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# The food retail environment in school neighborhoods and its relation to lunchtime eating behaviors in youth from three countries

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## ABSTRACT

This study examined the relation between the chain food retail environment surrounding schools, youths' lunchtime eating behavior, and youths' obesity levels across three countries. Participants consisted of 26,778 students 13–15 years old from 687 schools across Canada, Scotland and the US. The density of convenience stores, chain fast food restaurants, and chain cafés within 1 km of each school was measured. Lunchtime eating behaviors, weight, and height were self-reported. Although the density of chain food retailers was highest in the US, fewer American students (2.6%) routinely ate their lunch at a food retailer during the school week than did Canadian (7.7%) and Scottish (43.7%) students. The density of chain food retailers was associated with eating lunch at a food retailer in Canada only whereby students attending schools with 1–2, 3–4, and 5+ chain food retailers within 1 km from their schools were 1.39 (95% CI: 0.84–2.29), 1.87 (95% CI: 1.10–3.20), and 2.50 (95% CI: 1.56–4.01) times more likely to eat at a chain food retailer compared to students attending schools with no nearby chain food retailers. No associations were found between chain food retailer density and obesity.

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## 1. Introduction

Childhood obesity is a global public health problem (WHO, 1998; Wang and Lobstein, 2006) and there is a need to study its determinants to develop an evidence base for interventions. Eating behavior is recognized as an obesity determinant (Popkin, 1993; Janssen et al., 2005; Schmidhuber and Shetty, 2005; Hawkes et al., 2009; Wang and Lobstein, 2006) and the food retail environment is one contextual factor that influences the eating behavior and weight status of children (Cummins and Macintyre, 2006). The food retail environment refers to the quantity and type of food retailers available to a person. For young people this may include food retailers in proximity to their home and school. Of particular concern is the availability of convenience stores, fast food restaurants, and cafés as these retailers sell foods that are affordable to many youth, calorically dense, and of poor nutritional quality (French et al., 2001; Bowman et al., 2004; Young and Nestle, 2002; Glanz et al., 2005; Sallis and Glanz, 2006).

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The number of fast food restaurants has grown considerably in recent decades and there has been a cultural shift whereby chain food retailers have been replacing independently owned and operated food retailers (Bowman et al., 2004; Nielsen et al., 2002, Christian and Gereffi, 2010). For instance, globally there were 31,967 McDonald's restaurants in 2008, which is double the number of McDonald's restaurants in 2003 (McDonald's Inc., 2009). The availability, convenience, and affordability of foods sold at convenience stores, fast food restaurants, cafés, and similar retailers has contributed to secular changes in eating behaviors (e.g., increased intake of high sugar, processed foods) and obesity (Sallis and Glanz, 2006; Glanz et al., 2005).

Recent literature reviews (Fraser et al., 2010; Holsten, 2009; Cummins and Macintyre, 2006; Feng et al., 2010; Fleischhacker et al., 2010) have reported that the relationship between the food retail environment, eating behaviors, and weight status varies across settings. For example, in their review of fast food retailer proximity and density, Fraser and colleagues (Fraser et al., 2010) included 9 studies that examined eating behaviors and 14 studies that looked at weight status. Of the 9 eating behavior studies, 3 found a positive association, 3 found a negative association, and 3 identified no statistically significant associations. Of the 14 weight status studies, 6 found a positive association, 2 found a negative association, and 6 did not identify an association.

While several studies found no statistical association, their findings should not be discounted as the direction of the association was often positive and the studies may have been underpowered. Furthermore, most of the studies included in the recent literature reviews studied adults from the US (Cummins and Macintyre, 2006; Fraser et al., 2010; Holsten, 2009; Feng et al., 2010; Fleischhacker et al., 2010). The relevance of this literature to youth from other countries remains unclear.

Many of the existing studies that have examined the food retail environment of youth have focused on food retailers in proximity to the young persons' homes. Since school-aged youth often purchase their lunch and snacks off school grounds (Johnston et al., 2007; Nielsen et al., 2002), food retailers located in school neighborhoods may also influence their eating behavior and body weight. Although several authors have suggested that curbing the obesity epidemic among school-aged youth will require addressing the food environment in and around schools (Zenk and Powell, 2008; Sturm, 2008; Austin et al., 2005), few studies have directly assessed the relationship between food retailers in school neighborhoods with lunchtime eating habits and weight status (Seliske et al., 2009; Davis and Carpenter, 2009). Moreover, of these studies, conflicting results have been reported. For example, an American study found that youth with fast food restaurants located within 0.8 km of their school were 6% more likely to be overweight compared to youth attending schools with no fast food restaurants located within 0.8 km (Davis and Carpenter, 2009). Conversely, a Canadian study found that youth with fast food restaurants located within 1 km of their school were 30% less likely to be overweight compared to youth attending schools with no food retailers located within 1 km (Seliske et al., 2009). The differences observed may result from a variety of factors including whether or not youth actually consumed foods from the retailers.

Studies that examine relationships between the food environment surrounding schools, eating behavior, and the body weight of young people are needed in order to provide robust evidence about contextual determinants of obesity. Further, the study of these relationships in different countries will help determine if the effects of the food environment are consistent in different parts of the world thus providing guidance regarding international policy development and action. It is possible that the chain fast food environment influences youth differently in different countries as a result of cultural differences. For example in Scotland chip trucks/vans and independent food retailers are very popular while in Canada and the US chain retailers tend to be dominant (Bowker et al., 1999; Macintyre et al., 2005). The purpose of the current study was to determine whether the relation between the chain food retail environment surrounding schools, youths' lunchtime eating behavior, and youths' obesity levels are consistent across three different countries.

## 2. Methods

### 2.1. Study overview

The current study used data from 13–15 year old youth from three countries (Canada, Scotland, and the US) that participated in the Health Behavior in School-Aged Children Survey (HBSC). These countries represent three developed countries that are geographically and culturally distinct. Youths' weekday lunchtime eating behavior and body weight status were assessed via a questionnaire completed by individual students. The number of convenience stores, and chain fast food restaurants and cafés located within 1 km of the participants' schools within each country were extracted using Yellow Pages directories. Multi-level regression analyses were

used to determine if the number of food retailers surrounding the school was related to lunchtime eating behavior and body weight status of the student participants within each country. Cross-national differences in these relationships were explored.

### 2.2. HBSC survey

The study population consisted of participants from the 2009/2010 HBSC, a cross-national survey performed in collaboration with the World Health Organization (Currie et al., 2011). Youth aged 11, 13 and 15 years are the target for the international study with a minimum sample size of 1500 students in each age group (Currie et al., 2011). The 2009/2010 HBSC included 43 countries. In addition to the mandatory HBSC questionnaire items that were agreed upon internationally, the three countries studied here administered an optional dietary module with a question about where the lunchtime meal during the school week was consumed.

Each of the participating HBSC countries used school class as the unit of selection, with classroom grades chosen to reflect in a representative manner the national distribution of students aged approximately 11 (grade 6 in Canada and US, grade Primary 7 in Scotland), 13 (grade 8 in Canada and US, grade Secondary 2 in Scotland), and 15 (grade 10 in Canada and US, grade Secondary 4 in Scotland) years. The Canadian and US samples also included 12 (grade 7) and 14 (grade 9) year old students. Eleven and 12 year old students were excluded from the analyses as few of these students (< 1% in all three countries) reported that they usually ate their lunch at a food retailer, and within all three countries, many students of this age are not allowed to leave school grounds during the school day. Schools were selected using a weighted probability technique to ensure that the sample was representative by regional geography and key demographic features (e.g., religion, community size, school size, language of instruction). More details on the sampling procedures can be found elsewhere (Currie et al., 2011). A total of 437, 273, and 317 schools were included in the Canadian, Scottish, and US samples. The number of students who completed the questionnaire (ages 11 through 15) in these three countries were 26,078, 6771, and 12,649, respectively. Based on the inclusion criteria mentioned above (ages 13 to 15 only), the current study was comprised of 15,532 students from Canada, 4697 students from Scotland, and 6,867 students from the US representing 320, 178, and 189 schools, respectively.

Information obtained from the HBSC questionnaire included sociodemographic information (age, sex, socioeconomic status, etc.), health behaviors (eating behavior, food frequency, physical activity, smoking, alcohol and drug use, etc.), and a variety of health determinants. The questionnaire was administered to students in their classrooms during regular school hours and took approximately 1 h for students to complete. Ethics reviews for survey completion were obtained from all participating countries and consent was obtained from children and their parents or guardians. The ethics approach adopted in HBSC can be either a passive or active consent, depending on jurisdictional requirements.

### 2.3. Lunchtime eating

The primary outcome of this study was whether the participants usually ate their lunch (mid-day meal) during the school week at a food retailer. This information was based on responses to the question "Where do you usually eat your mid-day meal on schooldays?" There were 6 response options to this question (1. at school; 2. at home; 3. at someone else's home; 4. in a snack-bar, fast food restaurant, café; 5. somewhere else, please specify; 6. I never eat a mid-day meal). Those who selected option 4 were considered to

have the outcome. If option 5 was chosen and a convenience store, fast food restaurant, or café was specified the student was also said to have the outcome. This question and response options in the Scotland questionnaire were worded slightly differently from the Canadian and US instruments (“*On most school days, what do you do for lunch?*” 1. *school lunch in the dining room or canteen*; 2. *packed lunch in school*; 3. *go home for lunch*; 4. *buy lunch from local shop, café, or van*; 5. *I don’t eat lunch*; 6. *other, please specify*). Responses for 1 and 2 were combined to represent the category “at school” from the Canadian and US questionnaires and the category “at someone else’s house” from the Canadian and US questionnaires was left blank in the Scotland population.

#### 2.4. Overweight and obesity status

The secondary outcome of this study was overweight and obesity status, as determined by the self-reported height and weight of the participants. The body mass index (BMI, kg/m<sup>2</sup>) was calculated, and the age- and sex-specific BMI cut-points advocated by the International Obesity Task Force (Cole et al., 2000) were used to classify youth as having a normal, overweight, or obese BMI. These age- and sex-specific cut-points were derived from a large international sample. Regression techniques were used to pass a line through the health-related adult BMI cut-points at 18 years. Participants with BMI values corresponding to an adult BMI of <25.0, 25.0–29.9, and ≥30.0 were classified as normal weight, overweight, or obese, respectively (Cole et al., 2000). The overweight and obese groups were merged into a single category to create a dichotomous outcome measure (normal weight or overweight/obese).

#### 2.5. Covariates

Potential confounders included sex, grade, and family affluence (the validated HBSC measure of socioeconomic status Currie et al., 2008). Sex and grade were self-reported by students. The family affluence scale was developed by assessing participants’ answers to 4 questions regarding material conditions of their household (“*Does your family own a car, van or truck*”, “*Do you have your own bedroom for yourself*”, “*During the past 12 months, how many times did you travel away on holiday with your family*”, and “*How many computers does your family own*”). Based on responses, participants were classified into low, moderate, or high family affluence categories (Currie et al., 2008). Physical activity was not included as a covariate because it is not associated with the food retailer exposure variable and thus does not meet the criteria for confounding.

#### 2.6. Measurement of food retail environment surrounding schools

Information on the number of food retailers located within a 1 km circular buffer surrounding each of the schools that participated in the HBSC in each of the three countries was obtained using electronic Yellow Pages databases (Canada, [www.yellowpages.ca](http://www.yellowpages.ca); Scotland, [www.yell.com](http://www.yell.com); US, [www.yellowpages.com](http://www.yellowpages.com)). A distance of 1 km was chosen based on previous research (Austin et al., 2005; Aparicio et al., 2007; Seliske et al., 2009); this distance captured food retailers that were within a reasonable walking distance (~10 min or less) to schools. Convenience stores, fast food restaurants, and cafés (including sub/sandwich shops and donut/coffee shops) were selected as they provide a wide variety of inexpensive, high calorie, low nutrient foods that are known contributors to obesity (Nicklas et al., 2001; Sallis and Glanz, 2006; Glanz et al., 2005). Also, these food retailers match the response options to the lunchtime eating question that was part of the HBSC questionnaire.

In the Yellow Pages searches for all three countries, school addresses were inputted and food retailers within 1 km of each school were identified. Convenience stores were identified for each participating school by using the search term “convenience store”. There is not a single search term that can be used to capture fast food restaurants or cafés in the Yellow Pages search engine. For instance, many fast food restaurants are listed under the full service restaurant category. Therefore, we performed individual searches on the names of the most common fast food restaurants and cafés within each country. Within each country these searches were guided by food industry reports generated by Technomic, Inc. (Chicago, IL). Specifically, the Technomic reports for Canada and the US included a list of the top 200 chain restaurants by sales for 2009 and 2010, respectively, and the UK report included a list of the top 100 chain restaurants by sales for 2010. We separated these chains into fast food and café (donut/coffee shop) type chains. For Canada and the US, we determined which fast food restaurants or cafés comprised 75% of the total sales (Austin et al., 2005). Since the UK Technomic report only listed the top 100 chain retailers, the equivalent percentile cut-points for 100 chain restaurants were determined from the Canada and US reports of the top 200 chain retailers. This cut-point was 85%. In the end, Yellow Page searches in Canada were made based upon the name of 12 fast food restaurants and 2 cafés, Yellow Page searches in Scotland were made based upon the name of 7 fast food restaurants and 4 cafés, and Yellow Page searches in the US were made based upon the names of 18 fast food restaurants and 3 cafés. A list of the fast food restaurants and cafés that were included in the search for each country along with their total sales is included in Appendix A. Note that with this approach we assumed that the food retailer sales were similar in Scotland as in the UK as a whole.

For the purpose of the analyses, 4 categories were created for each food retailer type (total, convenience stores, fast food, and cafés): 0 stores located within 1 km, 1–2 stores, 3–4 stores, and 5 or more stores. The category representing 3–4 and 5+ cafés were collapsed due to few schools having 5+ cafés located within 1 km.

#### 2.7. Statistical analyses

Analyses were performed using SAS version 9.2 (SAS Institute, Cary, North Carolina). Overlapping confidence intervals around the means were used to see if the number of different types of food retailers surrounding schools varied across the 3 countries. Within each country multi-level logistic regression was used to examine associations between the study variables, which included individual-level variables (lunchtime eating, overweight/obesity status, covariates) and area-level variables (food retailers surrounding schools). Multi-level models were used because both individual-level variables (e.g., the covariates) and area-level variables (e.g., the food retailer variables) were being studied and because it allowed us to adjust the error estimates for the clustered nature of the data (e.g., participants were clustered within schools). First, an empty model was used to determine the interclass correlation coefficient, which provides an estimate of the proportion of the variation in the outcome that was due to differences between schools. Next, we examined multivariate relations that included the food retailer exposure variables and the covariates that were significant ( $p < 0.05$ ) in the bivariate models. Because all the covariates were significant in the bivariate models, only the final model containing all covariates is shown. The prevalence of students who ate lunch off school grounds and the prevalence of students who were overweight or obese were calculated for each food retail establishment and category (i.e., fast food retailer: 0, 1–2, 3–4, 5+ retailers within 1 km from the school).

**Table 1**  
Descriptive characteristics of the Health Behavior in School-Aged Children survey participants from the three participating countries.

	Canada (n=15,532)	Scotland (n=4,792)	United States (n=6454)
Sex (%)			
Boys	49.2	49.2	51.8
Girls	50.8	50.8	48.2
Grade (%)			
8	33.9	45.4	38.3
9	34.7	–	32.1
10	31.4	54.6	29.5
Family affluence scale (%)			
Low	15.8	12.1	13.9
Moderate	32.6	35.3	35.1
High	51.6	52.6	51.0
Body mass index			
Mean (95% CI)	21.2 (21.2–21.3)	19.8 (19.7–20.0)	22.1 (22.0–22.2)
Non-overweight, %	74.6	83.3	65.4
Overweight (including obese), %	25.4	16.7	34.6
Lunch time eating location (%)			
At school	67.2	45.6	71.6
At home	17.2	5.9	20.0
Snack bar, fast food, café	7.7	43.7	2.6
Never eat a mid-day meal	3.9	3.9	3.6
At someone else's home	2.0	n/a	1.2
Elsewhere	2.1	0.9	1.0

**Table 2**  
Type and number of chain food retailers located within 1 km of schools.

	Canada (n=320)	Scotland (n=178)	United States (n=189)	Country differences <sup>a</sup>
<i>All food retailers</i>				
Mean (95% CI)	3.2 (2.8–3.6)	3.1 (2.5–3.7)	5.1 (4.3–5.8)	C, S < US
0	32.1%	34.1%	22.2%	
1–2	24.5%	28.2%	24.7%	
3–4	19.7%	17.9%	13.3%	
5+	25.7%	19.8%	39.9%	
<i>Convenience stores</i>				
Mean (95% CI)	1.6 (1.3–1.8)	1.3 (1.1–1.6)	2.5 (2.1–2.8)	C, S < US
0	45.2%	55.0%	28.8%	
1–2	34.9%	23.1%	37.0%	
3–4	12.6%	14.7%	18.4%	
5+	7.3%	7.3%	15.8%	
<i>Fast food restaurants</i>				
Mean (95% CI)	1.2 (1.0–1.4)	0.8 (0.6–1.0)	2.0 (1.7–2.3)	C, S < US
0	53.0%	64.8%	42.7%	
1–2	30.7%	24.2%	27.5%	
3–4	10.6%	5.1%	14.9%	
5+	5.7%	5.9%	14.9%	
<i>Cafés</i>				
Mean (95% CI)	0.4 (0.3–0.5)	0.9 (0.7–1.2)	0.6 (0.4–0.8)	C < S
0	71.0%	65.6%	74.4%	
1–2	26.8%	23.8%	20.9%	
3–4	1.6%	5.9%	2.9%	
5+	0.5%	4.8%	1.9%	

<sup>a</sup> Country differences identified by non-overlapping confidence intervals; C=Canada, S=Scotland, US=United States

### 3. Results

Table 1 displays descriptive characteristics of the participants from each of the three countries. There was a relatively even distribution by sex and grade within each country. The majority (~50%) of participants in all three countries had high family affluence. The proportion of participants who were overweight or obese was higher in the US (34.6%) than in Canada (25.4%,  $p < 0.0001$ ) and Scotland (16.7%,  $p < 0.0001$ ). Conversely, the proportion of participants who normally ate their lunchtime meal at a snack bar, fast food restaurant, or café was lower in the US

(2.6%) than in Canada (7.7%,  $p < 0.0001$ ) and Scotland (43.7%,  $p < 0.0001$ ).

As shown in Table 2, the mean number of food retailers located within 1 km of schools in Canada, Scotland, and the US were 3.2 (95% CI: 2.8–3.6), 3.1 (95% CI: 2.5–3.7), and 5.1 (95% CI: 4.3–5.8), respectively. Approximately one third of schools in Canada and Scotland did not have a food retailer in close (1 km) proximity; compared to one fourth of schools in the US. Thus, there were more food retailers surrounding schools in the US than in Canada or Scotland. Similar observations were made for convenience stores and chain fast food restaurants.

**Table 3**  
Association between chain food retail environment surrounding schools and eating lunch at a snack bar, fast food restaurant, or café.

	Canada (n=15,532)		Scotland (n=4697)		United States (n=5820)	
	Prevalence (%)	Odds ratio <sup>a</sup> (95% CI)	Prevalence (%)	Odds ratio (95% CI)	Prevalence (%)	Odds ratio (95% CI)
<i>All food retailers</i>						
0	4.5	1.0	43.0	1.0	3.0	1.0
1–2	5.7	1.39 (0.84–2.29)	44.1	1.02 (0.70–1.49)	1.8	0.62 (0.25–1.56)
3–4	7.5	1.87 (1.10–3.20)	41.1	1.02 (0.69–1.50)	2.1	0.80 (0.27–2.37)
5+	11.5	2.50 (1.56–4.01)	43.7	0.98 (0.65–1.46)	3.3	1.21 (0.56–2.61)
<i>Convenience stores</i>						
0	4.9	1.0	45.6	1.0	2.5	1.0
1–2	8.3	1.52 (1.04–2.21)	34.1	0.58 (0.41–0.82)	2.8	1.02 (0.47–2.21)
3–4	10.8	1.84 (1.08–3.15)	43.0	0.90 (0.62–1.30)	2.1	1.47 (0.58–3.70)
5+	11.8	2.55 (1.47–4.44)	52.9	1.23 (0.71–2.12)	3.7	1.83 (0.70–4.78)
<i>Fast food restaurants</i>						
0	5.2	1.0	43.1	1.0	2.5	1.0
1–2	9.6	1.60 (1.09–2.34)	44.8	1.09 (0.79–1.50)	1.7	1.12 (0.52–2.43)
3–4	8.8	1.80 (1.09–2.99)	35.1	0.69 (0.37–1.30)	2.6	0.98 (0.42–2.32)
5+	10.7	2.17 (1.19–3.96)	37.5	0.82 (0.45–1.50)	4.7	1.67 (0.73–3.80)
<i>Cafés</i>						
0	6.1	1.0	41.1	1.0	2.3	1.0
1–2	10.3	1.49 (1.04–2.15)	47.6	1.33 (0.96–1.84)	3.5	0.96 (0.47–1.95)
3+	12.5	1.68 (0.66–4.27)	40.7	0.94 (0.63–1.44)	4.7	2.15 (0.54–8.58)

<sup>a</sup> Controlled for sex, grade, and family affluence.

**Table 4**  
Association between chain food retail environment surrounding schools and overweight (including obesity).

	Canada (n=11,945)		Scotland (n=4697)		United States (n=4928)	
	Prevalence (%)	Odds ratio <sup>a</sup> (95% CI)	Prevalence (%)	Odds ratio <sup>a</sup> (95% CI)	Prevalence (%)	Odds ratio <sup>a</sup> (95% CI)
<i>All food retailers</i>						
0	28.3	1.0	17.6	1.0	33.9	1.0
1–2	26.4	1.04 (0.85–1.28)	16.0	0.87 (0.61–1.23)	31.9	0.92 (0.74–1.15)
3–4	24.3	0.94 (0.75–1.17)	16.7	0.91 (0.64–1.30)	37.8	1.15 (0.89–1.49)
5+	25.5	0.97 (0.80–1.18)	16.4	0.89 (0.61–1.29)	34.9	1.01 (0.84–1.23)
<i>Convenience stores</i>						
0	26.0	1.0	17.1	1.0	33.4	1.0
1–2	26.4	1.16 (0.99–1.35)	14.9	0.83 (0.60–1.16)	33.7	1.03 (0.86–1.23)
3–4	27.9	1.04 (0.83–1.31)	17.7	1.01 (0.71–1.43)	35.1	1.02 (0.81–1.27)
5+	24.5	1.00 (0.79–1.26)	17.1	1.05 (0.61–1.80)	37.4	1.11 (0.87–1.40)
<i>Fast food restaurants</i>						
0	27.6	1.0	16.8	1.0	32.8	1.0
1–2	26.7	1.01 (0.87–1.18)	17.9	1.03 (0.77–1.38)	38.1	1.20 (0.99–1.45)
3–4	21.9	0.84 (0.68–1.04)	17.8	0.96 (0.51–1.81)	33.9	1.04 (0.85–1.28)
5+	22.1	0.81 (0.63–1.06)	10.4	0.60 (0.32–1.15)	33.4	0.99 (0.81–1.22)
<i>Cafés</i>						
0	26.8	1.0	17.8	1.0	34.4	1.0
1–2	25.6	1.09 (0.95–1.26)	15.9	0.84 (0.62–1.13)	34.0	0.99 (0.84–1.17)
3+	22.2	0.79 (0.53–1.21)	12.9	0.66 (0.42–1.03)	35.7	0.98 (0.66–1.41)

<sup>a</sup> Controlled for sex, grade, and family affluence.

The interclass correlation coefficient values in Canada, Scotland, and the US indicated that 8.6%, 1.9%, and 7.4% of the variation in the lunchtime eating outcome was due to school-level factors, respectively. Table 3 displays the prevalence and relative odds that youth ate their lunch during the school week at a food retailer according to the number of food retailers in the 1 km buffer surrounding their school. Relationships in Canada were consistent for all food retailers and the different food retailer types in that the odds of eating at a food retailer increased with increased food retailer availability. For example, in comparison to youth who attended a school with no food retailers in its surrounding environment, the relative odds for eating lunch at a snack bar, fast food restaurant or café were 1.39 (95% CI: 0.84–2.29) for youth who attended a school with 1 or 2 food retailers in

its surrounding environment, 1.87 (95% CI: 1.10–3.20) for youth who attended a school with 3 or 4 food retailers in its surrounding environment, and 2.50 (95% CI: 1.56–4.01) for youth who attended a school with 5 or more food retailers in its surrounding environment. Unlike Canada, within Scotland and the US there were no consistent patterns or associations between the number of food retailers (all food retailers, convenience stores, fast food restaurants, or cafés) and lunchtime eating behavior.

The interclass correlation values in Canada, Scotland and the US indicated that 1.5%, 0.1% and 1.4% of the variation in the overweight/obesity outcome was due to school-level factors, respectively. Table 4 displays the prevalence and relative odds of overweight and obesity according to the number of food retailers in the 1 km buffer surrounding the participants' schools.



Irrespective of country, no statistically significant relationships were observed between the food retailers and weight status.

#### 4. Discussion

The key findings of this study were that there are cross-national differences in the chain food retail environment surrounding schools, student lunchtime eating behaviors, and the relations between these variables. Although there are more chain food retailers located within 1 km from schools in the US than in Canada and Scotland, fewer American students in this age range typically eat their lunch at a food retailer during the school week. While an increase in the number of chain food retailers located close to schools was related to lunchtime eating behaviors in Canadian students, this was not the case in American or Scottish students.

Findings from previous US studies have suggested that there is no relationship between student eating behaviors and the presence of food retailers surrounding schools (Davis and Carpenter, 2009; Laska et al., 2010; van der Horst et al., 2008). For example, Davis and Carpenter reported that the relative odds for consuming vegetables, juice, soft drinks, and french fries were within 5% for students who attended schools located within 0.5 miles of a fast food restaurant compared to students who did not attend such schools (Davis and Carpenter, 2009). The non-significant results reported in these American studies (Davis and Carpenter, 2009; Laska et al., 2010; van der Horst et al., 2008) may reflect the lack of specificity of the food outcome measures (e.g., Davis and Carpenter, 2009) or the fact that they measured the total frequency of consumption, which could be influenced by home, school, and other environments. They may also reflect a true lack of association between food retail environments surrounding schools and eating behaviors within the US. Since only 2.6% of American students in the current study ate their lunch outside of school, it is perhaps not surprising that the chain food retail environment surrounding the US schools was not a determinant of students' lunchtime eating behaviors. The wide variety of foods available in a typical American school offered from food programs, cafeterias, and vending machines may be more relevant for the lunchtime eating behaviors of American school children (Finkelstein et al., 2008; Fox et al., 2009; Pasch et al., 2011; Rovernier et al., 2011).

Interestingly, few chain food retailers were identified within the 1 km buffers around the Scottish schools. However, the percentage of students eating their lunch at a food retailer was considerably higher in Scotland than in the other two countries. This finding may be a reflection of the popularity of chip trucks/vans (Bowker et al., 1999) and independent food retailers (Macintyre et al., 2005) in the UK, which were not captured in our food retailer measures. This finding could also be attributed to cultural differences across the studied countries.

Contrary to the US and Scottish data, within Canadian students, lunchtime eating behaviors were related to the number of chain food retailers located within 1 km from schools. We speculate that this cross-national difference may be driven by differences in the variety of foods offered both within and outside of schools in the three countries as well as in differences in school policies that may allow children to access outside food sources. For example, the US offers a variety of food programs within schools greatly increasing students' access to food without needing to leave school grounds (Finkelstein et al., 2008; O'Toole et al., 2007). On the contrary, in the UK, schools frequently do not have enough dining space for all pupils therefore many children leave the school premises during their lunch hour (Wills et al., 2005; Young et al., 2005).

Given the strong association between students' lunchtime eating behavior and food retailers surrounding schools in Canada, school-aged children within this country may benefit from the adoption of

municipal or regional (e.g., provincial) policies that regulate the number of food retailers located within close proximity of schools. Unfortunately, no studies to date have assessed whether or not implementing such a policy would be effective. A policy restricting fast food restaurants in a socioeconomically disadvantaged area in California was recently implemented but its effectiveness has not been evaluated (Sturm and Cohen, 2009). In addition, although several local councils across England have begun to ban new fast food retailers from opening within 400 yards of schools (Campbell, 2010), no evaluations of this policy have been conducted. However, there is some evidence that suggests that changing the food environment can positively impact eating behaviors. For example, the introduction of a new supermarket in a socioeconomically disadvantaged neighborhood in the UK had an impact on the fruit and vegetable consumption of the adults residing in that neighborhood (Wrigley et al., 2003). Thus, students eating behaviors may improve if their schools are surrounded by a healthier food environment.

While the availability of food retailers was related to lunchtime eating behaviors within the Canadian sample, no relationships were observed with BMI status in any of the three countries; a finding that adds to the mixed results that have been reported in the literature (Davis and Carpenter, 2009; Seliske et al., 2009; Howard et al., 2011; Currie et al., 2010). The lack of association observed for BMI, even within Canada where effects were seen for lunchtime eating behaviors, may reflect that there are many determinants of obesity other than lunchtime eating. The food environment surrounding schools may influence eating behavior at lunch during the school week, but should not influence breakfast, dinner, weekend meals, or evening snacks. Furthermore, because youth only attend school approximately 200 days per year and because calories consumed by youth at lunch represent only ¼ of their total daily caloric intake (Garriguet, 2004), the lunchtime meal during the school week only contributes to a small proportion of total energy intake. There are also several other non-dietary determinants of obesity that need to be taken into consideration such as a lack of moderate- to vigorous-intensity physical activity (Rennie et al., 2005), too much sedentary behavior (Prentice-Dunn and Prentice-Dunn, 2011; Rey-Lopez et al., 2008), and a lack of sleep (Chen et al., 2008). Thus, the lack of association between the school food retail environment and obesity is not surprising as the present study looked at one environmental factor in isolation.

As with all studies, this one has several limitations. First, this study only examined the chain food retail environment surrounding schools in relation to lunchtime eating behaviors. It is possible that youth purchase food from food retailers surrounding their school at snack time or when traveling to and from school. In addition, the chain retail environment surrounding youths' homes is also important and needs consideration to fully understand the eating behaviors of youth. Third, chip trucks/vans and independent fast food retailers and cafés were not captured in our food retailer measures. This likely resulted in non-differential misclassification of the food retailer exposure groups, particularly in Scotland, and underestimated associations. Fourth, only a single data source (Yellow Pages) was used in locating food retailers around schools which may have led to measurement error. Fifth, the 1 km buffer used to capture food retailers around schools was based on a circular buffer and thus does not reflect how people travel using a road network. Sixth, student's self-reported heights and weights were used to calculate BMI. Students tend to overestimate their height and to underestimate their weight (Sherry et al., 2007; Shields et al., 2008) likely biasing effects toward the null. Finally, several potential confounding variables (e.g., school food policies, school meal program participation, urban/rural status of the school, etc.) were not available for all three countries and thus were not included in the analyses. Additional analyses conducted within the Canadian sample indicated that urban/rural status was an effect modifier of the

**Table A1**

Chain food retailers included in food retailer measures according to country.

Canada		United Kingdom		Unites States	
Retailer	Sales (CA\$ 000)	Retailer	Sales (EU \$000)	Retailer	Sales (US \$000)
<b>Chain fast food restaurants</b>					
McDonald's	2,750,000	McDonald's	1,815,400	McDonald's	32,395,000
Subway	1,109,000	KFC	604,200	Subway	10,600,000
KFC	705,000	Pizza Hut	480,000	Burger King	8,710,000
A&W	645,000	Subway	454,350	Wendy's	8,340,000
Wendy's	559,000	Burger King	408,100	Taco Bell	6,950,000
Dairy Queen	385,000	Domino's Pizza	376,540	Pizza Hut	5,390,000
Pizza Pizza	373,200	Nando's	346,765	KFC	4,710,000
St. Hubert	342,000	–	–	SONIC Drive-Ins	3,623,476
Burger King	332,000	–	–	Chick-Fil-A	3,583,000
Pizza Hut	265,000	–	–	Domino's Pizza	3,305,636
Harvey's	221,904	–	–	Arby's	3,010,000
Quizno's Subs	175,500	–	–	Jack in the Box	2,930,000
–	–	–	–	Dairy Queen	2,445,000
–	–	–	–	Papa John's	2,097,272
–	–	–	–	Craker Barrel Old Country Store	1,911,664
–	–	–	–	Chipolte Mexican Grill	1,831,922
–	–	–	–	Hardee's	1,695,000
–	–	–	–	Golden Corral	1,639,726
<b>Chain cafés and coffee/donut shops</b>					
Tim Horton's	4,921,434	Starbucks Coffee	520,195	Starbucks Coffee	9,070,000
Starbucks Coffee	885,000	Greggs	473,550	Dunkin' Donuts	5,620,000
–	–	Costa Coffee	454,750	Panera Bread	2,916,441
–	–	Caffé Nero	204,510		

observed associations such that the odds of students eating out increased with an increasing number of chain retailers in urban schools but no such patterns were observed in rural schools.

A key strength of this study was the fact that the HBSC was designed to make cross-national comparisons, and as such comparable study methods and designs were used in Canada, Scotland, and the US. Cross-national comparisons such as this are lacking and are needed to help determine the consistency of the effects of the food environment on eating behaviors in different parts of the world, which could provide guidance regarding international policy development and action.

In conclusion, the results from this study suggest that cross-national differences exist in the food environment surrounding schools, the lunchtime eating behaviors of students, and the relations between these variables. The cross-national differences in the association between the food retail environment and eating behaviors may be explained by several cultural, behavioral, and/or environmental differences. While youth obesity is an issue in all three countries studied, our findings suggest that policies aimed at improving the food retail environment surrounding schools may distinctly benefit the eating behavior of Canadian students. However, it must be noted that cross-national comparisons are very difficult to conduct due to national differences in the food environment and school policies. Therefore, future studies are needed whereby such variables are evaluated and compared.

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### Appendix A

See Table A1.

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