RESEARCH
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Lunch on School Days in Canada: Examining Contributions to Nutrient and Food Group Intake and Differences across Eating Locations

Claire N. Tugault-Lafleur, PhD, RD*; Jennifer L. Black, PhD, RD‡

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*Certified in Canada.
‡Certified in the United States and Canada.

ABSTRACT

Background Recent federal proposals in Canada have called for changes in the delivery and funding of school lunches. Yet little evidence has documented the nutritional quality of meals eaten by school children, which is needed to inform school lunch reforms.

Objectives To assess the dietary contributions of lunch foods to daily food and nutrient intakes on school days and compare dietary intakes across eating locations (school, home, and off campus).

Design Cross-sectional analyses of school day data from the 2015 Canadian Community Health Survey—Nutrition.

Participants/setting Children aged 6 to 17 years who completed a 24-hour dietary recall falling on a school day in 2015 (n=2,540).

Main outcome measures Mean percent of daily intakes of energy, food groups, and nutrients contributed by foods reported at lunch and energy-adjusted intakes of nutrients and food groups consumed during the lunch meal.

Statistical analyses Descriptive statistics were used to assess the percent of daily energy, nutrients, and food groups contributed by lunch foods. Multivariable linear regression models examined differences in dietary outcomes across eating locations for the full sample and stratified by age group, with separate models for children aged 6 to 13 and 14 to 17 years.

Results On average, foods reported at lunch provided ~26% of daily calories on school days. Relative to energy, lunch foods provided lower contributions of dark green and orange vegetables, whole fruit, fruit juice, whole grains, milk and alternatives, fluid milk; minimally nutritious foods including sugar-sweetened beverages; and several related nutrients including total sugars; vitamins A, D, B-6, and B-12; riboflavin; and calcium. Yet, lunch foods provided proportionally higher contributions of grain products, non–whole grains, meat and alternatives, and sodium. Children aged 14 to 17 years who ate lunch at school reported higher intakes of total vegetables and fruit, whole fruit, whole grains, fiber, vitamin C, and magnesium but reported fewer calories from sugar-sweetened beverages compared with their peers who ate lunch off campus.

Conclusions Relative to its contribution to energy, lunch on school days contributed to proportionally lower intakes of many healthful foods such as dark green and orange vegetables, whole fruit, whole grains, and fluid milk but also proportionally lower intakes of other high-fat and high-sugar foods including sugar-sweetened beverages. This study adds to the growing body of evidence on dietary concerns during school time for Canadian children and highlights particular nutritional challenges for adolescents consuming lunch off campus.
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ENSURING THAT CHILDREN HAVE ADEQUATE ACCESS to healthy food to grow, learn, and thrive is important for achieving optimal child development outcomes and well-being.[1] Childhood and adolescence are critical windows for establishing healthy eating habits that can impact long-term weight status[2–4] and chronic disease outcomes later in life.[5] In Canada, nationally representative survey data from 2004 found that more than half of children and adolescents did not meet the minimum number of daily servings of vegetables and fruit recommended by the 2007 *Eating Well with Canada's Food Guide* (referred to here as the 2007 CFG).[6,7] The same data also showed that more than one

third of Canadian children aged 4 to 9 years and up to 61% of teen boys and 81% of teen girls did not meet the recommended number of servings of milk and alternatives recommended by the 1992 national dietary guidelines.[8] Although the diets of most Canadian children and adolescents provide adequate amounts of most essential nutrients needed for growth and development,[9,10] more than 10% of children (9 to 17 years) are estimated to consume inadequate intakes of vitamin A, calcium, and magnesium,[9] and concerns are raised around children's low intakes of potassium and fiber[9,10] as well high consumption of free sugars[11,12] and sodium.[13] Evidence suggests that Canadian children's dietary quality on school days has improved only modestly from 2004 to 2015.[14] In 2015, the average dietary quality of foods consumed by Canadian children during school hours remained, on average, well below recommendations for vegetables, whole fruit, whole grains, and dairy products.[14]

Schools in both the United States and Canada are proposed sites for action to improve children's dietary quality.[15-18] Schools can nurture healthy habits through nutrition education programs and supportive school food environments.[15-17,19,20] Previous literature evaluating the impact of federally funded school meals programs have reported improved quality of children's diet[21,22] and a reduction in disparities in children's fruit and vegetable intake across socioeconomic lines.[23] Leading national and international agencies including the Pan-Canadian Joint Consortium for School Health[24] and the World Health Organization[25,26] have long acknowledged the importance of promoting health and improving dietary outcomes through schools.

Insight into the consumption patterns of foods consumed for lunch on school days and how they contribute to children's overall dietary outcomes is valuable because it allows public health professionals to develop recommendations and strategies to improve the nutritional quality of school food offerings. In the United States, the contribution of lunch meals to daily nutrient intakes of children was documented in the School Nutrition Dietary Assessment Studies, which draw on nationally representative survey data from public schools participating in the National School Lunch Program (NSLP).[27] The third School Nutrition Dietary Assessment suggests that in 2004-2005, NSLP participants and nonparticipants obtained, on average, 31% and 30% of their total energy intake from lunch foods on school days. However, the lunches consumed by NSLP participants made significantly greater contributions to 24-hour intakes of many nutrients including protein; vitamins A, B-6, B-12; folate; niacin; riboflavin; thiamin; calcium; iron; zinc; magnesium; phosphorus; potassium; and sodium compared with lunches consumed by nonparticipants.[27] Drawing on more recent nationally representative data from the National Health and Examination Surveys (2007-2012), Cullen and Chen reported that NSLP school lunches provided, on average, 26% of children's total daily energy intake.[28] Compared with the mean energy contribution from all foods, vegetables, fruit, and dairy products provided by the NSLP lunches provided proportionally greater contributions (35%, 41%, and 60% respectively) to children's total 24-hour intakes of these foods.

Although the US literature has highlighted the nutritional importance of school meals in terms of contributing to children's total intake of nutritious foods and key nutrients of public health concern,[29,30] few recent Canadian studies have examined the extent to which foods consumed at lunch contribute to total 24-hour dietary intakes. Using national dietary data from the Canadian Community Health Survey (CCHS) 2004, one study reported that Canadian school-aged children consumed approximately one third of their daily calories during school hours (defined as from 9:00 to 14:00).[31] Relative to the mean energy contribution (34% of total daily calories), milk and alternatives provided proportionally lower contributions (24% of the total 24-hour intakes of milk and alternatives). In contrast, minimally nutritious foods such as sugary drinks and salty packaged snacks consumed during school hours provided, on average, 37% of the whole day's intakes of these foods. In 2015, Statistics Canada conducted a follow-up national nutrition survey (the 2015 CCHS—Nutrition) using methods that were similar to the ones used in 2004,[32] providing the first opportunity since 2004 to provide detailed evidence regarding the nutritional contributions and areas of concern pertaining to foods consumed at school by Canadian children.

Improved knowledge regarding the nutritional quality of foods consumed during school meals, how relative intakes at school compare with foods and nutrients consumed before and after school, as well as contextual factors, such as where children eat and whether eating location is associated with dietary intake, can provide foundational knowledge to plan and implement school wellness policies that better address priority nutritional concerns of Canadian children. Previous studies suggest that where children obtain and eat food can significantly influence dietary intakes.[33-37] In Canada, limited research (often focused on older adolescents) has examined where students typically acquire or eat lunch on school days and whether or how eating locations influence school day dietary intakes.[38-41] Jones and colleagues reported that eating lunch off campus was associated with more frequent consumption of sugar-sweetened beverages and eating a lunch from home was associated with more frequent intakes of vegetables and fruit in a regional sample of Canadian adolescents.[39] Woodruff and colleagues reported higher lunchtime amounts of meat products and junk foods among

RESEARCH SNAPSHOT

Research Questions: How much do lunch foods on school days contribute to Canadian children's daily nutrient and food group intake? Is lunchtime eating location associated with dietary intake?

Key Findings: Foods reported at lunch provided ~26% of daily calories on school days. Relative to energy, lunch provided proportionally lower contributions of nutritious foods, including dark green and orange vegetables, whole fruit, whole grains, and fluid milk and minimally nutritious foods including sugary beverages as well as several nutrients, particularly those found in milk and alternatives. On average, adolescents who ate lunch at school reported more vegetables and fruit, whole fruit, fruit juice, and whole grains and fewer calories from high-calorie sugary beverages compared with adolescents eating off campus.

adolescents eating off campus compared with their peers who consumed lunch at school or home.[38] Based on national data from the 2004 CCHS, another study reported that Canadian youth aged 9 to 17 years who brought lunch foods from home had, overall, a slightly more desirable average nutrient intake profile during school hours compared with their peers who ate off campus.[40] The CCHS 2015—Nutrition includes for the first time a contextual variable identifying where meals were consumed, providing an opportunity to explore associations between lunchtime eating locations and dietary intakes in a large sample of Canadian children.

Canada does not have a national school lunch program, but the 2019 Canadian federal budget plan announced an "intention to work with provinces and territories towards the creation of a National School Food Program."[42] This study provides timely evidence on children's dietary practices that can serve as a baseline benchmark to inform future school-based policies and interventions in Canada. The objectives of this study were therefore to (1) assess the dietary contributions of lunch foods to total 24-hour intakes of a comprehensive range of foods groups and nutrients among Canadian children aged 6 to 17 years and (2) compare lunchtime energy, food group, and nutrient intakes on school days by eating location (school, home, and off-campus locations).

MATERIALS AND METHODS

Data Source

Data were obtained from the 2015 CCHS—Nutrition, the most recent national dietary survey targeting Canadians aged 1 year and older living in private dwellings in Canada's 10 provinces.[32] The CCHS 2015 used a multistage stratified cluster sampling design to obtain a sample that was nationally representative for age, sex, geography, and socioeconomic status (n=20,487; response rate 61.6%).[32] A computer-assisted 24-hour recall method applied a modification of the automated multiple pass method[43] to obtain detailed information on foods consumed from midnight to midnight on the previous day including the time the food was consumed, the eating occasion (eg, breakfast, lunch), and a detailed description of the amounts of the reported foods.[44] Interviews for children aged 6 to 11 years were conducted with parental assistance (that is, both the child and caregiver participated in the interview) and respondents aged 12 years and above answered on their own. All respondents completed a 24-hour recall in person with a trained interviewer, and a random subset of subjects (approximately 35% of the total sample) completed a second 24-hour dietary recall by telephone 3 to 10 days later.[32] This study used the first interviewer-administered 24-hour recall because the mean of 1-day intakes is an acceptable estimate of the mean "usual," or long-term daily average, intake of a population when it is properly estimated—that is, when the days of the week and seasons of the year are adequately represented,[45] which was the case for the 2015 CCHS.[31] All foods and beverages were analyzed using the food composition data from the 2015 Canadian Nutrient File,[46] Canada's standard reference food composition database used in the 2015 CCHS.[32] Ethics approval was granted by the Statistics Act of Canada, and access to these data was provided by Statistics Canada's Research Data Center Program.[47]

For the first objective of this study, the analytical sample included 2,540 respondents aged 6 to 17 years who reported a first 24-hour dietary recall that occurred on a weekday (Monday through Friday) but excluded recalls that occurred during Christmas or winter holidays (December 22 to January 5), summer school vacation months (July and August up until Labor Day weekend), and Canadian national holidays. Of these 2,540 children, 43 did not report a location of consumption and 153 reported consuming no foods or beverages at lunch. The 196 children who either did not report a location of consumption or missed lunch were included in analyses assessing the dietary contributions of lunch foods (objective 1). However, when examining differences in dietary intakes across eating locations (objective 2), these 196 children were dropped from the analyses.

Variables of Interest

All foods reported for the lunch meal occasion on school days were classified as lunch foods. Foods and beverages in the 2015 Canadian Nutrient File were classified into main food groups using the framework of the 2007 CFG[6] and then further classified into food subgroups using the food grouping system of the 2014 Health Canada Surveillance Tool System framework.[48] These food groupings were used to report the types of foods and beverages consumed. The four main food groups in the 2007 CFG were vegetables and fruit, grain products, milk and alternatives (including fortified soy-based beverages), and meat and alternatives. Within the 2014 Health Canada Surveillance Tool System framework, foods are classified into four tiers, in which tier 1 foods are considered most nutritious and tier 4 foods are the least nutritious. For the purpose of this analysis, servings from all tiers were grouped together. "Other" foods consisted of foods and beverages that did not fall within the four recommended food groups in the 2007 CFG. In the 2015 Canadian Nutrient File, other foods included, for example, fats and oils (unsaturated fats, saturated or *trans* fats and oils), ingredients and seasonings, foods high in sugar or fat (eg, candies, chocolate bars, salty packaged snacks such as potato chips), high-calorie beverages (defined as providing >40 kcal/100 g, eg, regular soda), low-calorie beverages (defined as providing ≤40 kcal/100 g, eg, diet soda), alcohol-containing beverages, and finally foods and beverages not classified (eg, infant formula and most baby foods). In this study, the food subgroups examined included dark green and orange vegetables, white potatoes, other vegetables (ie, non–dark green or orange vegetables), whole fruit, fruit juices, whole grains, non–whole grains, fluid milk, other dairy products (eg, cheese, yogurt), high-fat or high-sugar foods, high- and low-calorie beverages. Intake was measured intake using 2007 CFG standard servings[6,49] for vegetables and fruit, grain products, milk and alternatives, and meat and alternatives (and food subgroups within these core food groups). For other foods (eg, high-calorie sugary beverages), amounts were quantified using energy intake (kilocalories) because there were no standard reference amounts (servings) for these foods defined by Health Canada.[48] This study did not include nutrient intakes derived from supplements but examined the comprehensive set of macro- and micronutrients available within the CCHS data set. Dependent variables therefore included mean intakes of calories, food

groups, and subgroups reported at lunch and related macro- and micronutrient intakes derived from foods and beverages consumed. Mean percent of daily intakes of energy, food groups, and nutrients contributed by lunch foods were also estimated.

In the CCHS 2015, eating location was assessed using one survey question that asked respondents where the meal was eaten during the dietary recall component of the interview.[50] The variable eating location included 15 possible response options.[44] To be consistent with previous literature exploring associations between eating location or food source with children's dietary quality in the school context, response options for the eating location variable were recoded into three categories: (1) school locations that included the school cafeteria, school (not the cafeteria), or a child-care center, (2) home or someone else's home, or (3) off-campus locations (restaurants, fast-food outlets, grocery store or corner store, cafeteria not in school, adult or family care center, sports venue or recreation centre, work, or in a car or vehicle).

Other available variables of interest from the survey included demographic and lifestyle characteristics. These variables were used to describe the sociodemographic characteristics of Canadian children represented by this study and consider potentially confounding factors when comparing nutrient and food group intakes across lunchtime eating location. Demographic variables included sex, age (in years), age group (6 to 13 years vs 14 to 17 years), rural vs urban location of residence, immigration status (recently or ever an immigrant to Canada vs nonimmigrant). Similarly to Ziauddeen and colleauges[36] and Barr and colleagues,[51] we dichotomized the variable ethnicity as white vs nonwhite due to the relatively small number of participants reporting other racial, cultural, or ethnic backgrounds (eg, black, Asian, Hispanic, mixed, and other ethnic groups). Based on previous research suggesting that age group moderated the association between lunchtime food source and children's diet,[40] we tested for differences in dietary intakes across eating locations separately for younger (6 to 13 years) and older (14 to 17 years) children. Socioeconomic characteristics examined highest household-level education, based on all household members aged 14 years and older who were asked about the highest certificate, diploma, or degree obtained.[49] The original response options listed seven possible categories, and household-level education was recoded into three groups including children whose household members (1) had a high school diploma or lower; (2) had a trade or college certificate (below the bachelor's level); (3) had attended or obtained a university degree (bachelor's degree or higher). Other socioeconomic measures included household-level food security status, which was assessed using the Household Food Security Survey Module.[52] The Household Food Security Survey Module contains 18 questions used to assess "uncertain, insufficient or inadequate food access, availability and utilization due to limited financial resources, and the compromised eating patterns and food consumption that may result" in the previous 12 months. The food security status of child and adult members of the household was determined by the number of food-insecure conditions reported—that is, by the number of questions in the Household Food Security Survey Module that the respondent answered affirmatively on behalf of the household. To be considered food secure, no items or only one item in the adult or child scale was affirmed. In these analyses, food insecurity was recoded as a dichotomous variable (food secure vs food insecure, which collapsed the moderate and severely food-insecure children). Lifestyle variables included smoking status (current smoker vs nonsmoker—only applicable to respondents aged 12 years and over), supplement use (used a dietary supplement in the past 30 days or not), and weight status (being overweight or obese or neither, using the body mass index age- and sex-specific cutoffs by the World Health Organization[49]) based on measured weight and height.

Statistical Analyses

Descriptive statistics (proportions and robust standard errors [SEs]) were used to describe sociodemographic and lifestyle characteristic of children for the whole sample, as well as by lunchtime eating location. Rao-Scott χ^2 tests were used to examine whether lunchtime eating location was associated with available sociodemographic and lifestyle characteristics (potential confounders in the relationship between eating location and dietary intakes). For the first objective, descriptive statistics (survey-weighted means and robust SEs) were used to estimate the proportions of daily energy, food groups and subgroups, and nutrients contributed by foods reported at lunch. The contribution of food groups and nutrients consumed during lunch were then compared with the estimated mean percent of calories consumed at lunch (Figures 1 and 2). This analysis provided insights about which nutrients and food groups provided proportionally lower and higher contributions to daily intake than would be expected based on quantity of intake (ie, calories) alone.[31,53,54] For the second objective, stratified multivariable linear regression models (run separately for 6- to 13-year-old children vs 14- to 17-year-old children) were used to compare each dependent variable (eg, lunchtime intake of whole fruit, fruit juice, potassium) across eating locations after adjusting for lunchtime energy intake and characteristics associated with lunchtime eating locations in this sample (age in years, ethnicity, and smoking status).

Sampling weights were applied to all analyses to generate nationally representative estimates and to account for the unequal probability of selection and nonresponse. Robust SEs were derived using the 500 sets of bootstrap weights provided by Statistics Canada.[55] Missing data for ethnicity and smoking status were handled by creating additional categories for missing and not applicable data to avoid dropping a large number of cases in covariate-adjusted models. All analyses were conducted using the statistical software Stata version 13, 2013 (LP Stata Corps),[56] with significance defined as P value<0.05 with a Bonferroni adjustment when assessing the significance of multiple comparisons.

RESULTS

Table 1 shows the demographic, socioeconomic, and lifestyle characteristics of children (6 to 17 years) represented by this sample (n=2,540 children) and broken down by respondents' lunchtime eating locations (n=2,344 children). Most children ate lunch at school (±SE) (68%±1.5%), followed by home (21.5%±1.4%) and off-campus locations (10.5%±1.0%). Children who ate lunch at school were significantly younger (mean±SE) (11±0.1) compared with children who ate lunch at home (12.1±0.3) and at off-campus locations (13±0.3).

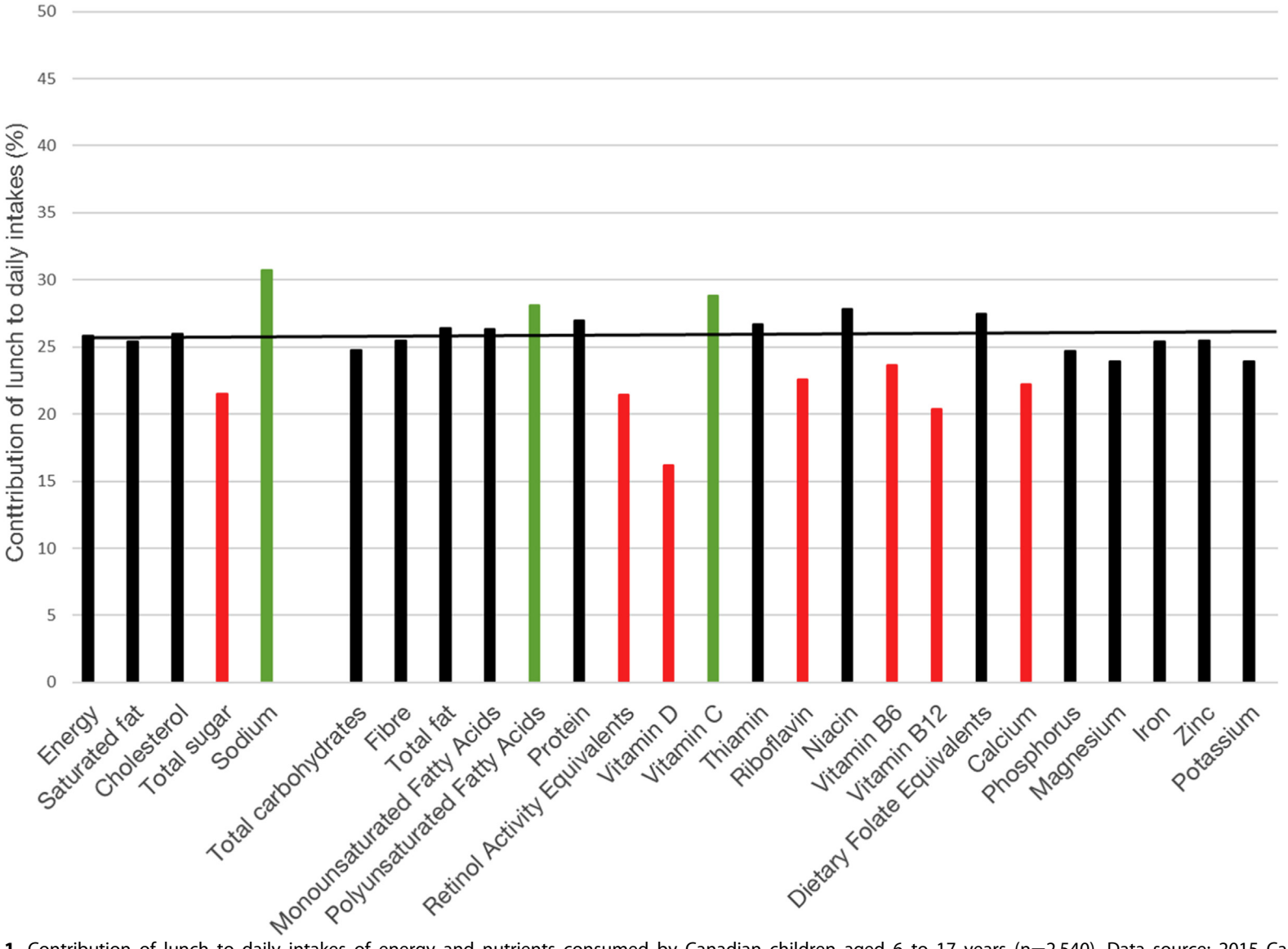

Figure 1. Contribution of lunch to daily intakes of energy and nutrients consumed by Canadian children aged 6 to 17 years (n=2,540). Data source: 2015 Canadian Community Health Survey-Nutrition. Lunch foods provided 25.8% of the total daily calories consumed on school days. The black bars indicate food groups that provided intakes within 2% percentage points of the mean energy contribution. The red bars indicate food groups that provided <23.8% to a full day's intake, whereas the green bars indicate food groups that provided >27.8% to total daily intake.

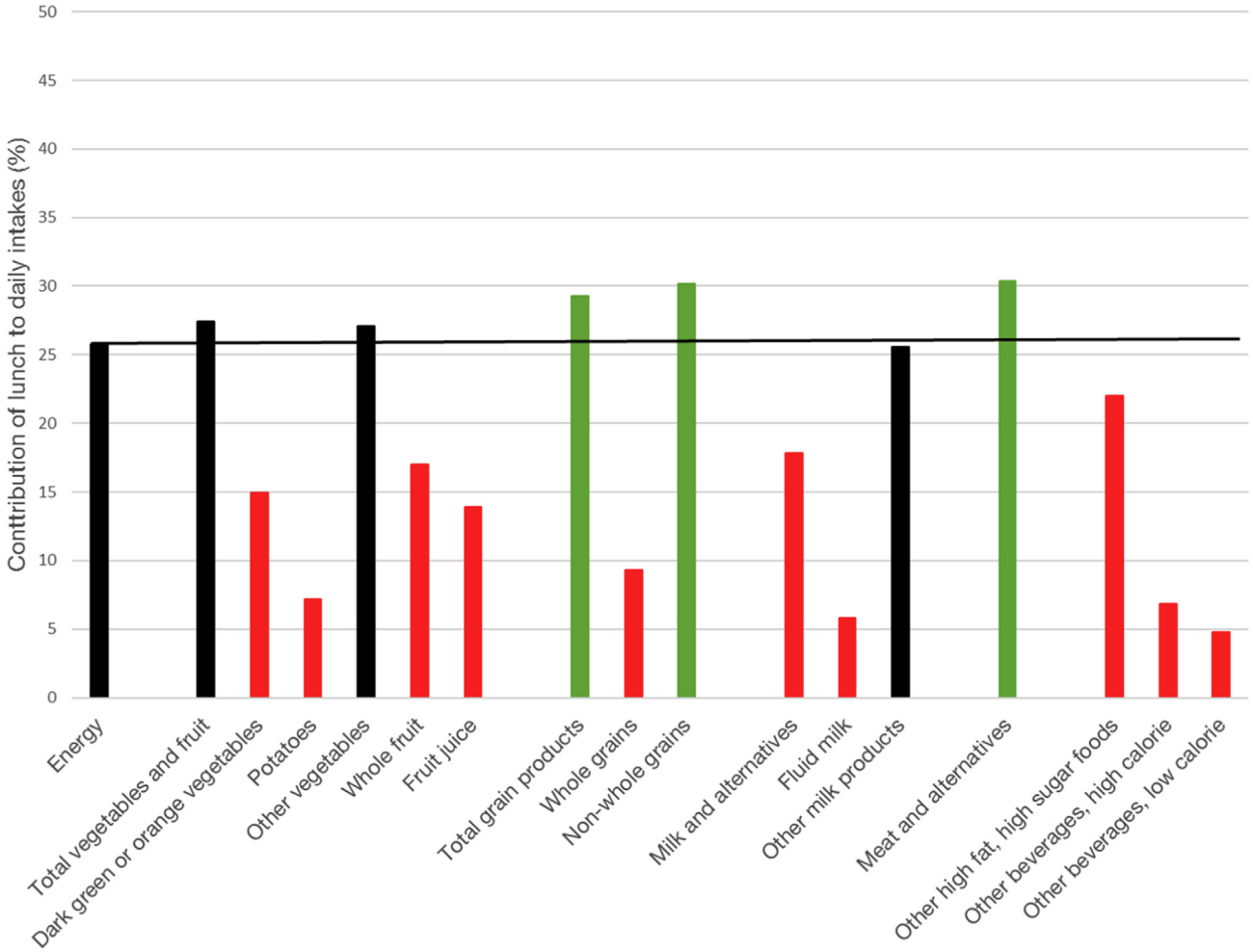

Figure 2. Contribution of lunch to daily intakes of food groups consumed by Canadian children aged 6 to 17 years (n=2,540). Data source: 2015 Canadian Community Health Survey-Nutrition. Lunch foods provided 25.8% of the total daily calories consumed on school days. The black bars indicate food groups that provided intakes within 2% percentage points of the mean energy contribution. The red bars indicate food groups that provided <23.8% to a full day's intake, whereas the green bars indicate food groups that provided >27.8% to total daily intake.

Indeed, just above half of adolescents (14- to 17-year-olds) ate lunch at school, with a higher proportion of adolescents reporting eating lunch either at home or at off-campus locations compared with younger students. A higher proportion of white students (12%±1.2%) ate lunch off-campus compared with nonwhite students (6.6%±1.7%). Older students who smoked were also less likely to eat lunch at school than nonsmokers (exact proportions of smokers and nonsmokers cannot be shown due to Statistics Canada rule regarding reporting minimum cell sizes[47]). Gender, urban vs rural residential location, immigrant status, parental education, food security status, supplement use, and weight status were not associated with lunchtime eating location.

Contributions from Lunch Foods to Total 24-Hour Intakes of Energy, Nutrients, and Food Groups

The mean energy from lunch foods for all children (6 to 17 years) was, on average, 497±11 kcal (mean±SE) representing 25.8% (or ~26%) of the daily calories consumed on school days. Figure 1 provides insight about which nutrients provided proportionally lower or higher contributions to the daily intakes of these nutrients compared with the mean energy contribution (defined here as providing ≥2 percentage points less than or greater than the mean energy percent contribution, respectively). A 2 percentage point difference above and below the mean energy contribution (25.8%) was used to facilitate comparison with a previous study examining school day dietary intakes of Canadian children.[31] Relative to the mean energy contribution, lunch provided proportionally lower contributions of vitamins A and D, riboflavin, vitamins B-6 and B-12, total sugars, and calcium (red bars in Figure 1). In contrast, polyunsaturated fatty acids, vitamin C, and sodium provided proportionally higher contributions compared with the average energy contribution (green bars in Figure 1). Relative to the mean percent energy contribution, lunch provided similar contributions of total carbohydrates, fiber, total fat, saturated fat, monounsaturated fatty acids, cholesterol, protein, thiamin, niacin, dietary folate

Table 1. Sample characteristics and associations between lunchtime eating location and sociodemographic and lifestyle characteristics for Canadian children aged 6 to 17 years, from the 2015 Canadian Community Health Survey—Nutrition[32]

Characteristics	All children (n=2,540[a])	All Eating Locations (n=2,344)[b] School (n=1,550)	Home (n=548)	Off campus (n=246)	*P* value
	←—*Survey-weighted % ± standard error of the mean*—→				
All children	100	68.0±1.5	21.5±1.4	10.5±1.0	—
Age group, y					<0.001
6-13	64.7±1.2	74.8±1.8	18.7±1.7	6.5±0.9	
14-17	35.3±1.2	54.8±2.9	27.0±2.4	18.2±2.3	
Sex					0.831
Male	50.9±1.3	68.8±2.2	21.4±2.0	9.9±1.3	
Female	49.1±1.3	67.3±2.1	21.7±2.0	11.1±1.4	
Location of residence					0.739
Rural	19.5±1.4	69.0±3.6	19.6±2.8	11.4±2.4	
Urban	80.5±1.4	67.8±1.7	22.0±1.6	10.2±1.0	
Ethnicity[c]					0.043
Non−white or European	29.0±1.7	67.6±3.3	25.9±3.2	6.6±1.7	
White or European	71.0±1.7	68.0±1.8	20.0±1.6	12.0±1.2	
Immigrant[d]					0.294
Nonimmigrant	88.6±1.1	69.0±1.6	20.5±1.4	10.6±1.1	
Immigrant	11.4±1.1	62.0±5.2	28.2±4.9	9.8±2.7	
Education[e]					0.457
High school degree or lower	16.6±1.2	64.7±3.9	26.6±3.5	8.7±2.0	
Trade school or college or other nonuniversity diploma or certificate	34.0±1.6	67.3±2.7	22.1±2.4	10.7±1.7	
Some university or higher	49.4±1.7	69.5±2.3	19.6±2.0	10.9±1.6	
Food security status[f]					0.861
Food secure	88.2±1.1	68.7±1.7	21.4±1.5	9.9±1.1	
Food insecure	11.8±1.1	68.2±4.6	20.4±3.9	11.4±2.6	
Current smoker[g]					<0.001
Nonsmoker	47.4±1.3	—	—	—	
Smoker	1.5±0.3	—	—	—	
Not applicable and missing	51.1±1.3	—	—	—	
Supplement use[h]					0.068
No	63.0±1.6	65.5±2.0	23.9±1.8	10.7±1.3	
Yes	37.1±1.6	72.2±2.3	17.6±1.9	10.2±1.5	

(*continued on next page*)

equivalents, phosphorus, iron, zinc, magnesium, and potassium intakes (black bars in Figure 1).

The contributions of lunch foods to daily intakes of food groups and food subgroups are shown in Figure 2. Relative to the mean percent energy contribution (~26% of total daily calories coming from lunch foods), lunch provided proportionally higher contributions of total grain products, non−whole grains, and meat and alternatives (green bars in Figure 2) while providing lower contributions of dark green and orange vegetables, potatoes, whole fruit, fruit juice, whole grains, milk and alternatives, fluid milk, "other" foods and both high- and low-calorie sugary beverages (red bars in Figure 2). Lunchtime contributions were lowest for food subgroups such as potatoes, whole grains, fluid milk, high- and low-calorie beverages (<10% of the total daily intakes of these foods were reported to be

Table 1. Sample characteristics and associations between lunchtime eating location and sociodemographic and lifestyle characteristics for Canadian children aged 6 to 17 years, from the 2015 Canadian Community Health Survey—Nutrition[32] (*continued*)

Characteristics	All children (n=2,540[a])	All Eating Locations (n=2,344)[b] School (n=1,550)	Home (n=548)	Off campus (n=246)	*P* value
	←—*Survey-weighted % ± standard error of the mean*—→				
Weight status[i]					0.927
Not overweight or obese	67.6±1.5	68.6±2.0	21.9±1.9	9.5±1.2	
Overweight or obese	32.4±1.5	69.0±2.7	20.8±2.5	10.2±1.9	

[a]The weighted percentages for the "All children" column sum downward (eg, for the variable age group: 64.7+35.3=100). All children include children who did not report eating lunch (n=153) and children who ate lunch but did not report a lunchtime eating location (n=43).
[b]Lunchtime eating locations are mutually exclusive. The analytical sample for the lunchtime eating location columns are summed sideways because they represent the percentage of children eating lunch in each location within a sociodemographic or lifestyle subgroup. The analytical sample for this analysis is slightly smaller (n=2,344) because children who did not report a lunchtime eating location were excluded from the analysis. Row percentages may not add up to 100% due to rounding error. Associations between lunchtime eating location and respondents' characteristics were tested using Rao-Scott χ^2 tests.
[c]Missing data for n=150 children.
[d]Missing data for n=2 children.
[e]Missing data for n=3 children.
[f]Missing data for n=30 children.
[g]The data reflect prevalence among those aged ≥12 years, who were asked about smoking (data on n=1,359 children). Exact proportions of smokers and nonsmokers across eating locations cannot be shown due to Statistics Canada rule regarding reporting minimum cell sizes.
[h]Missing data for n=1 child.
[i]The data reflect prevalence among children who had their heights and weights measured (data on n=2,071 children). This derived variable classifies children and youth aged 5 to 17 years as obese, overweight, normal, or thin according to the age- and sex-specific body mass index cutoff points as defined by the World Health Organization.

consumed at lunch). For example, only 7% and 5% of total daily calories derived from high- and low-calorie beverages were consumed at lunch.

Intake of Energy, Food Groups, and Nutrients by Lunchtime Eating Location

Table 2 shows the age-stratified and covariate-adjusted mean intakes of specific food groups across lunchtime eating locations. Multivariable linear regression models controlled for lunchtime energy intake, age in years, ethnicity, and smoking status. Among children age 6 to 13 years, those who ate lunch at school reported on average 0.2 additional servings of whole grains compared with their peers who ate lunch off campus. Children who ate lunch at home reported slightly more fluid milk compared with children eating lunch off campus and fewer meat and alternatives compared with their peers who ate at school. However, these differences remained small, in absolute terms (<0.2 servings).

Children aged 14 to 17 years who ate lunch at school reported consuming more total vegetables and fruit (1.4±0.1 vs 0.8±0.1 servings), whole fruit (0.4±0.1 vs 0.1±0.0 servings), fruit juices (0.4±0.1 vs 0.0±0.1 servings), and whole grains (0.4±0.1 vs 0.1±0.0) compared with their peers who ate lunch off campus. Energy from high-calorie beverages was also substantially lower among adolescents who ate lunch at school (8±3 kcal) or home (12±5 kcal) compared with their peers who ate lunch at off-campus locations (63±13 kcal).

In 2015, Canadian children and adolescents reported consuming, on average, between 489 and 640 kcal at lunch (depending on age group and eating location) (Table 3). Among children aged 6 to 13 years, students who ate lunch off campus reported significantly more lunchtime calories compared with students who ate lunch at home. However, among adolescents, no significant differences in lunchtime energy intakes were found across any eating locations. After adjusting for lunchtime energy and other covariates, children aged 6 to 13 years who ate lunch at school reported higher intakes of fiber, magnesium, and iron compared with students who ate lunch off campus, and those who ate a lunch at home reported higher intakes of fiber, vitamin D, and magnesium compared with their peers who ate lunch at off-campus locations. Among children aged 14 to 17 years, students who consumed a lunch at school reported higher intakes of fiber and magnesium and twice as much vitamin C compared with their peers who ate lunch off campus.

DISCUSSION

The objectives of this study were to examine the contributions of lunch foods to whole-day intakes of nutrients and foods of school-aged children and to assess whether lunchtime eating location was associated with nutritional differences in a large, nationally representative sample of Canadian children. Relative to energy, lunch provided proportionally lower contributions of several nutritious food subgroups including dark green and orange vegetables, whole fruit, whole grains, and milk and alternatives and key nutrients of public health concern due to low population-level average intakes such as vitamin D and calcium[9,10] and high intakes of sodium among Canadian children.[13] Adolescents who reported eating lunch at school also reported more total vegetables and fruit, whole fruit, whole grains, and several associated nutrients including fiber, vitamin C, and magnesium compared with students eating off campus. Adolescents who ate lunch at school also consumed on average 55 fewer

Table 2. Energy and covariate-adjusted lunchtime intakes of food groups reported by Canadian children aged 6 to 17 years by lunchtime eating location[a], from the 2015 Canadian Community Health Survey—Nutrition[32]

	Children 6-13 y			Adolescents 14-17 y		
Food groups	School (n=1,099)	Home (n=311)	Off campus (n=99)	School (n=451)	Home (n=237)	Off campus (n=147)
	←——— *Survey-weighted mean ± standard error of the mean* ———→					
2007 *Eating Well with Canada's Food Guide*,[6] recommended foods, servings						
Total vegetables and fruit	1.29±0.06	1.24±0.11	1.43±0.18	1.43±0.12[y]	1.17±0.12[y]	0.81±0.10[z]
Dark green or orange vegetables	0.11±0.01[yz]	0.23±0.05[y]	0.08±0.04[z]	0.21±0.05	0.18±0.04	0.17±0.06
Potatoes	0.05±0.01[y]	0.14±0.03[z]	0.23±0.09[yz]	0.19±0.08	0.09±0.03	0.22±0.06
Other vegetables	0.33±0.03	0.40±0.06	0.38±0.13	0.26±0.03	0.43±0.07	0.36±0.04
Whole fruit	0.43±0.04[y]	0.24±0.05[z]	0.24±0.09[yz]	0.35±0.08[y]	0.24±0.05[y]	0.05±0.03[z]
Fruit juice	0.37±0.03[y]	0.22±0.04[z]	0.49±0.13[yz]	0.42±0.06[y]	0.23±0.06[y]	0.02±0.05[z]
Total grain products	2.06±0.05	1.99±0.08	1.67±0.18	2.13±0.11	2.01±0.14	2.03±0.13
Whole grains	0.28±0.03[y]	0.25±0.05[yz]	0.10±0.06[z]	0.36±0.05[y]	0.11±0.03[z]	0.10±0.04[z]
Non–whole grains	1.77±0.05	1.74±0.09	1.56±0.19	1.77±0.11	1.90±0.14	1.92±0.14
Milk and alternatives	0.42±0.02	0.46±0.04	0.49±0.13	0.37±0.04	0.45±0.07	0.43±0.07
Fluid milk	0.10±0.01[yz]	0.12±0.02[y]	0.04±0.03[z]	0.07±0.03	0.15±0.04	0.11±0.05
Other milk products	0.32±0.02	0.33±0.04	0.44±0.12	0.30±0.04	0.31±0.06	0.32±0.05
Meat and alternatives	0.51±0.03[y]	0.38±0.04[z]	0.37±0.08[yz]	0.79±0.10	0.85±0.16	0.70±0.07
Other foods and beverages not in the food groups of the 2007 *Eating Well with Canada's Food Guide*,[6] kcal						
Other high-fat, high-sugar foods	31±2	31±6	53±22	62±18	56±11	50±10
High-calorie beverages, ≥40 kcal/100 g	7±1	10±3	20±7	8±3[y]	12±5[y]	63±13[z]
Low-calorie beverages, <40 kcal/100 g	3±1	6±2	13±5	6±2	14±5	11±5

[a]Data are weighted to the Canadian population. Differences in mean intakes of food groups across eating locations were examined using multivariable linear regression models adjusting for lunchtime energy intake, age in years, ethnicity, and smoking status. Models were run separately for children aged 6-13 years and for children aged 14-17 years. Because the variable smoking included a large number of missing respondents (marked as "not applicable" if they were under 13 years of age), a "not applicable" category was created to avoid dropping these respondents in the multivariable linear models.

[yz]Means in the same row with different superscript letters are significantly different from each other within each age group (P value <0.05 with Bonferroni adjustment to account for multiple comparisons). For example, among children aged 14-17 years (but not children aged 6-13 years), those who ate lunch at school or home reported fewer calories from high-calorie sugary beverages compared with their peers who ate lunch off campus.

daily calories from high-calorie sugary beverages compared with adolescents eating lunch off campus.

In 2015, Canadian children and adolescents reported consuming, on average, between 489 and 640 kcal at lunch (depending on age group and eating location), falling within the ranges of calories suggested as appropriate by the 2012 School Meal Standards issued by the US Department of Agriculture.[57] In our study, lunch provided on average ~26% of daily energy intake reported. There are no previous Canadian data with which to compare these findings, but these findings appear to be close to estimates from previous studies reporting energy contributions from lunch foods in the United States,[28,58] Sweden,[54] and the United Kingdom[59] (where estimates ranged between 27% and 29% of total daily energy). Another study from Australia reported a slightly lower estimate (23% of daily energy) than the findings reported in our study.[60] It is worth noting that the average energy contribution from lunch foods presented in this study (26%) also includes children who reported consuming no lunch (n=153 children, ~6% of the analytic sample). Estimates would therefore be slightly higher (27.5%) if students reporting consuming no lunch were excluded from the analysis.

Relative to energy, lunch foods provided proportionally lower contributions of many nutritious food subgroups such as dark green and orange vegetables, whole grains, milk and alternatives, and fluid milk. For example, lunch provided only 6% of children's whole-day intake of fluid milk (an important food source of vitamins A and D as well as calcium). Considering that in 2004, more than one third (37%) of children aged 4 to 9 years and up to 61% of boys and 83% of girls aged 10 to 16 years did not meet their recommended daily servings of milk recommended in previous national dietary guidelines,[8] the school lunch context provides an opportunity to increase the

Table 3. Energy and covariate-adjusted lunchtime energy and nutrient intakes from foods reported by Canadian children aged 6 to 17 years by lunchtime eating locations in 2015[a], from the 2015 Canadian Community Health Survey—Nutrition[32]

	Children 6-13 y			Adolescents 14-17 y		
Energy and nutrients	School (n = 1,099)	Home (n = 311)	Off campus (n = 99)	School (n = 451)	Home (n = 237)	Off campus (n = 147)
	←——— *Survey-weighted mean ± standard error of the mean* ———→					
Energy, kcal	489±11[yz]	451±24[y]	584±48[z]	619±31	559±38	640±40
Carbohydrates, g	66.7±0.9	63.7±1.7	69.1±5.1	73.8±2.0	69.7±3.4	74.4±2.2
Fiber, g	4.6±0.1[y]	4.5±0.2[y]	3.4±0.3[z]	5.2±0.2[y]	4.2±0.3[z]	3.6±0.2[z]
Total sugar, g	25.2±0.7	21.8±1.3	29.4±5.0	27.4±1.9	23.1±2.2	30.7±3.4
Total fat, g	16.3±0.3[y]	18.0±0.6[z]	16.0±1.5[yz]	23.8±0.8	23.6±1.0	23.9±0.8
Saturated fat, g	5.7±0.1	6.2±0.4	5.1±0.7	8.3±0.7	8.3±0.6	7.3±0.5
Monounsaturated fatty acids, g	5.6±0.1[y]	6.4±0.2[z]	5.9±0.6[yz]	8.2±0.6	8.3±0.4	9.3±0.5
Polyunsaturated fatty acids, g	3.4±0.1	3.6±0.2	3.6±0.4	5.2±0.4	4.7±0.3	5.4±0.4
Cholesterol, mg	51±2	52±5	44±8	62±6[y]	96±12[z]	82±16[yz]
Protein, g	19.7±0.4	18.9±0.8	17.9±1.9	25.6±1.8	29.8±3.3	24.2±1.2
Retinol activity equivalents	140±10	183±18	121±19	135±18	180±19	154±32
Vitamin D, μg	0.8±0.0[yz]	1.1±0.1[y]	0.6±0.1[z]	0.8±0.1	1.2±0.2	0.7±0.2
Vitamin C, mg	41±2[y]	32±3[z]	48±9[yz]	44±4[y]	39±7[yz]	21±4[z]
Thiamin, mg	0.47±0.01	0.44±0.02	0.42±0.04	0.53±0.03	0.50±0.03	0.53±0.03
Riboflavin, mg	0.42±0.01	0.42±0.01	0.37±0.03	0.47±0.02	0.54±0.03	0.50±0.04
Niacin, mg	9.6±0.2	8.9±0.3	8.7±0.8	12.8±0.9	15.0±2.2	11.8±0.8
Vitamin B-6, mg	0.33±0.01	0.34±0.02	0.32±0.04	0.43±0.02	0.50±0.06	0.38±0.03
Vitamin B-12, μg	0.66±0.03	0.72±0.05	0.57±0.10	1.10±0.20	1.06±0.09	1.01±0.13
Dietary folate equivalents	132±4	142±7	124±13	132±8	157±12	147±11
Calcium, mg	209±6	245±15	222±46	235±16	264±22	219±21
Phosphorus, mg	317±6	336±11	296±32	394±15	419±21	361±16
Magnesium, mg	65±1[y]	65±2[y]	55±3[z]	82±2[y]	79±3[yz]	65±5[z]
Iron, mg	3.3±0.1[y]	3.3±0.1[yz]	2.8±0.2[z]	3.9±0.2	3.8±0.2	3.6±0.1
Zinc, mg	2.4±0.1	2.5±0.1	2.1±0.3	3.4±0.4	3.3±0.2	3.1±0.2
Sodium, mg	856±18	846±32	819±83	1019±58	969±48	1072±60
Potassium, mg	603±12	599±26	591±45	730±34	692±32	617±41

[a]Data are weighted to the Canadian population. Models were run separately for children aged 6-13 years and for children aged 14-17 years. Differences in mean energy intake across eating locations were tested using multivariable linear regression models adjusting for age (in years), ethnicity, and smoking status. For all other nutrients, differences in amounts across eating locations were tested using multivariable linear regression models adjusting for lunchtime energy intake, age, ethnicity, and smoking status. Because the variable smoking included a large number of missing respondents (marked as "not applicable" if they were under 13 years of age), a separate answer category ("not applicable") in the coding scheme was created to avoid dropping these respondents in the multivariable linear models.

[yz]Means in the same row with different superscript letters are significantly different from each other within each age group (P value <0.05 with Bonferroni adjustment to account for multiple comparisons). For example, among children aged 6-13 years (but not children aged 14-17 years) those who ate lunch at school reported higher intakes of iron than their peers who ate lunch off campus.

consumption of fluid milk or milk alternatives, particularly among Canadian adolescents who are at the highest risk of having inadequate intakes of vitamin A and calcium.[9] These findings are particularly relevant given that Canada's newest food guide released in 2019 no longer explicitly emphasizes a milk and alternatives food group and no longer provides specific guidance for children or adolescents about frequency, types, or quantity of calcium- or vitamin D–rich foods to consume as part of a nutritionally adequate dietary pattern.[61] Given recent evidence that the dietary pattern depicted in the 2019 Canada's Food Guide Snapshot appears to be inadequate for meeting the calcium and vitamin D needs for the majority of female children and adolescents (and over a quarter of adolescent males for vitamin D),[62] these results further

suggest a strong need for additional guidance alongside Canada's Food Guide for planning nutritionally adequate schools meals.

The findings presented here are in line with an Australian study reporting that foods eaten at school provide (relative to the mean energy contribution from all lunch foods combined) lower contributions of fluid milk and dark green and orange vegetables.[63] Both Canada[64-66] and Australia[63] do not have national school lunch programs. Instead, funding for Canadian school lunch programs (if they exist at all) comes from provincial, municipal, and nongovernmental organizations, parents, corporate donations, and local fundraising.[65,67] In both Canada[40] and Australia,[63] the majority of children bring a home-packed lunch to school. In contrast, most US schools offer school meals at a low price or at no cost,[68] and school meals offered through the NSLP are required to offer both vegetables and fruit as well as low-fat or fat-free fluid milk daily for lunch.[69] As a result, national-level analyses from US samples suggest that the lunch meal appears to provide relatively higher contributions of vitamins A and D, calcium, and magnesium[27,58] compared with Canadian lunchtime contributions for these nutrients. Between-country differences could reflect differences in patterns of foods brought and consumed at lunchtime by children across countries and differences in access to school meal and milk programs.

Our findings indicate that most Canadian children aged 6 to 17 years (68%) ate lunch at school on a given school day, and homes were the second most common eating location. Unfortunately, the CCHS 2015 did not ask respondents explicit questions regarding where lunch foods were procured or prepared, so it not possible to determine what proportion of children eating lunch at school ate home-packed lunches vs lunch meals provided by or purchased at schools. It was also not possible to determine the specific sources where students obtained foods that they consumed in schools—for example, from locally operated school meal programs, à la carte cafeteria purchases, fundraisers, vending machines, or other nearby food vendors vs food brought from home. It is worth noting that among the children who reported eating lunch at school, 76% reported eating in school in a location other than the school cafeteria, and only 24% of children reported eating lunch in the school cafeteria. These differences are notable when considering the Canadian meal experience, where students commonly eat in classroom settings as many schools were historically built without cafeterias or lunchrooms.[70] Improved school food policies and appropriate, nutritionally adequate guidance for planning school lunch menus are now needed to advance Canadian children's nutritional outcomes and to narrow socioeconomic inequalities reported in dietary quality during school hours, where in 2015 the reported school-hour dietary quality for children from food-insecure households was found to lag behind that of food-secure children.[14]

In this national sample, differences in dietary intakes were found according to eating location. Among older children (14 to 17 years old), eating lunch at school was associated with more mean servings of total vegetables and fruit and whole fruit and fewer calories from sugary beverages compared with an off-campus lunch. This highlights the importance of considering children's age when examining the association between contextual factors such as eating location and food source on children's dietary intakes. Previous Canadian studies have similarly reported that adolescents who either obtained food from[39,40] or eat in off-campus locations[38] were more likely to have higher intakes of minimally nutritious foods and beverages compared with their peers bringing in lunches from home or eating their lunch at school. These findings could reflect greater autonomy in dietary choices and purchasing behaviors as children transition into adolescence or greater exposure to food retailers and fast-food restaurants nearby Canadian secondary schools.[71,72]

Strengths of this study included the large, nationally representative sample and the use of detailed dietary data, including the location of consumption, which is novel in the Canadian context. However, some limitations should be acknowledged. First, there are inherent issues when using self-reported dietary data, such as recall error, inaccurate estimation of portion size, and systematic error in dietary reporting to produce socially desirable answers. The accuracy of dietary recall methods among children in the school day context can vary widely depending on children's age and interview conditions (eg, the retention period, type of prompting, and use [or not] of parental assistance).[73] The issue of underreporting would not likely bias current analyses unless the reporting biases differed across eating occasions or eating locations (for example, lower accuracy of reporting among children eating lunch at school vs those eating lunch at off-campus locations). It is possible that both the recall and social desirability biases could be distributed differently across meal occasions among younger children (6 to 11 years) who completed the recall with parental assistance.[74] The presence of a parent could have been a selective confounder. The parent would know what was in a home-packed lunch, but the child might have been reluctant to report that he or she had not eaten part of the lunch. Second, analyses likely included some days when some children did not attend school (eg, professional development days for teachers) because the CCHS did not include a question asking respondents whether this was a school day. However, we limited the potential to include such days by eliminating any reporting days that occurred on a Canadian national holiday or possible school break. Third, we did not assess whether differences in dietary intakes observed on school days were similarly observed on weekend days (when children are not in school), so it is not possible to determine whether these differences are solely due to the school context. This could reflect specific sociocultural patterns in the types of foods typically eaten at lunch compared with the remainder of the day (regardless of whether lunch is consumed on a weekday or a weekend day) because our analysis focused on school days.

CONCLUSIONS

Foods consumed for lunch on school days represent, on average, just over one quarter of the total daily calories reported from foods and beverages. Relative to energy, lunch contributed to lower intakes of many nutritious foods such as dark green and orange vegetables, whole fruit, whole grains, and fluid milk and consequently contributed to lower intakes of key nutrients of concern for children including vitamins A, D, B-6, B-12; riboflavin; and calcium. These findings therefore add to recent calls for Canada's national dietary guidance to provide further direction appropriate for school lunch menu planners, dietitians, and parents regarding strategies for supporting dietary patterns that provide adequate amounts of key nutrients including calcium and vitamin D.[62]

Findings may also suggest that recent school food policies aiming to reduce the sales of minimally nutritious foods at school have influenced students' dietary outcomes. Overall, Canadian children reported consuming proportionally fewer calories from sugar-sweetened beverages and other high-fat, high-sugar foods during lunch on school days compared with Canadian children in 2004.[31] Yet this study also highlights challenges for Canadian adolescents consuming lunch from off-campus locations during school hours. Among adolescents, eating lunch at school was associated with fewer calories from high-calorie beverages and more vegetables and fruit, whole fruit, fruit juices, and whole grains (along with higher intakes of beneficial nutrients such as fiber, vitamin C, magnesium, and potassium). As Canadian policy makers now consider developing a national school meal program,[75] programmatic strategies should continue to consider avenues to ensure access to nutritious foods for all children, including foods identified here as underrepresented at lunchtime including dark green and orange vegetables, whole fruit, whole grains, and foods rich in calcium and vitamin D such as milk and alternatives.

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AUTHOR INFORMATION

C. N. Tugault-Lafleur is a postdoctoral fellow, School of Population and Public Health and the BC Children's Hospital Research Institute, The University of British Columbia, Vancouver, British Columbia, Canada. J. L. Black is an associate professor, Food, Nutrition and Health Program, The University of British Columbia, Vancouver, British Columbia, Canada.

Address correspondence to: Claire N. Tugault-Lafleur, PhD, RD, BC Children's Hospital Research Institute, 4480 Oak St, Room F514, Shaughnessy Building, Vancouver, BC, Canada V6H 3V4. E-mail: Claire.tugault-lafleur@ubc.ca

STATEMENT OF POTENTIAL CONFLICT OF INTEREST

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AUTHOR CONTRIBUTIONS

Both authors designed the study. C. N. Tugault-Lafleur prepared the data for analyses and conducted analyses. J. L. Black contributed to interpretation of results. C. N. Tugault-Lafleur wrote the first draft with contributions from J. L. Black. Both authors reviewed and commented on subsequent drafts of the manuscript.