)
1 (ref)				
Year * Grade 12 Onset * Male				
2	-2.26 (-4.77,0.26)	-0.27 (-1.15,0.60)	-1.53 (-4.73,1.67)	-0.68 (-1.59,0.24)
3	0.93 (-1.92,3.78)	0.54 (-0.37,1.45)	0.04 (-3.34,3.42)	-0.50 (-1.52,0.52)
4	-1.79 (-4.91,1.33)	0.16 (-0.76,1.08)	-2.43 (-5.55,0.68)	-1.04 (-1.94,-0.13) *
1 (ref)				

\* p < 0.05.

All models are adjusted for cohort, ethnicity, spending money, average daily MVPA and days of strength training, and school-level clustering.

analyze alcohol use among adolescents/young adults in relation to weight gain, however the current study seems to align with study results previously described in this paper (Berkey et al., 2008; Croezen et al., 2009; Oesterle et al., 2004). Among the literature that is available, one longitudinal study looking at young adults aged 18 to 26 showed an association between heavy episodic drinking and transitions to obesity and overweight after a five year period (Fazzino et al., 2017). Another by Pasch et al (2008) studied adolescence with a mean age of 12.7 over a two-year span which suggested that higher rates of substance use, alcohol included, predicted BMI increases from grade 7 to grade 8. There is also evidence of additional increases to body weight from alcohol in some cross-sectional studies (Croezen et al., 2009; Grech et al., 2017; Pasch et al., 2008) however they are limited in their

capacity to show any causal relationships between alcohol and weight gain over time.

Results from this study showed no consistent relationship between body weight, BMI and grade of current drinking onset. It has been suggested that those who consume only moderate amounts of alcohol may offset the extra calories within alcoholic beverages by partaking in a healthier lifestyle, such as getting ample exercise and consuming a healthier diet (French et al., 2010). Furthermore, the lifestyle characteristics of a binge drinker may account for differences in weight changes. Compared to moderate drinkers, some literature shows that those that binge drink or drink heavily are more likely to take part in other risky behaviours which could also contribute to excess weight gain (Farhat et al., 2010; Miller et al., 2007). There is additional

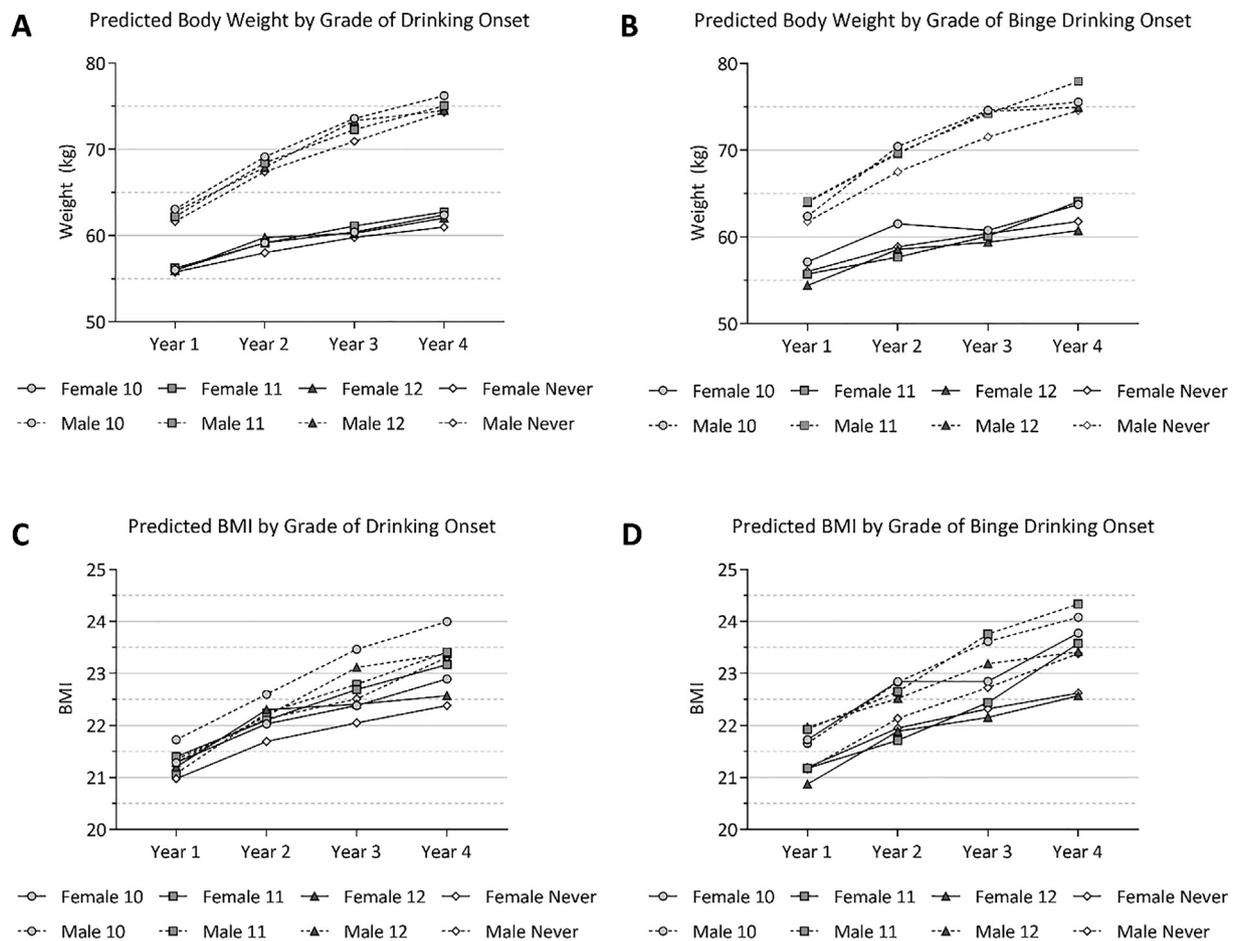


Fig. 2. Predicted body weight and BMI trajectories over the 4-year period for males and females based on grade of drinking onset (A,C) and binge drinking onset (B,D).

evidence to suggest that binge drinkers may carry a predisposition to habits such as binge eating, which combined with higher alcohol consumption rates might exacerbate the issue of weight gain (Ferriter and Ray, 2011; Piran and Robinson, 2006). More research should investigate the association between binge drinking and other health behaviours in youth to approach this issue comprehensively.

This study indicated that males who initiated binge drinking in grade 10 maintained their body weight increase in grade 11, whereas females did not. An increase to BMI was seen in grade 12 for females who began binge drinking in grade 10 or 11. As the measures in this study do not specify the amount of alcohol consumed beyond five drinks per month, it is unknown whether males are consuming more alcohol per binge episode than females. While there are only slight differences in drinking rates among adolescents by gender in Canada based on a definition of 5 drinks at one occasion in the last 12 months (Health Canada, 2017, 2016), a previous study using data from the 2013/14 COMPASS data collection year indicated males were more likely than females to more frequently binge drink within a month (Battista and Leatherdale, 2017). More specifically, males were twice as likely as females to binge drink once per week, and three times as likely as females to binge drink two or more times a week (Battista and Leatherdale, 2017). This could provide an explanation for the differences in weight trajectories, as males might consume more alcohol beyond the amount that this study used to define a 'binge drinker'. Additionally, this study did not provide information on the type of alcohol consumed by students, however previous research has suggested that male adolescents tend to consume higher amounts of beer, compared to their female counterparts (Freeman et al., 2014). Future analysis on specific amounts and type of alcohol consumption per drinking

occasion, as well as a more detailed measure of the number of drinking or binge drinking occasions would help to further explain gender differences.

### 5. Limitations

When measuring substance use using subjective reporting, students may either under or over-estimate their levels of alcohol intake, where research suggests underreporting is a result of the need to provide socially desirable answers, and over-reporting occurs as a result of the desire to impress others or gain attention (Johnson, 2014). The study protocol has attempted to reduce reporting bias by anonymizing entries and ensuring students' answers will remain confidential. Further to that, because we are tracking longitudinally, the reporting bias in absolute drinking rates is likely to remain consistent over time, meaning relative changes in use rates can still be valid.

There is also potential bias when using linked data, as analysis of previous linked data in the COMPASS study has shown that there was a significant difference between the linked and non-linked samples, noting that fewer linked students were considered current binge drinkers (Qian et al., 2015). The sample for this study may therefore be underestimating the number of binge drinkers in this population. Further to that, there is potential bias when using self-reported data to track weight, with the possibility to underestimate the prevalence of overweight students in this study population (Sherry et al., 2007). However, literature supports the use of self-reported weight and height in large surveillance studies, and more specifically for use when analyzing BMI changes over time with the same groups of students (Himes, 2009).

Additionally, only the drinking status of the students at onset of drinking was tracked and those individuals that may have stopped drinking within the 4 years were still maintained to be drinkers. An analysis showed that the number of individuals who moved from drinking status to non-drinking status was minimal, however, and will not likely influence associations in the study. There is also limitation with this study's measure of alcohol consumption, as it is unable to track specific amounts of alcohol consumed per occasion. Additionally, a binary measure of current drinking and binge drinking status lacks sensitivity in that it does not capture change in drinking or binge drinking frequency among current users. This study may be further strengthened by tracking students beyond high school to determine if a continuation of alcohol consumption patterns exists, and subsequently, its impact on the weight status of these students.

## 6. Conclusion

Considering the high prevalence of alcohol consumption throughout the adolescent stage of life, it is important to consider the implications of alcohol as a contributor to energy intake for this age group. Although there are inconsistencies in this study's results, there is still an indication that earlier onset of binge drinking may contribute to additional weight gain beyond what might be expected among Canadian adolescents. A variety of individual factors and health behaviours may influence the relationship between alcohol intake and weight gain over time, therefore, a comprehensive approach to prevention should be considered. More research is warranted to thoroughly investigate the role of alcohol in relation to weight gain in youth.

## 7. Declarations

### 7.1. Ethics approval and consent to participate

The COMPASS Study received ethics approval from the University of Waterloo Office of Research Ethics as well as participating school boards (ORE#: 30118). Using an active-information, passive-consent protocol, all participants gave consent for the use of their anonymous data.

### 7.2. Consent for publication

Ethics approval and consent to participate.

### 7.3. Availability of data and material

A data request form to access to the COMPASS data can be found at: <https://uwaterloo.ca/compass-system/information-researchers/data-usage-application>.

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### 7.5. Authors' contributions

JV drafted the manuscript and revised the manuscript for content. KB performed the statistical analyses, drafted the methods and results,

and revised the manuscript for content. STL conceived the host study, led the acquisition of all data, conceived the manuscript idea and revised the manuscript for critical content. All authors that have contributed significantly to the work presented within this manuscript have been listed above. All authors have read and approved the final manuscript.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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