

Geographic Comparison of Dietary Intake and Quality in Manitoba Adolescents

JOYCE SLATER, PhD, RD^a; ALAN KATZ, MBChB, MSc, CCFP^{b,c}; BHANU PILLI, MSc^a; AYNSLIE HINDS, PhD^d; MARCELO L URQUIA, PhD^b; JULIANNE SANGUINS, PhD^e; CHRIS GREEN, PhD^f; JAIME CIDRO, PhD^g; DAN CHATEAU, PhD^h; NATHAN NICKEL, PhD^b

^aDepartment of Food and Human Nutritional Sciences, University of Manitoba, Winnipeg, MB; ^bDepartment of Community Health Sciences, Max Rady College of Medicine, University of Manitoba, Winnipeg, MB; ^cDepartment of Family Medicine, Max Rady College of Medicine, University of Manitoba, Winnipeg, MB; ^dDepartment of Psychology, University of Winnipeg, Winnipeg, MB; ^eManitoba Métis Federation, Winnipeg, MB; ^fWinnipeg Regional Health Authority, Winnipeg, MB; ^gDepartment of Anthropology, University of Winnipeg, Winnipeg, MB; ^hResearch School of Population Health, Australian National University, Canberra ACT

ABSTRACT

Purpose: The Food and Nutrition for Manitoba Youth (FANS) study examined dietary intakes, food behaviours, food security status, health indicators, and body mass index of a cohort of grade 9 students. This paper describes regional differences and similarities in dietary intake (food and nutrients) and quality of youth participants in the FANS study.

Methods: Grade 9 students completed a web-based survey on dietary intakes (24-hour recall), food behaviours, self-reported health indicators, and sociodemographic variables. Nutrient intakes were compared with national guidelines and diet quality was assessed using a modified Healthy Eating Index.

Results: A total of 1587 students participated from northern, rural, and urban regions in Manitoba. Northern and rural students had higher intakes of sugar, sodium, and saturated fat compared with urban. Northern students consumed fewer grain products compared to urban, and more servings of “other” foods compared with rural and urban. While most participants were classified into the “needs improvement” or “poor” Healthy Eating Index categories, significantly more northern participants were in the “poor” category.

Conclusions: Most adolescents in the study are at nutritional risk; however, there are additional vulnerabilities for those in rural and northern communities. Dietitians can use results to advocate for and plan interventions to improve adolescent nutrition.

Key words: Diet, nutrition, adolescent, Healthy Eating Index, student, Manitoba, Canada.

(Can J Diet Pract Res. 2024;00:XX–XX)

(DOI: 10.3148/cjdpr-2024-004)

Published at [dcjournal.ca](https://doi.org/10.3148/cjdpr-2024-004) on XX XXXX XXXX

RÉSUMÉ

Objectif. L'étude FANS (Food and Nutrition Security for Manitoba Youth) a examiné les apports alimentaires, les comportements alimentaires, la situation en matière de sécurité alimentaire, des indicateurs de santé et l'indice de masse corporelle d'une cohorte d'élèves de 9e année. Cet article décrit les différences et les similitudes régionales quant à l'apport alimentaire (aliments et nutriments) et à la qualité dans le cadre de l'étude FANS.

Méthodes. Des élèves de 9e année ont répondu à un sondage Web sur les apports alimentaires (rappel de 24 heures), les comportements alimentaires, des indicateurs de santé autodéclarés et des variables sociodémographiques. Les apports en nutriments ont été comparés aux lignes directrices nationales, et la qualité de l'alimentation a été évaluée à l'aide d'un Indice de saine alimentation modifié.

Résultats. Au total, 1587 élèves provenant de régions nordiques, rurales et urbaines du Manitoba ont participé à l'étude. Les élèves des régions nordiques et rurales avaient un apport plus élevé en sucre, en sodium et en gras saturés que ceux des régions urbaines. Les élèves des régions nordiques consommaient moins de produits céréaliers que ceux des régions urbaines et plus de portions d'autres aliments que ceux des régions rurales et urbaines. Bien que la plupart des participants aient été classés dans les catégories « à améliorer » ou « mauvais » de l'Indice de saine alimentation, beaucoup plus de participants nordiques ont été classés dans la catégorie « mauvais ».

Conclusions. La plupart des adolescents de l'étude présentent un risque nutritionnel; toutefois, ceux des communautés rurales et nordiques montrent des vulnérabilités supplémentaires. Les diététistes peuvent utiliser ces résultats pour demander et planifier des interventions visant à améliorer la nutrition des adolescents.

Mots-clés : alimentation, nutrition, adolescent, Indice de saine alimentation, élève, Manitoba, Canada.

(Rev can prat rech diétét. 2024;00:XX–XX)

(DOI: 10.3148/cjdpr-2024-004)

Publié au [dcjournal.ca](https://doi.org/10.3148/cjdpr-2024-004) le XX XXXX XXXX

BACKGROUND

Nutritionally adequate diets are a cornerstone of health and well-being, especially during critical life stages [1]. Adolescence is a key period of growth and development with increased requirements for micro- and macronutrients [2]. Older children and adolescents are also becoming more independent from parents, with eating behaviours increasingly shaped by other factors such as personal preferences, peer influence, diverse social settings, and exposure to media and social media [3]. Poor dietary intakes and suboptimal nutritional behaviours during this time can compromise

adolescents' short- and long-term health through the development of obesity and other risk factors for non-communicable disease later in life such as Type 2 Diabetes [1]. Within higher-income countries, regional differences in nutritional health may be observed due to differential access to nutrient-dense foods such as fruits and vegetables [4–6].

There is evidence that Canadian adolescents are consuming a suboptimal diet. The Canadian Community Health Survey-Nutrition (2015) (CCHS) indicated that most adolescents are not meeting the minimum recommended number of Canada's Food Guide servings for vegetables and fruit [7].

Further analysis using the Health Canada Surveillance Tool Tier system (assesses nutritional quality of foods within the Food Guide recommendations) showed poor nutrition quality, with “Other” foods (outside the four food groups) accounting for 21–25% of daily energy intake and majority of these calories coming from high fat and sugary foods [8,9]. Diet is linked with excess body weight in Canadian adolescents [10]; 23.2% of 12–17 year olds were overweight or obese in 2020, with 28.9% in Manitoba [11].

Adolescents engage in food-related behaviours that contribute to their nutritional risk. These include meal skipping and weight loss dieting, which are associated with lower diet quality [12]. Some studies suggest that low frequency of family meal consumption is associated with less healthy dietary intake, including higher sugar-sweetened beverage and lower fruit and vegetable consumption [13]. Adolescents are also higher consumers of fast food compared to other age groups [14]. Dietary risk factors in adolescents may not, however, be equally distributed through the population, including geographically.

Canada is the second-largest country in the world geographically, yet one of the least densely populated [15]. The majority of Canada’s residents reside in urban centres; however, within each province or territory between 14% and 64% live in rural settings [16]. In Manitoba, 40% of the population live in non-metropolitan areas [17]. Many communities are remote, far from major towns and cities with services such as large grocery stores, creating different benefits and challenges for residents.

Research suggests that health indicators differ across the urban-to-rural gradient, such as child obesity being higher in rural and northern areas [18]. Rural communities have been shown to experience a health disadvantage [19]. Nutritional risk factors such as food insecurity may be a contributing factor. Northern communities have higher rates of food insecurity, with those living most remotely in the north (47%) having almost four times the Canadian average (12%) [20]. Lack of access to healthier foods, such as fruits and vegetables, and high prices due to transportation costs are contributing factors to the rural and northern food environments [21]. These and other factors related to procurement may also impact the availability of healthy food through school snack and meal programmes [22].

At the same time, rural communities may lack the plethora of fast-food outlets that increasingly inhabit the urban food scape [23]. Consequently, it is important to understand the impact of geographic residence on the nutritional health of adolescents in order to formulate appropriate policy responses. Provincial-level nutrition indicators such as those found in the CCHS-Nutrition (2015) can hide important regional differences, as the limited sample size of the CCHS makes sub-provincial analysis of adolescents difficult [24]. In order to overcome this limitation, the Food and Nutrition Security for Manitoba Youth (FANS) study undertook a nutrition survey of Manitoba grade 9 students with sufficient

sample size to describe regional differences and similarities in nutritional health. The purpose of this paper is to describe regional differences and similarities in dietary intake (food and nutrients) and dietary quality.

METHODS

Ethics approval for this study was obtained from the Joint Faculty Research Ethics Board at the University of Manitoba (protocol HS2166 J2018:040), and all experimental methods were performed in accordance with the relevant guidelines and regulations. Detailed methods for the FANS study have been published elsewhere [25].

Sample

The FANS survey was a self-administered web-based survey of grade 9 students (aged 13–16 years) that collected information on dietary intakes, food behaviours, self-reported health indicators, and sociodemographic variables. Thirty-seven (24 urban, 8 rural, and 5 northern) of 62 eligible English-speaking public schools agreed to participate. Data collection took place from October 2018 to May 2019. Overall, 1571 students completed the survey once.

Regional classification

Participating school divisions and schools were classified into northern, rural, and urban regions of the province. Classification criteria align with geographical boundaries of Manitoba Regional Health Authorities: School divisions within the Winnipeg Health Regional are urban, school divisions in the Northern Health Region are classified as northern (more remote and in the northern part of the province), and remaining school divisions are considered rural [26].

Measures

Dietary intakes were collected using the Waterloo Eating Behaviour Questionnaire (WEB-Q). WEB-Q has been validated as a reliable self-administered tool for measuring the food and nutrient intake of adolescents using a 24-hour dietary recall [27]. The survey was administered in schools and overseen by a research coordinator. Dietary intake was assessed through a 24-hour recall module that collected data separately for meals and snacks. Students chose foods and beverages they consumed from a list of approximately 800 food items that were included in the database. Prompt screens with photographic images and associated text assisted students with choosing foods, beverages, and respective portion sizes.

Nutrient intakes were assessed using the 2010 Canadian Nutrient File [28] and Food Processor (version 8.0, ESHA Research, Salem, OR, 2002) and compared with Dietary Reference Intakes (DRIs) [29]. Adequate intake was used for dietary fibre. Excess sodium intakes were assessed based on tolerable upper intake levels. Food groups and servings were based on Eating Well with Canada’s Food Guide (2007) (EWCFG) [30]. “Other” food servings (those not part of the

four EWCFG food groups) were determined from serving sizes based on the Canadian Nutrient File [28, 31].

Diet quality was assessed using a modified Healthy Eating Index-Canada (HEI-C) adapted from Statistics Canada [32]. HEI-C is based on recommended intakes from the dietary components of EWCFG and DRI. Two additional components were added to align with 2019 Canada's Food Guide recommendations: "low fat vitamin-D fortified milk and dairy-free beverage alternatives" and "seafood and plant based proteins" [33]. Possible HEI-C scores ranged from 0 to 100, and participant diets were categorized as poor (< 50), needs improvement (50–80), or good (> 50) [34].

Data analysis

Diet and survey records were manually checked for quality during the data collection period. Final line-level data were imported into SPSS software and verified for missing and biologically implausible values. Students' dietary intake data were excluded from analyses if they consumed less than 200 kcal/day or exceeded 6000 kcal/day ($n = 35$), which resulted in a final analytical sample of 1536.

Study data were analyzed using SAS (version 9.4, SAS Institute Inc., Cary, North Carolina, USA, 2013) (variable derivation) and SPSS (version 27, IBM Corp., Armonk, NY, USA, 2020) (tables and statistical outputs) statistical software packages. Chi-squared goodness of fit was used to compare sample data with existing student population data in the province of Manitoba. Mean and median nutrient and food group intakes were calculated with corresponding measures of variability. Chi-squared tests were performed to compare intakes for nutrients and food groups of northern, rural, and urban region participants, and Cramer's V was used as a measure of effect size. Chi-squared test was performed to determine significant differences in percentage not meeting recommendations. Data were checked for normality using the Shapiro–Wilk test.

Where assumptions of normality were violated, Kruskal Wallis H non-parametric test and post-hoc Mann–Whitney U-test for pair-wise comparisons were used. Fisher–Freeman–Halton Exact test was performed with HEI classification categories due to low expected cell counts. Statistical significance was accepted at $p \leq 0.05$. All analyses were undertaken using unweighted sample data.

RESULTS

Of the 1587 participants, 8%, 14%, and 78% were from northern, rural, and urban regions, respectively (Table 1). Just over half of respondents from northern and urban regions were female. A higher percentage of females participated from the rural region. Participant ages ranged from 13 to 16 years with the majority in northern (90.3%), rural (98.2%), and urban (96.4%) being 14 and 15 years old. The student sample was representative of the total sample frame (Manitoba School Division) for sex in the northern ($X^2_{\text{goodness of fit}} = 1.73$, $p = 0.19$) and urban ($X^2_{\text{goodness of fit}} = 3.00$, $p = 0.08$) regions, but not in the rural ($X^2_{\text{goodness of fit}} = 15.02$, $p < 0.001$) region.

Median energy intake was similar in the three regions (Table 2). Macronutrient and micronutrient intakes were generally similar by geographical region with some exceptions. While carbohydrate consumption did not vary significantly, median sugar, sodium, and saturated fat intake were each significantly higher in rural and northern regions. Vitamin C, folate, and calcium were also significantly higher in the northern region. Figure 1 shows that across regions the majority of adolescents did not meet requirements for several nutrients on the day of their dietary recall. Fibre, vitamin D, iron, folate, and zinc did not differ by region; however, significantly more urban students did not meet calcium recommendations compared to urban and rural.

More than 85% of participants did not meet requirements for fibre or vitamin D. Half of respondents did not meet

Table 1. Characteristics of Food and Nutrition Security for Manitoba Youth (FANS) study participants, by region ($n = 1587$).

	Northern ^b ($n = 134$)		Rural ($n = 223$)		Urban ^b ($n = 1230$)	
	n	% ^c	n	% ^c	n	% ^c
Sex ^a						
Female	70	54.3	129	61.4	603	51.5
Male	59	45.7	81	38.6	569	48.5
Age ^a						
13 years	9	6.8	3	1.3	42	3.4
14 years	86	64.7	160	71.7	1050	85.6
15 years	34	25.6	59	26.5	132	10.8
16 years	4	3.0	1	0.4	3	0.2

^aSelf-report.

^bChi-squared goodness of fit test for sex indicates percentages do not differ significantly from the population ($p > 0.05$).

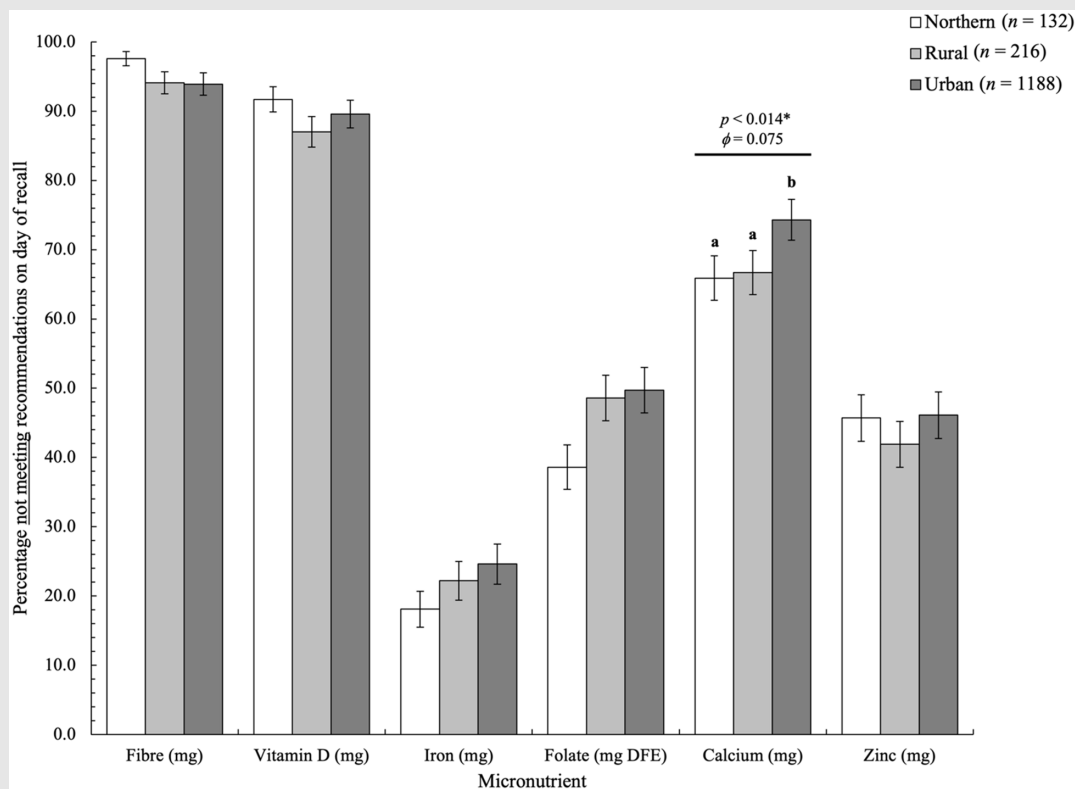
^cColumn percentages.

Table 2. Median nutrient intakes and interquartile ranges ($n = 1536$).

Variable	Reference	Recommended intakes	Northern ($n = 132$ recalls)			Rural ($n = 216$ recalls)			Urban ($n = 1188$ recalls)			p -value
			25 th	Median	75 th	25 th	Median	75 th	25 th	Median	75 th	
Energy (kcal)			1420.9	1987.1	2686.7	1430.1	1972.1	2623.8	1367.4	1956.8	2605.6	0.847
Nutrients												
Carbohydrates (g)	EAR	100	176.8	239.0	347.7	176.0	246.6	323.0	174.1	251.4	329.4	0.957
Sugart (g)			53.3	87.4 ^a	136.2	51.4	92.0 ^a	134.4	42.4	72.9 ^b	111.7	<0.001*
Fibre (g)	AI	26§, 38	9.5	13.8	21.1	9.9	16.4	22.2	9.0	14.2	20.4	0.064
Fat (g)			46.9	72.8 ^{a,b}	103.4	53.1	53.1 ^a	71.6	42.2	66.6 ^b	100.1	0.047*
Saturated fat (g)			16.6	27.2 ^{a,b}	38.9	18.1	25.8 ^a	36.9	13.8	23.5 ^b	36.6	0.034*
Monounsaturated fat (g)			16.4	24.9 ^b	37.8	15.3	23.5 ^{a,b}	34.3	13.5	22.3 ^a	33.4	0.044*
Polyunsaturated fat (g)			7.3	11.5	18.4	7.8	12.2	18.6	7.1	11.5	17.5	0.233
Unsaturated Fat (g)	EWCFG	30–45	24.6	36.4	54.8	24.4	36.2	53.2	21.1	34.1	51.0	0.098
Protein† (g/kg)	EAR	0.71§, 0.73	0.83	1.25	1.98	0.92	1.37	1.82	0.90	1.40	2.02	0.200
Vitamin A (µg RAE)	EAR	485§, 630	213.9	408.0	709.7	231.2	450.8	772.8	220.9	427.7	728.7	0.547
Thiamine, B1 (mg)	EAR	0.9§, 1.0	0.9	1.4	1.9	0.9	1.4	2.0	0.9	1.3	2.0	0.924
Riboflavin, B2 (mg)	EAR	0.9§, 1.1	1.2	1.7	2.8	1.2	1.7	2.4	1.1	1.6	2.4	0.159
Niacin, B3 (mg)	EAR	11§, 12	11.7	18.5	28.8	11.5	17.0	27.0	10.9	17.8	26.5	0.484
Vitamin B12 (µg)	EAR	2.0	2.1	3.5	5.9	1.8	3.5	5.6	1.8	3.4	5.6	0.807
Vitamin C (mg)	EAR	56§, 63	24.4	82.6 ^a	185.6	15.3	55.0 ^b	141.4	14.9	51.8 ^b	128.3	0.004*
Vitamin D (µg)	EAR	10	1.1	3.2	5.6	0.8	3.0	6.2	1.1	3.2	6.0	0.983
Folate (µg DFE)	EAR	330	256.6	395.4 ^a	517.0	229.2	336.5 ^{a,b}	516.7	197.6	331.6 ^b	500.4	0.042*
Calcium (mg)	EAR	1100	475.4	817.3 ^{a,b}	1267.9	494.2	791.6 ^a	1268.0	404.6	718.9 ^b	1112.2	0.025*
Iron (mg)	EAR	7.9§, 7.7	8.9	11.9	16.3	8.4	12.3	17.5	7.9	12.0	16.9	0.787
Zinc (mg)	EAR	7.3§, 8.5	5.6	8.1	10.9	5.2	8.5	12.6	5.3	8.2	12.2	0.886
Sodium (mg)	UL	2300	1736.3	2921.9 ^a	4350.1	1542.5	2708.2 ^{a,b}	3940.3	1411.2	2440.6 ^b	3738.7	0.022*
Saturated fat (% total E)	WHO	< 10%	9.4	12.3 ^a	15.0	9.5	12.7 ^a	14.5	8.5	11.4 ^b	14.03	0.001*

Note: AI, adequate intake; DFE, dietary folate equivalent; E, energy; EAR, estimated average requirement; EWCFG, Eating Well with Canada's Food Guide (2007); RAE, retinol activity equivalent; UL, upper limit; WHO, World Health Organization. † Sugar includes naturally occurring and added sugars. ‡ Protein requirements based on individual body size; total ($n = 1289$), females ($n = 634$), and males ($n = 602$). § Recommendations for females. || Recommendations for males. ^{a,b} Median intakes in a row with unlike letters are significantly different ($p \leq 0.05$). * $p \leq 0.05$: Kruskal Wallis H test for median nutrient intakes by region.

Figure 1. Percentage of students not meeting recommendations for select nutrients on day of recall. Estimated average requirement (EAR) guidelines were used for all micronutrients except for sodium (upper limit) and fibre (adequate intake). For guidelines that vary by sex (fibre, iron, zinc), participants not reporting sex ($n = 72$) were excluded from analysis. Histogram bars represent the percentage of participant not meeting recommendations; error bars represent 95% confidence intervals. p -values and Cramer's V are presented for comparison between regions. Bars with different letters (a,b) denote significant differences ($*p \leq 0.05$).



requirements for vitamin A or calcium, and one-quarter did not meet requirements for vitamin C or zinc, in all regions. Energy and sodium intake exceeded recommendations for all regions.

Food groups and 'Other' foods are compared by region in Table 3. Across the three regions, the majority of participants were not meeting requirements for most food groups. The median intake of grain products was lower in the north compared to the urban region, and a higher proportion of northern compared to urban participants were not consuming the recommended servings (55% vs. 41%). The median intake of milk and alternatives was lower in urban compared to rural, though the percentage not meeting recommendations did not differ significantly. Participants in northern and rural areas consumed significantly more servings of 'Other' foods (4.0 and 3.5 servings, respectively) than urban participants (3.0 servings).

Diet quality varied significantly by region, as shown in Table 4. Significantly more northern adolescents had "poor" HEI-C scores than those in urban or rural regions. Overall,

however, only 30 participants (2%) were in the "good" category, with the majority within northern (99.2%), rural (98.5%), and urban (97.8%) regions in the "needs improvement" and "poor" categories.

DISCUSSION

Research on adolescent nutrition is essential to inform appropriate food and nutrition-related programmes and policies that can reduce risk of future poor health outcomes and enhance well-being. This is one of the first studies in Canada with sufficient sample size to generate sub-provincial (urban, rural, northern) analyses of adolescent dietary patterns. Although not statistically representative, results point to challenges with adolescent nutritional health in Manitoba that, left unaddressed, will lead to significant human and financial health burdens down the road.

As described, almost no students were classified as having a "good" diet, while significantly more northern students were in the "poor" diet category than in rural or urban regions. Northern students had fewer servings of grain products but

Table 3. Eating Well with Canada's Food Guide (2007) food group servings, and percentage not meeting (NM) recommendations ($n = 1536$).

Food group servings	<i>EWCFG</i> recommended servings	Northern ($n = 132$ recalls)	Rural ($n = 216$ recalls)	Urban ($n = 1188$ recalls)	<i>p</i> -value
Grain products	6†, 7‡				
Mean (SD)		6.3 (4.0)	7.0 (4.0)	7.5 (4.1)	
Median (IQR)		5.7 ^a (4.3)	6.5 ^{a,b} (5.0)	7.0 ^b (5.5)	0.001*
NM, n (%)		70 ^a (55.1)	93 ^{a,b} (45.8)	463 ^b (40.8)	0.005*
Vegetables and fruit	7†, 8‡				
Mean (SD)		3.4 (3.0)	3.2 (2.5)	3.0 (2.6)	
Median (IQR)		2.6 (3.6)	2.7 (3.6)	2.5 (3.5)	0.276
NM, n (%)		116 (91.3)	187 (92.1)	1071 (94.4)	0.208
Milk and alternatives	3–4				
Mean (SD)		2.2 (1.7)	2.4 (2.3)	2.0 (1.9)	
Median (IQR)		2.0 ^{a,b} (2.2)	2.4 ^a (2.4)	1.6 ^b (2.3)	0.004*
NM, n (%)		94 (71.2)	152 (70.4)	896 (75.4)	0.203
Meat and alternatives	2†, 3‡				
Mean (SD)		2.3 (1.8)	2.3 (2.0)	2.4 (2.0)	0.697
Median (IQR)		1.9 (2.5)	2.0 (2.2)	2.0 (2.3)	0.731
NM, n (%)		76 (59.8)	118 (58.1)	641 (56.5)	
Other foods	NA				
Mean (SD)		5.1 (4.1)	4.3 (3.6)	3.6 (3.4)	
Median (IQR)		4.0 ^a (4.5)	3.5 ^a (4.0)	3.0 ^b (4.0)	< 0.001*
NM, n (%)		—	—	—	

Note: *EWCFG*, Eating Well with Canada's Food Guide (2007); IQR, interquartile range; NA, not applicable; NM, not meeting; SD, standard deviation. † Recommendations for females. ‡ Recommendations for males. ^{a,b} Values in a row with unlike letters are significantly different ($p \leq 0.05$). * $p \leq 0.05$: Kruskal Wallis H test for median food group servings and Pearson chi-squared test for percentage not meeting recommendations by region.

Table 4. Healthy Eating Index-Canada (HEI-C) categories, by region.

Category	Range	Northern ($n = 132$ recalls)		Rural ($n = 216$ recalls)		Urban ($n = 1188$ recalls)		<i>p</i> -value
		<i>n</i>	%	<i>n</i>	%	<i>N</i>	%	
Good	HEI-C > 80	1 ^E	0.8 ^a	3 ^E	1.5 ^a	26	2.3 ^a	< 0.001*
Needs improvement	HEI-C 50–80	65	51.2 ^a	146	71.9 ^b	808	71.3 ^b	
Poor	HEI-C < 50	61	48.0 ^a	54	26.6 ^b	300	26.5 ^b	

Note: HEI-C, Healthy Eating Index-Canada. ^{a,b} Values in a row with unlike letters are significantly different ($p \leq 0.05$). * $p \leq 0.05$: Fisher–Freeman–Halton Exact test for HEI-C categories by region. ^E use with caution (due to small numbers in “good category”).

significantly more servings of Other foods (e.g., sweets, salty snacks, sugar-sweetened beverages) than urban counterparts. This was reflected in regional variations for sugar, sodium, and saturated fat intake, which were higher in rural and northern students. Urban students consumed slightly fewer servings of milk and alternatives, which was reflected in lower calcium intakes; they also had slightly lower intakes of vitamin C and folate. While regional differences were not

found for energy, macronutrients, other micronutrients, vegetables and fruit, or the percentage not meeting milk and alternatives, the intakes of food group recommendations and several key nutrients were low for many students in all regions. Low intake of fruits and vegetables, and milk and alternatives, negatively impacts youth nutrition profiles through inadequate consumption of fibre, folate, vitamin D, and calcium, as shown in this study. This can increase the risk of

chronic illness in later life. These results are not surprising, as vegetable and fruit intake is low in all population groups in Canada and milk and alternative consumption has been decreasing in Canada [7, 35]. While vitamin D can be synthesized from sun exposure, the cold Canadian climate and reduced sunlight hours in winter can reduce vitamin D synthesis [36] and food sources are few. While milk in Canada is fortified with vitamin D, consumption data suggest that additional fortification strategies should be investigated to improve vitamin D status in all age and sex groups [37].

While there is a paucity of regional dietary data for Canadian adolescents, reports on regional differences in nutrition and health indicators for the overall population show similarities and differences between studies. A 2006 Canadian report showed that fewer rural residents consume five or more servings of vegetable and fruit each day compared with urban residents [19] while a 2019 Manitoba report showed no significant difference in those having five or more servings per day between urban, rural, and northern residents [38], as we also observed. Of note is that over 90% of students in all regions did not meet the vegetable and fruit recommendation. This is consistent with other reports that show low fruit and vegetable intakes across populations suggesting population-wide strategies are required to improve consumption [7, 39].

Higher prevalence of poor nutrition indicators and body mass index in northern and rural areas (reported elsewhere) [25, 40] may be related to factors such as food security. In particular, northern and some rural Manitoba communities have high rates of food insecurity due to reduced access to healthy foods, and high prices [4, 41, 42]. Healthier foods may be replaced by Other foods as suggested by the higher number of servings consumed by participants in northern and rural regions. These foods are often “ultra-processed” and high in salt, sugar, and saturated fat, which are typically more shelf-stable and more available than their fresh counterparts [43]. Northern and remote communities also have much less choice about where food is purchased, with many communities having no store, or only one store controlling the supply [44]. Subsidizing more nutrient-dense foods such as healthy grains, milk products, and fruits and vegetables could help improve access to healthier foods in these communities.

Residents of northern Manitoba are further disadvantaged from relatively high food prices by having significantly lower incomes. According to the 2016 Census, the mean household income in northern Manitoba was about \$10,000 lower than the provincial average [45].

This study has several limitations. Study results may not be representative of all grade 9 adolescents in Manitoba, as there may be selection bias. In particular, the study did not include schools in First Nation communities, where incomes are very low compared to other communities [46], and food costs and insecurity are much higher than other communities in Manitoba [47]. Therefore, results for the north and some rural regions may not be reflective of the true situation. There was,

however, participation by schools from all regions of the province, and the results are consistent with trends observed in other Canadian regions [31]. Finally, only one dietary recall was collected per student, and self-reported dietary intakes tend to under-estimate intake, do not reflect within-person variability, and may over/under-report foods due to social desirability (i.e. reporting consumption of more “healthy foods” and fewer “unhealthy foods”). Participants were also not asked about vitamin and mineral supplement intakes.

Further research should include ongoing, regionally representative surveillance of adolescent nutrition risk factors throughout the province, including biological markers. It should also assess adherence to the 2019 Canada’s Food Guide [33]. Research should also examine “on the ground” experiences in regional communities to determine local experiences and potential responses to the issues identified in this research.

RELEVANCE TO PRACTICE

This study examined the regional similarities and differences in nutrient and food group intakes in Manitoba adolescents. While most of the participants in this study are at nutritional risk, there appear to be additional vulnerabilities in rural and northern communities. Understanding these regional nuances is critically important for developing appropriate and effective programme and policy responses. Failure to do so will accelerate progress towards already too-high rates of nutrition-related chronic illness such as Type 2 Diabetes. The FANS study’s collaboration with education and community-based partners will strengthen these responses, which are urgently warranted. The situation may have worsened since this study due to COVID and resultant impacts on food supply chain issues and inflation.

The high number of students with poor diet quality throughout Manitoba, with a higher burden in northern and rural communities with respect to some indicators, demonstrate that provincial and regional responses are required to improve youth diets and reduce risk for obesity and future chronic illness. Dietitians can play a key role in advocating for regular monitoring of child nutritional health as a means to measure progress and effectiveness of interventions. These can include increasing availability of and subsidies for healthy foods in northern and remote communities; establishing universal school meal programmes that meet healthy eating guidelines and local preferences; and implementing universal school-based food literacy programmes.

Acknowledgments

The authors would like to acknowledge the study partners including school divisions and study participants.

Source of financial support: This study was funded by Canadian Institutes of Health Research (CIHR), FRN-156400, which played no other role in this study.

REFERENCES

- Norris SA, Frongillo EA, Black MM, Dong Y, Fall C, Lampl M, et al. Nutrition in adolescent growth and development. *Lancet*. 2022 Jan;399(10320):172–184. doi: [10.1016/S0140-6736\(21\)01590-7](https://doi.org/10.1016/S0140-6736(21)01590-7)
- Das JK, Salam RA, Thornburg KL, Prentice AM, Campisi S, Lassi ZS, et al. Nutrition in adolescents: physiology, metabolism, and nutritional needs. *Ann N Y Acad Sci*. 2017 Apr;1393(1):21–33. doi: [10.1111/nyas.13330](https://doi.org/10.1111/nyas.13330)
- Scaglioni S, De Cosmi V, Ciappolino V, Parazzini F, Brambilla P, Agostoni C. Factors influencing children's eating behaviours. *Nutrients*. 2018 May;10(6):706. doi: [10.3390/nu10060706](https://doi.org/10.3390/nu10060706)
- Wendimu MA, Desmarais AA, Martens TR. Access and affordability of “healthy” foods in northern Manitoba? The need for Indigenous food sovereignty. *Canadian Food Studies/La Revue canadienne des études sur l'alimentation*. 2018 May;5(2):44–72. doi: [10.15353/cfs-rcea.v5i2.302](https://doi.org/10.15353/cfs-rcea.v5i2.302)
- Hamidi S. Urban sprawl and the emergence of food deserts in the USA. *Urban Stud*. 2020 Jun;57(8):1660–75. doi: [10.1177/0042098019841540](https://doi.org/10.1177/0042098019841540)
- Tarasuk V, Fafard St-Germain AA, Mitchell A. Geographic and socio-demographic predictors of household food insecurity in Canada, 2011–12. *BMC Public Health*. 2019 Dec;19(1):1–2. doi: [10.1186/s12889-018-6344-2](https://doi.org/10.1186/s12889-018-6344-2)
- Polsky JY, Garriguet D. Change in Vegetable and Fruit Consumption in Canada between 2004 and 2015. Ottawa: Statistics Canada; 2020 [cited 2022 Nov 17]. Available from: [10.25318/82-003-x202000400001-eng](https://doi.org/10.25318/82-003-x202000400001-eng)
- Hack S, Jessri M, L'Abbé MR. Nutritional quality of the food choices of Canadian children. *BMC Nutr*. 2021 Dec;7(1):1–10. doi: [10.1186/s40795-021-00422-6](https://doi.org/10.1186/s40795-021-00422-6)
- Jessri M, Nishi SK, L'Abbe MR. Assessing the nutritional quality of diets of Canadian children and adolescents using the 2014 Health Canada Surveillance Tool Tier System. *BMC Public Health*. 2016 Dec;16(1):1–4. doi: [10.1186/s12889-016-3038-5](https://doi.org/10.1186/s12889-016-3038-5)
- Setayeshgar S, Ekwaru JP, Maximova K, Majumdar SR, Storey KE, McGavock J, et al. Dietary intake and prospective changes in cardiometabolic risk factors in children and youth. *Appl Physiol Nutr Metab*. 2017;42(1):39–45. doi: [10.1139/apnm-2016-0215](https://doi.org/10.1139/apnm-2016-0215)
- Statistics Canada. Body mass index, overweight or obese, self reported, youth (12 to 17 years old). Ottawa: Statistics Canada; 2021 [cited 2022 Nov 17]. Available from: <https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310009621>
- Rodrigues PR, Luiz RR, Monteiro LS, Ferreira MG, Gonçalves-Silva RM, Pereira RA. Adolescents' unhealthy eating habits are associated with meal skipping. *Nutrition*. 2017 Oct;42:114–20. doi: [10.1016/j.nut.2017.03.011](https://doi.org/10.1016/j.nut.2017.03.011)
- Robson SM, McCullough MB, Rex S, Munafò MR, Taylor G. Family meal frequency, diet, and family functioning: a systematic review with meta-analyses. *J Nutr Educ Behav*. 2020 May;52(5):553–64. doi: [10.1016/j.jneb.2019.12.012](https://doi.org/10.1016/j.jneb.2019.12.012)
- Black JL, Billette JM. Fast food intake in Canada: Differences among Canadians with diverse demographic, socio-economic and lifestyle characteristics. *Can J Public Health*. 2015 Jan;106(2):e52–8. doi: [10.17269/CJPH.106.4658](https://doi.org/10.17269/CJPH.106.4658)
- The World Bank. Population Density (people per sq. km of land area). World Bank Group; 2023 [cited 2023 Jun 18]. <https://data.worldbank.org/indicator/EN.POP.DNST?view=chart>
- Statistics Canada. Population and Dwelling Count Highlight Tables, 2016 Census. Ottawa: Statistics Canada; 2016 [cited 2022 Nov 17]. Available from: <https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hltfst/pd-pl/Table.cfm?Lang=Eng&T=703&SR=1&S=54&O=A&RPP=25>
- Bollman RD, Ashton W. Rural Population Size and Change. Brandon University Rural Development Institute; 2014 [cited 2022 Nov 17]. Available from: <https://www.brandonu.ca/rdi/files/2014/09/Rural-Population-Size-and-Change.pdf>
- Rao DP, Kropac E, Do MT, Roberts KC, Jayaraman GC. Childhood overweight and obesity trends in Canada. *Health Promot Chronic Dis Prev Can*. 2016 Sep;36(9):194–8. https://publications.gc.ca/collections/collection_2016/aspc-phac/HP33-2-36-9-eng.pdf
- Canadian Population Health Initiative. How Healthy are Rural Canadians? An Assessment of Their Health Status and Health Determinants. Ottawa: Canadian Institute for Health Information; 2006 [cited 2022 Nov 17]. Available from: https://secure.cihi.ca/free_products/rural_canadians_2006_report_e.pdf
- Tarasuk V, Mitchell A, Dachner N. Household Food Insecurity in Canada 2014. Toronto: PROOF Food Insecurity Policy Research; 2016 [cited 2022 Nov 17]. Available from: <https://proof.utoronto.ca/wp-content/uploads/2016/04/Household-Food-Insecurity-in-Canada-2014.pdf>
- Guo Y, Berrang-Ford L, Ford J, Lardeau MP, Edge V, Patterson K, et al. Seasonal prevalence and determinants of food insecurity in Iqaluit, Nunavut. *Int J Circumpolar Health*. 2015 Jan;74(1):27284. doi: [10.3402/ijch.v74.27284](https://doi.org/10.3402/ijch.v74.27284)
- McIsaac JLD, Spencer R, Chiasson K, Kontak J, Kirk SFL. Factors Influencing the Implementation of Nutrition Policies in Schools: A Scoping Review. *Health Educ Behav*. 2019 Apr;46:224–250. doi: [10.1177/1090198118796891](https://doi.org/10.1177/1090198118796891)
- DuBreck CM, Sadler RC, Arku G, Gilliland JA. Examining community and consumer food environments for children: An urban-suburban-rural comparison in Southwestern Ontario. *Soc Sci Med*. 2018 Jul;209:33–42. doi: [10.1016/j.socscimed.2018.05.004](https://doi.org/10.1016/j.socscimed.2018.05.004)
- Health Canada. Reference Guide to Understanding and Using the Data. 2015 Canadian Community Health Survey – Nutrition. Ottawa: Health Canada; 2017 [cited 2022 Nov 17]. Available from: <https://www.canada.ca/en/health-canada/services/food-nutrition/food-nutrition-surveillance/health-nutrition-surveys/canadian-community-health-survey-cchs/reference-guide-understanding-using-data-2015.html#a1.2.4.9>
- Slater J, Pilli B, Hinds A, Katz A, Urquia ML, Sanguins J, et al. The Food and Nutrition Security for Manitoba Youth (FANS) study: rationale, methods, dietary intakes and body mass index. *BMC Nutr*. 2022 Oct 20;8(1):116. doi: [10.1186/s40795-022-00611-x](https://doi.org/10.1186/s40795-022-00611-x)
- Fransoo R, Mahar A, Anderson A, Prior H, Koseva I, McCulloch S, et al. The 2019 RHA Indicators Atlas. Winnipeg: Manitoba Centre for Health Policy; 2019. Available from: http://mchp-appserv.cpe.umanitoba.ca/reference/RHA_Report_web.pdf
- Hanning RM, Royall D, Toews JE, Blashill L, Wegener J, Driezen P. Web-based food behaviour questionnaire: validation with grades six to eight students. *Can J Diet Pract Res*. 2009 Dec;70(4):172–8.
- Health Canada. Canadian Nutrient File (CNF). Ottawa: Health Canada; 2021 [cited 2022 Nov 17]. Available from: <https://food-nutrition.canada.ca/cnf-fce/index-eng.jsp>
- Government of Canada. Dietary Reference Intakes. Ottawa: Health Canada; 2022 [cited 2022 Nov 17]. Available from: <https://www.canada.ca/en/health-canada/services/food-nutrition/healthy-eating/dietary-reference-intakes.html>
- Health Canada. Eating Well with Canada's Food Guide 2007. Ottawa: Health Canada; 2007 [cited 2022 Nov 17]. Available from: <https://www.canada.ca/en/health-canada/services/canada-food-guide/about/history-food-guide/eating-well-with-canada-food-guide-2007.html>
- Wadsworth LA, McHugh TL, Thompson AM, Campagna PD, Durant MA, Murphy RJ, et al. Dietary intake of Nova Scotia youth: in grades 7 and 11. *Can J Diet Pract Res*. 2012 Mar;73(1):14–20. doi: [10.3148/73.1.2012.14](https://doi.org/10.3148/73.1.2012.14)
- Garriguet D. Diet Quality in Canada. Ottawa: Statistics Canada; 2009 [cited 2022 Nov 17]. Available from: <https://www150.statcan.gc.ca/n1/pub/82-003-x/2009003/article/10914-eng.pdf>
- Health Canada. Canada's Food Guide: Canada's Dietary Guidelines. Ottawa: Health Canada; 2019 [cited 2022 Nov 17]. Available from: <https://food-guide.canada.ca/en/guidelines/>
- Woodruff SJ, Hanning RM. Development and implications of a revised Canadian Healthy Eating Index (HEIC-2009). *Public Health Nutr*. 2010 Jun;13(6):820–5. doi: [10.1017/S1368980009993120](https://doi.org/10.1017/S1368980009993120)
- Vatanparast H, Islam N, Shafiee M. Consumption of Milk and alternatives decreased among Canadians from 2004 to 2015: evidence from the Canadian community health surveys. *BMC Nutr*. 2021 Nov;7(63):1–14. doi: [10.1186/s40795-021-00465-9](https://doi.org/10.1186/s40795-021-00465-9)
- Health Canada. What about Sun Exposure? Ottawa: Health Canada; 2020 [cited 2022 Nov 17]. Available from: <https://www.canada.ca/en/health-canada/services/food-nutrition/healthy-eating/vitamins-minerals/vitamin-calcium-updated-dietary-reference-intakes-nutrition.html#a12>
- Calvo MS, Whiting SJ. Survey of current vitamin D food fortification practices in the United States and Canada. *J Steroid Biochem Mol Biol*. 2013 Jul;136(2013):211–213. doi: [10.1016/j.jsbmb.2012.09.034](https://doi.org/10.1016/j.jsbmb.2012.09.034)
- Southern Health. Southern Health-Santé Sud Community Health Assessment 2019. Manitoba: Southern Health; 2019 [cited 2022 Nov 17]. Available from: https://www.southernhealth.ca/assets/AnnualReports/SH-SS-2019-Community-Health-Assessment_Final.pdf
- Minaker L, Hammond D. Low Frequency of Fruit and Vegetable Consumption Among Canadian Youth: Findings From the 2012/2013

- Youth Smoking Survey. *J Sch Health*. 2016 Jan;86(2):135–142. doi: [10.1111/josh.12359](https://doi.org/10.1111/josh.12359)
40. Slater J, Pilli B, Hinds A, Katz A, Urquia ML, Sanguins J, et al. Food behaviours and health indicators in Manitoba adolescents and relation to the Healthy Eating Index. *Int J Environ Res Public Health*. 2023 Jan 21;20(3):2007. doi: [10.3390/ijerph20032007](https://doi.org/10.3390/ijerph20032007)
41. Northern Food Prices Project Steering Committee. Northern Food Prices Report 2003: Exploring strategies to reduce the high cost of food in northern Manitoba. Government of Manitoba; 2003 [cited 2022 Nov 17]. Available from: https://www.gov.mb.ca/inr/food_prices/pubs/2003_northern_food_prices_report.pdf
42. Domingo A, Spiegel J, Guhn M, Wittman H, Ing A, Sadik T, et al. Predictors of household food insecurity and relationship with obesity in First Nations communities in British Columbia, Manitoba, Alberta and Ontario. *Public Health Nutr*. 2020 May;24(5):1021–1033. doi: [10.1017/S1368980019004889](https://doi.org/10.1017/S1368980019004889)
43. Polsky JY, Moubarac JC, Garriguet D. Consumption of ultra-processed foods in Canada. Statistics Canada; 2018 [cited 2023, Jun 18]. Available from: <https://www150.statcan.gc.ca/n1/pub/82-003-x/2020011/article/00001-eng.htm>
44. Kristin B, Kelly S, Travis H, Joseph L, Lori C. Retail food environments, shopping experiences, First Nations and the provincial Norths. *Health Promot Chronic Dis Prev Can*. 2017 Oct;37(10):333–341. doi: [10.24095/hpcdp.37.10.03](https://doi.org/10.24095/hpcdp.37.10.03)
45. Statistics Canada. North [Economic region], Manitoba and Manitoba [Province] (table). Census Profile, 2016 Census. Ottawa: Statistics Canada; 2017 [cited 2022 Nov 17]. Available from: <https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E>
46. Statistics Canada. Canadian Income Survey, 2020. Ottawa: Statistics Canada; 2022 [cited 2022 Nov 17]. Available from: <https://www150.statcan.gc.ca/n1/daily-quotidien/220323/dq220323a-eng.htm>
47. Batal M, Chan HM, Fediuk K, Berti PR, Mercille G, Sadik T, et al. First Nations households living on-reserve experience food insecurity: prevalence and predictors among ninety-two First Nations communities across Canada. *Can J Public Health*. 2021 Jun;112(1):52–63. doi: [10.17269/s41997-021-00491-x](https://doi.org/10.17269/s41997-021-00491-x)