**Title**: Fruit and vegetable intake is associated with food knowledge among children aged 9 – 14 years in Southwestern Ontario, Canada.


## Abstract

**Objectives**: It is widely accepted that the consumption of fruits and vegetables (FV) is important for maintaining health. Food-based dietary guidelines encourage the frequent intake of FV but consumption by children in Canada remains suboptimal. Attempts to improve dietary quality have had modest success and it has been suggested that food knowledge could be key to improvement: previous intervention programmes have been criticised for insufficiently connecting food knowledge with food skills and decision making about dietary intake. Therefore, the objective of this study was to investigate the factors associated with FV consumption by elementary school children in Ontario, Canada, including food knowledge, socioeconomic status, sociodemographic characteristics, and the food environment.

**Design**: In 2017-19, a cross-sectional survey was administered to 2,443 students at 60 schools across Southwestern Ontario (SWO), Canada. A parent survey was used to validate self-reported sociodemographic variables.

**Setting**: 60 elementary schools in SWO Ontario, Canada

**Participants**: 2,443 elementary students (grades 5-8)

**Results**: The mean intake of fruits and vegetables reported by these participants was 2.6 (SD 1.1) and 2.4 (SD 1.2) servings/day, respectively. A FV intake below WHO guidelines was reported by 40.7% of respondents. Knowledge score, child age, and parent employment status significantly predicted higher reported intake of FV.

**Conclusions**: This study shows that FV intake among school-aged children in SWO is low, and increased intake is associated with higher food knowledge. To encourage healthy eating, school-

based food and nutrition programs that incorporate multiple components and emphasise food literacy therefore have value among this population.

**Word Count**: 248

**Key Words**: Food Knowledge; Fruit Vegetable Consumption; Young Children; Diet Quality

## Introduction

It is widely accepted that fruits and vegetables (FV) are important for preventing lifestyle-related chronic disease and maintaining overall health [1]. Food-based dietary guidelines and other national recommendations, including the 2019 version of Canada's Food Guide (CFG), notably encourage the frequent intake of FV [2]. Despite such recommendations, intake of FV by children in Canada is suboptimal and evidence suggests that overall diet quality among school-aged (2 – 18 years) children living in Canada is poor [3,4].

Poor dietary patterns are linked to an increased risk of diabetes [5], some cancers [6], higher body mass indexes [7], and lower performance in school [8]. Furthermore, FV consumption is positively correlated with well-being in children [9]. Dietary behaviour patterns formed in childhood have been shown to predict adult lifestyle-related disease [10], and therefore, interventions aimed at children and youth have the capacity to influence long-term health.

It is critical to understand the predictors of children's dietary intake to address these negative health outcomes. Factors that are well known to influence poor dietary quality among children include the environment, such as availability and access to unhealthy food, individual preferences, and factors such as gender, age, and maternal education [11-13]. Attempts to improve dietary quality via interventions that impact these factors have had modest success [14]. Suggested reasons for this are that previous programmes have insufficiently connected food knowledge with food skills and decision making about dietary intake, and that the concept known as food literacy could be critical to improving outcomes of such interventions [15].

'Food literacy' is defined as being "*a set of interconnected attributes organised into the categories of food and nutrition knowledge, skills, self-efficacy/confidence, food decisions, and other ecologic (external) factors such as income security, and the food system*" [16]. A relatively new concept, a critical component of food literacy is food knowledge [17]. Despite the importance of food knowledge, relatively few studies have investigated the links between food knowledge and dietary intake [18]. Knowledge about food and nutrition has been shown to correlate with improved dietary intake among adults [18]. Among adolescents aged 14 to 19 years, knowledge of how to eat a healthy diet has been identified as one of a number of psychosocial factors (i.e.,

increased awareness and self-efficacy) associated with healthful dietary behaviours [19]. However, few studies have focused on the relationship between dietary intake and food knowledge in children younger than 14.

As fewer than one-third of Canadian children consume the recommended number of servings of FV as established by the CFG [20,21], it has become a national priority to improve children's dietary behaviours and to develop strategies that improve healthy eating early in childhood [22]. To do so, it is essential to conduct new research to inform public health professionals, policy makers, and educators about the factors associated with inadequate intake of FV. Therefore, the objective of this study was to investigate the factors associated with FV consumption by elementary school children in Southwestern Ontario (SWO), Canada, including food knowledge, socioeconomic status, sociodemographic characteristics, and the food environment.

## Methods

*Study design and population*

This cross-sectional study took place in elementary schools across the region of Southwestern Ontario, Canada, during the 2017-18 and 2018-19 school years and included schools in different geographical locations (urban and rural) to recruit students from a range of food environments and socioeconomic characteristics. Sixty schools from two English-language school boards (London District Catholic School Board (LDCSB) and Thames Valley District School Board (TVDSB)), representing the cities of London and St. Thomas, and all areas within the counties of Middlesex, Oxford, and Elgin, were randomly selected from a list of 160 schools. The principals at selected schools were sent a letter of information before agreeing to participate in the study, and an overview of the study was presented to school staff by the research team. Each participating school was visited by the research team to provide informational presentations for children in grades 4/5 to 8 (aged 9 – 14 years) to answer any questions, and a letter of information, as well as a parental consent form, parent/guardian survey, and child assent forms, were sent home. All students were required to have written parent consent and provide assent.

*Surveys*

The parents/guardian survey asked questions about individual/family level characteristics and their child's willingness to try FVs. Questions included those on parent/guardian education level, parental employment status, median family income, family structure, ethnic origin, postal code, and family meal habits. The parent/guardian survey took approximately 10-15 minutes to complete.

The research team visited each participating school to administer the child survey once during the school year, in fall, winter, or spring. All participating children were brought together in a central place (i.e., school gym, or library) to complete the survey; the research team reviewed child assent forms, provided instructions, and were available to answer questions during the survey. The self-report child survey included 124 questions under four main topics: sociodemographic information, eating habits, nutrition and food knowledge, and food preferences. Child-reported data were primarily used; however, where missing, parent-reported data were substituted. Questions involving individual- and family-level characteristics included

age, sex, ethnicity, and family structure. As self-report family income is prone to recall errors and high levels of missing responses, we followed an accepted approach adopted in similar survey-based studies of Canadian schoolchildren of using the median family income (CAD) from the 2016 Census of Canada measured at the dissemination area in which the home was located [23-25].

Dietary intake questions were developed by registered dietitians and adapted from previously used surveys [26-28]. Dietary behaviours were obtained in part from responses to two, multiple component food frequency questionnaire (FFQ) survey questions. Each student was asked: In a typical day, about how many servings of fruit do you eat? (Example – 1 serving is equal to: a piece of fresh fruit, like an apple; a small bowl of fruit salad). Each student was also asked: In a typical day, about how many servings of vegetables do you eat? (Example – 1 serving is equal to: a carrot or other fresh vegetable (do not count French fries, potato chips), or a small bowl of green salad or cooked vegetables). Response options for dietary variables ranged from 0, 1, 2; up to 4+. A variable for total FV intake was derived from these options. Scores from these two questions were added together and defined dichotomously as 'below five', or 'five and above', as suggested by the WHO [29].

Food knowledge questions were adapted from previously used surveys by members of our research team, which included registered dietitians and educators [26-28]. A variety of question types were included such as multiple choice, yes/no, true/false, Likert-type scale, and fill-in the blanks. A total food and nutrition knowledge score was calculated by summing the number of correct responses derived from 46 individual questions in the child survey. The survey included knowledge questions on the recommendations from CFG (2007), efficacy pertaining to healthy eating, food selection, locally sourced produce, nutrition content, and food preparation. For example, "How many servings of FV should children your age eat every day, based on Canada's Food Guide? (2-8 servings); "Which of the following FV are grown in Ontario? e.g., Apples (True, False)." The minimum possible score a child could achieve was 0 and the maximum was 46. If participants responded to less than or equal to half of the knowledge questions (n= 23), survey data were excluded from total score calculations. All remaining observations that were

not responded to, were considered 'I don't know' and as a result incorrect. A detailed analysis of these questions was carried out as part of another study [30].

*Ethics*

The study protocol was approved by the research offices of both school boards, school principals, as well as [BLINDED].

*Data analysis*

Data were analysed using IBM SPSS Statistics, version 24 (Armonk, NY: IBM Corp). Descriptive statistics were used to explore participant sociodemographic characteristics and total FV intake. The Pearson correlation coefficient was used to assess the strength and direction of the association between continuous sociodemographic variables and FV intake. As per Cohen, 1988, an r ± 0.10, 0.30, and 0.50 was considered a weak, moderate, and strong association, respectively [31]. Independent samples t-tests were used to compare group means between categorical variables and FV intake. Where categorical independent variables had three or more groups, the one-way analysis of variance (ANOVA) compared means of continuous dependent variables and the Tukey post hoc test assessed all pairwise comparisons. Multiple regression analysis was conducted to examine the relationship between fruit and vegetable intake and various predictor variables. To ensure adequate statistical power, there should be a minimum of 10 subjects for every predictor variable of interest [32]. With five independent variables in our multiple regression model, this required a sample size of at least 50 subjects with complete data. A p-value of $<0.05$ was considered statistically significant.

## Results

*Sample Characteristics*

Sociodemographic characteristics of the survey participants are shown in Table 1. Parent/guardian consent was obtained for 25.4% of (2,443) the eligible child participants and a total of 2,431 child participants assented to and completed the child survey. Participants ranged in age from 9 – 14 years with a mean age of 11.2 (SD 1.3); 58.2% of the sample was female. The majority of participants identified as Caucasian (86.4%). Most participants (80.5%) lived in two parent/guardian households with a median of two (mean 2.6 (SD 1.1)) children/household, and 35.4% of the sample lived rurally, with a mean distance from the nearest grocery store of 4.0 km (SD 4.0). Of participants' parents or guardians, 68.8% had a college or university-level education, and the mean family income was CAD $87,728.93 per annum (SD $19,234.70).

*Dietary intake and food knowledge*

The mean servings of fruits reported by these participants was 2.6 (SD 1.1) servings/day and of vegetables was 2.4 (SD 1.2) servings/day. Participants reported a total mean intake of FV of 5.0 servings/day (SD 2.0). A low FV intake was reported by 40.7% of respondents according to WHO guidelines.

The mean total knowledge score for the sample of elementary school children was 29.2 (SD = 7.1) out of a possible 46 points (63.5% correct responses) (Table 2).

Associations between children's reported intake of FVs and various sociodemographic factors are presented in Table 3. Statistically significant differences between gender and reported intake of FV was identified, with a higher mean intake (servings/day) reported for females (5.1, SD= 1.9) compared to males (4.8, SD 2.9); p= .046. There was a positive relationship between total knowledge score and intake of FV ($r = 0.27$; $p < 0.001$) and mean family income and intake of FV ($r = 0.05$; $p = 0.04$). Children's intake of FV were significantly different by urban/rural location, with mean daily servings of 4.7 (SD 2.2) for city dwellers, 5.0 (1.9) for small city dwellers, 5.1 (2.0) for those who live in a small town, and 5.1 (2.0) for those who live rurally (p=0.04). Higher levels of parental education were associated with increased intake of FV among children (p =0.03). There were no significant differences in intake of FVs by family

structure. No statistically significant associations between intake of FV and ethnicity, school food schedule, or number of children living in the household were found (Table 3).

Multiple regression analysis was used to test if sociodemographic variables significantly predicted participants' intake of FV (Table 4). The results of the regression indicated that the predictors explained 7.7% of the variance [$R^2$=0.077, F=14.16, p<0.00]. It was found that knowledge score (β= 0.257, p<0.001) significantly predicted higher reported intake of FV, as did child age (β= -0.072 p=0.001) and one parent being employed full time (β= 0.050, p=0.03).

## Discussion

The present study describes the intake of FV, and factors associated with higher intake of FV, among a large sample of children in SWO, Canada. Our results show that the proportions of children who report consumption of ≥ 5 servings of FV per day is lower than national recommendations, and the mean total food knowledge reported by our sample was also quite low at 63.5% [30]. Results further indicate that a higher knowledge score significantly predicted a higher reported intake of FV and reported intake of FV decreased as children became older. Gender, ethnicity, parental socioeconomic status, and urban/rural location did not significantly influence the reported intake of FV.

*Dietary Intake*

Our results show that just 59.8% of children reported consuming ≥ 5 servings of FV per day (as recommended by the WHO; Canada recommends 6 servings/day for this age group), supporting other Canadian studies that indicate the intake of FV is generally below national recommendations [3]. Encouragingly, however, the proportion of this sample reporting consumption of ≥5 FV per day is higher than those reported in other Canadian studies [20]. A possible explanation for this finding is that each of the schools in the study took part in the 'Ontario Student Nutrition Program' that provided students with at least one serving (according to the 2007 CFG portion recommendations) of fruit or vegetable three to five days each week. School-based programmes are generally well regarded and targeting the dietary intake of children in this way is a popular approach [3]; our results demonstrate the importance of developing and investing in such programmes.

*Food Knowledge*

The total food knowledge scores reported by our sample were quite low with an average score of 29.2 out of 46 (63.5% correct responses) [30]. Further analyses indicated that, when the influence of urban/rural location, parental education attainment and household income on FV intake was adjusted for, a higher knowledge score significantly predicted a higher reported intake of FV. To our knowledge, this is the first study that examined the association of food knowledge with intake of total FV among children aged 9 - 14 in Canada. Of the studies that focused on food knowledge and dietary intake, the majority have focused on adults [18], athletes [33,34] and

university students [35]. Very few studies internationally have investigated associations between food and nutrition knowledge among children; those that have been published are among children in Italy, Japan, and the US, and none focused specifically on FV intake. Italian children (N = 445, aged 4 – 16) with higher nutrition knowledge scores were less likely to have two or more snacks daily and to spend more than 3 h in sedentary activities daily (OR = 0·89, 95 % CI 0·83, 0·97 and OR = 0·92, 95 % CI 0·86, 0·99, respectively) [36]. Similarly, children in Japan (N = 1210, aged 6 – 12) with moderate or high nutrition knowledge showed higher vegetable intake, differing by sex (*p* for trend = 0.024 for boys and <0.0001 for girls in lower grades, <0.0001 for boys and 0.020 for girls in higher grades) [37]. A study among 532 children aged 11 – 13 living in urban Ohio, USA, showed a correlation between nutrition knowledge and general food choices for children in grades 7 and 8 (aged 10 - 13) [38].

Other studies have focused more broadly on food literacy, of which food knowledge is a component [39]. A systematic review assessing food literacy among adolescents examined the effects of interventions to improve food literacy. Overall, this review indicated that greater food literacy was linked to positive effects on dietary behaviours among youth, and while the effect was not strong, many of the included studies had methodological limitations, such as a lack of standardisation across dietary intake surveys, or instruments to measure nutrition literacy [39].

Several studies suggest that increasing food knowledge alone may be insufficient to improve dietary intake. A review of 29 studies concluded that, although many interventions showed some positive movement between increased knowledge and markers of diet quality among adults, associations were modest [18]. A review of 31 studies evaluating adherence to nutrition guidance in the U.S. showed that while many participants reported high rates of awareness of national guidance, as well as increased knowledge over time, adherence to the guidance was low [40]. Similar patterns have been described in the UK [41]. Previous research suggests that unreliable program delivery and intensity, along with inadequate program duration are limitations to the success of interventions to increase food knowledge, and that programs should consist of multiple components across the school and home environment [42-44]. In addition, many of these studies were conducted among adults and we know that dietary habits established during childhood tend to continue into adulthood [10].

Considered together, these studies suggest that interventions to increase food and nutrition knowledge among children are important and worthwhile, providing that the programs are of sufficient duration and are delivered consistently and reliably. The 2019 Ontario Health and Physical Education curriculum for children of this age includes a healthy eating component, based on CFG 2019 as part of the healthy living strand. Our study, conducted in 2017-2019, evaluated children's knowledge on the basis of CFG 2007; it would be worthwhile to assess children's knowledge of the updated food guidelines.

*Age*

Children in this study ranged in age from 9 to 14 years and age was negatively associated with dietary intake – as children increased in age, their reported intake of FV decreased. This finding is perhaps unsurprising as we know that adolescence is a period where children become more independent and increasingly make autonomous decisions; social support from friends, family and schoolteachers is considered among essential components in building self-efficacy for decisions relating to dietary behaviour [45,46]. Health-related behaviours such as dietary intake is an area where adolescents assert their independence [47], and dietary behaviours during this period are marked by an increase in meal-skipping, snacking, and fast-food consumption [15]. These results reinforce the importance of promoting healthy dietary behaviours at this stage of life.

*Null findings*

This study presents some interesting null findings: gender, ethnicity, mean family income, parental education level, and urban/rural location did not appear to significantly influence the reported intake of FV. A previous in-depth analysis of the food knowledge characteristics of this sample revealed an association between urban/rural settings and food knowledge: participants living in small town and rural settings had higher food and nutrition knowledge scores [30]. Other studies in Canada have shown that associations between urban/rural environment and dietary intake among children and adolescents [48,49], but these studies did not investigate levels of food knowledge among participants.

*Limitations*

Some limitations should be considered when interpreting our study's findings. We used a cross-sectional design which means that our results are representative of a specific point in time. Parent or guardian consent was obtained for 2,443 (25.4%) of eligible child participants, and despite the similarity of the sociodemographic characteristics with census results and those of other studies, this fairly low participation rate may restrict the generalizability of study results. It is possible that students who participated in this survey may have had different consumption habits than their peers who chose not to participate in the study, although there is little evidence of this when assessing associations between variables using multivariate statistics [50]. While questions used for dietary intake and food knowledge in the survey used in this study had been developed by registered dietitians and used in other studies, the questions were not pretested, or pilot tested. The survey relied on self-reported measures of knowledge and dietary intake and may be subject to recall bias, particularly in children. However, this may have been mitigated with strategies to reduce the likelihood for recall bias, including considerable time to complete the survey, support for students to ask questions, and a parent survey to validate sociodemographic responses.

*Conclusions*

This study shows that FV intake among school-aged children in SWO is low and is associated with food knowledge and age. School-based programs that incorporate multiple components and emphasise the development of food knowledge therefore have value among this population. Additional research is advised to assess the knowledge and impact of the CFG 2019 on this population.

Word count: 3298

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## Tables

Table 1: Sociodemographic Characteristics of the Sample (n=2412)

| Variable | N* | Proportion (%) | Mean/Median | SD |
|---|---|---|---|---|
| Age | 2412 | | 11.2/11 | 1.3 |
| Gender | | | | |
| F | | 58.2 | | |
| M | | 41.8 | | |
| Grade | 2050 | | | |
| 5 | | 29.3 | | |
| 6 | | 27.5 | | |
| 7 | | 23.5 | | |
| 8 | | 19.8 | | |
| Ethnicity | | | | |
| White/Caucasian | | 86.4 | | |
| Other | | 13.6 | | |
| Number of Children in Main Home | 2216 | | 2.6/2 | (1.1) |
| Mean Family Income | 2229 | | 87728.93/91264.00 | (19234.70) |
| Urban/Rural | 2224 | | | |
| City(> 100,000 population) | | 15.1 | | |
| Small City (between 10,000 and 100,000) | | 28.3 | | |
| Small Town (>1,000 population but <10,000) | | 21.2 | | |
| Rural | | 35.4 | | |
| Distance to Grocery Store | 2247 | | 4.0/2.12 | (4.0) |
| < 800 m | | 11.9 | | |
| 800 m – <1.6 km | | 28.3 | | |
| 1.6 – <2.4km | | 15.6 | | |
| 2.4 – <4.8 km | | 15.9 | | |
| >4.8 km | | 28.3 | | |
| Maximum Education of Either Parent | 2204 | | | |
| < High School | | 7.0 | | |
| High School | | 24.2 | | |
| University degree/College | | 59.8 | | |
| Graduate degree | | 9.0 | | |
| Parent 1 Employment | 2245 | | | |
| Employed full-time | | 62.5 | | |
| Not employed full-time | | 37.5 | | |
| Parent 2 Employment | 2185 | | | |
| Employed full-time | | 81.5 | | |
| Not employed full-time | | 18.5 | | |

* Any numbers unaccounted for were non-responses.

456

457 Table 2: Dietary Intake and Food Knowledge Score.

| Variable | N | Proportion | Mean/Median | SD |
|---|---|---|---|---|
| Servings Fruit | 2196 | | 2.6/3 | 1.1 |
| Servings Vegetables | 2208 | | 2.4/2 | 1.2 |
| Servings Fruit and Vegetables | 2189 | | 5.0/5 | 2.0 |
| Knowledge Score (out of 46) | 2226 | | 29.2/30 | 7.1 |
| Fruit and Vegetable Intake (WHO/median intake) | | | | |
| Low (<5) | 891 | 40.7 | | |
| High (≥5) | 1298 | 59.3 | | |

458

459 Table 3: Associations Between Participant Sociodemographic Variables and Servings of Fruits

460 and Vegetables*

| Variable | | Servings FV | Correlation | p-value |
|---|---|---|---|---|
| Child age | Mean (SD) | Mean (SD) | | <0.001 |
| | 11.2 (1.3) | 2.6 (1.1) | -0.08 | |
| Gender | | Mean (SD) | | 0.046 |
| | Female | 5.1 (1.9) | | |
| | Male | 4.8 (2.1) | | |
| Ethnicity | | Mean (SD) | | 0.10 |
| | White (n=1784) | 5.0 (2.0) | | |
| | Visible minority (n=286) | 4.8 (2.1) | | |
| Number of Children in the main home | Mean (SD) | Mean (SD) | | 0.81 |
| | 2.56 (1.1) | 2.6 (1.1) | 0.010 | |
| Mean Family Income | Mean (SD) | Mean (SD) | | 0.04 |
| | 87728.93 (19234.70) | 2.6 (1.1) | 0.05 | |
| Urban/Rural | | Mean (SD) | | 0.04 |
| | City(> 100,000 population) (n=312) | 4.7 (2.2) | | |
| | Small City (between 10,000 and 100,000) (n=570) | 5.0 (1.9) | | |
| | Small Town (>1,000 population but <10,000) (n=437) | 5.1 (2.0) | | |
| | Rural (n=707) | 5.1 (2.0) | | |
| Distance from grocery store | Mean (SD) | Mean (SD) | | 0.68 |
| | 4.0 (4.0) | 2.6 (1.1) | -0.01 | |
| Maximum Household Education | | Mean (SD) | | 0.03 |

| | | | | |
|---|---|---|---|---|
| | < High School (n=139) | 4.6 (2.0) | | |
| | High School (n=487) | 4.9 (2.1) | | |
| | University degree/College (n=1186) | 5.0 (1.9) | | |
| | Graduate degree (n=178) | 5.2 (2.0) | | |
| Parent 1 Employment | | Mean (SD) | | 0.04 |
| | Full Time (n=1279) | 4.9 (1.9) | | |
| | Not Full Time (n=747) | 5.1 (2.1) | | |
| Parent 2 Employment | | Mean (SD) | | 0.49 |
| | Full Time (n=1621) | 5.02 (1.98) | | |
| | Not Full Time (n=352) | 4.79 (2.02) | | |
| Knowledge Score | Mean (SD) | Mean (SD) | | <0.001 |
| | 29.2 (7.1) | 2.6 (1.1) | 0.27 | |

* Any numbers unaccounted for were non-responses.

Table 4: Regression Analysis of Participant Sociodemographic Variables, Total Knowledge Score, and Total Servings of Fruit and Vegetables (n=1889)

| Variable | B | SE B | β | p-value |
|---|---|---|---|---|
| Age | -.114 | .035 | -.072 | **.001** |
| Mean Family Income | .001 | .003 | .013 | .59 |
| Knowledge Score | .074 | .007 | .257 | **<.001** |
| Male | -.133 | .090 | -.033 | .14 |
| Caucasian | -.125 | .142 | -.021 | .38 |
| Parent 1 Employed FT | .189 | .086 | .050 | **.029** |
| City | -.144 | .151 | -.026 | .34 |
| Small City | -.034 | .112 | -.008 | .76 |
| Small Town | .024 | .120 | .005 | .84 |
| Education: Less than HS | -.113 | .189 | -.014 | .550 |
| Education: HS | -.092 | .106 | -.020 | .389 |
| Education Graduate | .250 | .158 | .036 | .114 |

Adjusted $R^2 = 0.077$