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Examining school day dietary intakes among Canadian children

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Abstract

Understanding how dietary intakes vary over the course of the school day can help inform targeted school-based interventions, but little is known about the distribution or determinants of school day dietary intakes in Canada. This study examined differences between school hour and non-school hour dietary intakes and assessed demographic and socio-economic correlates of school hour diet quality among Canadian children. Nationally representative data from the Canadian Community Health Survey were analyzed using 24-h dietary recalls falling on school days in 2004 ($n = 4827$). Differences in nutrient and food group densities during and outside of school hours and differences in School Healthy Eating Index (School-HEI) scores across socio-demographic characteristics were examined using survey-weighted, linear regression models. Children reported consuming, on average, 746 kcal during school hours (1/3 of their daily energy intakes). Vitamin A, D, B12, calcium, and dairy products densities were at least 20% lower during school hours compared to non-school hours. Differences in School-HEI scores were poorly explained by socio-demographic factors, although age and province of residence emerged as significant correlates. The school context provides an important opportunity to promote healthy eating, particularly among adolescents who have the poorest school hour dietary practices. The nutritional profile of foods consumed at school could be potentially improved with increased intake of dairy products, thereby increasing intakes of protein, vitamin A, D, calcium and magnesium.

Key words: dietary intakes, diet quality, children, temporal analysis, school day, Canada

Introduction

In Canada, like other affluent countries (Serra-Majem et al. 2004, Vereecken et al. 2005, Wong et al. 2014, Gu and Tucker 2017), evidence suggests that the majority of children and adolescents do not meet national dietary guidelines for either vegetables and fruit or dairy products (Garriguet 2006), and overall diet quality is poor (Garriguet 2009). Schools are a proposed site for action to reduce health inequities since they can reach a large number of children from diverse socio-economic backgrounds (Pérez-Rodrigo and Aranceta 2001, Lee and Gortmaker 2012) and most children consume one or more meals at school on week days. Leading national (Pan-Canadian Joint Consortium for School Health 2016) and international agencies (World Health Organisation 1997, 2016) have long acknowledged the importance of promoting health and improving dietary outcomes through schools.

Understanding the nutritional impact of foods consumed during school hours relative to the whole school day can help inform the design of effective school-based interventions by identifying salient areas of concern and potentially modifiable loci for intervention at school. Yet, few national studies in Canada or elsewhere have examined the dietary contributions of foods consumed at school (Nelson et al. 2007, Prynne et al. 2011, Stevens and Nelson 2011, Osowski et al. 2015). From the modest available literature, it is estimated that in Sweden, the mean caloric contribution from school lunches was 27%, with most macro- and micronutrients providing similar (27% or higher) contributions to daily intakes (Osowski et al. 2015). In the U.K., one study examining dietary contributions of nutrients from lunch among older adolescents reported relatively lower intakes of vitamin C, folate, calcium and iron compared to the mean caloric contribution (Prynne et al. 2011). In Canada, a limited number of studies from regional,

context-specific samples have examined in-school dietary intakes suggesting overall poor dietary practices (Woodruff et al. 2010, Taylor et al. 2012, Ahmadi et al. 2015, Neilson et al. 2016), but no study has assessed the dietary contributions from foods eaten at school in relation to whole day intakes or compared nutrient intake patterns between school and non-school hours.

Multiple factors operate at different scales (at the individual, household and broader community and regional level) to influence the food practices of children (Bronfenbrenner 1979, Story et al. 2002). At the individual-level, U.S. and Canadian literature has shown that age is a well-established determinant of consumption practices, with diet quality declining as children age (Larson et al. 2007, Riediger et al. 2007, Garriguet 2009). Previous international (Golley et al. 2011) and Canadian (Riediger et al. 2007, Garriguet 2009) research also suggests that household socio-economic status (SES) (e.g. parental income, education, food security status) is positively associated with older children's dietary quality. For example, national-level Canadian analyses indicate that adolescents coming from households with higher education and income reported higher daily frequency of fruit and vegetable consumption (Riediger et al. 2007). Moreover, adolescents living in food insecure households are more likely to report poorer quality diets (Kirkpatrick and Tarasuk 2008). However, Canadian studies drawing from smaller, regional samples report weak associations about the role of SES in shaping dietary outcomes for younger children (Attorp et al. 2014, Ahmadi et al. 2015). No study has compared in-school dietary outcomes across demographic and socio-economic characteristics in a large nationally representative sample of Canadian children. To assess whether targeted interventions have the potential to improve in-school dietary intakes among Canadian children, it is important to explore whether socioeconomic inequities in dietary outcomes are substantial in the school context.

At the regional level, all 10 Canadian provinces have issued school-based food and nutrition guidelines, policies and initiatives in the past decade (Browning et al. 2013, School Breakfast Club of Canada 2015, Dietitians of Canada 2016, Godin et al. 2017). Yet no study to date has described national-level school food practices of Canadian children preceding these school-based policy changes. Moreover, wide variation in provincial school nutrition policies and guidelines (Godin et al. 2017), funding and capacity for school meals programs (Jeffery and Leo 2007) has been reported. Insights about national dietary practices and whether dietary quality differs by province is needed to provide foundational knowledge for local efforts.

The present study therefore addresses gaps in the literature by: 1) examining differences between school hour and non-school hour dietary intakes; and 2) assessing demographic and socio-economic correlates of school hour diet quality among Canadian children.

Methods

Data source

Nationally representative data were obtained from the 2004 Canadian Community Health Survey Cycle (CCHS) 2.2 which used a complex multistage stratified cluster sample nationally representative for age, sex, geography and socio-economic status ($n = 35,107$; response rate, 76.5%) (Health Canada 2006, Statistics Canada 2008). The survey targeted residents of all ages living in private dwellings in Canada's 10 provinces. A computer-assisted 24-hour dietary recall method asked respondents about all foods and beverages consumed in the past 24 hours, including types and amounts of foods consumed, eating occasion (e.g. breakfast, lunch, snack) and time of consumption (Health Canada 2006). The approach used for the 24-hr recall was

based on the United States Department of Agriculture Automated Multiple-Pass Method (AMPM). The AMPM is an automated questionnaire that guides the interviewer through a series of questions and probes to maximize the interviewees' opportunities for remembering and reporting foods eaten in the previous 24 hours (United States Department of Agriculture 2016). Although a second telephone-administered dietary recall was performed in a sub-sample of participants, this study used only the first interviewer-administered 24-hour recall. Interviews for children aged 6 to 11 years were conducted with parental/caregiver assistance, while children aged 12 years and above were interviewed alone. All foods and beverages were analyzed using the food composition data from the 2001b version of the Canadian Nutrient File database (Statistics Canada 2008). Owing to the nature of the study design (secondary data analysis) and the lack of personal identifiers, the present study was exempted by the Research Ethics Board of the University of British Columbia.

Analyses included respondents ($n = 4945$) age 6 to 17 years who reported attending school full-time and who completed a valid first 24-hour dietary recall which fell on a Canadian week day (Monday through Friday) but excluded recalls which fell on the last week of December or the first week of January (typical Christmas/winter breaks), other statutory/national holidays or during summer months (June 21 to September 7). Diet recalls with daily energy intakes reported either above or below 3 standard deviations from the mean (>6365 kcal/d or <486 kcal/d) were considered extreme outliers and excluded ($n = 28$ children). Children who did not report consuming any energy during school hours or outside of school hours were also excluded from these analyses ($n = 90$). The final analytical sample consisted of 4827 children.

Measures

Foods reported to be consumed between 9:00 to 14:00 were classified as those consumed during school hours. Time of consumption was used to classify foods and beverages as either falling within or outside of school hours as the CCHS 2.2 did not ask respondents to state where the food or beverage was consumed (Statistics Canada 2008). Since public school hours vary by Canadian jurisdictions (Government of Canada 2009), it was not possible to determine the exact time window which would include school hours for all Canadian children. The 9:00 to 14:00 time frame was chosen since it was most likely to include school hours for the majority of Canadian children and this study aimed to capture dietary intakes occurring within school food environments. Sensitivity analyses confirmed that widening this time period by 30 minute increments did not result in substantial increases in energy intake up until 15:00 when Canadian schools are often at or near closing time and hence a substantial number of children are likely to be consuming food at or en route home.¹

Dietary intake variables included the amounts of energy, nutrients and food groups consumed during, and outside of school hours on school days, and the relative contributions (percentage intake) from school hours relative to total daily intakes (TDIs). To address the multidimensional nature of diet quality, we adapted a validated measure of diet quality for Canadians (the Canadian Healthy Eating Index (C-HEI) (Garriguet 2009)). The C-HEI is based on the U.S. 2005 HEI (Guenther et al. 2008), with modifications to reflect how well diets comply with Canadian dietary guidance from the most recent 2007 version of Canada's Food Guide (CFG) (Health Canada 2007). The C-HEI contains 11 components (maximum score = 100 points), reflecting both the adequacy and moderation dimensions of a healthy diet. The C-HEI

¹ See Supplemental Table S1.

components are based on *daily* intake standards (e.g. 2 servings of milk and alternatives/day recommended for children age 6-8 years) to provide sub-scores for each of its components.

To compute C-HEI scores adapted specifically for school hours, the scoring criteria for each component were scaled to reflect the mean energy contribution from school hours (9:00-14:00) to daily energy intake (see Table 1 for a list of the components of the School HEI (School-HEI)). The food group components' scoring criteria for the School-HEI were scaled to reflect one third of the total daily servings recommended for each age and sex group, based on preliminary analyses confirming that foods consumed during school hours provided, on average, 1/3 of the daily calories consumed. For example, the scoring criterion for total fruit and vegetables for earning maximum points on the sub-score for children age 6-8 years (whose recommended daily intake is 5 servings/day) was 1.67 servings. This approach is similar to the standards set by U.S. National School Lunch Program which uses 1/3 of the 1989 Recommended Daily Allowances for energy, protein, iron, calcium, vitamin A and C as minimal nutritional quality criteria for school meals (United States Department of Agriculture 2012). A similar approach has also been used in previous Canadian studies which used 1/3 of the daily recommended intakes as nutritional criteria for meals consumed at school (Taylor et al. 2012, Neilson et al. 2016). For the C-HEI, diet quality categories have been previously established (Garriguet 2009). A 'high quality diet' is defined as above 80 points; a diet 'requiring improvement' falls within 50-80 points and a 'poor quality diet' is <50 points. Similar to the C-HEI, scores for the School-HEI range from 0 to 100 points, so the same categories were used for interpretation of School-HEI scores.

To compare our results with another composite measure of diet quality, findings were compared with Nutrient Rich Food (NRF) index scores (Fulgoni et al. 2009). The NRF index is a composite nutrient-based diet quality indicator which calculates a score based on the sum of the percent consumed of the reference U.S. daily values for nutrients to encourage (i.e. protein, fibre, vitamin A, vitamin C, calcium, iron, magnesium, and potassium) from which is subtracted the sum of the percent consumed of reference daily values for nutrients to limit (saturated fat and sodium), expressed per 100 kcal (Fulgoni et al. 2009).

Statistical analyses

Descriptive statistics (survey-weighted means and robust standard errors of the mean (SEM)) were used to obtain average absolute dietary intakes and dietary contributions (in percent) from school hours relative to whole day intakes. Because energy intake during school hours was significantly lower than non-school hours, densities (nutrient and food group amounts per 1,000 kcal) were calculated for foods consumed during school hours and during non-school hours. Survey-weighted simple linear models then tested for significant differences in nutrient and food group densities across time period using a dichotomous variable for school hours as the independent variable. Since nutrient intakes are measured in different units (e.g. carbohydrate in grams vs. vitamin C in milligrams), a common unit of comparison was needed to compare the magnitude of the differences between school and non-school hours. Results were therefore expressed as percent differences from school hours relative to non-school hours. This was calculated by taking the estimated mean difference in nutrient or food group density between time periods divided by the nutrient or food group density during non-school hours. The difference was then multiplied by 100 to express this difference in relative terms.

To examine differences in school hour diet quality by select demographic and socio-economic characteristics, simple linear regression models were used with a Bonferroni adjustment to account for multiple comparisons in regression models with multiple dummy variables (e.g. province of residence). These models did not include an energy term since the algorithm for the C-HEI and School-HEI already computes scores based on age and sex specific food and nutrient requirements. Since age group emerged as a significant predictor of school hour diet quality, we also estimated mean School-HEI total and sub-component scores (for example, School-HEI sub-scores for whole fruit) and NRF 8.2 scores by age group.

Missing data were handled with case-wise deletion. Therefore, analytical sample sizes varied slightly across analyses. Sampling weights were applied to all analyses to generate nationally representative estimates. The 500 sets of bootstrap weights supplied by Statistics Canada were used to derive robust standard errors (Statistics Canada 2008). All analyses were conducted using Stata 13 (LP Stata Corp, Texas, USA), with significance defined as p value < 0.05 (Bonferroni-adjusted p value $< 0.05/n$, with n being the number of comparisons).

Results

Table 2 provides the sample characteristics of Canadian children age 6-17 years whose first 24-h dietary recall fell on a Canadian school day in 2004. Young children (6-8 years) comprised approximately a quarter of all children surveyed, 43% were age 9-13 years and close to one third were older adolescents (14-17 years). Fifty-one percent of participants were male. The majority of children identified themselves as having European ethnicity, lived in urban areas, and had at least one household member who had completed some post-secondary education (college or

university). Close to 9% of children were classified as 'food insecure' while slightly over 1/3 lived in a low income household.

School hour dietary intakes and their relative contribution to total daily intakes

Mean school hour dietary intakes and their relative contributions to whole school day dietary intakes are shown in Table 3. The mean energy from foods and beverages consumed during school hours was 746 kcal, representing 33.6% of the total daily energy consumed on school days. The relative dietary contributions of total carbohydrates, fibre, total sugars, total fats and saturated fats were similar to the energy contribution. However, intakes of polyunsaturated fatty acids, linoleic and linolenic fatty acids provided higher contributions during school hours (defined as providing $\geq 36\%$ of their TDIs) while contributions from protein and cholesterol were lower (defined as providing $\leq 31\%$ of their TDIs). Foods consumed during school hours provided lower contributions of vitamin A, D, riboflavin, B₆, B₁₂, calcium, phosphorus, magnesium, zinc and potassium (all $\leq 31\%$ of their TDIs) but higher contribution of vitamin C (38% of TDI).

On average, children consumed 2.5 servings of grain products, 1.5 servings of vegetables and fruit (including fruit juice), and 0.6 servings each of milk products and meat and alternatives during school hours. Children also consumed on average 175 kcal from 'other' foods (foods not part of the four core food groups from the CFG and typically minimally nutritious foods such as candy bars and salty packaged snacks) during school hours, providing 37% of total daily calories from minimally nutritious foods. The contribution from grain products was higher (37% of TDI) whereas the contribution of milk products was lower (25% of TDI) during school hours.

Comparing dietary intakes during school and non-school hours

Mean nutrient and food group densities (amounts per 1,000 kcal) for both school and non-school hours, and relative percent differences between school and non-school hours are shown in Table 4. Statistically significant differences were found in nutrient and food group densities between school and non-school hours for the majority of dietary outcomes. However, the magnitude of these differences was often small ($\leq 20\%$ relative difference between school hours and non-school hours). Larger differences ($>20\%$) were observed for cholesterol, vitamin A, D, B₁₂, calcium, and milk product densities, which were all lower during school hours, while vitamin C density was higher during school hours. Vitamin D and milk product densities emerged as those with largest relative percent differences between time periods (54% and 33% lower during school hours, respectively). For milk products, this translated into an estimated difference of 0.4 servings/1,000 kcal consumed between time periods.

Demographic and SES correlates of school hour diet quality

Table 5 shows the results from linear regression analyses testing associations between school hour diet quality with select demographic and socio-economic characteristics. Age, household-level education and province of residence were associated with statistically significant differences in school hour diet quality. Children age 6-8 years had, on average, school hour diet quality scores which were 9 points higher than 14-17 year olds. Children in Quebec had, on average School-HEI scores which were at least 5 points or higher compared to children living in Newfoundland & Labrador, Nova Scotia, Ontario and Manitoba. No differences in School-HEI scores were observed across any of the other demographic or socio-economic characteristics (sex, ethnicity, residential location, income, or food security status). Moreover, none of these

models had a large (>0.05) coefficient of determination (R^2), suggesting that with the exception of age, none of the other characteristics examined explained a substantial proportion of the variation in school hour diet quality.

Table 6 shows total and sub-scores for the School-HEI, stratified by age group. The average total School-HEI score was 53.4 points, suggesting that mean diet quality during school hours for Canadian children ‘required improvement’ (HEI 50-80 points). School-HEI scores (means $\pm$ SEMs) by age group ranged from 58 ± 0.7 points (children age 6-8 years) to 49 ± 0.6 points (children age 14-17 years) and were significantly different between young children (6-8 years) vs. pre-adolescents (9-14 years) and adolescents (14-17 years). Children age 6-13 years had significantly higher School-HEI scores for total vegetables and fruit, whole fruit, and meat and alternatives compared to children age 14-17 years. Compared to children age 9-17 years, children age 6-8 years also had higher School-HEI sub-scores for milk products. Compared to children age 14-17 years, children age 6-8 years had significantly higher School-HEI sub-scores for dark green and orange vegetables (although these sub-scores were, in absolute terms, low for all age groups), and percent energy from minimally nutritious foods. NRF 8.2 scores declined significantly with age, with children age 6-8 years having significantly higher NRF 8.2 scores compared to children age 9-17 years.

Discussion

Findings revealed that in 2004, foods and beverages consumed by Canadian children between 9:00 to 14:00 provided close to one third of the total energy consumed on a school day. While relative intakes of most nutrients and food groups were proportional to the contribution to energy intake ($\sim 33\%$), dietary intakes from milk products and key nutrients found in milk

(protein, vitamin A, D, B₁₂, calcium) provided smaller contributions to TDIs. Moreover, nutrient densities for these outcomes were significantly lower during school hours. Finally, only age group was a substantive predictor of school hour diet quality (although school hour diet quality required improvement for all age groups).

To our knowledge, this is the first Canadian study to compare dietary intakes between school hours and non-school hours on school days and few other studies are available for comparison. In a sample of Swedish children in grade two and five, the mean energy contribution of school lunches was 27% of daily intake, and the mean nutrient contributions were either proportional or higher than the caloric contribution, with the exception of carbohydrates which provided a relatively smaller contribution (24%). In contrast, Canadian findings here suggest that total carbohydrates (and grain products) represented a similar or higher dietary contribution relative to the mean energy contribution. In the U.K., Nelson and colleagues compared the lunch-time contributions from foods across school meal participation status and between elementary and secondary school students (Nelson et al. 2007). In contrast to our study, the contributions from protein and calcium were close to the energy contribution regardless of age or school meal participation status. Another U.K. study comparing the lunch-time contributions from foods by school meal participation status revealed the dietary contribution for the majority of nutrients was similar to the energy contributions with the exceptions of vitamin C (lower for both boys and girls regardless of school meal participation status), vitamin A (lower among girls eating a home-packed lunch), and folate (lower among boys, regardless of school meal participation status) (Prynne et al. 2011). Although it is not possible to directly compare our findings to these studies due to methodological differences on how dietary contributions were defined (contributions from the lunch meal vs. all foods consumed during school hours), our

findings suggest important nutritional quality differences between time periods in Canada. Most notably, substantially lower intakes were reported for key nutrients such as vitamin A, D, calcium, phosphorus and magnesium during school hours compared to non-school hours. Between-country differences could reflect differences in patterns of foods consumed at lunch-time by school-age children and differences in access to school meal and milk programs.

Canada remains the only G8 country without a national school meal program (McKenna 2010, Godin et al. 2017), and some advocates have proposed a federally funded school meal program (Jeffery and Leo 2007, Kimmett 2011, Anonymous 2013, Hyslop 2014, Collier 2015). Moreover, wide variation in provincial and local-level school nutrition policies and guidelines (Godin et al. 2017) and funding and capacity for school meal programs (Jeffery and Leo 2007) has been reported. In the U.S., the beneficial effects of children's participation in universal school meal programs on dietary outcomes are well-established (Clark and Fox 2009, Hanson and Olson 2013). Understanding where Canadian children acquire foods from during school hours and whether lunch-time food source is associated with dietary quality is important for evaluating policy decisions and informing debates about school meal programs for Canadian children. Next steps in our research will explore these associations using national dietary data.

Our findings indicate that specific aspects of in-school dietary patterns could be improved. Overall, there was substantial room for improvement in the school hour dietary intakes of Canadian children given that the mean School-HEI score for Canadian children was 53 points out of a possible maximum score of 100 points. Similar to previous U.S. studies characterizing the quality of foods consumed in the school context (Cullen et al. 2011, Au et al. 2016), the lowest School-HEI sub-scores (for all age groups) were for green and orange vegetables, whole

fruit, whole grains and milk products. Moreover, we also found that vitamin A, D, B₁₂, calcium, and milk products densities were at least 20% lower during school hours compared to non-school hours. These findings align with other Canadian studies reporting low intakes of milk products at school (Woodruff et al. 2010) and low frequency of milk consumption during school hours (Ahmadi et al. 2015, Velazquez et al. 2015). Considering that in 2004, more than a third (37%) of children aged 4-9 years and up to 61% of boys and 83% of girls age 10-16 years did not meet their recommended daily servings of milk (Garriguet 2006), the school context represents an opportunity to increase intakes of milk products among Canadian children and youth. Hence, Canadian school-based nutrition policies and program should focus on improving access to and affordability of healthy food choices (particularly vegetables, whole fruit, whole grains and milk products) in Canadian schools.

Age was a meaningful predictor of diet quality during school hours, with mean School-HEI scores declining as children aged. Younger children (age 6-8 years) also reported proportionally fewer calories from minimally nutritious foods compared to adolescents. These findings align with other studies reporting declining diet quality as children age (Garriguet 2006, 2009, Larson et al. 2007, Riediger et al. 2007, Velazquez et al. 2015). No differences in School-HEI scores were reported across ethnicity, residential location, household-level income and food security status. Although the association between School-HEI scores and parental education was significant ($p=0.04$), the low R^2 (<1%) suggests it did not explain a meaningful proportion of variation in-school hour diet quality. The lack of association between household income and school hour diet quality was not surprising. A large repeat cross-sectional study among U.S. children and adolescents reported no association between parental income and U.S. HEI-2010 scores over a 13 year period (Gu and Tucker 2017). Similarly, the associations between food

insecurity and diet quality among young children in Canada remain unclear. Food security is thought to impact diet quality by limiting access to resources to purchase more expensive food items such as fresh produce and dairy products (Dachner et al. 2010). Previous analyses using the CCHS 2.2 have confirmed differences in nutritional adequacy between food secure and food insecure households, but only among adolescents and not younger children (Kirkpatrick and Tarasuk 2008). It is possible that the effect of food insecurity on household members may differ whereby parents compromise their own intake to buffer younger children (Glanville and McIntyre 2006). Children living in food insecure households may also have access to local school-based meal programs in some regions. However CCHS 2.2 did not include any questions on children's participation in a local school meal program which could have allowed us to examine their potentially buffering effect.

Strengths of this study included its large, nationally representative sample and the use of a composite diet quality indicator to capture the multidimensional nature of diet quality in the specific context of school hours. However, some limitations should be acknowledged. First, 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 socio-cultural patterns in the types of foods typically eaten at lunch compared to the remainder of the day (regardless of whether lunch is consumed on a week day or a weekend day) since our analysis focused on school days. Another limitation was the use of self-reported data. The accuracy of dietary recall methods among children can vary widely depending on children's age, interview conditions (e.g. the retention period, type of prompting, and use (or not) of parental assistance) (Sharman et al. 2016, Tugault-Lafleur et al. 2017). Studies conducted among children

have also confirmed substantial under-reporting of energy intake (McPherson et al. 2000, Burrows et al. 2010). Dietary recall methods can also be affected by social desirability bias, a type of systematic error when subjects selectively misreport certain foods due to their norms and beliefs about what they should eat (Hébert 2016). However, it is reasonable to believe that both the recall and social desirability biases would be similarly distributed during school and non-school hours for older children who completed the recall without any parental assistance. Yet for children aged 6-11 years who completed the recall with parental assistance, 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/she had not eaten part of the lunch.

Implications for school-based nutrition programs in Canada

Given that foods eaten during school hours for Canadian children represent 1/3 of the total daily energy consumed, the school context provides an important opportunity to promote healthy eating among Canadian children. Energy-adjusted intakes of vitamin A, D, B12, calcium, and milk products were substantially lower during school hours compared to non-school hours. The quality of Canadian children's dietary intakes at school could potentially be improved by increasing intake of nutritious foods including dairy products, thus increasing the intake of key nutrients such as protein, vitamin A, D, calcium and magnesium. Mean school hour diet quality scores required improvement for all age groups and declined as children aged. School-based health promotion strategies should target lunch meals for all children, but particularly among adolescents who are at highest risk of poor diet quality at school.

Conflict of interest disclaimer

The authors report no conflicts of interest associated with this manuscript.

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Table 1. Scoring criteria for the School Healthy Eating Index (School-HEI)*

Component	Ranges of scores	Maximum score criteria	Minimum score criteria
Adequacy	0-60 points		
Total vegetables and fruit	0-10	1.67-2.67 servings [†]	0 serving
Whole fruit	0-5	0.35-0.56 servings [†] (21% of the recommendation for 1/3 of the total daily vegetables and fruit for each age-sex group)	0 serving
Dark green and orange vegetables	0-5	0.35-0.56 servings [†] (21% of the recommendation for 1/3 of the total daily vegetables and fruit for each age-sex group)	0 serving
Total grain products	0-5	1.33-2.33 servings [†]	0 serving
Whole grains	0-5	0.67-1.17 servings [†] (50% of the recommendation for 1/3 of the total grains for each age-sex group)	0 serving
Milk and alternatives	0-10	0.67-1.17 servings [†]	0 serving
Meat and alternatives	0-10	0.33-1 servings [†]	0 serving
Unsaturated fats	0-10	10-15g [†]	No oil
Moderation[*]	0-40 points		
Saturated fats	8-10	<7% of school hour energy intake	≥7% to 10% of school hour energy intake
	0-8	10% of school hour energy intake	>15% of school hour energy intake
Sodium	8-10	<1/3 of Adequate Intake	≥1/3 of Adequate Intake to ≤1/3 of Tolerable Upper Level intake
	0-8	1/3 of Tolerable Upper Level intake	≥2/3 of Tolerable Upper Level intake
Other foods [§]	0-20	≤5% of school hour energy intake	≥40% of school hour energy intake

* Adapted from the Canadian Healthy Eating Index from Garriguet (Garriguet 2009); [†] Scores differ according to age and sex, as specified in 2007 Canadian Food Guide (Health Canada 2007a). These scoring criteria represent one third of the scoring criteria used to compute sub-scores for the HEI-C. The cut-offs for whole fruit, dark green and orange vegetables and whole grains reflect the Canadian food guide quality recommendations for these food groups. Guidelines in Canada recommend one serving each of dark green and orange vegetable per day, and the consumption of whole fruits and vegetables rather than juice. The Canadian threshold used the same American threshold (0.8 servings of whole fruit or dark green and orange vegetable per 1,000 kcal) but it is expressed here as a percentage of total vegetable and fruit intake. The U.S. HEI-2005 density standards for total fruit are 1.6 servings per 1,000 kcal and 2.2 servings of total vegetables per 1,000 kcal. So, 0.8 servings of whole fruit or dark green and orange vegetables (per 1,000 kcal) represent 21% of the total number of servings of vegetables and fruit (per 1,000 kcal): $0.8 / (1.6 + 2.2) = 21\%$. In Canada, it is recommended that whole grains make up half of total grain products so the cut-offs for total grains for each age-sex group was divided in half to obtain the whole grain School-HEI cut-offs for each age-sex group; [‡] For moderation components, 10 or 20 points were given for minimum or less, 0 points for maximum or more, and proportional for amounts between the minimum and maximum. [§] Other foods include any foods not part of the four 'core' food groups in Canada's Food Guide (for example, chocolate, candies, sugar-sweetened beverages, salty snacks and condiments).

Table 2. Sample characteristics of Canadian children 6-17 years whose first 24h dietary recall fell on a Canadian school day in 2004 ($n = 4827$)

Socio-demographic characteristics		Survey-weighted percent (%)
Age group		
	6-8 years	24.7
	9-13 years	43.1
	14-17 years	32.1
Females		49.4
Household highest level of education*		
	Secondary school education or lower	16.7
	Some post-secondary education	83.3
Income adequacy†		
	Low	36.0
	High	64.0
Household food security status‡		
	Food secure	91.1
	Food insecure	8.9
Residence type		
	Urban	80.5
	Rural	19.5
Ethnicity§		
	White, European	80.2
	Other	19.8

* Educational attainment was recoded as a dichotomous variable which grouped respondents as either having at least one adult household member who completed high school or less vs. households which had at least one adult member who completed some post-secondary education (trades, college, or university education). Sample for parental education was smaller as there were missing education data for 76 children; † To align with the coding method adapted by Health Canada, a dichotomous indicator of 'low' and 'high' income was created by grouping households in the first two lower and the last two higher income adequacy groups from the original income adequacy classification which grouped households into quartiles based on the adequacy of income for household members (Health Canada 2007b). Sample for income was smaller as there were missing income data for 620 children; ‡ A dichotomous food security variable was constructed characterising respondents as food insecure (marginal, moderate and severely food insecure) or food secure to enhance comparability with previous Canadian studies on food security (Kirkpatrick and Tarasuk 2008, Kirkpatrick et al. 2015). Sample for food security was smaller as there were missing data for 36 children. § Self-reported ethnicity was dichotomized as either being of Caucasian/European descent vs. belonging to any other ethnic group (including mixed origins).

Table 3. Dietary intakes and relative dietary contributions from school hours (9:00-14:00) to whole day intakes for Canadian children 6-17 years ($n = 4827$)^{*}

	Dietary intakes School hours	Contributions from school hours to daily intakes [†] (%)
Energy, kcal	746±11	33.6±0.4
Carbohydrates, g	103.8±1.6	34.0±0.4
Fibre, g	5.2±0.1	33.8±0.5
Total sugar, g	47.6±1.0	34.6±0.5
Total fat, g	27.0±0.6	34.6±0.4
Saturated fat, g	9.0±0.2	33.4±0.5
Monounsaturated fatty acids, g	10.8±0.3	35.3±0.5
Polyunsaturated fatty acids, g	4.7±0.1	36.5±0.5
Linoleic fatty acids, g	3.97±0.12	37.2±0.5
Linolenic fatty acids, g	0.61±0.02	36.6±0.6
Cholesterol, mg	63.8±1.8	29.4±0.6
Protein, g	24.7±0.5	30.8±0.4
Retinol Activity Equivalents	167.8±4.5	27.4±0.6
Vitamin D, µg	1.25±0.04	21.8±0.6
Vitamin C, mg	58.5±1.7	37.6±0.7
Thiamin, mg	0.61±0.01	33.1±0.5
Riboflavin, mg	0.66±0.01	30.6±0.5
Niacin, mg	11.52±0.22	32.2±0.4
B6, mg	0.48±0.01	29.2±0.5
B12, µg	1.05±0.03	27.3±0.6
Dietary Folate Equivalents	156.1±2.9	34.5±0.5
Calcium, mg	315.7±7.3	29.3±0.5
Phosphorus, mg	412.2±7.6	29.7±0.4
Magnesium, mg	86.1±1.5	29.8±0.4
Iron, mg	4.7±0.1	32.3±0.4
Zinc, mg	3.2±0.1	30.7±0.5
Sodium, mg	1163.5±23.0	36.1±0.5
Potassium, mg	844.3±14.9	29.9±0.4
Grain products, servings [‡]	2.49±0.05	36.9±0.5
Vegetables and fruit, servings [‡]	1.48±0.04	32.9±0.8
Milk and alternatives, servings [‡]	0.63±0.02	24.9±0.7
Meat and alternatives, servings [‡]	0.63±0.02	33.1±0.8
Energy from other foods [§] , kcal	175±6	37.1±0.8

^{*} Values are survey-weighted means ± robust SEM; [†] The relative contribution of school hour dietary intakes to whole day intakes considered food sources only and excluded intakes from nutritional supplements (e.g. a multivitamins); [‡] Servings for each food group are defined according the 2007 version of Canada's Food Guide (e.g. 1 slice of bread is equivalent to 1 serving of grain product, 250 ml of milk is equivalent to 1 serving of milk and alternatives) (Health Canada 2007a); [§] Other foods included foods outside of the four core food groups from Canada's Food Guide which is often minimally nutritious foods such as sugar-sweetened beverages, chocolate bars, and salty packaged snacks.

Table 4. Comparison of nutrients and food group densities* during school hours (9:00-14:00) and non-school hours and relative percent differences (school vs. non-school hours) on Canadian school days ($n = 4827$)

	School hours intake (per 1,000 kcal)	Non-School hours intake (per 1,000 kcal)	Linear regression coefficient [†]	P-value	Relative % difference [‡]
	Mean±SEM	Mean±SEM	$\beta \pm \text{SEM}$		Mean ±SEM
Carbohydrates, g	144.2±0.9	139.8±0.6	4.4±1.1	0.000	3.2±0.9
Fibre, g	7.31±0.10	7.30±0.09	0.01±1.12	0.918	0.1±1.6
Total sugar, g	66.8±1.0	62.1±0.6	4.7±1.1	0.000	7.6±1.8
Total fat, g	34.3±0.3	33.5±0.2	0.8±0.4	0.036	2.4±1.2
Saturated fat, g	11.6±0.2	11.9±0.1	-0.3±0.2	0.122	-2.5±1.7
Monounsaturated fatty acids, g	13.48±0.16	12.76±0.11	0.73±0.18	0.000	5.7±1.4
Polyunsaturated fatty acids, g	5.98±0.09	5.39±0.07	0.59±0.11	0.000	10.9±2.0
Linoleic fatty acids, g	5.04±0.08	4.43±0.06	0.61±0.10	0.000	13.8±2.3
Linolenic fatty acids, g	0.76±0.02	0.69±0.02	0.08±0.03	0.003	11.6±4.3
Cholesterol, mg	82.4±2.2	107.6±2.3	-25.3±3.2	0.000	-23.5±3.0
Protein, g	32.7±0.4	38.2±0.3	-5.5±0.5	0.000	-14.4±1.3
Retinol Activity Equivalents	239.3±6.3	328.7±6.4	-89.4±8.9	0.000	-27.3±2.7
Vitamin D, µg	1.57±0.05	3.39±0.07	-1.82±0.08	0.000	-54.0±2.4
Vitamin C, mg	91.4±2.7	68.7±1.6	22.7±3.1	0.000	33.0±4.5
Thiamin, mg	0.83±0.01	0.89±0.01	-0.06±0.02	0.000	-6.7±2.2
Riboflavin, mg	0.90±0.01	1.05±0.01	-0.16±0.02	0.000	-15.2±1.9
Niacin, mg	15.46±0.17	16.70±0.16	-1.24±0.23	0.000	-7.4±1.4
B6, mg	0.67±0.01	0.83±0.01	-0.16±0.02	0.000	-19.3±2.4
B12, µg	1.33±0.03	2.04±0.07	-0.71±0.08	0.000	-35.0±3.9
Dietary Folate Equivalents	217.6±3.1	211.8±2.6	6.3±4.0	0.149	3.0±1.9
Calcium, mg	423.4±7.6	546.7±7.4	-123.3±10.1	0.000	-22.6±1.8
Phosphorus, mg	550.3±6.7	678.2±5.7	-127.9±8.5	0.000	-18.9±1.3
Magnesium, mg	120.9±1.5	143.5±1.1	-22.5±1.7	0.000	-15.7±1.2
Iron, mg	6.46±0.08	7.20±0.09	-0.74±0.12	0.000	-10.3±1.7
Zinc, mg	4.31±0.05	5.13±0.07	-0.82±0.10	0.000	-16.0±1.9
Sodium, mg	1599.2±25.8	1393.0±14.6	206.2±28.5	0.000	14.8±2.0
Potassium, mg	1203.1±17.8	1418.9±12.7	-215.8±20.8	0.000	-15.2±1.5
Grains products, servings	3.40±0.05	2.99±0.04	0.41±0.06	0.000	13.7±2.0
Vegetables and fruit, servings	2.29±0.07	2.11±0.04	0.18±0.08	0.016	8.5±3.8
Milk and alternatives, servings	0.81±0.02	1.21±0.02	-0.40±0.03	0.000	-33.1±2.5
Meat and alternatives, servings	0.83±0.03	0.88±0.02	-0.04±0.03	0.190	-4.5±3.4

* Because energy intake during school hours was significantly lower than non-school hours, densities (nutrient and food group amounts per 1,000 kcal) were calculated for foods consumed during school hours and during non-school hours to standardise dietary intakes and compare energy-adjusted differences across time periods. Values were weighted using sampling weights to generate nationally representative estimated means ± SEM; [†] Simple linear models tested for significant differences in nutrient and food group densities across time period using a dichotomous variable for school hours as the independent variable. Non-school hours are the reference period; [‡] Relative difference is the energy-adjusted difference in amounts consumed between school and non-school hours divided by non-school hour amounts, then multiplied by 100 to express relative percent differences.

Table 5. Marginal mean School Healthy Eating Scores (School-HEI) and linear regression coefficients, by select demographic, geographic, and socio-economic characteristics for Canadian children age 6-17 years ($n = 4827$)*

		School-HEI scores	Linear regression coefficients	P-value	R ²
Sex					
	Male	53.0±0.5	Reference	0.335	0.00
	Female	53.7±0.5	0.8±0.7		
Age					
	6-8 years	58.3 ^a ±0.7	Reference	0.000	0.05
	9-13 years	53.5 ^b ±0.5	-4.8±0.9		
	14-17 years	49.3 ^c ±0.6	-9.0±0.9		
Ethnicity					
	White/European	53.6±0.4	Reference	0.311	0.00
	Other	52.7±0.8	-1.1±0.9		
Residence type					
	Rural	54.4±0.8	Reference	0.137	0.00
	Urban	53.1±0.4	-1.3±0.9		
Provinces					
	Newfoundland & LB	48.4 ^a ±1.1	-3.8±1.2	0.001	0.02
	PEI	53.7 ^{abc} ±1.3	1.5±1.4	0.308	
	Nova Scotia	50.6 ^{ab} ±1.3	-1.6±1.4	0.266	
	New-Brunswick	54.7 ^{bc} ±1.2	2.5±1.3	0.064	
	Quebec	56.9 ^c ±0.8	4.6±1.0	0.000	
	Ontario	52.2 ^{ab} ±0.5	Reference	-	
	Manitoba	52.7 ^{ab} ±0.9	0.5±1.0	0.658	
	Saskatchewan	53.6 ^{abc} ±1.1	1.3±1.2	0.272	
	Alberta	52.3 ^{abc} ±1.2	0.0±1.3	0.983	
	British Columbia	52.9 ^{abc} ±0.9	0.7±1.0	0.533	
Education [†]					
	≤ secondary school	51.9 ^a ±0.8	Reference	0.04	0.00
	Some post-secondary	53.8 ^b ±0.4	1.9±0.9		
Household Income [‡]					
	Low	53.5±0.6	Reference	0.902	0.00
	High	53.6±0.4	0.1±0.8		
Household-level food insecurity [§]					
	Food secure	53.4±0.4	Reference	0.897	0.00
	Food insecure	53.3±1.2	-0.2±1.2		

* Values are survey-weighted marginal means ± SEM. Differences in total School-HEI scores were tested using survey-weighted univariate (simple) linear regression models with a Bonferroni correction for variables with more than 2 levels. Estimated marginal means sharing a group letter (^{a, b, c}) are not significantly different; [†] Sample for parental education was smaller as there were missing education data for 76 children; [‡] Sample for income was smaller as there were missing income data for 620 children; [§] Sample for food security was smaller as there were missing data for 36 children.

Table 6. School Healthy Eating Index (School-HEI) scores* by age group for Canadian children age 6-17 years ($n = 4827$)

	6-8 years	9-13 years	14-17 years
School-HEI (maximum score)			
Vegetable and fruit (10)	5.7 ^a ±0.2	5.1 ^a ±0.1	4.4 ^b ±0.2
Dark green or orange vegetable (5)	0.7 ^a ±0.1	0.6 ^{ab} ±0.05	0.5 ^b ±0.05
Whole fruit (5)	2.0 ^a ±0.1	2.0 ^a ±0.1	0.3 ^b ±0.1
Grain product (5)	4.4 ^a ±0.1	3.8 ^b ±0.1	3.6 ^c ±0.1
Whole grains (5)	1.1±0.1	1.0±0.1	0.9±0.1
Milk & alternatives (10)	5.5 ^a ±0.2	4.1 ^b ±0.2	3.9 ^b ±0.2
Meat & alternatives (10)	6.3 ^a ±0.2	6.0 ^a ±0.2	4.9 ^b ±0.2
Unsaturated fats (10)	8.6 ^{ab} ±0.1	8.8 ^b ±0.1	8.3 ^a ±0.1
Saturated fats (10)	6.1±0.2	6.3±0.1	6.3±0.2
Sodium (10)	5.2±0.2	4.9±0.1	5.1±0.2
% kcal other foods (20)	12.7 ^a ±0.4	10.9 ^b ±0.3	10.2 ^b ±0.3
Total School-HEI index scores (100)	58.4 ^a ±0.7	53.5 ^b ±0.5	49.3 ^c ±0.6
NRF 8.2 index scores [†]	30.1 ^a ±1.1	26.5 ^b ±0.7	25.4 ^b ±1.1

* Values are survey-weighted means ± SEM obtained from simple linear regression models showing differences in mean dietary quality scores by age group. Means sharing a group letter (^{a, b, c}) are not significantly different between age groups (Bonferroni-adjusted, $p < 0.016$); [†] The Nutrient Rich Food index (NRF) is a group of nutrient-based composite diet quality indicators (Fulgoni et al. 2009) designed to assign higher diet quality scores to foods which provide higher amounts of recommended Daily Values (DV) for 'desirable' nutrients and/or lower amounts of the recommended DV for 'undesirable' nutrients. Conversely, lower NRF scores are given for foods which provide higher amounts of the DV for 'undesirable' nutrients and/or lower amounts of the DV for 'desirable' nutrients. For the purpose of this analysis, the NRF 9.3 was slightly modified to a 'NRF 8.2' index, which excluded vitamin E and the added sugars since these are not available in the Canadian Nutrient Files.