Obesity, lifestyle and socio-economic determinants of vitamin D intake: A population-based study of Canadian children

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ABSTRACT

OBJECTIVE: Vitamin D intake in childhood is primarily for the prevention of rickets. Inconsistent evidence has associated adequate blood concentrations with a decreased risk of certain health conditions. Further, obese individuals may have lower vitamin D status. The estimated average requirement (EAR) for children recently doubled to 400 IU/day. Our aim was to examine dietary intake of vitamin D in different body mass index (BMI) categories, in addition to assessing determinants.

METHODS: Data from two provincial surveys of grade 5 children, including a food frequency questionnaire and measured BMI, were used. Rao-Scott chi-square statistic tested the bivariate association between provinces and adequate dietary vitamin D intake. Key correlates were examined using multi-level logistic regression.

RESULTS: Those below the EAR differed between Alberta (78%) and Nova Scotia (81%). Those drinking <2 glasses of milk/day had 0.02 times the odds of meeting the EAR (95% CI: 0.01-0.02) compared to those drinking more. No significant difference was observed for BMI, though those consuming <1 glass of milk/day were more likely to be obese than those consuming ≥2 glasses/day. Income and physical activity were negatively correlated with meeting the EAR.

CONCLUSION: Many children did not meet the EAR for vitamin D from dietary sources and milk consumption was an important determinant. Given trends towards a more sedentary lifestyle and limited sun exposure, we recommend prioritizing public health efforts to support dietary vitamin D intake alongside interventions to increase physical activity and reduce sedentary behaviour. Further investigation is required to determine the need for targeted strategies for obese children.

KEY WORDS: Vitamin D; children; dietary reference intake; obesity; health behaviour; intake

La traduction du résumé se trouve à la fin de l'article.

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Childhood obesity is a pervasive global population health issue. Eating behaviours, such as inadequate intake of certain micronutrients, is an emerging concern despite evidence of adequate macronutrient consumption in obese children.^{1,2} Vitamin D, a fat-soluble vitamin, has gained attention as those who are obese may have lower 25-hydroxyvitamin D [25(OH)D] blood concentrations than normal weight individuals, potentially due to differing storage and metabolism.³⁻⁵ In 2010, the Institute of Medicine released revised dietary reference intakes for vitamin D, indicating an increase from the adequate intake of 200 IU/day to an estimated average requirement (EAR) of 400 IU/day and a recommended dietary allowance (RDA) of 600 IU/day for children over 1 year of age.⁵ A main source of vitamin D, in the form of vitamin D₃ (cholecalciferol), is endogenously produced on exposure to sunlight. However, this has become a less viable source due to widespread use of sunscreen and a more sedentary, indoor lifestyle.⁵ There are few natural food sources, though vitamin D₃ can be found in some animal-based foods, such as fatty fish and egg yolks. Further, certain fungal sources contain vitamin D₂ (ergocalciferol).

Since the requirements for vitamin D may be difficult to achieve through consumption of natural food sources, Canada implemented mandatory vitamin D fortification in 1975, which included milk and fortified plant-based beverages (35-45 IU/100 mL) and margarine

(530 IU/100 g).⁶ However, no new policies have been introduced to support intake at the revised recommended levels.

Vitamin D sufficiency prevents rickets in young children and osteomalacia in older children and adults.⁵ Though results have been inconsistent, there is mounting evidence implicating adequate blood concentrations of 25(OH)D in a decreased risk of

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certain health conditions, for example certain types of cancer, cardiovascular disease and glucose intolerance.⁷⁻⁹ Considering the growing prevalence of childhood obesity and the health ramifications of low vitamin D status, the overall aim of this research was to examine dietary intake of vitamin D in different body mass index categories, in addition to assessing lifestyle and socio-economic determinants of adequate dietary vitamin D intake in children 10-11 years of age.

METHODS

Study design

We used data from two cross-sectional, provincial surveys – the 2011 Nova Scotia Children's Lifestyle And School-performance Study (CLASS II) and the 2011 Raising healthy Eating and Active Living Kids in Alberta (REAL Kids Alberta) – that investigated nutrition, physical activity and body weight in grade 5 students. The survey methodology is described briefly here and in detail elsewhere.^{10,11}

CLASS II Sample and Survey Administration

All public schools in Nova Scotia were invited to participate in both data collection cycles, with a positive response rate of 269 schools (94.1%). A consent form and parent questionnaire, which requested information on socio-demographic factors and food insecurity, was sent home with students to be completed and returned by mail. The average parent response rate was 67.4%. In the school setting, trained CLASS personnel administered a slightly modified version of the Harvard Youth Adolescent Food Frequency Questionnaire (YAQ),¹² a questionnaire on physical and sedentary activities and measured heights and weights. Information for 1,019 children was eliminated due to non-response to at least one of the questionnaires; the remaining 5,560 children were included in the analysis.

REAL Kids Alberta Sample and Survey Administration

A one-stage stratified random sampling design was used to select REAL Kids Alberta survey participants. All elementary schools in Alberta were included in the sampling frame, with the exception of francophone (2% of all schools), charter (1%), private (7%) and on-reserve federal schools (2%). Schools were stratified according to urban, city (population ≥40,000) or rural-town (population <40,000) regions, and randomly selected within each stratum to ensure proportional representation of schools from each geographic region. Of a total of 164 invited schools, 151 (92%) agreed to participate. A home survey and parent consent forms were sent home with an average response rate of 66%. Trained evaluation assistants administered the YAQ in schools. Information for 258 students was eliminated due to non-response to at least one of the questionnaires, leaving 3,140 students available for analysis.

Selected anthropometric, dietary and lifestyle factors

Body Mass Index: Standing height (without shoes) was measured to the nearest 0.1 centimetre and body weight to the nearest 0.1 kilogram on calibrated digital scales. The measurements generally took place in the classroom, behind a mobile screen. Body mass index (BMI) was calculated by dividing weight (kg) by

Table 1. Participant characteristics by dietary intake of vitamin D below the estimated average requirement (EAR) by province

Characteristics	Overall (n=8958)	Below EAR in Alberta (n=3398)	Below EAR in Nova Scotia (n=5560)
Total	–	78.0%	81.0%
Sex			
Female	50.9%	81.1%	84.2%
Male	49.1%	74.4%	76.8%
Body mass index category			
Not overweight or obese	71.6%	77.1%	80.3%
Overweight	19.3%	79.5%	81.4%
Obese	9.2%	77.9%	79.6%
White milk			
<1 glass/week	47.4%	97.2%	97.6%
1 glass/day	15.0%	95.9%	96.5%
≥2 glasses/day	37.6%	46.5%	51.1%
Chocolate milk			
≤1 glass/month	76.1%	83.5%	85.7%
>1 glass/month	23.9%	59.7%	63.9%
Margarine			
<1/week	60.7%	81.0%	82.5%
1-6/week	29.3%	78.5%	83.0%
1/day	10.0%	56.2%	64.4%
Fresh fish			
<1/month	55.8%	78.6%	82.5%
2-6/month	33.5%	79.1%	81.4%
≥1/week	10.6%	69.0%	70.8%
Tuna sandwich			
<1/month	65.6%	80.3%	82.5%
2-6/month	24.4%	76.9%	81.4%
≥1/week	10.0%	64.5%	68.0%
Fried food at home			
<1/week	46.0%	79.8%	82.8%
1-3/week	47.3%	78.2%	80.6%
≥4/week	6.6%	62.0%	63.1%
Fried food away from home			
<1/week	56.6%	80.7%	82.5%
1-3/week	40.2%	75.3%	79.6%
≥4/week	3.1%	57.4%	63.9%
Multivitamin supplement			
No	38.5%	78.4%	81.7%
Yes	61.5%	77.2%	79.4%
Multivitamin supplement frequency			
≤2/week	32.7%	80.6%	79.4%
3-5/week	25.3%	80.5%	80.5%
≥6/week	42.0%	73.1%	78.9%
Multivitamin supplement duration			
0-1 year	30.3%	77.7%	78.4%
2-4 years	38.1%	79.2%	83.7%
≥5 years	31.7%	74.8%	75.6%
DQI (without supplement)			
1 st tertile (poorest)	32.9%	82.3%	84.3%
2 nd tertile	33.4%	74.2%	77.9%
3 rd tertile	33.7%	76.8%	79.7%
Eating habits			
Healthy	63.2%	79.0%	81.1%
Somewhat healthy/ Unhealthy	36.8%	75.6%	80.2%
Computer time			
<1 hour/day	51.5%	78.8%	82.5%
1-2 hours/day	41.8%	77.0%	80.0%
≥3 hours/day	6.7%	72.3%	75.9%
PAQ-C score			
1 st tertile (least active)	31.8%	84.2%	84.9%
2 nd tertile	35.6%	79.6%	82.0%
3 rd tertile	32.6%	69.7%	74.8%
Income			
<\$50,000	23.8%	74.3%	78.0%
\$50,000-\$100,000	39.2%	77.6%	80.6%
>\$100,000	37.0%	77.9%	82.3%
Education			
Below secondary	23.9%	75.5%	77.2%
Community college	39.5%	77.0%	80.5%
University	36.6%	79.6%	82.7%
Region			
Urban	47.9%	78.5%	81.9%
Rural/small town	52.1%	77.1%	78.5%
No money			
Often true	1.5%	69.0%	81.7%
Sometimes true	8.5%	73.6%	77.6%
Never true	90.0%	78.5%	81.1%

Table 2. Multi-level logistic regression analysis of associations for milk intake by body mass index category

	Obese† (OR)	Obese‡ (OR)	Overweight or obese† (OR)	Overweight or obese‡ (OR)
White milk				
<1 glass/day	1.29 (1.11-1.51)*	1.34 (1.10-1.64)*	1.22 (1.10-1.35)*	1.09 (0.96-1.24)
1 glass/day	1.15 (0.94-1.42)	1.34 (1.03-1.74)*	1.20 (1.05-1.37)*	1.09 (0.91-1.30)
≥2 glasses/day	1	1	1	1
Chocolate milk				
≤1 glass/month	0.99 (0.76-1.29)	1.38 (0.93-2.05)	1.01 (0.84-1.21)	1.13 (0.89-1.44)
>1 glass/month	1	1	1	1

* $p < 0.05$.

† Adjusted for standardized energy intake.

‡ Adjusted for standardized energy intake, sex, region of residence, household income, parental education.

height squared (m^2), then categorized according to adult definitions of overweight (≥ 25 kg/m^2) and obesity (≥ 30 kg/m^2), adjusted to age- and sex-specific cut-off points proposed by the International Obesity Task Force.¹³ Three BMI categories were assessed: underweight or normal weight; overweight; and obese. Students without height and weight measurements were excluded from analyses related to weight status ($n=360$).

Assessment of Dietary Intake and Diet Quality: The Harvard YAQ was used to assess dietary intake. Validation procedures for this tool have been described previously.¹² The YAQ is intended for use with children and adolescents 9 to 18 years of age and collects detailed information on the frequency of intake for certain foods, supplement consumption and meal-time behaviours. Intake of foods from recommended food groups was calculated, as well as nutrient and energy intakes.¹⁴ We standardized the measure by assuming that each child consumes 2000 kcal each day.^{15,16} Vitamin D intake was categorized using the EAR, which indicates the median daily intake value that is estimated to meet the requirement of half the healthy individuals in a life-stage and gender group.⁵ The frequency of consumption for food sources of vitamin D (i.e., white milk, chocolate milk, margarine, fish) was assessed. Dietary habits were examined as self-reported health of eating habits and consumption of fried foods at or away from home. Multivitamin supplements use was assessed in general, though contribution of vitamin D from supplements could not be determined as specific information was not requested.

The Diet Quality Index International (DQI-I) was used to examine diet quality as a composite measure that encompasses dietary adequacy, variety, moderation and balance.¹⁷ An overall score from 0 to 100 (best possible diet quality) is assigned. The participant's ability to afford food was assessed through his or her response to the statement "The food that we bought just didn't last and we didn't have money to get more."

Physical Activity: A composite measure for physical activity was created using questions (composed of 29 items) largely adopted from the Physical Activity Questionnaire for Children (PAQ-C).¹⁸ These questions included: i) mode of transport to and from school; ii) time spent getting to and from school; iii) frequency of child's activities outside school hours; iv) activities at morning and lunch recess in the past 7 days; and v) frequency of involvement in sports and physical activities in the past 7 days. A score was derived – ranging from 0 to 5 – based on the score given to the 29 items.

Data analysis

Descriptive statistics (frequencies, percentiles) were used to characterize the population by province and by EAR for vitamin

D. We used Rao-Scott chi-square statistic to test the bivariate association between provinces and inadequate vitamin D intake (<400 IU [EAR]).¹⁹ Multi-level logistic regression analyses, considering school-level and province-level effects as random effects, accounted for the study design, which nested students within schools and schools within province. These regression analyses were used to examine associations between BMI categories and intake of white milk and chocolate milk. The odds ratios were adjusted for energy intake and demographic covariates.

Analyses were restricted to students with an energy intake of more than 500 kcal and less than 5000 kcal, as per established criteria based on the analyses of food frequency data ($n=294$ excluded).¹⁵ Multiple risk factors may be associated with dietary vitamin D intake, thus three separate models were created to ensure adequate sample sizes in the examination of: 1) food sources of vitamin D and supplement use; 2) BMI, socio-demographic factors and ability to afford food; and 3) dietary habits and physical activity. Each regression was adjusted for standardized energy intake, demographic factors (sex, household income, parent's education, urban or rural/small town dwelling and ability to afford food) and other variables in the model. The statistical analyses on the children of Nova Scotia were weighted for non-response bias.²⁰ These were calculated based on average household incomes according to postal code data from the 2011 Census for participants and non-participants to account for non-response bias due to lower participation rates in residential areas with lower household incomes. For the Alberta cohort, all analyses were weighted to accommodate the design effect so that the estimates apply to the grade five student population of Alberta.²¹ The multi-level regressions were conducted in residual maximum pseudo likelihood approach using the GLIMMIX procedure in SAS version 9.3 and Figure 1 was constructed in R (version 3.0.2). A p -value of <0.05 was used to determine significance. The Dalhousie University and University of Alberta Health Research Ethics Boards approved all study procedures.

RESULTS

Vitamin D intake was below the EAR in 78% of Alberta participants, which was significantly different from the 81% of Nova Scotia participants below the EAR (Table 1; Rao-Scott p -value = 0.01). A significant difference also existed in the prevalence of obesity between the provinces, with participants having a lower prevalence of obesity in Alberta than in Nova Scotia (8.7% vs. 11% respectively). In Alberta, 97% of grade 5 students who consumed <1 glass of white milk per day had a vitamin D intake below the EAR; the proportion was similar for

Figure 1. Cumulative percentile distributions of dietary vitamin D intake (IU) by province and body mass index (BMI) category using data from the 2011 Children's Lifestyle and School Performance Study II (CLASS-II) and Raising healthy Eating and Active Living Kids in Alberta (REAL Kids Alberta) (2011). The vertical lines indicate the estimated average requirement (400 IU) and recommended dietary allowance (600 IU) for vitamin D intake.

participants in Nova Scotia (98%). The proportion decreased for children who drank ≥ 2 glasses of white milk per day for both Nova Scotia (51%) and Alberta (47%).

Participants who consumed <1 glass of white milk per day or 1 glass per day were more likely to be obese than those who drank ≥ 2 glasses of white milk per day (Table 2), after adjusting for standardized energy intake and demographic variables (OR=1.34, 95% CI: 1.10-1.64 and OR=1.34, 95% CI: 1.03-1.74 respectively). The association between consumption of chocolate milk and weight status was not statistically significant.

Figure 1 demonstrates the cumulative percent distributions by province and BMI category. Inadequate dietary vitamin D intake was evident across percentiles, with the EAR being achieved only above the 80th percentile, regardless of province or BMI category.

In addition to white milk, food sources of vitamin D were associated with achieving the EAR (Table 3a). Children who drank ≤ 1 glass of chocolate milk per month (OR=0.51, 95% CI: 0.40-0.66) were less likely to achieve a vitamin intake above the EAR, in the model adjusted for demographic factors, than those who drank >1 glass per month. Children who consumed margarine less often were less likely to have a vitamin D intake above the EAR and children who consumed fresh fish less than once per month, as opposed to once or more per week, were more likely to have vitamin D intake above the EAR.

BMI and ability to afford food were not significantly associated with vitamin D intake above the EAR. This was also true of the demographic variables, with the following exception: children

living in a household with a combined income below \$50,000/year were less likely to have a vitamin D intake above the EAR than those in households with a combined income $> \$100,000$, after adjusting for standardized energy intake (OR=0.79, 95% CI: 0.66-0.95).

Computer time and eating habits were not associated with achieving the EAR for vitamin D. Children who were less physically active (PAQ-C in the 1st [OR=0.50; 95% CI: 0.41-0.60] or 2nd tertile [OR=0.64; 95% CI: 0.54-0.76]) were less likely to have vitamin D intake above the EAR than children who were more physically active, in the fully adjusted model (Table 3b). Children with a lower diet quality were more likely to have vitamin D intake above the EAR than those in the highest diet quality tertile. Children who consumed fried food at home or away from home $< \text{once per week}$, as opposed to > 4 times per week, were more likely to achieve the EAR ([OR=1.37, 95% CI: 1.00-1.88] and [OR=2.4, 95% CI: 1.55-3.73] respectively), and for fried food away from home this was also significant at 2 to 6 times per week (OR=1.79, 95% CI: 1.17-2.73).

DISCUSSION

This population-based study provides new insights on vitamin D intake in Canadian children. It was determined that approximately 80% of children in Canada did not meet the EAR of 400 IU per day. Recent research has shown that 25(OH)D blood concentrations are lower among obese children, however, our study demonstrated that dietary intake of vitamin D was in fact

Table 3a. Multi-level logistic regression analysis for associations of intake of food sources of vitamin D with achieving the estimated average requirement (EAR) for vitamin D in children in Nova Scotia and Alberta

Variables	OR adjusted for standardized energy intake	OR adjusted for demographic variables	OR adjusted for all factors in model†
Chocolate milk			
≤1 glass/month	0.44 (0.37-0.53)*	0.51 (0.40-0.66)*	0.01 (0.01-0.01)*
>1 glass/month	1	1	1
Margarine			
<1/week	0.52 (0.44-0.62)*	0.60 (0.48-0.75)*	0.43 (0.36-0.51)*
1-6/week	0.47 (0.39-0.57)*	0.51 (0.40-0.65)*	0.31 (0.26-0.38)*
1/day	1	1	1
Fresh fish			
<1/month	1.53 (1.26-1.86)*	1.59 (1.23-2.06)*	1.43 (1.19-1.72)*
2-6/month	1.34 (1.09-1.64)*	1.26 (0.96-1.64)	1.06 (0.88-1.28)
≥1/week	1	1	1

* $p < 0.05$.

† Adjusted for demographic variables (sex, region of residence, household income, parental education), white milk intake and all other variables in the model. Frequency of consuming a tuna sandwich and self-reported multivitamin supplement use were not significant in the model (data not shown).

Table 3b. Multi-level logistic regression analysis for associations of dietary intake and physical activity habits with achieving the estimated average requirement (EAR) for vitamin D in children in Nova Scotia and Alberta

Variables	OR adjusted for standardized energy intake	OR adjusted for demographic variables	OR adjusted for all factors in the model†
Fried food at home			
<1/week	1.39 (1.1-1.75)*	1.3 (0.97-1.73)	1.37 (1.00-1.88)*
1-3/week	0.98 (0.78-1.23)	0.9 (0.68-1.19)	0.94 (0.69-1.26)
>4/week	1	1	1
Fried food away from home			
<1/week	2.12 (1.53-2.95)*	1.39 (0.92-2.09)	2.40 (1.55-3.73)*
1-3/week	1.63 (1.18-2.25)*	1.03 (0.69-1.54)	1.79 (1.17-2.73)*
>4 per week	1	1	1
DQI (without supplement)			
1 st tertile (poorest)	2.20 (1.85-2.62)*	2.04 (1.63-2.56)*	2.74 (2.21-3.39)*
2 nd tertile	1.63 (1.40-1.9)*	1.54 (1.26-1.88)*	1.81 (1.51-2.18)*
3 rd tertile	1	1	1
PAQ-C score			
1 st tertile (least active)	0.56 (0.48-0.64)*	0.59 (0.49-0.72)*	0.50 (0.41-0.60)*
2 nd tertile	0.68 (0.59-0.78)*	0.68 (0.57-0.81)*	0.64 (0.54-0.76)*
3 rd tertile	1	1	1

* $p < 0.05$.

† Adjusted for demographic variables (sex, region of residence, household income, parental education) and all other variables in the model. Computer time and healthfulness of eating habits were not significant in the model (data not shown).

similar across weight categories. Other than the consumption of milk, margarine and fish, we did not identify important determinants of vitamin D intake. Therefore, we recommend further promotion of these food products, though we acknowledge that recommendations that are consistent with Canada's Food Guide would still result in intakes below the current EAR of 400 IU/d.

Our results are consistent with those from a nationally representative sample of Canadian children (9-13 years of age), where 85% of boys and 93% of girls did not achieve the EAR from food sources alone.¹ Similarly, more than 75% of a representative sample of Americans (9-13 years of age) from the National Health and Nutrition Examination Survey were not achieving the EAR for vitamin D through dietary intake.²² In our study population, there was no difference in dietary vitamin D intake by BMI category.

Milk is fortified with vitamin D, thus milk consumption was a strong predictor of vitamin D intake.^{5,23} Fluid milk consumption has decreased in several countries – including Canada and the United States – in recent years.^{24,25} For example, total fluid milk consumption in Canada has decreased from a peak of 98.5 litres per capita in 1980 to less than 80 litres per capita in 2003.²⁴ Further, using data from the 2004 Canadian Community Health Survey (CCHS), cycle 2.2, it was demonstrated that 37% of children aged 4 to 9 years did not consume the recommended 3 servings of milk products each day.²⁶ An additional examination determined

that intake of sugar-sweetened beverages may be displacing milk consumption in youth 9 to 18 years of age, and further, vitamin D intake was lower among those in the low-income group.^{23,27}

Blood concentrations of 25(OH)D have been the subject of global research efforts due to concerns regarding potentially deficient or inadequate vitamin D status. The link between dietary intake of vitamin D and 25(OH)D concentrations cannot be established in the current study, however, other studies appear to demonstrate that the majority of Canadian children are meeting required blood concentrations. For example, an investigation of a nationally representative sample, using data from the 2007-2009 Canadian Health Measures Survey, revealed that the percentage of children aged 6 to 11 years who did not meet the 25(OH)D cut-off considered consistent with the EAR (<40 nmol/L; measured using the "LIAISON" kit) was too low to reliably report.^{5,28} This high proportion of adequate 25(OH)D blood concentrations may be due to the LIAISON method giving higher values than other assay methods.²⁹ Further, the age range includes younger children than those included in our study, which may have led to higher 25(OH)D concentrations. Notwithstanding, our sample indicates that dietary intake is inadequate and that future research is needed to investigate the link between low dietary intake as a determinant of 25(OH)D concentrations below the specified IOM cut-offs.

Obese children may be more at risk of lower 25(OH)D blood concentrations than their normal-weight counterparts, though

the mechanism is unclear.^{28,30} It has been hypothesized that vitamin D is stored in adipose tissue and not released when needed, or that there may be enhanced uptake and clearance by adipose tissue.⁵ Thus, if dietary intake of vitamin D contributes to 25(OH)D blood concentrations, obese children may be more at risk of low vitamin D status.

Our examination of key correlates of adequate dietary vitamin D may inform population health interventions to enhance dietary intake behaviours. Those in the lowest income group were less likely to achieve the EAR for vitamin D, which may be due to lack of access to adequate sources. Interestingly, there was no significant relationship between those respondents reporting an inability to afford food and those not, though only one question explored this factor. Consuming fried food at or away from home less often and higher levels of physical activity were related to vitamin D intake above the EAR, indicating that promoting healthy lifestyle behaviours may support improved dietary intake. Studies examining lifestyle correlates of vitamin D intake in children are lacking.^{31,32} A study of one small cohort of 385 Lebanese children aged 10 to 16 years, which assessed nutritional intake using a food frequency questionnaire validated by a 7-day food record, found that greater physical activity was a correlate of increased vitamin D intake.³¹ Children with healthier behaviours may also be more likely to consume vitamin D-rich sources, such as milk. Interestingly, a negative correlation between diet quality scores in the lowest tertile and achieving the EAR in our study population seems to contradict this theory. This may be due to type I error, but it is also possible that participants' overall diet quality is lower, though vitamin D intake is sufficient, or that higher milk intake, but not higher overall diet quality, may account for this finding. Since milk contributes approximately 50% of the vitamin D in the diet of Canadian children (see Table 1 for frequency of white milk intake by province), a separate analysis was conducted that revealed no significant relationship between diet quality and frequency of milk intake (Supplementary Table 1). The relationship between these factors requires further investigation that is beyond the scope of the current analyses.

Strengths of this study include a large sample size, data from school children in two socio-economically diverse provinces, and our ability to consider a wide range of lifestyle and dietary factors. There are also measured anthropometric indicators and adjustment for non-response bias. In this study, we were unable to identify vitamin D intake from supplemental sources, and further, the contributions of endogenous production of vitamin D. It has been observed that supplement users are more likely than non-supplement users to demonstrate 25(OH)D blood concentrations above the IOM cut-offs, and further that 13% of boys and 18% of girls (6 to 11 years of age) in Canada reported consuming supplements containing vitamin D.³³ Thus, intake could be underestimated in the current analysis. Further, though we used the validated YAQ, the responses were self-reported and thus the estimation of vitamin D intake may be subject to error. We attempted to minimize this error by having research assistants read the questionnaire aloud and provide unbiased assistance when necessary. Future research is needed to explore the potential association of dietary vitamin D intake and food security using more comprehensive measures, since only one

question addressing the participant's ability to afford food was included in the current analyses.

This research highlights the need for public health strategies to support intake of dietary sources of vitamin D. Recent research indicating that most children are achieving a vitamin D status consistent with the EAR is contradictory to our finding that the majority of children are not achieving adequate dietary vitamin D intake. Thus, the interplay between vitamin D intake, blood concentrations and socio-economic and behavioural predictors must be unraveled to ensure the most effective interventions are planned. Further investigation is required to determine whether targeted strategies are needed for those in the higher BMI category. Given trends towards a more sedentary lifestyle and limited sun exposure, we recommend prioritizing public health efforts to support dietary vitamin D intake alongside interventions to increase physical activity and reduce sedentary behaviour.

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RÉSUMÉ

OBJECTIF : L'apport en vitamine D durant l'enfance sert principalement à prévenir le rachitisme. Bien que les données probantes divergent, des études associent des concentrations sanguines adéquates à un moindre risque de contracter certains troubles médicaux. De plus, les personnes obèses pourraient avoir un statut plus faible en vitamine D. Le besoin moyen estimatif (BME) en vitamine D des enfants a récemment été doublé à 400 UI/jour. Notre but était d'examiner l'apport alimentaire en vitamine D dans différentes catégories de l'indice de masse corporelle (IMC), en plus d'en évaluer les déterminants.

MÉTHODE : Nous avons utilisé les données de deux enquêtes provinciales auprès d'élèves de 5^e année comportant un questionnaire sur la fréquence de consommation des produits alimentaires et des mesures de l'IMC des élèves. Le test du khi-carré de Rao-Scott a analysé l'association bivariée entre les deux provinces et la suffisance de l'apport alimentaire en vitamine D. Les principaux corrélats ont été examinés par régression logistique multiniveau.

RÉSULTATS : La proportion d'enfants dont l'apport est en-deçà du BME était différente en Alberta (78 %) et en Nouvelle-Écosse (81 %). Les enfants qui buvaient <2 verres de lait/jour avaient 0,02 fois la probabilité d'avoir un apport supérieur ou égal au BME (IC de 95 % : 0,01-0,02) que ceux qui en buvaient plus. Aucun écart significatif n'a été observé pour l'IMC, mais les enfants qui consommaient <1 verre de lait/jour étaient plus susceptibles d'être obèses que ceux qui en consommaient ≥2 verres/jour. Le revenu et l'activité physique présentaient des corrélations négatives avec le statut par rapport au BME.

CONCLUSION : De nombreux enfants avaient un apport en vitamine D de sources alimentaires en-deçà du BME, et la consommation de lait en était un important déterminant. Étant donné la tendance à la sédentarisation des modes de vie et l'exposition limitée au soleil, nous recommandons de privilégier les efforts de santé publique qui appuient l'apport alimentaire en vitamine D en plus des interventions pour accroître l'activité physique et réduire les comportements sédentaires. Il est nécessaire de pousser la recherche pour déterminer s'il faudrait des stratégies ciblant les enfants obèses.

MOTS CLÉS : vitamine D; enfant; apports nutritionnels de référence; obésité; comportement en matière de santé; apport