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Determinants of vitamin D supplement use in Canadians

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Abstract

Objective: To determine the prevalence of vitamin D supplement use in Canadian adults and associations with demographic and socio-economic variables.
Design: Data from the Healthy Aging module of the Canadian Community Health Survey were used to investigate the prevalence of vitamin D supplement use in Canadians aged 45 years and over. The prevalence of supplement use stratified by various behavioural and demographic characteristics was calculated and adjusted models were used to find associations with those factors.
Setting: The ten provinces of Canada.
Subjects: Canadians aged 45 years and over who participated in the Healthy Aging module of the Canadian Community Health Survey from 2008–2009.
Results: The highest observed prevalence for women was 48·0 % in the 65–69 years age group and the highest prevalence for men was 25·3 % in the 70–74 years age group. 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 did not engage in leisure-time 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 health-care services. Associations with higher income and education suggest a strong socio-economic influence and that individuals may not have the expendable income to purchase vitamin D supplements or knowledge of their health benefits.

Keywords
Adults
Canada
Determinants
Survey
Vitamin D

Vitamin D is a pro-hormone and 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 UV-B radiation in sunlight[1]. Vitamin D supplementation has been observed to improve bone health by greatly increasing intestinal absorption of Ca[2], which aids in bone mineralization[2], increases bone density[2] and helps reduce fracture[3,4]. However, there is conflicting evidence which suggests that supplementation may provide little benefit to bone health beyond those who are very deficient[5]. Newer areas of vitamin D research include cancer[6], CVD[7] and autoimmune disorders[8].

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[9]. The Dietary Reference Intakes currently endorsed by Health Canada are drawn from a 2011 Institute of Medicine report on Ca and vitamin D. The report set the 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 15 μg (600 IU) for individuals 1–70 years of age[10].

Studies have estimated that subcutaneous synthesis may not be feasible from November to February at latitudes greater than 42°[11,12]. As the vast majority of Canada's population lives north of 42° latitude, and further evidence suggests that this period may extend from October to April in Edmonton[11], 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 show the prevalence of Canadians aged 6–79 years with serum

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25(OH)D < 50 nmol/l is 25·7 %, with a significantly higher prevalence among men than women[13]. Research also shows a significantly higher prevalence among non-whites[13,14]. Using different cut-off points, analysis of the Canadian Multicentre Osteoporosis Study showed that only 2·3 % of Canadians aged 35 years and over fall below 27·5 nmol/l and 59·2 % fall below 75 nmol/l[14]. Vitamin D supplements are a viable option to compensate for minimal sun exposure. The purpose of the present 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 on data from the Canadian Community Health Survey (CCHS) – Health Aging conducted by Statistics Canada in 2008 and 2009[15]. The survey targeted the Canadian population 45 years of age and over, 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 participants were enrolled in the survey with a response rate of 74·4 %[15]. 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. BMI was calculated as [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, participants were classified as non-smokers.

Individuals were grouped into five household income categories (< $CAN 20 000, $CAN 20 000–39 999, $CAN 40 000–59 999, $CAN 60 000–79 999, ≥ $CAN 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-time 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 the various factors described above. Logistic regression modelling 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 $\alpha = 0{\cdot}05$. The CCHS employed unequal probability sampling and therefore sampling weights were used to make point estimates representative of the Canadian population. Detailed sampling structure information was not included in the publicly released data files and we calculated variance estimates by using adjusted weights that took the average design effect into consideration. The design effect is a ratio of the estimated variance from a complex survey design over a similar estimate from a simple random design, and the average design effect for the survey was calculated and provided by Statistics Canada. All the statistical analyses were conducted by using the statistical software package SAS version 9·3.

Results

Vitamin D supplement use was much higher among women than men aged 45 years and older (Table 1). Overall, the highest prevalence of supplement use was observed in women aged 65–69 years at 48·0 %. Among men, the highest prevalence was in the 70–74 years age group where 25·3 % reported using supplements daily. Supplement use increased with age up to 65–74 years and then declined somewhat thereafter. For women, supplement use was highest in those of normal weight and lowest in the obese, and these differences were not notable in men. Supplement use showed only a modest variation among the income or education groups.

Current smokers had a lower prevalence of supplement use than former or non-smokers. Those who engaged in leisure-time physical activities and those with chronic conditions had a higher prevalence of supplement use than those who did not and healthy individuals. Participants who were non-white had a lower prevalence of supplement use in both sexes, and female immigrants had a slightly lower proportion of vitamin D supplement use than female non-immigrants, with no similar difference in men.

Logistic regression analysis yielded similar associations where vitamin D supplement use increased with age up to the age of 70–74 years in both sexes (Table 2). Compared with women of normal weight, overweight and obese women had significantly lower odds of supplement use after adjustment for covariates. A similar but non-significant association 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 $CAN 80 000 had significantly lower odds of use than those from households earning $CAN 80 000 or more. A similar trend was

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Table 1 Proportion of Canadians who took a vitamin D supplement daily according to various factors, the Canadian Community Health Survey – Healthy Aging, 2008–2009

	Men			Women		
	Total	*n*	%*	Total	*n*	%*
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
BMI (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 ($CAN)						
<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	10 036	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
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-time physical activities						
Yes	11 347	2124	16·5	14 417	1257	37·5
No	1911	293	12·5	3097	1535	32·0
Unknown	10	3	12·1	8	3	22·4
Race						
White	11 679	2168	16·4	15 634	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	10 301	1858	16·0	14 000	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	10 733	2101	17·7	15 057	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.

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Table 2 Adjusted* odds ratios (AOR) and 95 % confidence intervals for taking vitamin D supplement daily in relation to various factors, the Canadian Community Health Survey – Healthy Aging, 2008–2009

	Men		Women		Total	
	AOR	95 % CI	AOR	95 % CI	AOR	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
BMI (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
Household income ($CAN)						
<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	1·00	Reference	1·00	Reference	1·00	Reference
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-time 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
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

*Odds ratio estimates for a given independent variable are adjusted for all additional variables that appear in the table.

seen in education, where men and women who did not complete high school had significantly lower odds of supplement use than those who attended or graduated from a post-secondary institution.

Smokers had significantly lower odds of taking supplements relative to former and non-smokers. Men and women who did not engage in leisure-time 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 lower odds of supplement use, although when stratified by sex it became non-significant in men.

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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. The 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[13,16]. Women as a whole had more than three times the odds of supplement use compared with men and this association was evident in every age group. Previous research has found women to have a significantly higher mean 25(OH)D[17] and a lower prevalence below thresholds of 30 nmol/l, 40 nmol/l and 50 nmol/l[13]. Research also suggests that the higher vitamin D status of Canadian women may be largely due to their higher prevalence of supplement use as they have less sun exposure, more frequent use of sunscreen and similar dietary intakes of vitamin D to men[14].

Another notable finding in the present study was an association between vitamin D supplement use and age. Unlike men, where supplement use increased gradually from middle to old age, supplement use in women was most strongly associated with the 65–74 age group and declined thereafter. This may partially explain the narrowing of sex differences in vitamin D status with increasing age[13,17], although it is worth noting that a much higher proportion of women than men used vitamin D supplements in every age group. The ability of the skin to produce 25(OH)D decreases with age[18], but there is evidence suggesting that conversion of 25(OH)D to 1,25-dihydroxyvitamin D ($1,25(OH)_2D$), the active metabolite, in the kidney also slows with age and may have a neutralizing effect[18].

Vitamin D supplement use increased steadily 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 low-income individuals expressed that taking supplements is a low priority when faced with a shortage of food and money[20]. This illustrates a problem with supplements as a whole, and fortification of food may be a more effective method of increasing the vitamin D status of certain groups.

Education followed a similar pattern whereby those with a 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, such as lacking knowledge of their specific benefits[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 behaviours, being a current smoker and not engaging in leisure-time 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 do not actively 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 inversely associated with vitamin D levels in several studies[24,25] and it has been hypothesized that obesity may reduce the bioavailability of 25(OH)D, increasing one's risk of deficiency[26]. It is also possible that low 25(OH)D levels in obese people are explained by a low vitamin D intake.

Data from the National Health and Nutrition Examination Survey (NHANES) in 2003–2006 showed vitamin D supplement use to be 56·3 % for women and 44·0 % for men aged 60 years and older[27], notably higher than our results of ~45 % and ~23 %. Supplement use in the USA increased significantly from 1988–1994 to 2003–2006, especially in people aged 60 years and over who had comparable use to the general adult population in 1988–1994[27], perhaps due to increased recommendations since then. Demographic analysis of US users of vitamin and mineral supplements of any kind yielded similar results to ours where age, being female, white and not overweight or obese were associated with general supplement use[28].

There was a consistent inverse relationship between self-perceived health and vitamin D supplement use. Self-perceived health appears to be a product of many factors including socio-economic status, maintaining a healthy weight, exercise, not having a chronic condition and not smoking[29] which, conversely, were found to be positively associated with supplement use in the current analysis.

The current RDA taken from the 2011 Institute of Medicine Report only consider bone health outcomes such as the risk of fracture and osteomalacia[10]. For conditions such as autoimmune disorders, cancer and CVD, the report cited insufficient evidence for effect and causality and a lack of randomized clinical trials as the rationale for excluding most of the considered outcomes[10]. Research into the benefits of vitamin D supplementation has been somewhat inconsistent, which may be due to using too low a dose. Health Canada currently recommends that

individuals over the age of 50 years take a daily 10 μg (400 IU) vitamin D supplement and an earlier report shows that ~70 % of Canadians who use vitamin D supplements use ≤10 μg (≤400 IU)[13]. However, several meta-analyses[4,30] have found significant differences between trials using low doses (<10 μg (400 IU)) *v.* high doses (>17·5 μg (>700 IU)) of vitamin D to improve bone health. In their meta-analysis of over 63 000 participants, Tang *et al.*[31] found that the addition of vitamin D to Ca 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. Several other meta-analyses have found that vitamin D supplementation provides little to no benefit for fractures[32,33] and bone mineral density[5].

Reid *et al.*[5] contend that many trials compare a combined Ca and vitamin D intervention against a placebo and so are not designed to isolate an independent effect, citing the trial of Tang *et al.* who found no additional benefit when adding vitamin D to Ca. Reid *et al.* conclude that current vitamin D supplement recommendations are likely only appropriate for particularly deficient groups such as elderly individuals with little sunlight exposure and not for the general population over 50 years old.

The present study has several limitations that must be considered. Participants 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 the current study as participants were scored as supplement users only 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 the study. Furthermore, the study did 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 combined with Ca or because they accepted supplements from a health-care provider without reading the label. As with any cross-sectional analysis, it is not possible to make casual inferences on the associations observed herein. Furthermore, a number of comparisons were made in the analysis and there may be an increased possibility of observing significant associations.

Conclusion

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

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