Objective: To determine rates of vitamin D supplement use in Canadian adults and associations with demographic and socioeconomic variables.

Design: Data from the Healthy Aging module of the Canadian Community Health Survey was used to investigate rates of vitamin D supplement use in Canadians aged 45 and over. The prevalence of supplement use stratified by various behavioral and demographic characteristics was calculated, and adjusted models were used to find associations with those factors.

Setting: All provinces and territories of Canada.

Subjects: Canadians aged 45 and over who participated in the Healthy Aging module of the Canadian Community Health Survey from 2008-2009.

Results: Women had higher odds of vitamin D supplement use than men in all age groups. Not using supplements was more common in smokers, those who were not engaged in leisurely physical activities and who were either overweight or obese. Vitamin D supplement use increased with household income and level of education, and decreased with self-perceived health. Supplement use was higher in those with chronic conditions.

Conclusions: The inverse association with self-perceived health could be partly explained by age, chronic conditions and increased use of healthcare services. Associations with income and education suggest a strong socioeconomic influence that individuals may not have the expendable income to purchase vitamin D supplements, or knowledge of their health benefits.

Introduction

Vitamin D is a hormone and is one of the essential vitamins important for good health. Foods naturally rich in vitamin D include fatty fish and liver, although most of the intake for adults and children is achieved through biosynthesis in the skin when exposed to ultraviolet B (UVB) radiation in sunlight(1). Vitamin D supplementation has proven most effective in improving bone health by greatly increasing intestinal absorption of calcium, which aids in bone mineralization(2), increases bone density(2) and helps reduce fracture(3,4). Newer areas of vitamin D research including cancer(5), cardiovascular disease(6) and autoimmune disorders(7).

An individual's vitamin D level is most often measured using its inactive but main circulating metabolite 25-hydroxyvitamin D (25(OH)D), as it is representative of vitamin D intake from food and supplements, and due to sun exposure(8). The Dietary Reference Intakes (DRIs) currently endorsed by Health Canada are drawn from a 2010 Institute of Medicine (IOM) report on calcium and vitamin D. The report set the Recommended Dietary Allowance (RDA) at 50 nmol/L (20 ng/mL), which is the amount estimated to meet the requirements of at least 97.5% of the population and corresponds to a daily dietary intake of 600IU for individuals 1-70 years of age(9).

Studies have estimated that subcutaneous synthesis may not be feasible from November to February beginning at 42 degrees latitude(10,11). As the vast majority of Canada's population lives north of 42 degrees latitude, and further evidence suggests that this period may extend from October to April in Edmonton(10), it is not possible for many Canadians to obtain sufficient vitamin D from subcutaneous synthesis for a significant portion of the year.

Data from the Canadian Health Measures Survey shows the prevalence of Canadians with serum 25(OH)D < 50 nmol/L is 25.7%, and a significantly higher prevalence among men than women(12). Research also shows a significantly higher prevalence among non-whites(12). Using different cut-points, 12.7% of Canadians aged 6-79 fells below 40 nmol/L(12), and 35.4% below 75 nmol/L(13). Vitamin D supplements are a viable option to compensate for minimal sun exposure. The purpose of this study was to determine the factors associated with vitamin D supplement utilization among Canadian adults. To our knowledge, this is the first nationally representative

analysis on vitamin D supplement usage in Canada.

Methods

The current analysis was based data from the Canadian Community Health Survey (CCHS)- Health Aging conducted by Statistics Canada in 2007 and 2008 (Canadian Community Health Survey – Healthy Aging. User guide. December 2010 microdata file. Statistics Canada, Health Statistics Division). The survey targeted the Canadian population aged 45 years of age or more, excluding residents of the three territories, persons living on Indian Reserves or Crown lands, those residing in institutions, full-time members of the Canadian Armed Forces and residents of certain remote regions. A multistage stratified sampling design was used and a total of 30,865 subjects were enrolled in the survey with a response rate of 74.4%.

The survey asked the following question: "In the past month, how often did you take vitamin D supplements?" and daily use of vitamin D supplements was affirmed if a participant answered "every day" to the question. Thirty-one participants who did not answer the question were excluded from the analysis. Body mass index (BMI) was calculated: BMI = weight (kg)/[height (m)]^2 and participants were grouped into the following categories: <18.5, 18.5-24.9, 25.0-29.9 and ≥30.0 kg/m^2. Current smokers were respondents who reported smoking cigarettes every day at the time of the survey. Former smokers were those who reported smoking cigarettes daily in the past but were not smoking at the time of the survey. Otherwise, subjects were classified as non-smokers. Individuals were grouped into five household income categories (<$20,000, $20,000-$39,999, $40,000-$59,999, $60,000-$79,999, ≥$80,000) and three education categories (low - secondary school not completed, medium -secondary school completed, high – post-secondary education). Other variables included in the analysis were age (45-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75-79, ≥80 years), marital status (married or common law partner, single, separated or divorced or widowed), race (white, non-white), immigrant status (yes, no), alcohol drinking (none, occasional, regular), leisure physical activity (yes, no), self-perceived health (poor, fair, good, very good, excellent), and having a chronic condition (yes, no).

We calculated the proportion of daily vitamin D supplement use according to

various factors described above. Logistic regression model was used to assess the relationships between each predictor and daily vitamin use after adjustment for other factors in men and women separately. Model parameters were estimated by using the method of maximum likelihood and were tested for significance by using the Wald statistic at $\alpha = 0.05$. Due to the nature of a complex survey design, all the point estimates were weighted to the Canadian population and the variance estimates took the average design effect into consideration. All the statistical analyses were conducted by using the Statistical Analysis System (SAS) version 9.3 (SAS Institute, Inc., Cary, North Carolina).

Results

Table 1 shows that vitamin D supplement use was much higher among women than men aged 45 years or older. Overall, 36.7% of women and 16.0% of men took vitamin D supplements daily. Supplement use increased with age, peaking in the 65-74 year age group and declining somewhat afterward. In women, supplement use was the highest in those of normal weight and the lowest in the obese, and the differences were not marked in men. Supplement use showed only a modest variation among the income or education groups.

Current smokers were less likely to use supplements than former or non-smokers. Those who engaged in leisurely physical activities and those with chronic conditions were more likely to use than those who did not and healthy individuals. Non-white and female immigrants had slightly lower proportions of vitamin D supplement use than whites and female non-immigrants.

Logistic regression analysis yielded similar trends where vitamin D supplement use increased with age in both sexes (Table 2). Compared to women of normal weight, overweight and obese women had significant lower odds of supplement use after taking other factors into account. A similar but non-significant trend was observed in men.

The odds of vitamin D supplement use decreased with decreasing household income in both sexes, where those from households with incomes less than $80 000 had significantly lower odds of use than those from households earning $80 000 or more. A similar trend was seen in education where men and women with a low level of education were significantly less likely to use supplements than those with high education.

Smokers had significantly lower odds of taking supplements relative to former and non-smokers. Men and women who did not engage in leisurely physical activities had lower odds of using vitamin D supplements than those who did. Little difference was observed in association with alcohol drinking. Immigrants had significantly higher odds of supplement use and race showed a non-significant association with vitamin D supplement use.

The odds of vitamin D supplement use were higher among participants who rated their health lower than "Excellent", and men who rated their health as "Poor" had the highest odds of use. Odds of supplement use were significantly higher in both men and women with chronic conditions.

Discussion

A strong association was observed between sex and vitamin D supplement use, similar to previous reports(14,15). Women as a whole had more than three times the odds of supplement use as men and this trend was evident in every age group. Previous research has found women to have a significantly higher mean 25-hydroxy D(16) and a lower prevalence below thresholds of 30 nmol/L, 40 nmol/L and 50 nmol/L(12). Research also suggests that the higher vitamin D status of Canadian women may be largely due to their higher rates of supplement use as they have less sun exposure, more frequent use of sunscreen and similar dietary intakes of vitamin D as men(14).

Another notable finding in this study was a consistent inverse association between vitamin D supplement use and age, where those aged 45-49 had approximately one-third the odds of those 80 or older (Table 2). Unlike men, where supplement use gradually increased from middle to old age, supplement use in women peaked in ages 65-74 and declined into old age. This may partially explain the narrowing of sex differences in vitamin D status with increasing age(12,16), though it is worth noting that a much higher proportion of women than men used vitamin D supplements in every age group (Table 1). The ability of the skin to produce 25(OH)D decreases with age(17), but there is evidence suggesting the conversion of 25(OH)D to $1,25(OH)_2D$, the active metabolite, in the kidney also slows with age and may have a neutralizing effect(18).

Vitamin D supplement use steadily increased with household income in both

sexes, and mineral and vitamin supplement use in Canada as a whole appears to follow this trend(19). Focus groups of low-income Canadians have shown that barriers to supplement use in general are similar to those for a healthful diet including lack of accessibility and lack of knowledge about what to buy and its potential health benefits(20). Approximately one-third of low-income households in Canada experience food insecurity(21), which has been associated with a significant reduction in vitamin D intake(22) and respondents expressed that taking supplements are a low priority when faced with a shortage of food and money(20).

Education followed a similar pattern where those with low level of education were significantly less likely to use vitamin D supplements than those with a medium or high level of education. This is not surprising as education is highly correlated to income, and some of the factors identified as being barriers to supplement use (ex. lack of information)(19) may stem from a lack of education. Being an immigrant was modestly associated with not using vitamin D supplements, which may be due to differences in cultural views towards vitamin supplements.

Among health behaviour factors, being a current smoker and not engaging in leisurely physical activities were most strongly associated with not using vitamin D supplements. These two traits are commonly associated with less frequent supplement use as a whole(23), and may be indicative of individuals who are more inactively promote their health. Furthermore, women who were overweight or obese had significantly lower odds of using vitamin D supplements than women of normal weight. BMI and other measures of adiposity have been associated with vitamin D levels in several studies(14,24), and it has been hypothesized that obesity may reduce the bioavailability of 25(OH)D, increasing one's risk of deficiency(25). It is also possible that low 25(OH)D levels in obese people are explained by a low vitamin D intake

There was a consistent inverse relationship self-perceived health and vitamin D supplement use, though previous work has shown self-perceived health to be inversely correlated to age(26), which may confound this association. Furthermore, self-perceived health appears to be a product of many factors including socioeconomic status, maintaining a healthy weight, exercise, not having a chronic condition, and not smoking(27) which, conversely, were found to be positively associated with supplement

use in this analysis.

The current RDAs taken from the 2010 IOM Report which only considered bone health outcomes such as risk of fracture and osteomalacia(9). For conditions such as autoimmune disorders, cancer and cardiovascular disease, the report cited insufficient evidence for effect and causality and a lack of randomized clinical trials as rational for excluding most of the considered outcomes(9).

Part of the inconsistency in research on the benefits of vitamin D supplementation may be due to administering a dose that is too low to incur an effect, or one below statistical significance. Several meta-analyses(3,4,28,29) have found significant differences between trials using low doses (<400IU) vs. high doses (>700IU) of vitamin D to improve bone health. In their meta-analysis of over 63 000 participants, Tang et al. (2007) found that the addition of vitamin D to calcium supplementation did not provide significant further reduction in rates of bone fracture, but there was a significant difference between trials using higher doses and those using lower doses. The authors comment that the much larger number of low dose trials may have attenuated the associations observed in the high dose trials when combined into one overall measure.

Similar issues may occurring in trials on vitamin D supplementation and cancer prevention, where results have been less consistent. Having a larger number of high quality high dose trials will better inform government researchers when nutrition guidelines are being evaluated in the future. Health Canada currently recommends that individuals over the age of 50 take a daily 400IU vitamin D supplement and an earlier report shows that ~70% of Canadians who use vitamin D supplements use ≤400IU(12), but several meta-analyses(3,4,28,29) of clinical trials have concluded that this dose is insufficient to reduce rates of fracture.

This study has several limitations that must be considered. Subjects might have taken a vitamin supplement daily for the past month or more but were unaware which supplement it was. Recall bias may be less of a factor in this study as subjects were only scored as supplement users if they took vitamin D supplements daily, which may be more easily recalled than a less frequent practice. Participants who took vitamin D less frequently than daily were scored as negative and the doses taken were not recorded so some of the diversity in use may not be captured in this study. Furthermore this study

does not include Aboriginal peoples living on reserve who are at higher risk of vitamin D deficiency. Some participants may be unaware they are taking vitamin D daily due to it being in a multivitamin or because they accepted supplements from a healthcare provider without reading the label. As with any cross-sectional analysis, it is not possible to make casual inferences on the associations observed here.

In this representative sample of Canadians aged 45 and over, vitamin D supplement usage was consistently higher in women and increased with age in both sexes. Similar to previous reports, vitamin D supplement use was associated with education and household income. Supplement use was also associated with engaging in leisurely physical activities, never smoking and a low level of self-perceived health and chronic condition.

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Table 1. Proportion of Canadians who took vitamin D supplement daily according to various factors, the Canadian Community Health Survey – Healthy Aging

	Men			Women		
	No.	Cases	%*	No.	Cases	%
Age (years)						
45-49	1138	80	7.3	1321	279	21.1
50-54	1177	117	11.9	1527	446	29.7
55-59	2177	331	16.4	2605	1023	39.6
60-64	2159	356	16.5	2379	1034	43.8
65-69	1875	404	20.9	2077	944	48.0
70-74	1374	350	25.3	1639	774	47.6
75-79	1205	282	25.0	1751	770	45.0
≥80	2163	500	24.0	4223	1651	40.1
Body mass index (kg/m^2)						
<18.5	66	12	12.8	471	200	38.1
18.5-24.9	4460	856	16.8	7184	3119	40.5
25.0-29.9	5507	1033	16.3	5435	2116	36.4
≥30.0	2747	441	14.6	3418	1167	29.8
Unknown	488	78	12.9	1014	319	34.2
Household income						
<$20,000	1349	163	11.0	3266	1205	35.6
$20,000-39,999	3057	524	14.3	4090	1668	37.7
$40,000-59,999	2292	469	16.1	2538	1020	35.8
$60,000-79,000	1651	322	16.9	1593	663	38.0
≥$80,000	3094	624	17.6	2535	1015	35.8
Unknown	1825	318	14.9	3500	1350	37.5
Education						
Low	3955	565	13.1	5864	2025	35.1
Medium	2597	471	16.5	3952	1598	36.8
High	6580	1369	17.1	7543	3251	37.7
Unknown	136	15	5.1	163	47	26.9
Smoking status						
Non-smoker	4957	992	16.6	10036	4037	38.3
Former smoker	6200	1226	18.0	5153	2187	38.2
Smoker	2097	200	9.5	2315	691	28.4
Unknown	14	2	2.5	18	6	25.4

Table 1: Continued

Alcohol drinking								
None			3010	531	18.8	5928	2136	37.1
Occasional			1873	327	12.5	4068	1595	37.8
Regular			8371	1557	15.5	7508	3182	37.1
Unknown			14	5	17.4	18	8	28.7
Leisure physical activities								
Yes	11347	2124	16.5		14417	1257	37.5	
No			1911	293	12.5	3097	1535	32.0
Unknown			10	3	12.1	8	3	22.4
Race								
White	11679	2168	16.4		15634	6307	37.6	
Non-white			1458	224	13.9	1728	564	31.8
Unknown			131	28	11.4	160	50	24.3
Immigrant								
Yes			2739	520	16.0	3261	1199	33.1
No	10301	1858	16.0		14000	5645	38.1	
Unknown			228	42	11.6	261	77	24.1
Marital status								
Married /common law			9279	1802	16.6	8052	3224	36.0
Widowed			1422	269	17.6	5912	2352	41.4
Divorced /separated			1448	180	10.8	2374	894	35.4
Single			1113	158	13.6	1178	447	35.2
Unknown			6	1	10.4	6	4	62.1
Self-perceived health								
Poor			715	140	19.0	953	362	35.4
Fair			2072	395	16.7	2647	1018	37.5
Good			4251	749	16.2	5520	2140	37.2
Very good			4138	772	16.6	5587	2304	38.5
Excellent			2084	364	13.4	2808	1094	33.0
Unknown			8	0	0.0	7	3	14.6
Chronic condition								
Yes	10733		2101	17.7		15057	6174	39.3
No			2356	289	10.9	2192	642	25.9
Unknown	179		30	16.1		273	105	39.4

* Weighted to the Canadian population.

Table 2. Adjusted odds ratios (ORs) and 95% confidence intervals (95% CIs) for taking vitamin D supplement daily in relation to various factors, the Canadian Community Health Survey – Healthy Aging

	Men		Women		Total	
	OR	95% CI	OR	95% CI	OR	95% CI
Sex						
Male					1.00	Reference
Female					3.17	2.91, 3.46
Age (years)						
45-49	0.19	0.13, 0.26	0.37	0.29, 0.47	0.28	0.24, 0.35
50-54	0.33	0.25, 0.45	0.58	0.46, 0.73	0.47	0.39, 0.57
55-59	0.47	0.35, 0.63	0.91	0.72, 1.14	0.71	0.59, 0.86
60-64	0.51	0.37, 0.68	1.12	0.89, 1.41	0.84	0.70, 1.01
65-69	0.73	0.54, 0.99	1.38	1.09, 1.74	1.10	0.91, 1.32
70-74	0.99	0.73, 1.34	1.38	1.09, 1.74	1.23	1.02, 1.49
75-79	0.98	0.71, 1.35	1.20	0.95, 1.53	1.13	0.93, 1.37
≥80	1.00	Reference	1.00	Reference	1.00	Reference
Body mass index (kg/m^2)						
<18.5	0.71	0.20, 2.58	0.85	0.59, 1.21	0.84	0.60, 1.20
18.5-24.9	1.00	Reference	1.00	Reference	1.00	Reference
25.0-29.9	0.94	0.81, 1.10	0.72	0.64, 0.81	0.79	0.72, 0.87
≥30.0	0.84	0.69, 1.03	0.56	0.48, 0.64	0.64	0.57, 0.72

Table 2: Continued

Household income						
<$20,000	0.54	0.43, 0.68	0.76	0.61, 0.94	0.66	0.55, 0.79
$20,000-39,999	0.68	0.55, 0.84	0.78	0.66, 0.93	0.69	0.60, 0.79
$40,000-59,999	0.88	0.72, 1.09	0.78	0.66, 0.92	0.74	0.65, 0.84
$60,000-79,000	0.71	0.57, 0.89	1.02	0.88, 1.21	0.95	0.84, 1.09
$80,000	1.00	Reference	1.00	Reference	1.00	Reference
Education						
Low	0.61	0.50, 0.74	0.77	0.67, 0.88	0.70	0.62, 0.78
Medium	0.99	0.84, 1.17	0.98	0.87, 1.10	0.97	0.88, 1.07
High						
Smoking status						
Non-smoker	1.00	Reference	1.00	Reference	1.00	Reference
Former smoker	0.94	0.81, 1.08	0.96	0.85, 1.08	0.96	0.88, 1.05
Smoker	0.62	0.49, 0.77	0.69	0.59, 0.80	0.68	0.60, 0.77
Alcohol drinking						
None	1.00	Reference	1.00	Reference	1.00	Reference
Occasional	0.77	0.61, 0.96	1.11	0.97, 1.26	1.02	0.92, 1.14
Regular	1.25	1.05, 1.50	0.95	0.84, 1.09	1.03	0.93, 1.15
Leisure physical activities						
Yes	1.00	Reference	1.00	Reference	1.00	Reference
No	0.81	0.65, 1.01	0.78	0.61, 0.91	0.78	0.69, 0.88

Table 2: Continued

Immigrant						
Yes	1.00	Reference	1.00	Reference	1.00	Reference
No	1.14	0.98, 1.34	1.36	1.20, 1.54	1.28	1.17, 1.41
Marital status						
Married /common law	1.00	Reference	1.00	Reference	1.00	Reference
Widowed	0.81	0.57, 1.14	1.00	0.85, 1.18	0.93	0.81, 1.07
Divorced /separated	0.81	0.62, 1.07	1.00	0.85, 1.18	0.95	0.82, 1.09
Single	1.26	0.94, 1.69	1.09	0.88, 1.36	1.12	0.94, 1.33
Self-perceived health						
Poor	1.73	1.19, 2.50	1.24	0.93, 1.64	1.36	1.08, 1.70
Fair	1.28	0.98, 1.67	1.21	0.99, 1.48	1.21	1.04, 1.42
Good	1.23	1.00, 1.51	1.21	1.04, 1.41	1.21	1.07, 1.36
Very good	1.26	1.04, 1.53	1.25	1.08, 1.44	1.25	1.11, 1.40
Excellent	1.00	Reference	1.00	Reference	1.00	Reference
Chronic condition						
Yes	1.00	Reference	1.00	Reference	1.00	Reference
No	0.73	0.61, 0.87	0.64	0.56, 0.74	0.67	0.60, 0.76