Vitamin D Supplementation Among Women of Childbearing Age: Prevalence and Disparities

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Abstract

Background: Maternal vitamin D deficiency is associated with numerous adverse health conditions. However, most women of childbearing age are vitamin D deficient. [1] Although scientific and public awareness about vitamin D deficiency's role in health has increased in recent years, current data are not available to assess whether there have been concomitant increases of supplementation among women of childbearing age.

Methods: We assessed prevalence and significant associations of vitamin D supplementation among childbearing-age women (16–49 years) in the most recently available National Health And Nutrition Examination Survey (NHANES) dataset (2007-2008). We examined prevalence of vitamin D supplementation in stratified demographic (age, race/ethnic), socioeconomic (education, income, food security, health insurance, years in U.S.) and health (BMI, waist circumference, exercise, diabetes, weight-loss attempts, parity/breastfeeding) subgroups to determine disparities in supplementation. Logistic regression models (both unadjusted and adjusted) were used to examine associations between Vitamin D supplementation and these variables. Sampling weights were applied to account for the complex survey design and ensure generalizability to women of childbearing age among the non-institutionalized population in the US. [2] Analyses were conducted using Stata versions 11 and 12 (College Station, TX).

Results: Of 1749 women, 459 (33%) had taken supplements containing vitamin D during the past 30 days. We observed low supplementation prevalence (range 12%–27%) among teenagers, those with high body mass index (BMI), low socio-economic status (low-income, low education, ethnicity other than white, food insecurity, or no/government insurance), as well as parous women who had never breastfed, and women with no history of vigorous or moderate exercise. In the fully adjusted regression models, Mexican-American race/ethnic identity (OR: .53, 95% CI .33–.86), low food security (OR: .65, 95% CI .44–.95), no health insurance (OR .65, 95% CI .42–1.00), government/other health insurance (OR: .66, 95% CI .45–.96), and parity without breastfeeding (OR: .63, 95% CI .40–.99) were associated with lower likelihood of vitamin D supplement use compared with the reference groups.

Conclusions: Disparities in vitamin D supplementation parallel and may exacerbate disparities in nutrition and health. Supplementation rates may reflect inequalities. Findings should influence public health practice and advocacy.

Introduction

The Problem

Low vitamin D levels are associated with health risks including cardiovascular disease, cancers, metabolic health, bone strength, autism, multiple sclerosis, diabetes, mental health problems, and all-cause mortality.[3] [4] [5] [6] Serum vitamin D levels are lower among women than men, and among pregnant than non-pregnant women.[7]

Past research (2001-2006 data) suggests most childbearing-age women in the U.S. are deficient in vitamin D, and pregnant women are at even higher risk.[1] Deficiency has implications for women whether or not they will become pregnant, as well as health during pregnancy, and health of offspring (in-utero and beyond).[1,8,9] Maternal deficiency is associated with reproductive health problems,[10] lower fertility, higher Caesarian risk lower birth weight, gestational diabetes, preterm delivery, preeclampsia, inadequate fetal exposure to vitamin D, and other factors.[9,11,12] Fetal Vitamin D exposure depends on maternal vitamin D status.[13] Vitamin D plays a crucial role in fetal development, and deficiency is associated with detrimental infant outcomes, including muscular and bone development and adiposity risks.[14] Demographic inequalities in some maternal and child health outcomes, such as low birth weight, are associated with maternal vitamin D status.[13]

Intake and Supplementation

Vitamin D is primarily synthesized subsequent to skin exposure to sunlight; factors like melanin levels, time in sun, and extent of covering by clothing influence levels.[15] Latitude is a factor; residents of northern states may not generate vitamin D from sun exposure during winter.[16] Due to issues like diet and obesity in maintaining adequate vitamin D levels, deficiency is also a problem in the southern U.S.[17] Access to vitamin D in a modern Western diet is limited. Dietary sources include certain fatty fish and shellfish (wild salmon, mackerel, oysters), fish eggs, fortified dairy, and fatty animal foods including organ meats and egg yolks.[18–21] Some cultures developed traditional food-derived supplements (e.g. cod liver oil, oolichan grease).[22,23] While peer-reviewed studies are needed, there is anecdotal evidence that shifts in food production methods may have reduced vitamin D in animal-derived foods.[18,24] Many of vitamin D-rich foods or food-derived supplements are uncommon in a modern diet, and may be even less common among lower socioeconomic status populations.

Vitamin D supplementation, which can improve serum status,[25] is associated with improved health outcomes, although individual dose may depend on factors like obesity.[3] Adequate attention has not recently been paid to the prevalence and disparities in: supplementation, dose, and duration among women of childbearing age. Widespread deficiency among mothers and neonates suggests even quantities in prenatal vitamin supplements may not be sufficient.[26]

Disparities

Previous studies of US populations highlight some race/ethnic and socioeconomic disparities among women of childbearing age in vitamin D deficiency, supplementation, and associated health risks.[27]

Obesity, which parallels other health disparities, is of particular concern as a potential bi-directional factor in deficiency; higher rates of deficiency may be found in adolescents and adults who are obese.[28–31] Vitamin D deficiency is highly correlated with BMI, as well as challenging experiences losing weight.[7,29,32,33] Obese and overweight people may require higher doses of supplementation to achieve sufficiency.[31,34] Disparities in access to healthy food and exposure to unhealthy food exacerbate obesity along lines of inequality. It is critical to examine whether populations with high obesity, lower socioeconomic status, variations in vitamin D intake from food, or other risk factors for deficiency are less likely to supplement with vitamin D, further exacerbating health inequalities. Future studies may also examine associations with disparities in access to outdoor time.

Disparities may also reflect access to new health information. Since 2000, researchers and the public have increasingly been aware of health risks associated with vitamin D deficiency (Figure 1). Much of this rise in awareness has taken place beginning in 2007. A search of 2007 publications in scientific journal articles (PubMed) revealed 748 with "vitamin D" in the title, up from 623 in 2006. A search of Access World News for the same decade revealed a similar rise in media attention to vitamin D (newspaper and magazine headlines), particularly in 2008.[35] In November 2008, the American Academy of Pediatrics, citing the role of vitamin D in disease prevalence, doubled its recommended childhood daily intake.[36] In November of 2010, the Institute of Medicine (IOM) released its report *Dietary Reference Intakes for Calcium and Vitamin D*, recommending 600 IU for ages 1-70, and 800 IU for ages 71 and older.[37]

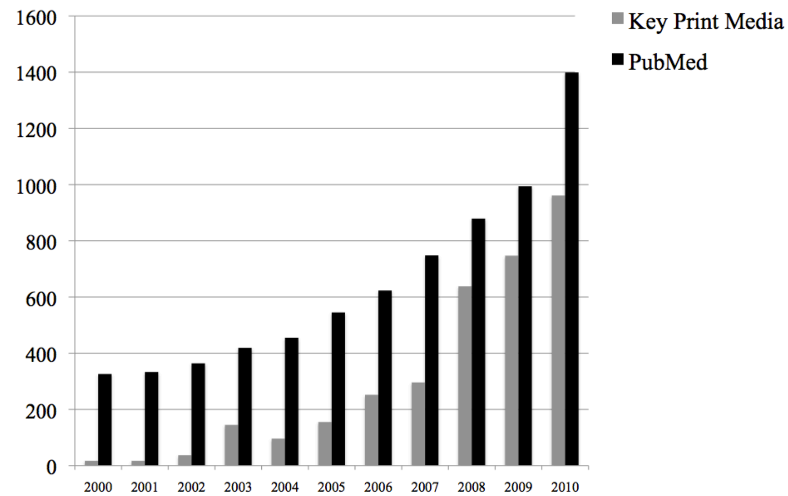

Figure 1. Attention to Vitamin D

A recent paper analyzed vitamin D supplementation and serum status in pregnant and non-pregnant women in 2001-2006, but did not examine detailed demographic, socioeconomic, or health disparities.[1] An analysis of 1988-2006 NHANES data demonstrated increased vitamin D supplementation during those years, largely attributable to intake among older adults.[38] There is a need for examination of newer data on prevalence of vitamin D supplementation among women of childbearing age, as well as disparities in supplement intake. Clearer understanding of prevalence and associations with vitamin D supplementation among women of childbearing age can advance epidemiological research and public health practice, and lay groundwork for comparison with later data releases.

This study focuses on data collected in 2007–2008 to determine more recent prevalence of vitamin D intake and whether there are additional disparities within demographic, socioeconomic, and health variables.

Materials and Methods

Data Source and Sample

The National Health And Nutrition Examination Survey (NHANES) is a publicly-available, biennial, nationally-representative survey of health, behavior, and diet. It is sponsored by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC).[39] The most recently available dietary data were gathered in 2007-2008 from 10,149 interview respondents, reflecting a response rate of 78.4% (81.4% among women ages 16–49), and 9,762 examination respondents, reflecting a response rate of 75.4% (78.0% among women ages 16–49). All women of childbearing age (16–49) were eligible for inclusion in our study sample (n= 1749). Few (n=57) were ascertained to be pregnant.

The study was approved as exempt from review by the University of Washington Human Subjects Division (HSD).

Dependent Variables

Three primary outcomes were examined: (1) vitamin D supplement (combined D2/D3) intake (any/none) in the past 30 days by household interview, (2) duration of vitamin D supplement intake among users categorized in years (<1 year, >1 years), and (3) dose of vitamin D supplementation among users, categorized in international units (IU; <=400 IU/day; >400 & <800 IU/day and >800 IU/day).

Independent Variables

Independent variables were examined as potential correlates of intake and indicators of disparities.

For demographics, we selected age (years) categorized as 16–19, 20–35 and 36–49 (reference group), and race/ethnicity categorized as Mexican-American, other Hispanic, non-Hispanic black, other race/multi-racial, and white (reference group). While location/geography or interview date are not available, NHANES offers a broad variable containing both temporal and geographical components, categorizing participants into two pools: those interviewed between November and April *and* in the southern half of the U.S., or those interviewed between May and October *and* in the northern half of the U.S. (reference group). This NHANES methodology means subjects are interviewed during seasons when there is likelihood of vitamin D availability from sunlight; supplementation in the northern U.S. during winter months may be higher than NHANES data suggest.

For socioeconomic variables, we selected years in the U.S. and citizenship, categorized as non-citizens living in the U.S. less than five years, non-citizens living in the U.S. five or more years, and citizens (reference group); household income, as less than $25,000 per year, $25,000–$45,000 per year, $45,000–$65,000, $65,000–$75,000, and over $75,000 (reference group); adult food security measured in NHANES' terms of very low food security, low food security, marginal food security, and full food security (reference group); health insurance status as uninsured, having government or other non-private insurance, and having private insurance (reference group); and education level as below grade level for youth 16–19, at grade level for youth 16–19, adults with less than high school education, adults with high school diploma/GED/equivalent, adults with some college or AA, and college graduates/above (reference group).

We selected health variables BMI <25, 25–30, 30–35, and >35 (reference group); waist circumference <35 inches and ≥35 inches (reference group); weight loss attempts in past year (yes/no — "no" as reference group); diabetes status (a combined variable including whether a doctor told participant she had diabetes during/not during pregnancy) with no diabetes as reference group; parity and breastfeeding, measured as nulliparous, parous never having breastfed, and parous having breastfed at least one month (reference group); moderate/vigorous exercise, as a binary variable of no daily moderate or vigorous exercise or recreation, and any daily moderate vigorous exercise or recreation (reference group); and vitamin D intake from food, as <400 IU from food per day compared to ≥400 IU from food per day (reference group).

Data about intake, demographics, and socioeconomic status were collected in interviews. Health metrics such as BMI and waist circumference were assessed in a separate examination by NHANES-trained health technicians and recording assistants using methods from the NHANES 2007-2008 Body Measurement Procedures Manual.

Statistical Analysis

We examined prevalence (n, percent) of any vitamin D supplementation in the past 30 days. Among users, we evaluated differences in duration and dosage of supplementation in all independent variable subgroups. Using a multivariate logistic regression model, we examined associations of the variables with Vitamin D supplementation in the past 30 days, controlling for variables; health insurance was highly collinear (VIF>20) with income and education, and waist circumference with BMI, so variables for waist circumference and income were excluded from final models. Among those who reported taking Vitamin D supplements in the past 30 days, similar models were estimated for associations with taking >400 IU (yes/no) and duration of supplementation >1 years (yes/no).

Analyses were conducted using Stata versions 11 and 12 (College Station, TX). Sampling weights were applied to adjust standard errors for the complex survey design, with estimates generalizable to women of childbearing age in the U.S. non-institutionalized population.[2] Statistical significance was set at $p \leq 0.05$.

TABLE 1. Use of Vitamin D-containing supplement

Variable	Total participants in study, stratified (n)	Percent of stratum taking vitamin D in past 30 days
All women of childbearing age	1749	33%
Age (n=1749)		
16-19	290	23%
20-35	739	31%
36-49	720	38%
Six month time period (n=1712)		
November – April (South)	831	33%
May – October (North)	881	33%
Race/ethnicity (n=1749)		
Mexican-American	363	18%
Other Hispanic	233	23%
Non-Hispanic Black	390	26%
Other Race or Multi-Racial	73	35%
Non-Hispanic White	690	37%
Years in US/Citizenship (n=1734)		
Non-citizen less than 5 years	69	15%
Non-citizen 5+ years	194	30%
Citizen, any years	1471	34%
Household Income (n=1679)		
<$25,000 per year	529	21%
$25,000-$45,000 per year	356	27%
$45,000-$65,000 per year	253	32%
$65,000-$75,000 per year	98	35%
>$75,000 per year	399	45%
Food Security (adult) (n=1738)		
Very low food security	116	19%
Low food security	205	19%
Marginal food security	257	24%
Full food security	1160	37%
Health Insurance Status (n=1746)		
Uninsured	491	21%
Government or Other Insurance	379	20%
Private Insurance	876	40%
Education Level (n=1748)		
Below grade level (youth 16-19)	25	12%
At grade level (youth 16-19)	265	24%
Less than high school (adult)	375	18%
High school/GED/equivalent (adult)	323	27%
Some college or AA (adult)	473	37%
College graduate or above (adult)	287	47%
BMI (n=1749)		
<25	642	36%
25-30	458	35%
30-35	281	35%
≥35	368	22%
Waist Circumference (n=1749)		
< 35 inches	766	37%
≥ 35 inches	983	30%
Tried to lose weight in last year (n=1545)		
Yes	680	35%
No	865	30%
Diabetes (n=1749)		
Told had diabetes (including during pregnancy)	152	31%
No diabetes	1597	33%
Parity (age 20+) (n=1501)		
Nulliparous (never been pregnant)	237	34%
Parous, never breastfed	411	25%
Parous, breastfed 1+ mo	563	40%
Moderate or Vigorous Exercise (n=1749)		
No moderate or vigorous exercise per day	899	25%
Any moderate or vigorous exercise per day	850	39%
Vitamin D intake from food (n=1749)		
< 400 IU from food avg day	1672	33%
≥400 IU from food avg day	77	42%

From 30-day recall. Vitamin D intake includes multivitamins and other supplements that contain vitamin D. All numbers weighted. Participant numbers (n) vary in each category due to missing entries in NHANES.

Table 2. Average daily dose (IU/day) among participants taking vitamin D supplements

Variable	**Took vitamin D in past 30 days (n)**	**Average dose per day — percent of stratum**		
		≤ 400 IU/day	**>400 & <800 IU/day**	**≥ 800 IU/day**
Women of childbearing age	459	73%	13%	14%
Age				
16-19	47	93%	7%	0%
20-35	188	77%	10%	13%
36-49	224	67%	13%	14%
Six month time period				
November – April (South)	220	77%	12%	12%
May – October (North)	233	71%	13%	16%
Race/ethnicity				
Mexican-American	63	84%	6%	11%
Other Hispanic	53	81%	4%	15%
Non-Hispanic Black	93	80%	6%	13%
Other Race or Multi-Racial	22	61%	22%	17%
Non-Hispanic White	228	72%	14%	15%
Years in US				
Non-citizen less than 5 years	9	100%	0%	0%
Non-citizen 5+ years	41	76%	5%	19%
Citizen, any years	403	73%	13%	14%
Household Income (n=430)				
<$25,000 per year	93	75%	9%	16%
$25,000-$45,000 per year	81	79%	10%	11%
$45,000-$65,000 per year	67	71%	10%	20%
$65,000-$75,000 per year	30	81%	7%	12%
>$75,000 per year	159	69%	17%	14%
Food Security (adult)				
Very low food security	16	72%	0%	28%
Low food security	36	72%	14%	14%
Marginal food security	59	81%	8%	11%
Full food security	347	73%	13%	14%
Health Insurance Status (n=455)				
Uninsured	84	80%	9%	11%
Government/Other Insurance	65	83%	7%	10%
Private Insurance	306	70%	14%	15%
Education Level				
Below grade level (youth 16-19)	4	100%	0%	0%
At grade level (youth 16-19)	43	93%	8%	0%
Less than high school (adult)	55	87%	5%	7%
High school/GED/equivalent (adult)	77	68%	14%	18%
Some college or AA (adult)	152	70%	14%	18%
College graduate or above (adult)	128	72%	14%	14%
BMI				
<25	186	72%	17%	11%
25-30	130	69%	11%	21%
30-35	72	72%	12%	16%
≥35	71	88%	3%	9%
Waist Circumference				
< 35 inches	222	69%	18%	13%
≥ 35 inches	237	77%	7%	16%
Tried to lose weight in last year				
Yes	189	78%	11%	11%
No	200	71%	14%	15%
Diabetes (n=455)				
Told had diabetes	34	71%	0%	29%
No diabetes	421	73%	14%	13%
Parity (age 20+) (n=338)				
Nulliparous (never been pregnant)	67	59%	15%	26%
Parous, never breastfed	89	79%	11%	9%
Parous, breastfed 1+ mo	182	72%	14%	15%
Moderate or Vigorous Exercise (n=455)				
No moderate or vigorous exercise per day	186	75%	6%	19%
Any moderate or vigorous exercise per day	269	72%	16%	22%
Vitamin D intake from food				
< 400 IU from food avg day	433	73%	13%	15%
≥400 IU from food avg day	26	79%	13%	9%

Participant numbers (n) vary in each category due to missing entries in NHANES.

Table 3. Duration of vitamin D supplement use (years) among participants taking vitamin D supplements

Variable	Taken vitamin D in past 30 days (n)	Duration of ongoing vitamin D supplement use (% stratum) ≤1 year	> 1 year
Women of childbearing age	459	45%	55%
Age			
16-19	47	52%	49%
20-35	188	51%	49%
36-49	224	39%	61%
Six month time period			
November – April (South)	220	47%	53%
May – October (North)	233	44%	56%
Race/ethnicity			
Mexican-American	63	71%	29%
Other Hispanic	53	70%	30%
Non-Hispanic Black	93	60%	40%
Other Race or Multi-Racial	22	57%	43%
Non-Hispanic White	228	38%	62%
Years in US			
Non-citizen less than 5 years	9	85%	14%
Non-citizen 5+ years	41	51%	49%
Citizen, any years	407	44%	56%
Household Income			
<$25,000 per year	94	53%	47%
$25,000-$45,000 per year	82	54%	45%
$45,000-$65,000 per year	67	62%	37%
$65,000-$75,000 per year	30	50%	50%
>$75,000 per year	161	33%	67%
Food Security (adult)			
Very low food security	16	79%	21%
Low food security	36	62%	39%
Marginal food security	59	63%	37%
Full food security	347	41%	59%
Health Insurance Status			
Uninsured	84	52%	49%
Government/Other Insurance	66	69%	30%
Private Insurance	309	40%	59%
Education Level			
Below grade level (youth 16-19)	4	72%	29%
At grade level (youth 16-19)	43	51%	49%
Less than high school (adult)	55	57%	43%
High school/GED/equivalent (adult)	77	49%	51%
Some college or AA (adult)	152	43%	57%
College graduate or above (adult)	128	39%	61%
BMI			
<25	186	39%	61%
25-30	130	54%	47%
30-35	72	30%	69%
≥35	71	66%	34%
Waist Circumference			
< 35 inches	222	40%	60%
≥ 35 inches	237	50%	50%
Tried to lose weight in last year			
Yes	190	44%	56%
No	203	45%	55%
Diabetes			
Told had diabetes	35	48%	53%
No diabetes	424	44%	55%
Parity (n=341)			
Nulliparous (never been pregnant)	69	36%	64%
Parous, never breastfed	90	46%	54%
Parous, breastfed 1+ mo	182	45%	55%
Moderate or Vigorous Exercise (n==455)			
No moderate/vigorous exercise per day	186	58%	42%
Any moderate/vigorous exercise per day	269	72%	28%
Vitamin D intake from food			
< 400 IU from food avg day	433	46%	54%
≥400 IU from food avg day	26	32%	68%

Participant numbers (n) vary in each category due to missing entries in NHANES.

Results

In the study population, 33% (459) had taken vitamin D supplements in the past 30 days. We found differences in supplementation prevalence in demographic, socioeconomic, and health strata (Table 1). Tables 1–3 measure prevalence only rather than statistical associations.

Demographic groups with low prevalence of supplement intake included ages 16–19 and those who identified as Mexican-American (18%), other Hispanic (23%), or non-Hispanic black (26%). In socioeconomic categories, we observed low prevalence of supplement intake in income \$25,000–\$45,000 (27%) and lower than \$25,000 (21%), all food security categories (24%–19%) other than full food security, those with no health insurance (21%) or government/other health insurance (20%), and those with low education (12%–27%). In health categories, low prevalence of intake was prevalent with high BMI (22%), parous women who had never breastfed (25%), and those engaging in no vigorous/moderate exercise (25%).

In terms of dosage (Table 2), of women taking vitamin D, 73% took ≥400 IU/day, 13% took 400–800 IU/day, and 14% took ≤800 IU/day. Teenagers were more likely to take a 400 IU/day dose (93% of those supplementing) rather than a higher dose, as were non-citizens who had been in the U.S. less than five years (100%), women with marginal food security (81%), with no health insurance (80%) or government/other health insurance (83%), with BMI ≥35 (88%), with low education (87%–100%), and parous women who had never breastfed (79%).

Fewer participants (Table 3) had taken vitamin D for ≤ one year (45% of those taking vitamin D supplements). Disparities in duration of intake were apparent. Certain variable categories show higher likelihood to have started supplementation in the past year, including those from all racial/ethnic groups other than non-Hispanic whites, living in the U.S. less than five years (non-citizen), with low food security, with low education, with BMI ≥35, who did not exercise, and who were getting less than 400 IU from food.

In fully adjusted regression models (Table 4), Mexican-American identity was associated with lower odds of supplement use (OR .53, 95% CI .33–.86) with non-Hispanic whites as the reference group. We found associations between lower odds of vitamin D supplementation and low food security (OR .65, 95% CI .44–.95) when examined with full food security as the reference group, as well as government/other health insurance (OR .66, 95% CI .45–.96) and no health insurance (OR .65, 95% CI .42–1.00) with private insurance as the reference variable. We found an association between low odds of supplementation and the lowest tier of education (less than high school for adults or below grade level for youth) (OR .52, 95% CI .33–.80) when compared with college graduates as reference. Parity without breastfeeding was associated with lower odds of vitamin D supplement use (OR .63, 95% CI .40–.99) when compared with parous women who had breastfed.

Among users of vitamin D supplements (Table 5), women ages 20–35 years had lower odds of taking more than 400 IU/day (OR .50, 95% CI .27–.93) compared to those ages 36–49 years. Those with less than high school education or below grade level also had lower odds (OR .44, 95% CI .21–.95) of taking more than 400 IU/day. For duration of supplementation (Table 6), women ages 20–35 years had lower odds (OR .50, 95% CI .35–.72) of having taken vitamin D for a year or more relative to those ages 36–49 years. Those with Mexican-American (OR .36, 95% CI 1.67–.80) and other Hispanic ethnicity (OR .37, 95% CI .19–.75) had lower odds of having taken supplementation for a year or more compared to non-Hispanic white women.

Table 4. Associations of demographic, socioeconomic, and health variables with vitamin D supplement use

Variable	Taken vitamin D in past 30 days (n)	OR (95% CI)	p	Adjusted OR (95% CI)	Adjusted p
Age					
16-19	47	.50 (.30–.84)	0.011	.63 (.31–1.30)*	0.199*
20-35	188	.73 (.60–.90)	0.005	.77 (.58–1.02)	0.068
36-49	224	—	—		—
Six month time period					
November – April (South)	220	1.00 (.65–1.54)	0.988	1.08 (.73–1.59)	0.695
May – October (North)	233	—	—	—	—
Race/ethnicity					
Mexican-American	63	.37 (.38–.94)	<0.001	.53 (.33–.86)	0.014
Other Hispanic	53	.49 (.32–.75)	0.003	.68 (.44–1.04)*	0.071*
Non-Hispanic Black	93	.60 (.38–.94)	0.029	.78 (.51–1.19)	0.233
Other Race or Multi-Racial	22	.89 (.52–1.50)	0.631	.89 (.49–1.64)	0.697
Non-Hispanic White	228	—	—	—	—
Years in US/Citizenship					
Non-citizen less than 5 years	9	.34 (.16–.72)	0.008	0.158 (.19–1.34)	0.158
Non-citizen 5+ years	41	.83 (.43–1.58)	0.541	1.20 (.53–2.71)	0.645
Citizen, any years	407	—	—	—	—
Household Income					
<$25,000 per year	94	.34 (.21–.57)	<0.001	*	*
$25,000-$45,000 per year	82	.48 (.35–.66)	<0.001	*	*
$45,000-$65,000 per year	67	.63 (.30–1.02)	0.061	*	*
$65,000-$75,000 per year	30	.72 (.30–1.76)	0.446	*	*
>$75,000 per year	161	—	—	—	—
Food Security (adult)					
Very low food security	16	.40 (.22–.70)	0.003	.70 (.42–1.18)	0.166
Low food security	36	.40 (.28–.56)	<0.001	.65 (.44–.95)	0.027
Marginal food security	59	.53 (.29–1.00)	0.049	.92 (.54–1.54)	0.730
Full food security	347	—	—	—	—
Health Insurance Status					
Uninsured	84	.38 (.53–.86)	<0.001	.65 (.42–1.00)	0.045
Government or Other Insurance	66	.40 (.26–.61)	<0.001	.66 (.45–.96)	0.034
Private Insurance	309	—	—	—	—
Education Level					
Less than high school (adult) or below grade level (youth 16-19)	59	.29 (.24–.36)	<0.001	.52 (.33–.80)	0.005
High school/GED/equivalent (adult) or at grade level youth 16–19)	120	.42 (.28–.62)	<0.001	.63 (.39–1.04)	0.067
Some college or AA (adult)	152	.68 (.48–.96)	0.033	.92 (.61–1.40)	0.687
College graduate or above (adult)	128	—	—	—	—
BMI					
<25	186	—	—	—	—
25-30	130	.98 (.71–1.33)	0.869	1.04 (79–138)	0.766
30-35	72	.94 (.58–1.52)	0.804	1.09 (.69–1.72)	0.687
≥35	71	.50 (.28–.87)	0.018	.64 (.35–1.16)	0.132
Waist Circumference					
< 35 inches	222	—	—	—	—
≥ 35 inches	237	.58 (.51–1.05)	0.084	*	*
Tried to lose weight in last year					
Yes	190	1.19 (.90–1.55)	0.197	1.03 (.80–1.34)	0.784
No	203	—	—	—	—
Diabetes					
Told had diabetes (incl. during pregnancy)	35	.90 (.62–1.31)	0.575	.96 (.65–1.42)	0.835
No diabetes	424	—	—	—	—
Parity (age 20+)					
Nulliparous (never been pregnant)	69	.93 (.67–1.30)	0.650	.72 (.40–.99)	0.116
Parous, never breastfed	90	.62 (.42–.90)	0.016	.63 (.40–.99)	0.048
Parous, breastfed 1+ mo	182	—	—	—	—
Moderate or Vigorous Exercise					
No moderate or vigorous exercise per day	186	.52 (.37–.74)	<0.001	.69 (.43–1.12)*	0.126*
Any moderate or vigorous exercise per day	269	—	—	—	—
Vitamin D intake from food					
< 400 IU from food avg day	433	.65 (.28–1.56)	0.315	.59 (.26–1.35)	0.197
≥400 IU from food avg day	26	—	—	—	—

**Adjusted OR values are calculated controlling for all other variable categories, with the exception of waist circumference and income. These were found to be highly collinear (VIF>20) with other health or socioeconomic variables. When we tested the model with waist circumference and income instead of BMI, health insurance, and education, BMI was not associated (OR .80, p=0.166); significance was found in additional categories age 16-19 (OR.36, p=0.002), age 20-35 (OR .76, p=0.43), Hispanic race (OR .65, p=0.039), no moderate or vigorous exercise (OR .62, p=0.034), income under $25,000/year (OR .52, p=0.018), and income $25,000-$45,000/year (OR .70, p=0.013).*

Discussion

Overall intake of vitamin D supplements among women of childbearing age (33%) has not changed significantly since 2001-2006, when an earlier study on NHANES data reported prevalence as 32%.[1] Further outreach may be needed to women of childbearing age. While attention to vitamin D rose in 2007-2008, there are numerous factors in determining whether, when, and in what circumstances health information will change behavior.[40] NHANES does not indicate when in 2007-2008 interviews took place. We recommend comparison of our results with future NHANES data when they become available. The 2001-2006 study also found association between nonuse of vitamin D supplements and Hispanic and non-Hispanic black identity, as well as poverty–income ratio of ≤1. Most demographic, socioeconomic, and health variables we examined indicated differences in vitamin D supplementation that parallel other inequalities in nutrition and health. Our estimates are useful for public health and medical practitioners seeking to identify subgroups at risk for non-supplementation.

Strategies may be necessary to reach younger women and race/ethnicity groups other than non-Hispanic white, particularly Mexican-Americans. Disparities of race/ethnicity are noteworthy because darker skin pigmentation is associated with obtaining less vitamin D from endogenous synthesis.[41]

Disparities along lines of income, food security, and health insurance status are concerning because these categories indicate limited access to healthful food and full health care. Disparities suggest a large role of socioeconomic status in supplement intake equality.

Low likelihood of supplementation among those with high BMI is worrisome given relationships between obesity and vitamin D serum status and need for higher dosages among those with high BMI.[29]

Parity and breastfeeding results suggest that future studies might examine correlation between education about breastfeeding and education about vitamin D.

Our population-level estimates of dosage and duration of supplement use lay a comparative baseline for future studies. Differences between and within strata were less pronounced than results for prevalence of vitamin D supplement use, suggesting fewer disparities among those who choose supplementation. Women with high BMI (≥35) who are in need of higher vitamin D doses are most likely to be taking the smallest dose in our strata, of concern for the reasons mentioned above. Socioeconomic factors again stand out as relevant for advocates and practitioners. The significant results of adjusted data for age group 20–35 are notable given that this age group is a common childbearing range, and given vitamin D needs of pregnant women.

Overall, levels of supplementation were very low among women of childbearing age. Only one third took a vitamin D-containing supplement of any kind, and the majority took 400 IU or less. This is of concern for all women of childbearing age, beyond disparities, and raises questions about whether prevalence and dosage will have increased in later data.

These results come from a carefully-designed, large, nationally-representative sample of women in the United States and are generalizable to women of childbearing age (16–49 years). The data highlight disparities in vitamin D supplement use that parallel other inequalities in health status and nutrition access, and will be useful in practice, promotion, research, and advocacy. Rather than identical outreach to all women of childbearing age, attention should be paid to ensure reaching women with lower likelihood of vitamin D supplementation and to those who might need vitamin D supplements and at higher dosages than their peers. Advocates and educators who study social inequalities and who pursue nutrition and health from a social justice framework should be aware of disparities in this study.

Future research is recommended with NHANES 2009-2010 and 2011-2012 data when they become available to assess changes in prevalence, disparities, and associations of vitamin D supplementation. Further research with longitudinal data is needed to examine the etiology of disparities in vitamin D supplement use. Studies may also examine disparities in types of D supplement intake, such as D2 versus D3, vitamin D with other nutrients, cod liver oil, or multivitamins.

This study has some limitations. NHANES 2007-2008 does not have a comprehensive list of race/ethnicity categories. However, the demographics that are available indicate clear disparities even without additional categories. NHANES does not distinguish between intake of vitamin D2 and D3. While we would have liked to compare serum status of 25(OH)D with supplement intake among women of childbearing age, the variable measuring serum status has been delayed due to changes in measurement format. This keeps our focus on supplement intake and disparities. We suggest that future research examine serum status and supplementation to see if disparities are exacerbated.

There are also limitations inherent to cross-sectional nutritional epidemiology. Establishing causality is not possible. Dietary interviews can include accuracy challenges and potential social desirability bias. NHANES addresses some of these limitation by asking to see the supplement container if it is available. NHANES data does not disclose where respondents lived. Regional and seasonal differences might be correlated with vitamin D supplement use, particularly given differences in availability from sunlight. However, even living in the southern U.S. is not protective against vitamin D deficiency,[17] and we found no difference between the two broad season/geography categories NHANES provides. NHANES does not reveal when in 2007-2008 the data were collected. The increase in national attention was high in 2008, and at least some of the data would have already been collected. However, since behavior change does not always immediately follow information exposure, this underscores the value of comparatively repeating our study with the 2009-2010 data when available. NHANES 2007-2008 includes very few pregnant women, particularly when compared with previous NHANES years. However, while NHANES is a nationally-representative dataset, its pregnant women may not be representative of pregnant women in the U.S. We recommend findings from this study be examined among pregnant and breastfeeding women in future studies. Per study power, most of our observations maintain fairly tight confidence intervals, one exception being nulliparity as an association with dose, in Table 5. Some of our other strata are small. The demographic, socioeconomic, and health factors we examined are crucial for understanding disparities, and even initial analysis of smaller numbers lays groundwork for detailed examinations.

Table 5. Key significant associations with dose ≥400 (adjusted)

Variable	**Dose ≥ 400 IU Adjusted OR (95% CI)**	**Adjusted p**
Age		
16-19	.43 (.07–2.47)	0.321
20-35	.50 (.27–.93)	0.030
36-49	—	—
Education Level		
Less than high school (adult) or below grade level (youth 16-19)	.44 (.21–.95)	0.037
High school/GED/equivalent (adult) or at grade level youth 16–19)	1.16 (.52–2.55)	0.705
Some college or AA (adult)	1.37 (.80–2.33)	0.231
College graduate or above (adult)	—	—
Parity (age 20+)		
Nulliparous (never been pregnant)	2.56 (1.07–6.14)	0.037
Parous, never breastfed	.78 (.41–1.48)	0.420
Parous, breastfed 1+ mo	—	—

Non-citizen with less than five years in the U.S. predicted failure perfectly and was dropped from the model by Stata.

Table 6. Key significant associations with supplementation duration (adjusted)		
Variable	**Duration > 1 years Adjusted OR (95% CI)**	**Adjusted p**
Age		
16-19	.56 (.17–1.85)	0.319
20-35	.50 (.35–.72)	0.001
36-49	—	—
Race/Ethnicity		
Mexican-American	.36 (1.67–.80)	0.014
Other Hispanic	.37 (.19–.75)	0.009
Non-Hispanic Black	.52 (.25–1.04)	0.064
Other Race or Multi-Racial	.57 (.16–2.05)	0.369
Non-Hispanic White	—	—

Conclusion

Vitamin D supplementation prevalence, dosage, and duration vary across lines of disparity in demographic, socioeconomic, and health categories. Many of these variables are statistically significantly associated with vitamin D supplementation. Socioeconomic variables, race/ethnicity, education, and BMI are of particular concern. Disparities may reflect differences in access to resources or information; causality should be explored.

Our study has implications for practice, research, and policy. Policy makers working to ensure quality health insurance for all may note the association between low vitamin D supplementation and both lack of health insurance and having government/other health insurance. Practitioners working with women of childbearing age and/or women who are pregnant or breastfeeding may want to discuss these findings with patients. Advocates working on intersections between nutrition, food access, and sustainability may consider disparities in vitamin D supplement access as related to their work on vitamin D in food production methods and food access equity. These results should influence strategies for targeting public health practice and education regarding vitamin D supplement use to various populations, and should raise concerns among advocates and policy makers who focus on reducing disparities in health status and nutrition/food access.

Education and raising awareness pose challenges; when presented with information, people do not necessarily follow medical advice. A study from Ireland found that advice to new mothers about vitamin D supplementation was not often followed.[42] We recommend advocates and researchers build strategies for health promotion about vitamin D supplementation in groups at risk for low supplementation, and engage these populations in strategizing for successful and demographically-relevant outreach and education in their own communities.

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