

# Are closed campus policies associated with youth eating behaviours?

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## Research

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# Abstract

## Purpose

The effectiveness of school nutrition regulations may be undermined by the food environment surrounding schools, particularly among adolescents, as they are less likely to eat lunch at school and have their own spending money. Given challenges in regulating the external food retail, policies where students are unable to leave the school property during the day have been suggested to improve student nutrition. The aim of this study was to examine whether closed campus policies (CCP) are associated with student eating behaviours.

## Methods

The current study used student- and school-administrator survey data from 60,610 grade 9-12 students and 134 Canadian secondary schools participating in year 7 (2018/2019) of the COMPASS study. Multiple ordinal regression models tested school CCP as a predictor of weekday dietary behaviours (0-5 days), controlling for student- (grade, gender, spending money, ethnicity) and school-level (urbanicity, province, area median household income, school vending machines) covariates.

## Results

A total of 16 schools reported CCP. Students who attended schools with CCP reported eating lunch purchased from fast food places or restaurants on fewer weekdays, but consumed sugar sweetened beverages (sodas/sports drinks or sweetened coffee/tea drinks) and snacks purchased from school vending machines on more weekdays, relative to students at schools with open campus policies. No significant differences in student reports of eating lunch brought from home, eating lunch purchased from the school cafeteria, or snacks purchased off-school campus were observed between schools with open and CCP.

## Conclusion

CCP may help improve youth eating behaviour by reducing sugar sweetened beverages and lunch time fast food consumption on weekdays; however, students already purchasing food may shift from off-campus to within school options, highlighting the importance of ensuring healthy school food environments and encouraging students to bring home-prepared lunches. Future studies using experimental longitudinal designs are needed to determine the effect of school CCP on various health behaviours and outcomes.

## 1. Introduction

Youth represent a key target for population nutrition initiatives. Lifelong health habits become more established over adolescence, as a period of increasing autonomy. Relatedly, declines in diet quality occur with age and transitions to secondary school (1). Currently, few Canadian youth meet nutritional

guidelines (2, 3). Based on national dietary intake surveys, adolescents aged 14 to 17 report the poorest nutritional profiles across all age groups (2, 3), with 43% of youth in Ontario and Alberta having a poor diet quality rating (4). Youth diets are commonly characterized by fewer servings of fruit, vegetables, and whole grains, while “other” foods (i.e., low nutrient, high energy foods) comprise a higher proportion of their total daily caloric intake (5, 6). The primary nutritional concerns among youth – including inadequate calcium and fibre, and excess sodium and sugar (5, 6) – place them at increased risk of multiple chronic health conditions including diabetes, cardiovascular disease, osteoporosis, dental caries, fatty liver disease, and various types of cancer (7).

Applying a socioecological model, factors at multiple interacting levels shape adolescent dietary behaviours, from proximal (e.g., individual food preferences, family meals, parental role models) to more distal influences (e.g., social norms, culture, family socioeconomic level) (8, 9). Determined across levels, the availability and accessibility of food is among the strongest correlates of food choices among youth (10, 11, 12). Accordingly, environmental measures (i.e., policies/regulations) appear most effective for promoting population level change in health behaviours such as nutrition (13). School nutrition policies primarily focus on restricting minimally nutritious items and increasing the availability of healthy options for sale in the school environment. Schools are widely recognized as a key context for equitable delivery of interventions, as the location where most youth spend the majority of their waking weekday hours and consume at least one meal per day, and thus can impact social norms. In Canada, school nutritional policies are the responsibility of provincial/territorial governments (5). All 10 Canadian provinces have issued school food and nutrition policies and initiatives, but wide variation exists across them (e.g., voluntary/mandatory nature) (14).

School nutrition policies are limited to food sold within the school, yet the majority of Canadian schools have open campus policies, in which some or all students are permitted to leave the campus during lunch time hours. Schools are often within walking distance of many food retailers (15), primarily selling the foods that nutrition policies intend to restrict (i.e., low nutrient food high in sugar, fat, salt, and calories). There tends to be a greater density of fast food restaurants and convenience stores around schools compared with healthier retail food establishments (16, 17). Easy access to fast food restaurants in school areas has been linked with poor dietary intake among adolescents (18), including increased intake of sugar sweetened beverages (SSB) (19) and fast food purchases (20, 21), although evidence is mixed (22). Therefore, the effectiveness of school nutrition regulations may be undermined by the food environment surrounding schools (23, 21).

The off-campus environment is particularly relevant to adolescents as they are less likely to eat lunch at school (23, 21). Approximately one-third of grade 9 and 10 students in a Canadian representative study reported usually eating lunch somewhere other than at school and almost one in ten usually ate lunch at a food retailer (21). A recent study found over one third of Ontario secondary school students ate meals prepared by fast food restaurants at least once per week (23). Similarly, in an online survey of youth from 7 Canadian provinces, 27.4% reported buying lunch out three or more days a week and another 56.7% on one-to-two days, while 12.1% and 24.4% bought lunch at school three-to-five and one-to-two days/week,

respectively; only 15.9% of students did not buy lunch from a fast food restaurant, convenience store, or other off-campus option at all in the previous school week (24).

Lunches prepared at home are generally considered the most nutritious option, relative to meals purchased from fast food, restaurants, and convenience store outlets (24, 23). In Canadian secondary school students, those who bring a home-packed lunch report better total dietary quality, and consume fewer SSBs (25) and more fruit, vegetable (26), and whole grain servings, compared to their peers who purchase lunch from school or off campus (24, 27). For purchased lunches, most studies support the school cafeteria food as the healthier alternative to food purchased at fast food outlets or other restaurant and retail options. Students who eat lunch or snacks purchased at fast food outlets or restaurants report higher consumption of SSBs (25, 26, 28) and fried foods, and have greater sodium, sugar, and total caloric intakes than their peers who eat lunch prepared at home or by the school cafeteria (23, 24, 28). However, some evidence suggests school obtained lunches are generally equivalent to food purchased off-school property (24, 27).

Concerns about the external food environment led to new emphasis for nutrition regulations to be extended to retail settings in the communities immediately surrounding schools (23, 21). Given the many barriers to implementing healthy eating zones around schools, CCP that restrict students from leaving school property during the day have been proposed. While such a policy does not prevent students from purchasing food at nearby food retailers before or after school, youth consume approximately one third of their total energy intake during school hours (27, 28, 29), providing considerable potential to improve student nutrition. To our knowledge, only one study has examined CCP in association with food purchasing and consumption patterns. In a randomly selected sample of 1088 high school students from 20 Minnesota U.S. suburban high schools, students at schools with CCP during lunchtime were less likely to eat lunch at a fast food restaurant and consume food purchased at convenience stores than students at schools with open campus policies (30). Otherwise, the limited number of other studies comparing open to CCP have focused on factors unrelated to diet, including using conditional incentives for improving academic performance (31) and the prevention of student motor vehicle accidents (32). Given significant cross-national differences in the school and surrounding food environment, further evaluation in the Canadian context is necessary. This study explored student lunch, snack, and beverage purchase and consumption patterns on weekdays among a large cohort of Canadian youth based on whether they attended secondary schools with closed or open campus policies. We hypothesized that students attending schools with a CCP would report consumption of SSBs and food purchased from off-campus retail outlets on fewer weekdays; instead, these students may shift to purchasing food from school cafeterias and vending machines (VM), or ideally, to bringing a packed lunch from home more often.

## **2. Methods**

### **2.1. Design**

This study used cross-sectional student- and school-level data from Year 7 (collected during the 2018/2019 school year) of the *Cannabis use, Obesity, Mental health, Physical activity, Alcohol use, Smoking, Sedentary behaviour (COMPASS)* study. COMPASS (2012–2021) collects hierarchical longitudinal health data once annually from a rolling cohort of students in grades 9–12 and the secondary schools they attend across Canada (33). School boards and schools were purposefully selected based on whether they permitted active-information passive-consent parental permission protocols (33), which were used to reduce demands on schools, increase participation rates, and to collect robust data among youth (34). All grade 9 through 12 students attending participating schools were eligible to participate and could decline at any time. Student-level data were collected using the COMPASS student questionnaire (Cq), a paper-based survey designed to collect student-reported data on multiple health domains (physical activity, substance use, diet, sedentary behaviour, etc.), correlates (e.g., bullying, school connectedness, academic achievement), and demographic characteristics. The Cq was completed during one classroom period by whole school samples. School-level data was collected via an online survey (the COMPASS School Program and Policy Scan Tool [SPP]) at the same time as the student data collection. The SPP was designed to assess the presence or absence of policies, practices, and resources relevant to student health behaviours in the school environment (33). The school administrator(s) most knowledgeable about the school program and policy environment were emailed a link to the survey, and encouraged to consult with other staff members and have a small group complete the SPP to support accuracy of reports. COMPASS staff followed up by phone/email to clarify any unclear or missing data.

COMPASS received ethics approval from the University of Waterloo Human Research Ethics Committee (ORE#17264), Brock University Research Ethics Committee, and participating school boards. Additional details regarding COMPASS recruitment methods (35) and study methods can be found online ([www.compass.uwaterloo.ca](http://www.compass.uwaterloo.ca)) or in print (33).

### **Weekday dietary behaviours**

Students were asked “In a usual school week (Monday to Friday), on how many days do you do the following?” (i) “Eat lunch purchased at a fast food place or restaurant”; (ii) “Eat lunch at school – lunch packed and brought home”; (iii) “Eat lunch at school – lunch purchased in the cafeteria”; (iv) “Eat snacks purchased from a vending machine, corner store, snack bar, or canteen off school property”; (v) “Eat snacks purchased from a vending machine in your school”; (vi) “Drink sugar-sweetened beverages (soda-pop, Kool-Aid, Gatorade, etc.) (Do not include diet/sugar-free drinks)”; and (vii) “Drink coffee or tea with sugar (include cappuccino, Frappuccino, iced-tea, iced-coffees, etc.)”. Six response options were provided from “None” to “5 days” and coded 0–5 as an ordinal outcome.

## **2.2. School-level measures**

- To classify schools according to whether they had open or CCP, the school administrator survey (SPP) included the following item: “Does your school have a closed-campus policy whereby students are generally not allowed to leave school property during breaks in the day (except for school-related

activities/events, or personal appointments)?” Schools responding “yes” were classified as having CCP. Schools responding “no” were assumed to have an open campus policy.

## 2.3. Covariates

Student-level covariates included gender (female, male, nonresponse), grade (9, 10, 11, 12), race/ethnicity (white, black, Asian, Latin American/Hispanic, Other [other, multiple ethnicities selected, none indicated]), and money available weekly for spending or saving from allowance or part-time employment (None, \$1–20, \$21–100, >\$100, I don’t know).

School-level covariates included province (Ontario, Alberta, British Columbia [BC], Quebec), urbanicity (rural, small urban, medium urban, large urban) and school-area median household income (\$25,000–50,000, \$50,001–75,000, \$75,001–100,000, \$100,000+), based on Statistics Canada data cross-referenced with school postal codes. Urbanicity was included as a proxy of the food retail environment surrounding schools. Models for SSB intake (including soda pop/sports drinks and sugar-sweetened coffee/tea drinks) and snack purchasing outcomes also controlled for the number of snack (0–4) and beverage (0–6) VM available to students and located within schools, which were assessed by trained research staff during school data collections.

## 2.4. Statistical analyses

Descriptive statistics were calculated for students attending schools with and without CCP. Multiple ordinal regression models were used to test whether attending schools with CCP predicted student weekday eating behaviours, controlling for student- and school-level covariates. No interactions by grade and urbanicity were found when tested (results not shown).

## 3. Results

### 3.1. Sample

Sample descriptives are presented in Table 1. A total of 74,501 students at 134 secondary schools (8 Alberta, 15 BC, 61 Ontario, 52 Quebec) participated in year 7 (2018/2019) of the COMPASS study. Only students in typical North American “high school” grades of 9–12 were included in analyses. Quebec students in Secondary I and II (equivalent grades 7 and 8) were removed (n = 13891), and students in Secondary III to V were classified as grade 9 through 11 respectively. Students with missing outcome data were removed from each respective model, thus varying by outcome (3049 were missing data on home-packed lunches; 2646 for cafeteria lunches; 2479 for fast food/restaurant lunches; 2319 for school VM snacks; 2483 for snacks purchased off-school property; 2504 for soda consumption; and 2462 were missing data for sugar-sweetened coffee/tea).

Table 1

Descriptive statistics for grade 9–12 students in secondary schools with Open and Closed Campus Policies

		Campus Policies		
		Open	Closed	p-value
<b>Sociodemographic variables</b>		<b>% (N)</b>	<b>% (N)</b>	
Gender	Females	49.1 (26495)	49.1 (3241)	.6952
	Males	49.6 (26804)	49.8 (3287)	
	No response	1.3 (705)	1.2 (78)	
Grade	9	28.4 (15323)	29.8 (1971)	.002
	10	28.5 (15369)	27.7 (1832)	
	11	26.2 (14149)	27.1 (1791)	
	12	15.6 (8427)	14.1 (930)	
	No response	1.4 (736)	1.2 (82)	
Race/Ethnicity	White	65.1 (35154)	64.2 (4242)	< .0001
	Black	3.9 (2120)	5.8 (384)	
	Asian	12.2 (6615)	10.0 (662)	
	Hispanic/Latin American	2.8 (1535)	2.7 (177)	
	Other, Mixed, or Missing	15.9 (8580)	17.3 (1141)	
Weekly money available for spending/saving	None	15.2 (8104)	16.6 (1082)	< .0001
	\$1–20	22.4 (11954)	22.4 (1459)	
	\$21–100	24.5 (13062)	23.9 (1555)	

Note: Data from Year 7 (2018/2019) of the COMPASS Study.

		<b>Campus Policies</b>		
	>\$100	22.8 (12121)	19.2 (1250)	
	I don't know	15.1 (8029)	17.9 (1168)	
Province	Alberta	3.7 (244)	5.7 (3057)	< .0001
	BC	3.8 (250)	18.8 (10152)	
	Ontario	63.6 (4204)	49.0 (26471)	
	Quebec	28.9 (1908)	26.5 (14324)	
Urbanicity	Large urban	57.3 (30920)	42.5 (2806)	< .0001
	Median urban	12.0 (6502)	16.2 (1071)	
	Rural	1.1 (603)	17.6 (1164)	
	Small urban	29.6 (15979)	23.7 (1565)	
School area median household income	\$25,000– 50,000	14.0 (7537)	0.0 (2)	< .0001
	\$50,001– 75,000	57.6 (31126)	59.4 (3922)	
	\$75,001-100,000	23.9 (12890)	14.7 (973)	
	>\$100,000	4.5 (2451)	25.9 (1709)	
Number of school snack vending machines	0	25.4 (13719)	19.2 (1268)	< .0001
	1	35.5 (19165)	48.5 (3201)	
	2	32.6 (17588)	20.5 (1357)	
	3	6.5 (3532)	0 (0)	
	4	0 (0)	11.8 (780)	

Note: Data from Year 7 (2018/2019) of the COMPASS Study.

		Campus Policies		
Number of school beverage vending machines	0	9.9 (5336)	6.2 (409)	< .0001
	1	23.5 (12713)	38.1 (2520)	
	2	30.5 (16464)	17.9 (1181)	
	3	18.4 (9940)	9.8 (645)	
	4	10.9 (5905)	0 (0)	
	5	4.5 (2429)	28.0 (1851)	
	6	2.3 (1217)	0 (0)	

Note: Data from Year 7 (2018/2019) of the COMPASS Study.

CCP were reported by 16 secondary schools, including eight in Ontario (2 private, 6 public), a private school in BC, a public school in Alberta, and six Quebec schools (3 private, 3 public). Schools reporting CCP were in rural (n = 3), small (n = 4), medium (n = 3), and large (n = 6) urban areas.

## 3.2. Ordinal regression models

See Fig. 1(a-g) for student reported dietary measures by presence/absence of CCP. Regression model results are presented in Tables 2–4.

Table 2

Models examining attending Closed Campus Schools (versus Open) and student weekday lunch behaviours (0–5 days)

	Ate home-packed lunch at school		Purchased lunch in school cafeteria		Purchased lunch in fast food/restaurant	
	Est.	95% CI	Est.	95% CI	Est.	95% CI
Gender (Ref: Female)						
Male	-0.12***	-0.17, -0.07	-0.01	-0.08, 0.07	0.40***	0.35, 0.46
No response	-0.33**	-0.55, -0.11	-0.02	-0.23, 0.19	0.29	0.04, 0.55
Grade (Ref: 9)						
10	-0.02	-0.07, 0.03	-0.09**	-0.16, -0.02	0.05	-0.03, 0.12
11	-0.07*	-0.12, -0.02	-0.14***	-0.22, -0.07	0.11*	0.02, 0.20
12	-0.25***	-0.33, -0.17	-0.42***	-0.54, -0.31	0.35***	0.23, 0.46
No response	-0.22	-0.44, 0.00	-0.06	-0.26, 0.15	0.43***	0.19, 0.67
Race/Ethnicity (Ref: White)						
Black	-0.63***	-0.75, -0.50	0.65***	0.51, 0.79	0.82***	0.68, 0.96
Asian	-0.08	-0.22, 0.05	0.55***	0.39, 0.71	-0.01	-0.18, 0.16
Hispanic/Latin American	-0.22***	-0.33, -0.12	0.31***	0.19, 0.43	0.33***	0.20, 0.47
Other/Mixed/Missing	-0.34***	-0.40, -0.27	0.25***	0.14, 0.35	0.32***	0.24, 0.41
Weekly Spending Money (Ref: \$0)						
\$1 to \$20	-0.31***	-0.37, -0.25	0.63***	0.55, 0.71	0.79***	0.71, 0.87
\$21 to \$100	-0.62***	-0.70, -0.53	0.87***	0.78, 0.96	1.19***	1.11, 1.28
More than \$100	-0.71***	-0.80, -0.63	0.80***	0.69, 0.90	1.39***	1.32, 1.47

\*p < 0.05; \*\*p < 0.01; \*\*\*p < 0.001

	Ate home-packed lunch at school		Purchased lunch in school cafeteria		Purchased lunch in fast food/restaurant	
I don't know	-0.16***	-0.22, -0.10	0.45***	0.36, 0.53	0.64***	0.56, 0.72
School-area median household income (Ref: \$25000–50000)						
\$50001–75000	-0.35**	-0.59, -0.10	0.47***	0.23, 0.72	-0.07	-0.48, 0.33
\$75000–100000	-0.15	-0.42, 0.13	0.33*	0.02, 0.64	-0.14	-0.63, 0.36
>\$100000	-0.28	-0.58, 0.02	0.25	-0.19, 0.69	-0.22	-0.76, 0.32
Province (Ref: ON)						
AB	-0.05	-0.29, 0.18	-0.02	-0.40, 0.37	0.24	-0.10, 0.58
BC	0.34***	0.14, 0.54	-0.25	-0.52, 0.01	-0.37**	-0.64, -0.10
QC	0.62***	0.39, 0.85	-0.16	-0.43, 0.11	-0.95***	-1.27, -0.64
Urbanicity (Ref: Large Urban)						
Medium Urban	-0.03	-0.28, 0.21	-0.08	-0.46, 0.31	0.20	-0.13, 0.52
Rural	-0.01	-0.42, 0.39	0.04	-0.66, 0.75	-0.16	-0.94, 0.63
Small Urban	-0.35**	-0.56, -0.13	0.36**	0.11, 0.61	0.27	0.00, 0.55
Closed Campus Policy (Ref: No)						
Yes	-0.23	-0.62, 0.16	0.46	-0.04, 0.97	-0.45**	-0.75, -0.14
*p < 0.05; **p < 0.01; ***p < 0.001						

Table 3  
 Models examining attending Closed Campus Schools (Versus Open) and student weekday snack behaviours (0–5 days)

	Purchased snacks from school vending machines		Purchased snacks from off-campus retail	
	Est.	95% CI	Est.	95% CI
Gender (Ref: Female)				
Male	0.11**	0.04, 0.18	0.38***	0.31, 0.44
No response	0.29*	0.04, 0.55	0.51***	0.24, 0.79
Grade (Ref: 9)				
10	-0.20***	-0.27, -0.12	-0.06	-0.13, 0.00
11	-0.39***	-0.48, -0.30	-0.22***	-0.29, -0.15
12	-0.70***	-0.84, -0.56	-0.38***	-0.48, -0.29
No response	0.28*	0.03, 0.53	0.27**	0.07, 0.48
Race/Ethnicity (Ref: White)				
Black	0.63***	0.51, 0.75	0.64***	0.53, 0.75
Asian	0.06	-0.12, 0.25	0.03	-0.10, 0.16
Hispanic/Latin American	0.27***	0.13, 0.40	0.12*	0.00, 0.25
Other/Mixed/Missing	0.22***	0.11, 0.33	0.24***	0.16, 0.32
Weekly Spending Money (Ref: \$0)				
\$1 to \$20	0.61***	0.52, 0.69	0.65***	0.58, 0.73
\$21 to \$100	0.75***	0.66, 0.84	0.80***	0.72, 0.88
More than \$100	0.70***	0.61, 0.78	0.87***	0.87, 0.79
I don't know	0.43***	0.34, 0.52	0.47***	0.39, 0.55
School-area median household income (Ref: \$25000–50000)				
\$50001–75000	0.32*	0.02, 0.61	-0.06	-0.30, 0.17
\$75000–100000	0.34	-0.07, 0.75	-0.29	-0.61, 0.03
>\$100000	0.17	-0.30, 0.63	-0.39	-0.77, 0.00
Province (Ref: ON)				

\*p < 0.05; \*\*p < 0.01; \*\*\*p < 0.001

	Purchased snacks from school vending machines		Purchased snacks from off-campus retail	
AB	0.97***	0.53, 1.41	0.62***	0.35, 0.89
BC	0.64**	0.21, 1.06	0.42**	0.16, 0.67
QC	0.50***	0.25, 0.74	0.08	-0.13, 0.29
Urbanicity (Ref: Large Urban)				
Medium Urban	-0.08	-0.43, 0.26	-0.05	-0.29, 0.20
Rural	0.10	-0.39, 0.59	0.00	-0.76, 0.75
Small Urban	0.19	-0.04, 0.43	0.00	-0.20, 0.21
Number of school vending machines (VM)				
Snack VMs (0–4)	0.34***	0.20, 0.48	0.01	-0.10, 0.12
Beverage VM (0–6)	0.03	-0.08, 0.13	-0.02	-0.08, 0.04
Closed Campus Policy (Ref: No)				
Yes	0.42**	0.11, 0.74	0.00	-0.37, 0.37
*p < 0.05; **p < 0.01; ***p < 0.001				

Table 4  
 Models examining attending Closed Campus Schools (versus Open) and weekday Sugar-Sweetened Beverage consumption (0–5 days)

	Soda-pop / sports drinks		Sugar-sweetened coffee/tea drinks	
	Est.	95% CI	Est.	95% CI
Gender (Ref: Female)				
Male	0.60***	0.56, 0.64	-0.63***	-0.67, -0.58
No response	0.60***	0.39, 0.81	-0.36**	-0.60, -0.13
Grade (Ref: 9)				
10	-0.12***	-0.16, -0.08	0.09***	0.04, 0.14
11	-0.22***	-0.27, -0.17	0.19***	0.14, 0.25
12	-0.33***	-0.38, -0.27	0.32***	0.25, 0.39
No response	0.00	-0.19, 0.19	0.46***	0.25, 0.67
Race/Ethnicity (Ref: White)				
Black	0.58***	0.47, 0.68	0.06	-0.05, 0.18
Asian	-0.07	-0.16, 0.01	-0.05	-0.14, 0.03
Hispanic/Latin American	0.06	-0.04, 0.17	0.12	-0.01, 0.25
Other/Mixed/Missing	0.16***	0.10, 0.23	0.25***	0.19, 0.31
Weekly Spending Money (Ref: \$0)				
\$1 to \$20	0.36***	0.31, 0.41	0.35***	0.29, 0.41
\$21 to \$100	0.48***	0.42, 0.54	0.59***	0.53, 0.66
More than \$100	0.52***	0.46, 0.59	0.74***	0.67, 0.80
I don't know	0.31***	0.25, 0.37	0.31***	0.24, 0.37
School-area median household income (Ref: \$25000–50000)				
\$50001–75000	0.08*	0.00, 0.16	0.05	-0.08, 0.17
\$75000–100000	0.03	-0.06, 0.12	0.00	-0.14, 0.13
>\$100000	0.05	-0.11, 0.20	-0.01	-0.19, 0.16
Province (Ref: ON)				
AB	0.23*	0.03, 0.43	0.24**	0.09, 0.39

\*p < 0.05; \*\*p < 0.01; \*\*\*p < 0.001

	Soda-pop / sports drinks		Sugar-sweetened coffee/tea drinks	
BC	-0.27***	-0.37, -0.16	-0.05	-0.18, 0.08
QC	-0.24***	-0.32, -0.16	-0.90***	-1.00, -0.80
Urbanicity (Ref: Large Urban)				
Medium Urban	0.11*	0.01, 0.21	0.06	-0.06, 0.18
Rural	0.18	-0.02, 0.37	-0.14	-0.35, 0.08
Small Urban	0.17***	0.09, 0.26	0.08	0.00, 0.17
Number of school vending machines (VM)				
Beverage VM (0–6)	-0.02	-0.04, 0.00	-0.01	-0.04, 0.02
<b>Closed Campus Policy (Ref: No)</b>				
Yes	<b>-0.18***</b>	<b>-0.29, -0.07</b>	<b>-0.17***</b>	<b>-0.28, -0.07</b>
*p < 0.05; **p < 0.01; ***p < 0.001				

### 3.2.1. Differences by student- and school-level covariates

Student and school-level covariates were associated with differences in several outcomes. At the student-level, students in higher grades were more likely to purchase lunch from external sources, and less likely to eat a home-packed or cafeteria lunch, and to purchase snacks from convenience stores and external retail options, on more weekdays than grade 9 students. In terms of SSB, older students were more likely to consume sweetened tea/coffee drinks but less likely to consume soda/sports drinks on more weekdays than their grade 9 counterparts. Students identifying as black, Hispanic/Latin American, or other/mixed race/ethnicity, were less likely than white students to eat a home-packed lunch and more likely to eat lunch from fast food restaurants and snacks from school VM on more weekdays. Students of black or other/mixed race/ethnicity were also more likely to consume SSB and snacks from off-campus retail locations on more weekdays than white students. Males were less likely to bring a home-packed lunch and more likely to consume fast food lunches, snacks from school VMs, and soda/sports drinks, while females consumed sweetened coffee/tea drinks on more weekdays. Students with any amount of spending money were less likely to bring a home-packed lunch often, and more likely to purchase lunch or snacks within school or off campus and to report consumption of SSBs on more weekdays, than their peers without spending money.

At the school-level, the number of snack VM was positively associated with students purchasing snacks from school VM on more days, but not with snacks purchased from convenience stores and other off-campus options. On the other hand, school drink VM were not associated with weekday SSB consumption. Provincially, frequently eating a home-prepared lunch was more common in BC and Quebec schools than in Ontario, while purchasing lunch at a fast food outlet or restaurant was reported

less frequently. Relative to Ontario students, at Quebec, BC, and Alberta schools, students purchased snacks from school VM on more weekdays, and students in Alberta and BC schools also purchased off-campus snacks more often. No provincial differences resulted in the likelihood of students eating a cafeteria-prepared lunch or in soda consumption. Students in small urban areas were less likely to bring a home packed lunch and more likely to consume cafeteria-purchased lunches and soda/sports drinks on more weekdays, than those attending schools in areas of high population density. Urbanicity had no impact on snacks purchases, fast food lunches, or sweetened coffee/tea drinks. Lastly, students attending schools in areas with median household incomes of \$50,001-\$75,000 were less likely to bring lunch from home and more likely to buy a cafeteria lunch on more weekdays, than those attending schools located in areas with lower household incomes.

### **3.2.2. Closed versus open campus policies**

There was no difference in the likelihood of the number of weekdays that student ate lunches packed and brought from home or snacks purchased off-school property, based on whether they attended a school with closed or open campus policies. Attending a school with CCP was associated with a higher likelihood of eating snacks purchased from school VM on more days, and a lower likelihood of eating lunch purchased from a fast food place or restaurant off-school property. Lastly, students attending schools with CCP were less likely to consume SSBs, including sodas/sports drinks and coffee/tea drinks with sugar, on more weekdays than their peers at open campus policies.

## **4. Discussion**

The current study is the first to evaluate youth dietary behaviours in relation to open-closed campus school policies in Canada. In a sample of 134 secondary schools in Ontario, Alberta, Quebec, and BC, only 16 schools reported CCP, in which students were not allowed to leave school property during breaks in the day. Consistent with our hypotheses, students at closed campus schools were more likely to eat snacks from school VMs, and less likely to drink SSBs (sodas/sports drinks or sweetened coffee/tea drinks) and to purchase lunch from a fast food or restaurant outlet on weekdays, than their peers attending schools with open campus policies. However, the likelihood of bringing a home-packed lunch to school, purchasing lunch in the school cafeteria, or eating snacks purchased from convenience stores or similar off-campus retail options, did not differ significantly based on attendance at open-closed campus schools. Therefore, while prospective studies are needed to examine within-student changes after policy implementation, cross-sectional results align with US evidence (30) suggesting CCP may help improve youth diets by preventing the external food retail environment from compromising school nutrition policies.

Given the increased likelihood of purchasing snacks from school VM on more days, but no association with the frequency of home-prepared lunches, CCP may lead only those students already purchasing food to shift from buying lunch at off-campus sources to options available for sale in schools. Consequently, the influence of the school food environment on student diets is likely heightened in closed campus schools. The Canadian Pediatric Society advises schools to limit food and beverages low in nutrients and

high in calories, fat, sugar, and/or sodium (including fruit flavoured drinks, soft drinks, sports and energy drinks, and sweetened hot or cold drinks, including those with caffeine) (5). However, existing research indicates many schools are not compliant with nutrition policies in regards to the food and beverages offered for sale within cafeterias or VM (3, 37, 38, 39, 40). In Canada, with school food regulation purely market-based and restricted to within school sales, student access to external food retail options is recognized as a key barrier to healthful school nutrition environments (41); hence, CCP may serve to support policy adherence by reducing competitive sources that undermine financial-viability. Moreover, CCP represent a cost-effective intervention, with potential revenue gains for school cafeterias, and no expense to implement.

Results also suggest that spending money is the largest determinant of youth dietary behaviours on school days among the covariate and predictor variables considered. Students with any amount of money available for spending were less likely to bring a home-packed lunch and more likely to consume SSBs and purchase lunch or snacks from within-school or off-campus sources on more weekdays, than their peers without available spending money. Consistent with previous research (30), VM availability within schools was positively associated with students purchasing snacks from school VM. On the other hand, school drink VM were not associated with weekday SSB consumption, which may be expected given the regulation of SSB sales within schools, yet issues with compliance appear common (39). Previous studies have found greater SSB consumption in association with the availability of SSB (42) and sweetened coffee-tea drinks (19) in schools. No association resulted between the number of school snack VMs and student purchases of snacks from off-campus convenience stores and other retail options.

As expected with increased autonomy, students in higher grades were more likely to purchase lunch from outside sources on more days, and less likely to eat a home-packed or cafeteria lunch; however, contrary to expectations, they purchased snacks from convenience stores and external retail options on weekdays less often than grade 9 students. Unlike lunch, it is plausible that the weekday snacks were purchased before or after school. Purchasing behaviours outside of school hours may also explain the lack of association between CCP and snack purchases from convenience stores and similar retail off-school property. In contrast, Neumark-Sztainer et al. (2005) found students at suburban US schools with CCP during lunchtime were less likely to eat food purchased at convenience stores than students at open campus schools (30). Other researchers have noted that CCP would not be effective in preventing students from purchasing food at nearby food retailers before or after school (21). While this may be the case, particularly for snacks, these preliminary cross-sectional results suggest an overall reduction in SSB consumption and fast food lunches during the school week; and given that at least one-third of students' total caloric consumption occurs during school hours (43, 44, 28), improving the lunchtime meal among youth has considerable potential to advance population nutrition.

Home-prepared lunches are generally associated with healthier diets than purchased options from either school cafeterias or fast food/restaurant outlets (26); however, prohibiting students from leaving campus does not appear to encourage more students to bring their lunch from home. In a recent photovoice study

of high school students' perspectives of food in schools, youth who brought a home-packed lunch perceived it to be a healthier, affordable, and convenient option that permitted autonomy; while students who went off campus to purchase food reported the proximity, low cost, space for social interaction, and perceived higher quality of food available as reasons (45). Youth voice a desire for healthier options at schools and being involved in the decision making about what types of foods are offered for sale in schools (45), which could be a critical consideration for policy implementation. Schools considering CCP should explore how they can engage students in the process.

Beyond food, students emphasize the importance of the places and spaces available to eat and socialize safely and comfortably during the lunch period (45). School cafeterias are considered loud and chaotic (45), with long lines to purchase food or use microwaves deterring intentions to stay at school for lunch (46). In response, some researchers have suggested changing the school timetables to staggered lunch hours and creating more youth friendly spaces outside (46). In fact, one reason for open-campus policies is to reduce cafeteria congestion during lunch hours (32). Schools with walkable neighbourhoods and food retailers in close proximity are more likely to have open campuses (47). Another motive is to support adolescence autonomy and independence. In US schools that changed to open campus environments, grade 11 and 12 students felt more control over their environment than their peers at closed campuses; however, some students also reported disciplinary problems, poorer grades, less school spirit, and reductions in their social life both in and out of school (48). Future research is needed to compare positive and negative effects of school open and CCP on various behavioural, social, mental, and academic outcomes to inform best practices moving forward.

## **Strengths and Limitations**

A key strength of this study is the large sample size, with data at both the student- and school-levels in varied school contexts in four Canadian provinces. While these factors support generalizability, the COMPASS study was not designed to be provincially or nationally representative and uses a convenience sample. Relatedly, additional confounders not controlled for may contribute to differences in schools with and without CCP and students attending these schools. For instance, while school area urbanicity, province, and median household income, and the number of within school VM, are controlled for, the current study does not account for differences in the food environment surrounding schools. The primary limitations of the current study are the use of cross-sectional data and self-reported dietary measures. Future studies should further examine CCP using prospective data and quasi-experimental natural experiment designs to test whether students transition from purchasing food off-campus to purchasing food within the school after a CCP is implemented. Student reported dietary behaviours and school administrator-reported policy measures introduced possible recall and social desirability biases. Also, the dietary measures are limited to assessing the number of days that students engaged in the dietary behaviour indicated, and do not account for the number of times per day (e.g., the SSB measures assess the number of weekdays that students consume SSB but do not indicate if students drink multiple SSBs in a day). Lastly, the measures for snacks purchased from off-campus retail and SSB assess weekday consumption/purchasing, but do not indicate when during the day (i.e., during school hours, or

before/after school); however, overall weekday consumption is more important to determine full nutritional impact.

## Conclusions

A healthy environment is critical to support nutritious choices among adolescents, as they increasingly make decisions independent from their families and have their own spending money. Helping youth establish healthy habits while in a more controlled context will put them on a healthy trajectory beyond school into adulthood. Within Canada, the food environment surrounding schools is cited as a key barrier to successful implementation of school nutrition policies, as these spaces fall outside the jurisdiction of provincial and territorial regulations (15, 41). CCP have the potential to protect youth from the food environment in close proximity to schools and improve their diet quality, including reduced weekday consumption of SSB and lunches from fast food/restaurant outlets, but otherwise, the impact on student diet quality may depend on the food available for sale within schools. Students already purchasing food may shift from off-campus retail options to options available within the school, highlighting the importance of ensuring healthy school food environments and/or encouraging students to bring home-prepared lunches. Future studies using experimental longitudinal designs are needed to determine the effect of school CCP on student nutrition, and various other health behaviours, along with social, mental, and academic outcomes.

## Abbreviations

BC

British Columbia

CCP

Closed Campus Policy

COMPASS

The Cannabis use, Obesity, Mental health, Physical activity, Alcohol use, Smoking, and Sedentary behaviour study

VM

Vending machine

## Declarations

## Ethics approval and consent to participate:

The University of Waterloo Office of Research Ethics (ORE#17264) and participating school boards approved all procedures. All students attending participating schools were invited to participate using active-information passive-consent parental permission protocols. Students could withdraw from the study at anytime.

## Consent for publication:

Not applicable.

## Availability of data and material:

COMPASS study data is available upon request through completion and approval of an online form: <https://uwaterloo.ca/compass-system/information-researchers/data-usage-application> The datasets used during the current study are available from the corresponding author on reasonable request.

## Authors' contributions:

KAP and AC conceptualized the manuscript. KAP lead the writing and wrote the first draft on the manuscript. MM assisted with the literature review. WQ conducted the statistical analysis. STL is the lead of the COMPASS study. All authors (KAP, AC, WQ, MM, MV, STL) informed the design of the study, contributed to interpretation of results, provided feedback on drafts, and approved the final version of the manuscript.

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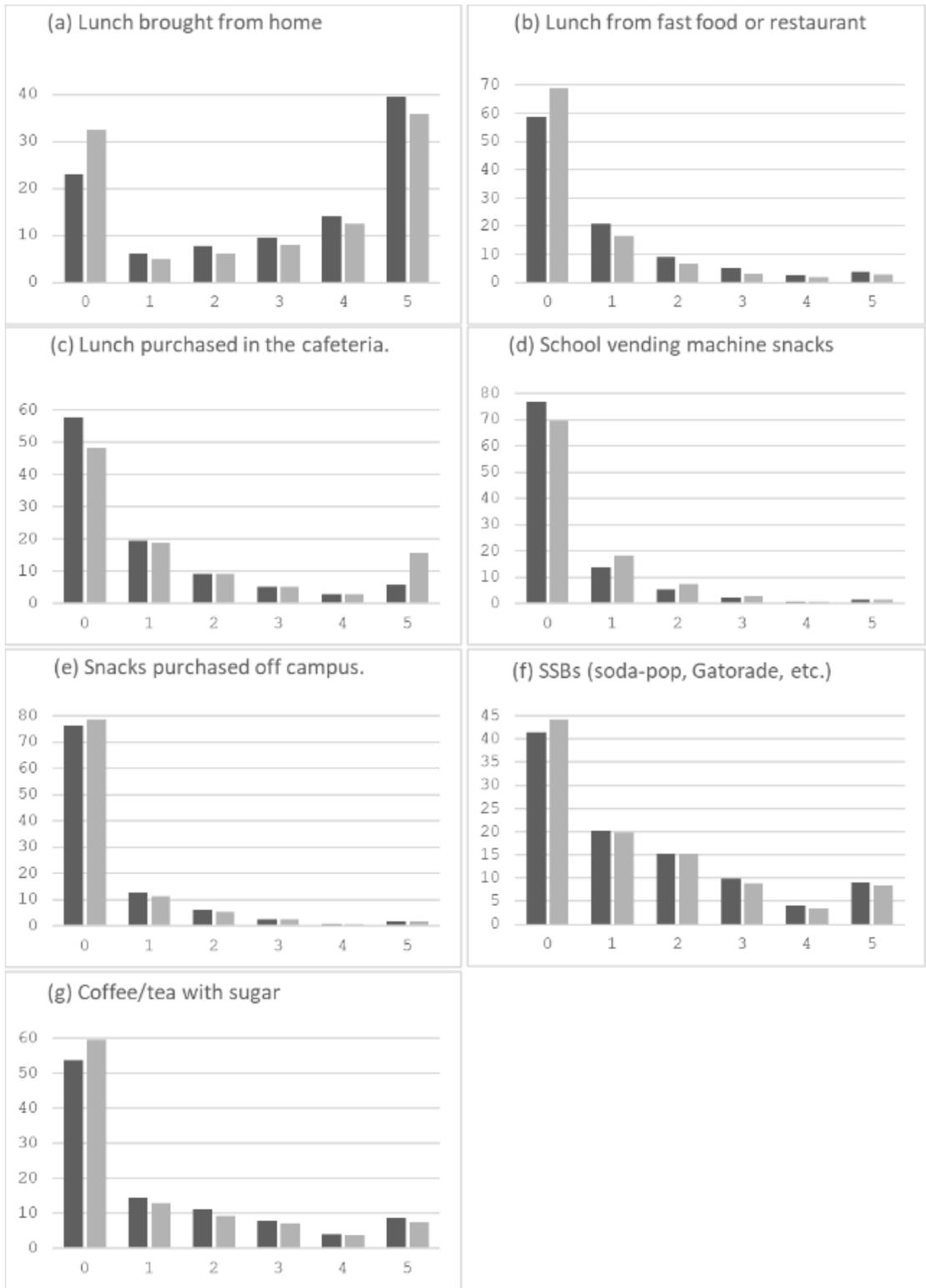
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## Figures



**Figure 1**

Students (%) that reported eating behaviours (0-5 weekdays) at Open (lighter grey) and Closed (darker grey) Campus Schools