Examining the effects of increased vitamin D fortification on dietary inadequacy in Canada

Yaseer A. Shakur, PhD,[1] Wendy Lou, PhD,[2] Mary R. L'Abbe, PhD[1]

ABSTRACT

OBJECTIVES: Despite mandatory fortification of milk and margarine, most Canadians have inadequate vitamin D intake and consequently poor vitamin D status, especially in the winter. Increasing vitamin D fortification is one possible strategy to address this inadequacy. The purpose of our study was to examine the modelled effect of increased vitamin D fortification on the prevalence of inadequacy and the percentage of intakes greater than the Tolerable Upper Intake Level (UL) using different fortification scenarios.

METHODS: Dietary intakes (24-h recall) from the 2004 Canadian Community Health Survey 2.2 (n=34,381) were used to model increased vitamin D levels in milk and the addition of vitamin D to cheese and yogurt at various levels to meet label claims of an "excellent source" based on the recommended dietary intakes. The Software for Intake Distribution Evaluation was used to estimate the prevalence of inadequacy and intakes >UL.

RESULTS: Fortification of milk, yogurt and cheese at 6.75 µg (270 IU)/serving led to more than doubling of vitamin D intakes across all sex/age groups and a drop in the prevalence of dietary inadequacy from >80% to <50% in all groups. Furthermore, no intakes approached the UL under any fortification scenario in any sex/age group.

CONCLUSION: There is a pressing need to improve vitamin D status among Canadians.

Increasing vitamin D fortification of dairy products, consistent with their positioning in Canada's Food Guide, can lead to increased intake without a risk of excess. This is a population-wide public health strategy that should be given consideration in Canada.

KEY WORDS: Vitamin D; fortification; dietary inadequacy; Tolerable Upper Intake Level; dairy products

La traduction du résumé se trouve à la fin de l'article. *Can J Public Health* 2014;105(2):e127-e132.

Food fortification has played an important role for decades in ensuring that Canadians' nutrient requirements are met, and perhaps the most successful food fortification campaign was the addition of vitamin D to milk to eradicate rickets in the 1940s.[1] While poor skeletal health remains an important consequence of vitamin D deficiency, in recent years there has been a growing body of evidence suggesting that vitamin D deficiency may be associated with several other negative consequences, including cancer, asthma, cardiovascular disease, type 2 diabetes, negative pregnancy outcomes and autoimmune diseases.[2,3] Nonetheless, skeletal health was the outcome used by the Institute of Medicine (IOM) to set the Dietary Reference Intakes (DRIs), which were recently raised significantly for most age groups.[4]

Analysis of Canadian Community Health Survey 2004 (CCHS) data shows that in all age/sex groups over 75% of Canadians consume inadequate vitamin D from food sources.[5] Furthermore, Whiting et al. used 2007-2009 Canadian Health Measures Survey data to show that over 25% of Canadians have serum 25-hydroxyvitamin D [25(OH)D] <50 nmol/L, although 50 nmol/L is the biochemical level of vitamin D thought to be comparable with the corresponding Recommended Dietary Allowance (RDA).[6] These biochemical estimates of inadequacy are lower than the dietary estimates possibly because the body endogenously synthesizes vitamin D from exposure to UVB (ultraviolet B) light in the summer months.[4] The authors also reported higher 25(OH)D levels in the summer compared with winter and among Whites compared with non-Whites. In fact, approximately two thirds of Canadians have serum 25(OH)D <75 nmol/L,[7] a level thought to be desirable for overall health benefits and disease prevention.[8]

Authors of a recent review have called for an urgent need to increase vitamin D status among Canadians,[9] as vitamin D deficiency is estimated to cost $14.4 billion annually in Canada.[9] One possible solution to improve vitamin D status among Canadians is to increase its fortification in the food supply.[10] Currently, mandatory vitamin D fortification in Canada covers only fluid milk (2.6-2.8 µg/250 mL) and margarine (13.25 µg/100 g);[11] it may be added on a voluntary basis to a few other food items, including orange juice and yeast-leavened bakery products.[12] Canada's Food Guide (CFG) recommends that all Canadians consume 2-4 Milk and Alternatives servings daily,[13] mainly to achieve adequate calcium and vitamin D intakes.[14] In its directional statements appearing beside the number of servings, the CFG also

Author Affiliations

1. Department of Nutritional Sciences, Faculty of Medicine, University of Toronto, Toronto, ON
2. Dalla Lana School of Public Health, University of Toronto, Toronto, ON

Correspondence: Mary R. L'Abbe, Earle W. McHenry Professor and Chair, Department of Nutritional Sciences, Faculty of Medicine, University of Toronto, FitzGerald Bldg, Rm 315, 150 College St, Toronto, ON M5S 3E2, Tel: 416-978-7235, E-mail: mary.Labbe@utoronto.ca

Acknowledgements: This study was funded by a grant from Dairy Farmers of Canada. Dairy Farmers of Canada had no role in the implementation, analysis or interpretation of the data. Yaseer Shakur also received funding from a Comprehensive Research Experience for Medical Students scholarship from the Faculty of Medicine, University of Toronto.

Conflict of Interest: None to declare.

© Canadian Public Health Association, 2014. All rights reserved.

recommends that Canadians have 500 mL (2 cups) of milk for adequate vitamin D. This would mean that for many age groups (particularly young children and adults aged 19-50), all their Milk and Alternatives servings would have to come from fluid milk or a fortified soy beverage, rather than the other options shown in the CFG. While 50%-70% of adults and 53%-80% of children aged 4-18 years consume milk daily,[15,16] many Canadians choose their Milk and Alternatives servings from non-milk foods such as yogurt and cheese. Therefore, the objective of this analysis was to conduct dietary modelling to investigate the impact on Canadians' intakes of adding vitamin D to cheese and yogurt and of increasing the fortification levels in milk.

METHODS

Data source and subjects

For this analysis, we used dietary intake data from the 2004 CCHS 2.2, a nationally representative cross-sectional survey with the most recent data on dietary intake in the population.[17] The CCHS 2.2 is described in detail elsewhere.[17] We included data from all non-pregnant, non-lactating respondents ≥1 year, which led to a final sample of 34,381 subjects. The analyses were stratified by sex and age groups as defined in the IOM's DRI.[18] Ethics approval for this study was obtained from the Research Ethics Board at the University of Toronto.

Food intake data collection

The CCHS 2.2 employed a modified version of the US Department of Agriculture's (USDA) Automated Multiple Pass Method for 24-h food recall, and approximately one third of respondents were re-interviewed to estimate usual (long-term) intake.[17] The nutrient composition of foods consumed, as reported in the CCHS 2.2, was based on the Canadian Nutrient File (CNF) version 2001b,[19] which itself was primarily derived from the USDA Nutrient Database for Standard Reference, Release 13.[20]

Vitamin D modelling

We simulated the addition of vitamin D to the diet by first identifying foods to be modelled, followed by accessing each food record of each respondent in our sample and identifying which of their consumed food items were candidates to be fortified. We then adjusted the vitamin D content of candidate foods and summed up each respondent's total vitamin D intake.

Identifying foods to be modelled

We used CNF data along with food composition data in the CCHS 2.2 files to identify milk, cheese and yogurt foods as candidates to be fortified. The Nutrition Surveillance System food codes were used as identifiers to link the foods back to those consumed in the 24-h dietary recalls in the CCHS 2.2. For mixed dishes that contained milk, cheese or yogurt, the amount of milk, cheese or yogurt in the dish was estimated according to the composition of the mixed dish.

Modelling scenarios

The analyses were conducted using the schedule M standard reference amounts as the serving size,[21] as these are the serving sizes used in the Canadian Food and Drug Regulations.

Model 1: This model served as a reference against which the fortification scenarios were compared. We used vitamin D intake data as reported in the CCHS 2.2 with one modification: on the basis of the 2011 Interim Marketing Authorization allowing vitamin D addition to yeast-leavened bakery products, we modelled vitamin D in these products by adding 2.25 µg/100 g.[12] The remaining models all included this modification in addition to their individual adjustments.

Model 2: Cheese and yogurt were modelled to contain 25% (1.25 µg/serving) of the current Recommended Daily Intake (RDI) of 5 µg,[22] and milk was left at 2.7 µg/250 mL. The RDI is the amount of a vitamin or mineral nutrient established by the Canadian Food and Drug Regulations for the purposes of nutritional labelling and establishing nutrient content claims.[11]

Model 3: Milk, cheese and yogurt were modelled to contain 25% (3.75 µg/serving) of the new proposed RDI of 15 µg,[23] the labelling level that would correspond to the new higher DRIs for vitamin D.

Model 4: Milk was modelled at 45% (6.75 µg/serving) of new proposed RDI, and cheese and yogurt were modelled at 25% (3.75 µg/serving) of the new proposed RDI of 15 µg.[23]

Model 5: Milk, cheese and yogurt were modelled to contain 45% (6.75 µg/serving) of the new proposed RDI of 15 µg.[23]

Mature market scenario

The above models all mimicked fortification scenarios assuming 100% compliance with fortification. However, under voluntary fortification, for mature market scenarios[24] it is unlikely that all cheeses and yogurts would be fortified with vitamin D, resulting in consumers not always choosing vitamin D-fortified yogurts and cheeses. Therefore, assuming one third compliance, we used simulations to fortify 33% of cheeses and yogurts from models 2 to 5 (i.e., the scenarios in which cheeses and yogurts are modelled) and reran the analyses for these models.

Estimation of the prevalence of inadequacy and intakes >UL

The IOM's recently published revised DRI values for vitamin D were adopted when estimating the prevalence of inadequacy and percentage of intakes >UL.[4] The prevalence of inadequacy for vitamin D was estimated using the Estimated Average Requirement (EAR) cut-point method.[18] We also estimated the proportion of individuals with usual vitamin D intakes >UL. Recognizing the limitations of using the UL as a strict risk assessment cut-off, we merely infer that intakes below the UL are safe.[25]

Statistical analysis

All analyses were performed with the SAS software (version 9.2; SAS Institute Inc, Cary, NC). SIDE (version 1.11, Department of Statistics and Center for Agricultural and Rural Development, Iowa State University) was used to estimate the respondents' usual (long-term) vitamin D intakes from the second 24-h recall in a subset of respondents, as others have described previously.[26] Full distributions of intakes can be found in Appendix 1 – Supplementary Tables 2 to 10. The SIDE program was also used to estimate the prevalence of inadequacy and percentage of intakes >UL among all respondents.

Since the sampling design for the CCHS 2.2 was complex and multi-stage, variance estimation for these analyses was calculated using the bootstrap balanced repeated replication technique.

Table 1. Mean usual vitamin D intake (µg/day) stratified by sex and age subgroups based on modelling full fortification scenarios*

				Model 1†		Model 2‡		Model 3§		Model 4||		Model 5¶	
Sex	**Age (y)**	**EAR****	**N**	**mean**	**(SE) ††**	**mean**	**(SE)**	**mean**	**(SE)**	**mean**	**(SE)**	**mean**	**(SE)**
Both	1-3	10	2193	7.2	0.1	8.2	0.2	12.4	0.3	18	0.4	20.7	0.4
	4-8	10	3343	7	0.1	8.3	0.1	12.5	0.2	17.1	0.3	20.2	0.4
Male	9-13	10	2149	8.5	0.2	10	0.2	14.8	0.3	20.3	0.5	23.8	0.6
	14-18	10	2397	9	0.2	10.8	0.3	16.2	0.4	21.4	0.5	25.6	0.6
	19-30	10	1897	8	0.2	9.6	0.3	14.2	0.4	17.8	0.5	21.8	0.7
	31-50	10	2750	7.6	0.2	9	0.3	12.6	0.4	15.5	0.6	18.5	0.7
	51-70	10	2725	8.2	0.4	9.3	0.4	12.1	0.5	14.7	0.5	17	0.6
	>70	10	1601	7.9	0.4	8.8	0.5	11.2	0.6	14.4	0.8	15.9	0.9
	≥19	10	8973	7.9	0.2	9.2	0.2	12.5	0.2	15.6	0.3	18.3	0.4
Female	9-13	10	2043	6.9	0.2	8	0.2	11.9	0.3	16	0.4	19	0.5
	14-18	10	2346	6.3	0.2	7.6	0.2	11.4	0.3	15	0.4	18.1	0.5
	19-30	10	1915	5.7	0.2	6.9	0.2	10.3	0.3	13.1	0.4	16	0.6
	31-50	10	2851	6	0.3	7.1	0.3	10.1	0.4	12.6	0.4	15.1	0.5
	51-70	10	3407	6.4	0.3	7.3	0.3	10	0.3	12.4	0.3	14.6	0.4
	>70	10	2769	6.3	0.7	7.1	0.7	9.3	0.7	12.1	0.7	13.6	0.7
	≥19	10	10,942	6.1	0.2	7.1	0.2	9.9	0.2	12.5	0.2	14.7	0.3

* Model scenarios were conducted using Schedule M reference amounts21 as the serving size.
† This model served as the baseline model and it included current vitamin D fortification practices and the 2011 Interim Market Authorization, i.e., simulation of yeast-leavened bakery products to contain 2.25 µg of vitamin D per 100 g of product.
‡ Milk was simulated at 2.7 µg of vitamin D per 250 mL serving, and cheeses and yogurts were simulated to contain 1.25 µg of vitamin D per serving.
§ Milk, cheeses and yogurts were simulated to contain 3.75 µg of vitamin D per serving.
|| Milk was simulated at 6.75 µg of vitamin D per 250 mL serving, and cheeses and yogurts were simulated to contain 3.75 µg of vitamin D per serving.
¶ Milk, cheeses and yogurts were simulated to contain 6.75 µg of vitamin D per serving.
** Estimated average requirement (µg).
†† All standard errors were calculated using the bootstrap method for variance estimation.

Table 2. Mean usual vitamin D intake (µg/day) stratified by sex and age subgroups based on modelling mature market scenarios*

				Model 1†		Model 2‡		Model 3§		Model 4||		Model 5¶	
Sex	**Age (y)**	**EAR****	**N**	**mean**	**(SE) ††**	**mean**	**(SE)**	**mean**	**(SE)**	**mean**	**(SE)**	**mean**	**(SE)**
Both	1-3	10	2193	7.2	0.1	7.6	0.1	10.3	0.2	15.9	0.4	16.6	0.4
	4-8	10	3343	7	0.1	7.5	0.1	10	0.2	14.5	0.3	15.6	0.3
Male	9-13	10	2149	8.5	0.2	9.1	0.2	12	0.3	17.4	0.4	18.7	0.4
	14-18	10	2397	9	0.2	9.7	0.2	12.7	0.3	17.9	0.5	19.4	0.5
	19-30	10	1897	8	0.2	8.5	0.2	10.9	0.3	14.6	0.5	16	0.5
	31-50	10	2750	7.6	0.2	8.2	0.3	10.1	0.4	13	0.6	14	0.6
	51-70	10	2725	8.2	0.4	8.7	0.4	10.2	0.4	12.9	0.5	13.7	0.5
	>70	10	1601	7.9	0.4	8.5	0.5	10	0.5	13.2	0.8	13.8	0.7
	≥19	10	8973	7.9	0.2	8.5	0.2	10.3	0.2	13.4	0.3	14.3	0.3
Female	9-13	10	2043	6.9	0.2	7.3	0.2	9.5	0.2	13.6	0.4	14.6	0.5
	14-18	10	2346	6.3	0.2	6.7	0.2	8.9	0.2	12.5	0.4	13.5	0.4
	19-30	10	1915	5.7	0.2	6.2	0.2	7.9	0.2	10.6	0.4	11.7	0.4
	31-50	10	2851	6	0.3	6.5	0.3	8	0.3	10.5	0.4	11.4	0.4
	51-70	10	3407	6.4	0.3	6.8	0.3	8.2	0.3	10.7	0.3	11.4	0.3
	>70	10	2769	6.3	0.7	6.7	0.7	8.1	0.7	10.8	0.7	11.4	0.7
	≥19	10	10,942	6.1	0.2	6.6	0.2	8.1	0.2	10.6	0.2	11.4	0.2

* Model 1 is the comparison model and therefore based on a full fortification scenario; in Models 2-5, mature market scenarios were used assuming fortification of 33% of cheeses and yogurts; model scenarios were conducted using Schedule M reference amounts21 as the serving size.
† This model included current vitamin D fortification practices and the 2011 Interim Market Authorization, i.e., simulation of yeast-leavened bakery products to contain 2.25 µg of vitamin D per 100 g of product.
‡ Milk was simulated at 2.7 µg of vitamin D per 250 mL serving, and cheeses and yogurts were simulated to contain 1.25 µg of vitamin D per serving.
§ Milk, cheeses and yogurts were simulated to contain 3.75 µg of vitamin D per serving.
|| Milk was simulated at 6.75 µg of vitamin D per 250 mL serving, and cheeses and yogurts were simulated to contain 3.75 µg of vitamin D per serving.
¶ Milk, cheeses and yogurts were simulated to contain 6.75 µg of vitamin D per serving.
** Estimated average requirement (µg).
†† All standard errors were calculated using the bootstrap method for variance estimation.

Five hundred replicate sample survey weights were generated each by random selection, with replacement, from the original sample, and then all the performed adjustments were applied to this selected sample. A p-value <0.05 was considered statistically significant in all analyses.

RESULTS

Under modelling scenarios 4 and 5, there was a doubling of mean vitamin D intakes when compared with model 1, and several sex and age subgroups nearly tripled their mean intake in model 5 (Table 1). Model 5 represented the greatest increase in vitamin D intake over model 1, and males aged 14-18 showed the greatest increase in vitamin D intake, from 9 µg in model 1 to 25.6 µg in model 5. When mature market scenario was assumed, the effect of each model was dampened (Table 2), but there was still a doubling of intakes for the majority of sex and age subgroups under modelling scenario 5 when compared with model 1.

The increase in vitamin D intake under each scenario led to an expected decrease in the prevalence of vitamin D inadequacy (Figure 1). For models 4 and 5, all sex and age subgroups had a prevalence of inadequacy less than 50%, and it reached below 10% among children 1-13 and males 14-30 years old in model 5. As expected, when mature market scenario was assumed, the decrease in prevalence of inadequacy was diminished compared with the full modelling scenarios, and it was only in model 5 that all groups had a prevalence of inadequacy less than 50% (Figure 2).

The percentage of intakes >UL was zero for all groups under all modelling scenarios (Appendix 1 – Supplementary Table 1). In fact, the 95th percentile intake never reached above 50 µg (2000 IU) for any sex and age subgroup under any modelling scenario, which is

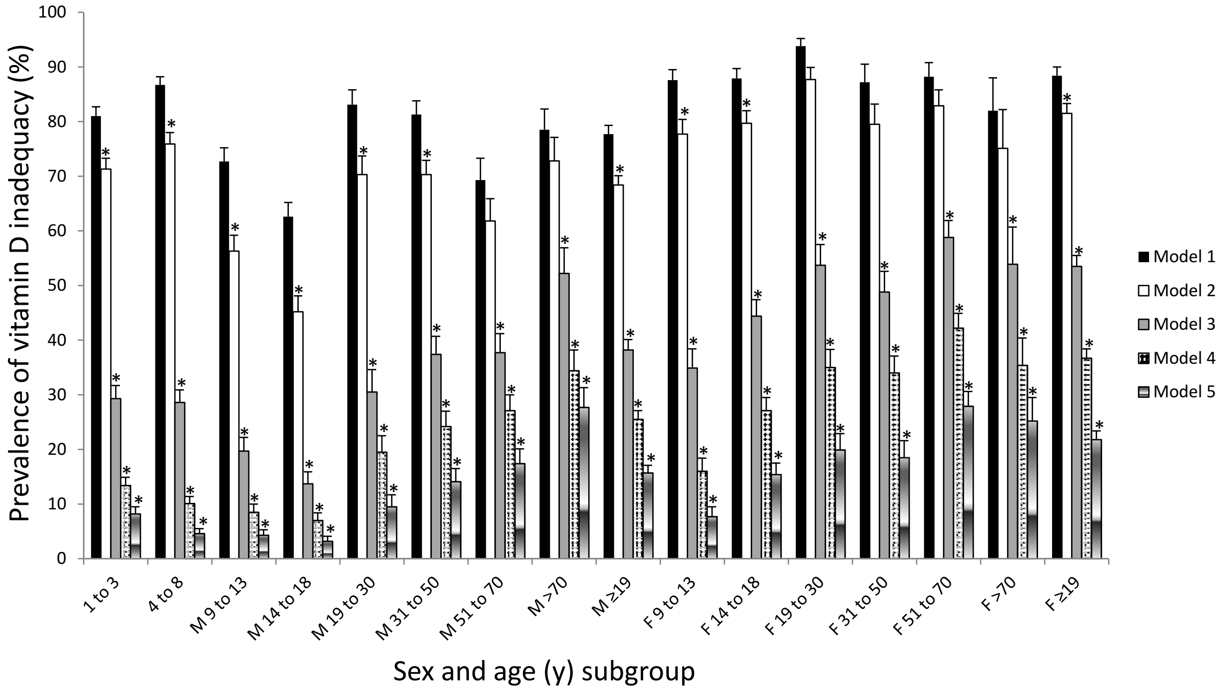

Figure 1. Prevalence of vitamin D inadequacy, stratified by sex and age subgroups and based on modelling full fortification scenarios. Error bars represent the standard error of the mean. Children 1-3y, n = 2193; 4-8y, n=3343; males 9-13y, n=2149; males 14-18y, n=2397; males 19-30y, n=1897; males 31-50y, n=2750; males 51-70y, n=2725; males >70y, n=1601; males ≥19y, n=8973; females 9-13y, n=2043; females 14-18y, n=2346; females 19-30y, n=1915; females 31-50y, n=2851; females 51-70y, n=3407; females >70y, n=2769; females ≥19y, n=10942. *95% confidence interval does not overlap with that of Model 1 of the same sex and age category.

half of the new UL (100 µg or 4000 IU) (Appendix 1 – Supplementary Tables 2 to 10).

DISCUSSION

This is the first study using nationally representative Canadian data to model the effects of fortifying cheese and yogurt in addition to milk on vitamin D intakes and inadequacy among Canadians. We observed doubling of intakes in modelling scenarios 4 (6.75 µg/serving of milk; 3.75 µg/serving of cheese and yogurt) and 5 (6.75 µg/serving of milk, cheese and yogurt) with a concurrent drop in the prevalence of inadequacy to below 50% in both models. Also, assuming a mature market scenario for cheese and yogurt under which only one third of these products are fortified, the prevalence of inadequacy still dropped below 50% in model 5. These prevalence estimates are a sizeable improvement over the current situation, in which the prevalence of inadequacy is >80% in most sex/age groups. Furthermore, the fact that none of the modelling scenarios resulted in intakes that approached the UL indicates that none of the fortification scenarios pose the risk of excessive intakes among Canadians.

We chose yogurt and cheese as candidates for vitamin D fortification because these two foods, along with milk, form the main items in the Milk and Alternatives Food Group of the CFG.[13] Moreover, a national survey showed that 31% of men and 49% of women believe that milk and other milk products contain vitamin D.[27] More specifically, approximately 30%-40% of Canadians believe that both cheese and yogurt contain vitamin D.[27] Although processors can use fortified milk to make yogurt and cheese, this practice is not mandatory and tends to result in much lower vitamin D levels than those found in milk. The CFG currently recommends "having 500 mL (2 cups) of milk every day for adequate vitamin D".[13] Thus, if cheeses and yogurts contained vitamin D, this directional statement can be broadened to include cheeses and yogurts, thereby providing more options for Canadians to consume adequate vitamin D. Yogurt has been fortified with vitamin D in Finland (0.5 µg/100g) since 2003,[28] and recent biochemical analyses have shown that vitamin D can be added to both yogurt and hard cheeses without compromising its stability.[29,30]

While it is well established that food fortification can improve nutrient status, there is always a need to balance the benefits of increased intake with possible risks of excess.[1] In the presence of mandatory fortification of milk and margarine and optional fortification of other products, the fact that there is still widespread prevalence of dietary inadequacy and approximately a quarter of Canadians with suboptimal serum 25(OH)D levels indicates that the current program is ineffective and there is a need for increased intakes. We have shown here that unless there is increased food fortification with vitamin D (in this case, with higher levels in milk, and fortification of cheese and yogurt), the majority of Canadians will continue to consume inadequate amounts from food alone and, as a result, there is likely to be no improvement in vitamin D status, especially in winter, when there is inadequate endogenous production of vitamin D from exposure to UVB light. Furthermore, no risk of intakes >UL under any fortification scenario indicates that increased fortification can result in the substantial benefit of increased intake without the risk of excess.

While supplemental vitamin D consumption does increase vitamin D intake and improve vitamin D status,[5,6] only 28%-31%

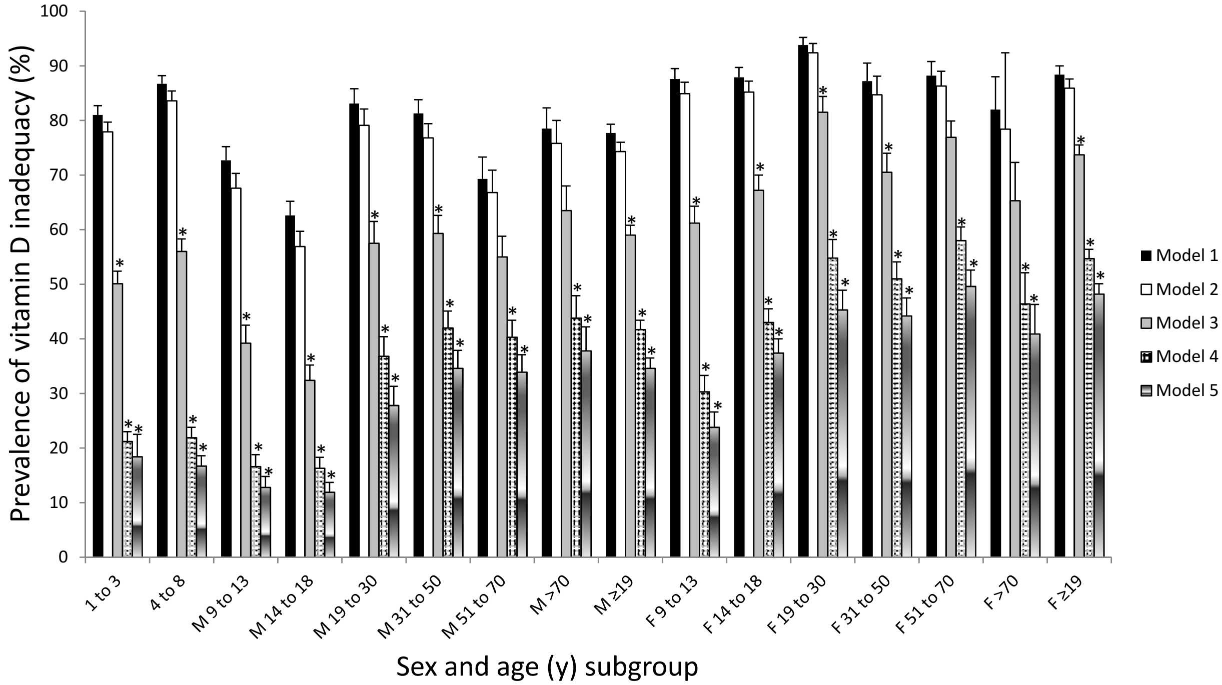

Figure 2. Prevalence of vitamin D inadequacy, stratified by sex and age subgroups and based on modelling mature market scenarios. Error bars represent the standard error of the mean. Children 1-3y, n = 2193; 4-8y, n=3343; males 9-13y, n=2149; males 14-18y, n=2397; males 19-30y, n=1897; males 31-50y, n=2750; males 51-70y, n=2725; males >70y, n=1601; males ≥19y, n=8973; females 9-13y, n=2043; females 14-18y, n=2346; females 19-30y, n=1915; females 31-50y, n=2851; females 51-70y, n=3407; females >70y, n=2769; females ≥19y, n=10942. *95% confidence interval does not overlap with that of Model 1 of the same sex and age category.

of Canadians consume a supplement containing vitamin D.[5,6] Furthermore, supplement use is associated with healthier lifestyles and higher socio-economic backgrounds, and therefore supplements are probably not consumed by those who need them the most to overcome dietary inadequacies.[31] In these analyses, we did not include supplemental vitamin D intake. However, even under model 5, which yielded the highest vitamin D intake, adding as much as 50 µg (2000 IU) of supplemental vitamin D to the diet would not result in a total intake >UL.

Our study now provides tangible evidence supporting the recommendations of an Expert Advisory Committee to Health Canada, demonstrating a potential lower prevalence of inadequacy with the addition of vitamin to more foods without a risk of excessive intakes.[32] A limitation of this study is that we used the CCHS 2.2, in which dietary intake data were collected eight years before our analysis. However, we are unaware of literature suggesting that Canadians' dietary patterns have changed since that time and, furthermore, the CCHS 2.2 remains our most recent nationally representative dietary intake data collection. A second limitation is that we estimated vitamin D inadequacy on the basis of dietary intake data alone and did not investigate clinical parameters of deficiency, because the CCHS 2.2 does not contain biochemical data. However, any discrepancy between estimates of inadequacy based on diet and estimates derived from clinical measures is only likely to occur in the summer months, when there is endogenous vitamin D synthesis from sun exposure. Also, this study limited fortification vehicles to dairy products, as we believe that the first step in expanding the current fortification program is to fortify non-milk dairy products. In the future, if vitamin D inadequacy continues to be a problem in Canada, it is possible to consider staple foods from the other three food groups.

CONCLUSION

Vitamin D fortification of yogurt and cheese, along with increased fortification of milk, has the potential to double dietary intakes of vitamin D in Canada and lower the documented high prevalence of inadequacy among Canadians. Furthermore, we show here that fortification, even at levels of 6.75 µg/serving, will not lead to intakes anywhere near the UL. Giving the growing evidence suggesting several other negative consequences of suboptimal vitamin D status, in addition to poor skeletal health, and the documented economic burden of poor vitamin D status, increased vitamin D fortification is a policy well worth pursuing in Canada. Such fortification would provide a more inclusive Milk and Alternatives CFG food group with respect to vitamin D, ensuring that cheese and yogurt, the most commonly consumed dairy products after fluid milk, also contain vitamin D at comparable levels.

REFERENCES

1. Food and Nutrition Board, Institute of Medicine. *Dietary Reference Intakes: Guiding Principles for Nutrition Labeling and Fortification*. Washington, DC: National Academies Press, 2003.
2. Bodnar LM, Catov JM, Simhan HN, Holick MF, Powers RW, Roberts JM. Maternal vitamin D deficiency increases the risk of preeclampsia. *J Clin Endocrinol Metab* 2007;92:3517-22.
3. Holick MF. Vitamin D deficiency. *N Engl J Med* 2007;357:266-81.
4. Food and Nutrition Board, Institute of Medicine. *Dietary Reference Intakes for Calcium and Vitamin D*. Washington, DC, 2011.
5. Shakur YA, Tarasuk V, Corey P, O'Connor DL. A comparison of micronutrient inadequacy and risk of high micronutrient intakes among vitamin and mineral supplement users and nonusers in Canada. *J Nutr* 2012;142:534-40.
6. Whiting SJ, Langlois KA, Vatanparast H, Greene-Finestone LS. The vitamin D status of Canadians relative to the 2011 Dietary Reference Intakes: An

examination in children and adults with and without supplement use. *Am J Clin Nutr* 2011;94:128-35.
7. Langlois K, Greene-Finestone L, Little J, Hidiroglou N, Whiting S. Vitamin D status of Canadians as measured in the 2007 to 2009 Canadian Health Measures Survey. *Health Rep* 2010;21:47-55.
8. Vieth R. Why the minimum desirable serum 25-hydroxyvitamin D level should be 75 nmol/L (30 ng/ml). *Best Pract Res Clin Endocrinol Metab* 2011;25:681-91.
9. Grant WB, Schwalfenberg GK, Genuis SJ, Whiting SJ. An estimate of the economic burden and premature deaths due to vitamin D deficiency in Canada. *Mol Nutr Food Res* 2010;54:1172-81.
10. Calvo MS, Whiting SJ, Barton CN. Vitamin D fortification in the United States and Canada: Current status and data needs. *Am J Clin Nutr* 2004;80:1710S-6S.
11. Health Canada. *Food & Drug Act*. Ottawa, ON, 1985.
12. Health Canada. Interim Marketing Authorization (IMA) to permit the optional addition of vitamin D2-yeast to yeast-leavened bakery products at a level of 2.22 ug per 100 g. Ottawa: Canada Gazette, 2011.
13. Health Canada. Eating Well with Canada's Food Guide. In: Food and Nutrition, ed., 2007. Available at: http://www.hc-sc.gc.ca/fn-an/food-guide-aliment/index-eng.php
14. Health Canada. Eating Well with Canada's Food Guide – A Resource for Educators and Communicators, 2011.
15. Garriguet D. Beverage consumption of Canadian adults. *Health Rep* 2008;19:23-29.
16. Garriguet D. Beverage consumption of children and teens. *Health Rep* 2008;19:17-22.
17. Health Canada. Canadian Community Health Survey, Cycle 2.2, Nutrition (2004) – A Guide to Accessing and Interpreting the Data. Ottawa, 2006.
18. Food and Nutrition Board, Institute of Medicine. *Dietary Reference Intakes: Applications in Dietary Assessment*. Washington, DC: National Academies Press, 2000.
19. Health Canada, The Canadian Nutrient File. Available at: http://www.hc-sc.gc.ca/fn-an/nutrition/fiche-nutri-data/cnf_aboutus-aproposdenous_fcen-eng.php (Accessed November 10, 2009).
20. USDA Agricultural Research Service. USDA National Nutrient Database for Standard Reference Release 19. Available at: http://www.ars.usda.gov/ba/bhnrc/ndl (Accessed July 10, 2007).
21. Canadian Food Inspection Agency. Food Labelling for Industry. February 21, 2012. Available at: http://www.inspection.gc.ca/english/fssa/labeti/guide/ch6e.shtml (Accessed June 3, 2012).
22. Canadian Food Inspection Agency. Nutrient content claims. In: CFIA Guide to Food Labelling and Advertising. Chapter 7.
23. *Codex Alimentarius* Commission. Guidelines on Nutrition Labelling (CAC/GL 2-1985). Adopted 1985. Revisions 1993 and 2011. 2011.
24. Health Canada. Addition of Vitamins and Minerals to Foods, 2005: Health Canada's Proposed Policy and Implementation Plans. In: Nutrition Fa, ed. Ottawa, 2005. Available at: http://www.hc-sc.gc.ca/fn-an/consult/_summary_report-rapport_sommaire/summary_report_vitamins-rapport_sommaire_vitamines-eng.php
25. Carriquiry AL, Camano-Garcia G. Evaluation of dietary intake data using the tolerable upper intake levels. *J Nutr* 2006;136:507S-5013S.
26. Dodd KW, Guenther PM, Freedman LS, Subar AF, Kipnis V, Midthune D, et al. Statistical methods for estimating usual intake of nutrients and foods: A review of the theory. *J Am Diet Assoc* 2006;106:1640-50.
27. Kalergis M, Lefebvre MA, Hovius J, MacDonald A. Consumer perceptions regarding the vitamin D content of milk products. *Can J Diet Pract Res* 2010;71:e57.
28. Tylavsky FA, Cheng S, Lyytikainen A, Viljakainen H, Lamberg-Allardt C. Strategies to improve vitamin D status in northern European children: Exploring the merits of vitamin D fortification and supplementation. *J Nutr* 2006;136:1130-34.
29. Hanson AL, Metzger LE. Evaluation of increased vitamin D fortification in high-temperature, short-time-processed 2% milk, UHT-processed 2% fat chocolate milk, and low-fat strawberry yogurt. *J Dairy Sci* 2010;93:801-7.
30. Wagner D, Rousseau D, Sidhom G, Pouliot M, Audet P, Vieth R. Vitamin D3 fortification, quantification, and long-term stability in cheddar and low-fat cheeses. *J Agric Food Chem* 2008;56:7964-69.
31. Guo X, Willows N, Kuhle S, Jhangri G, Veugelers PJ. Use of vitamin and mineral supplements among Canadian adults. *Can J Public Health* 2009;100:357-60.
32. Goltzman D, Atkinson S, Forest P, Gray-Donald K, Hanley D, Patel M, et al., Expert Advisory Committee of the Canadian Academy of Health Sciences. Responses to Questions from Health Canada on Implementation of Dietary Reference Intakes for Calcium and Vitamin D. Submitted to Health Canada, January 2012.

Received: June 14, 2013
Accepted: February 12, 2014

RÉSUMÉ

OBJECTIFS : Malgré l'enrichissement obligatoire du lait et de la margarine, la plupart des Canadiens ont un apport insuffisant en vitamine D – et donc un statut médiocre en vitamine D, surtout l'hiver. Accroître l'enrichissement en vitamine D est une stratégie possible pour combler cette carence. Nous avons cherché à examiner l'effet modélisé d'un accroissement de l'enrichissement en vitamine D sur la prévalence des carences et sur le pourcentage d'apports supérieurs à l'apport maximal tolérable (AM) selon divers scénarios d'enrichissement.

MÉTHODE : Les apports alimentaires (rappel 24 heures) tirés de l'Enquête sur la santé dans les collectivités canadiennes 2.2 de 2004 (n=34 381) ont servi à modéliser des niveaux accrus de vitamine D dans le lait et l'ajout de divers niveaux de vitamine D au fromage et au yogourt pour respecter les allégations d' « excellente source de vitamine D » sur les étiquettes en fonction des apports alimentaires recommandés. L'outil *Software for Intake Distribution Estimation* a servi à estimer la prévalence des carences et les apports >AM.

RÉSULTATS : L'enrichissement du lait, du yogourt et du fromage à 6,75 µg (270 UI)/portion ferait plus que doubler les apports en vitamine D chez les deux sexes et dans tous les groupes d'âge et abaisserait la prévalence des carences nutritionnelles de >80 % à <50 % dans tous les groupes. Au demeurant, aucun apport ne s'approche de l'AM, peu importe le scénario d'enrichissement, dans aucun groupe d'âge ou de sexe.

CONCLUSION : Il existe un besoin pressant d'améliorer le statut en vitamine D de la population canadienne. Accroître l'enrichissement en vitamine D des produits laitiers, en respectant les niveaux recommandés dans le Guide alimentaire canadien, peut mener à des apports accrus sans risque d'excès. C'est une stratégie de santé publique à l'échelle de la population qui devrait être envisagée au Canada.

MOTS CLÉS : vitamine D; enrichissement; carences nutritionnelles; apport maximal tolérable; produits laitiers