# Modifiable lifestyle factor correlates of vitamin D status in United States adults

## AN INITIAL ANALYSIS OF NHANES DATA

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# Vitamin D

- A core component for attaining optimal bone health
- Increasing attention given to vitamin D's potential role in non-skeletal health factors (i.e., chronic diseases)
- Vitamin D receptors have been found in over 35 tissues throughout the body
- Implicate vitamin D involvement in many physiological functions

R. Bouillon, Okamura, & Norman, 1995; Norman, 2008; Avenell, Mak, & O'Connell, 2014; Ross, Taylor, Yaktine, & Del Valle, 2011; Weatherall, 2000; Weaver et al., 2016

# Dietary Intake and Serum 25(OH)D Guidelines

| IOM RDA for Vitamin D | | | | |
|---|---|---|---|---|
| **Age** | **Male** | **Female** | **Pregnancy** | **Lactation** |
| 0–12 months* | 400 IU | 400 IU | | |
| | (10 mcg) | (10 mcg) | | |
| 1–13 years | 600 IU | 600 IU | | |
| | (15 mcg) | (15 mcg) | | |
| 14–18 years | 600 IU | 600 IU | 600 IU | 600 IU |
| | (15 mcg) | (15 mcg) | (15 mcg) | (15 mcg) |
| 19–50 years | 600 IU | 600 IU | 600 IU | 600 IU |
| | (15 mcg) | (15 mcg) | (15 mcg) | (15 mcg) |
| 51–70 years | 600 IU | 600 IU | | |
| | (15 mcg) | (15 mcg) | | |
| >70 years | 800 IU | 800 IU | | |
| | (20 mcg) | (20 mcg) | | |

| IOM Serum 25(OH)D Cut Points | | |
|---|---|---|
| **nmol/L** | **ng/mL** | **Health status** |
| <30 | <12 | Deficiency |
| 30 to <50 | 12 to <20 | Inadequacy |
| ≥50 | ≥20 | Adequacy |
| >125 | >50 | Potential adverse effects |

1 ng/mL = 2.4959 nmol/L; 1 nmol/L = .401 ng/mL

Ross et al., 2011

# Usual intake of vitamin D among adults by race/ethnicity (IU/day (SE))

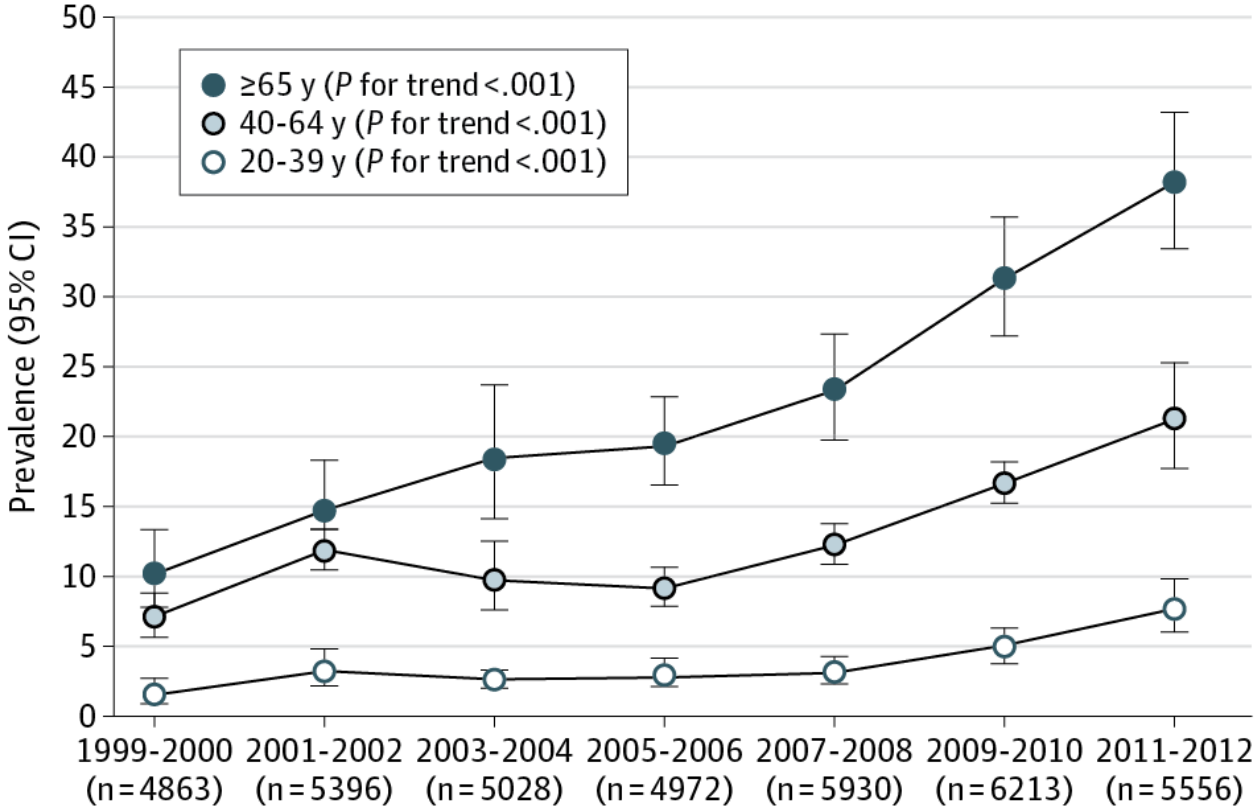
| | NH-White | | NH-Black | | Hispanic | | NH-Asian | |
|---|---|---|---|---|---|---|---|---|
| | Food Only | Total Intake | Food Only | Total Intake | Food Only | Total Intake | Food Only | Total Intake |
| **NHANES 2009–2012** | 204.4 (3.2) | 648 (36) | 158.8 (4.8) | 371.2 (14.4) | 187.2 (3.6) | 340 (13.6) | 188.4 (12.8) | 600 (40) |

*Total Intake consists of food + vitamin D supplement intake among supplement users.*
*Food Only consists of total vitamin D intake from food sources only in both users and non-users.*
*Non-Hispanic whites (NH-white), non-Hispanic Blacks (NH-black), Hispanics (Mexican Americans and other Hispanics), and non-Hispanic Asians (NH-Asian)*

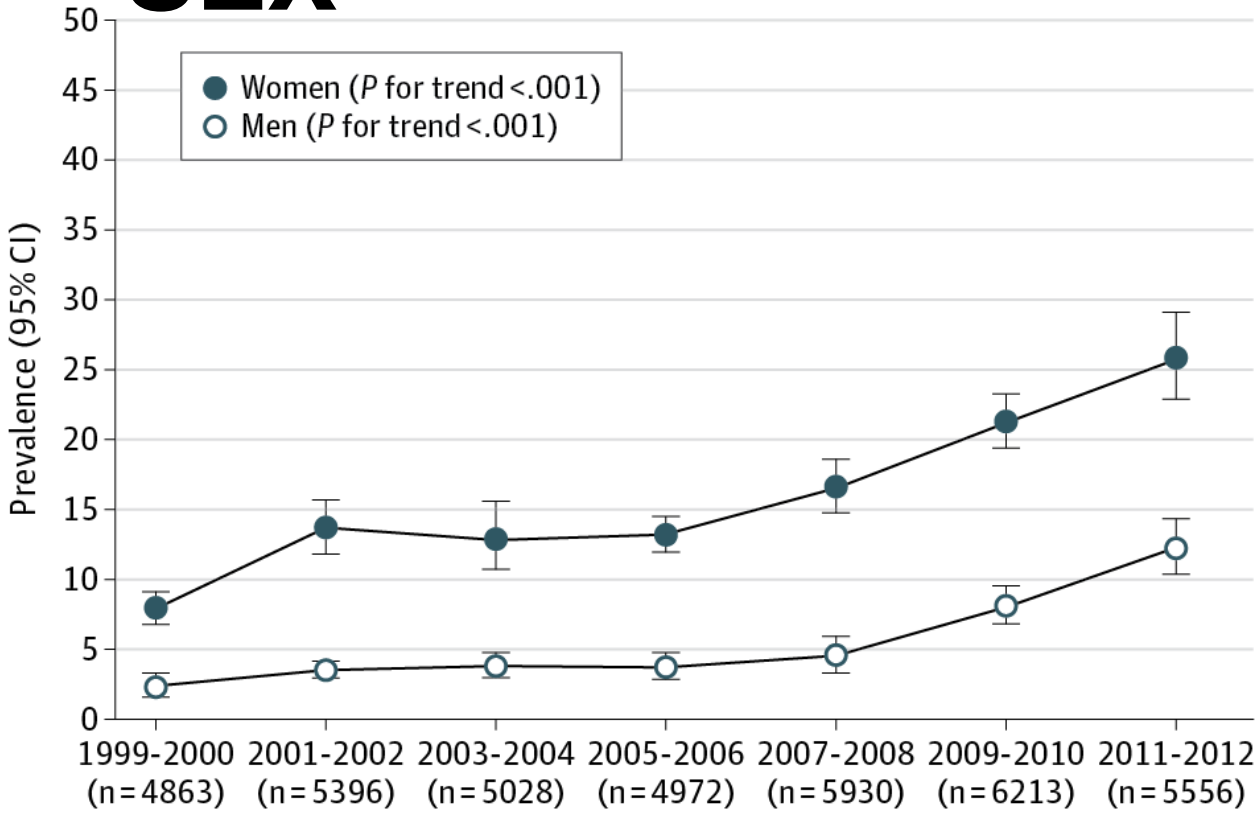
Blumberg et al., 2017

# Trends in Use of Vitamin D Among US Adults, Excluding MVMMs

## AGE



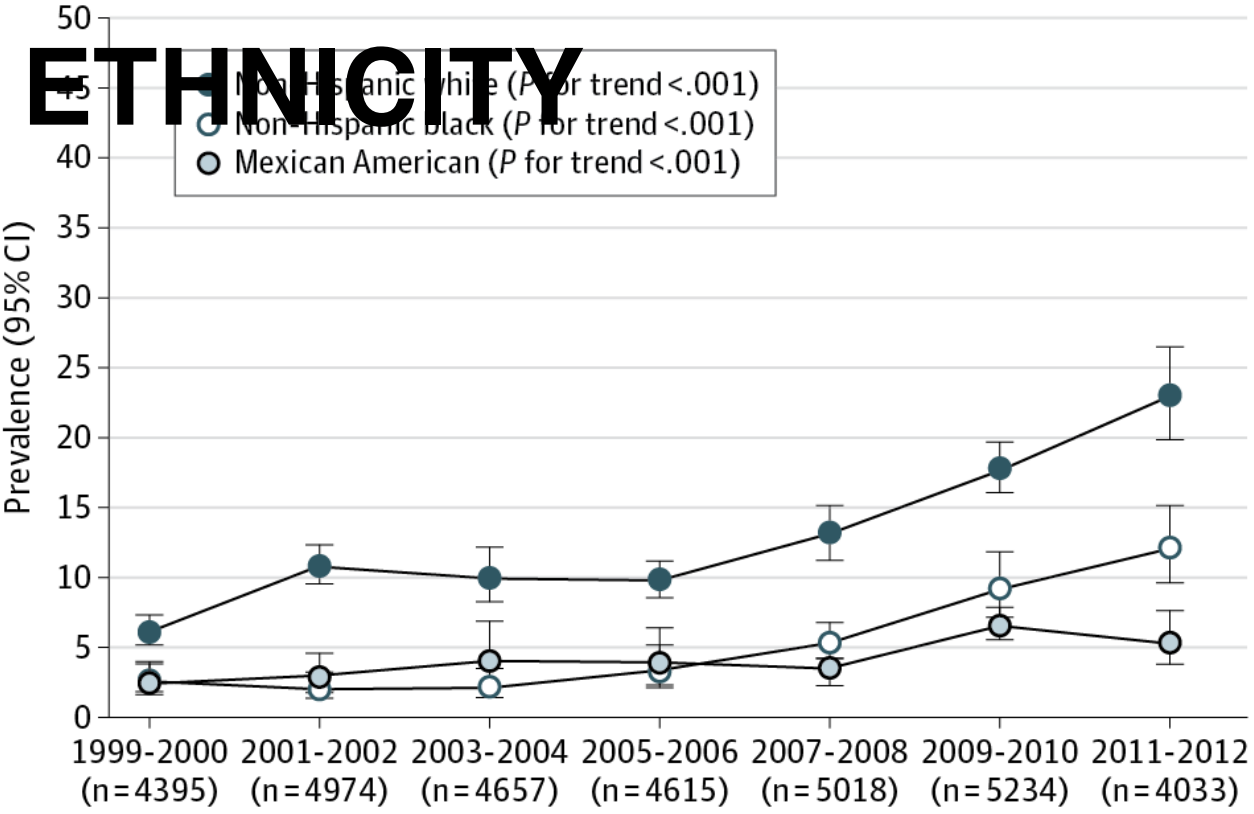

## SEX



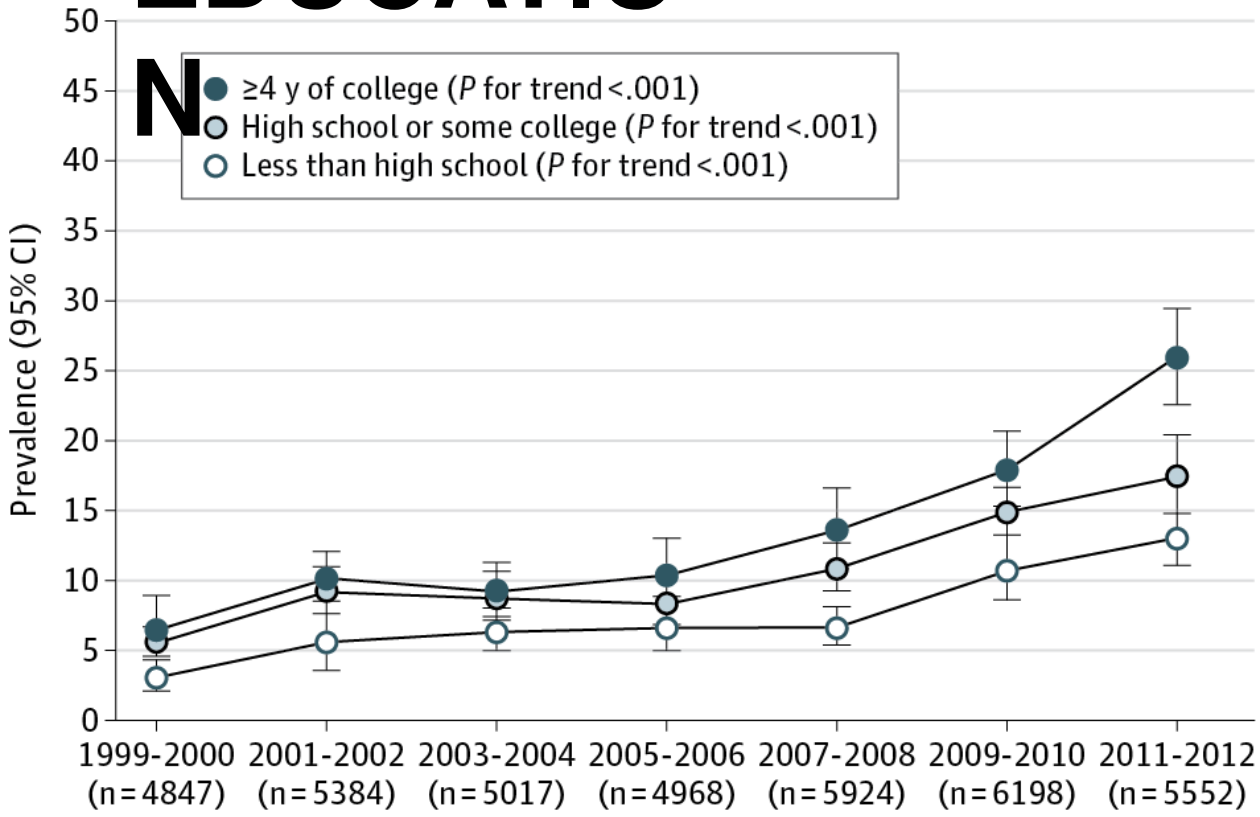

HS (high school); MVMM (multivitamin/multimineral); data are weighted to be nationally representative; adults are defined as those aged ≥20 years.

# Trends in Use of Vitamin D Among US Adults, Excluding MVMMs

## RACE/ ETHNICITY

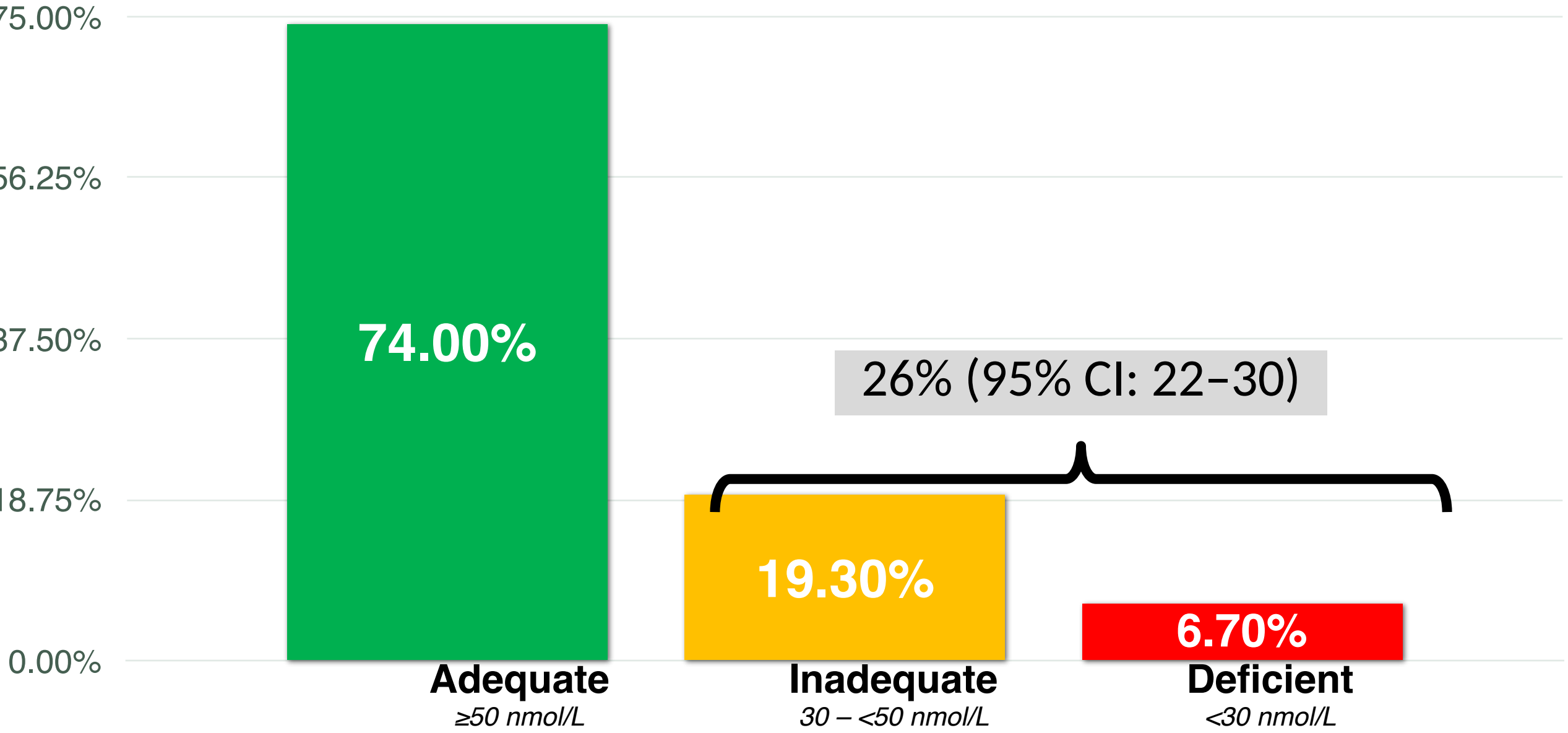



## EDUCATION

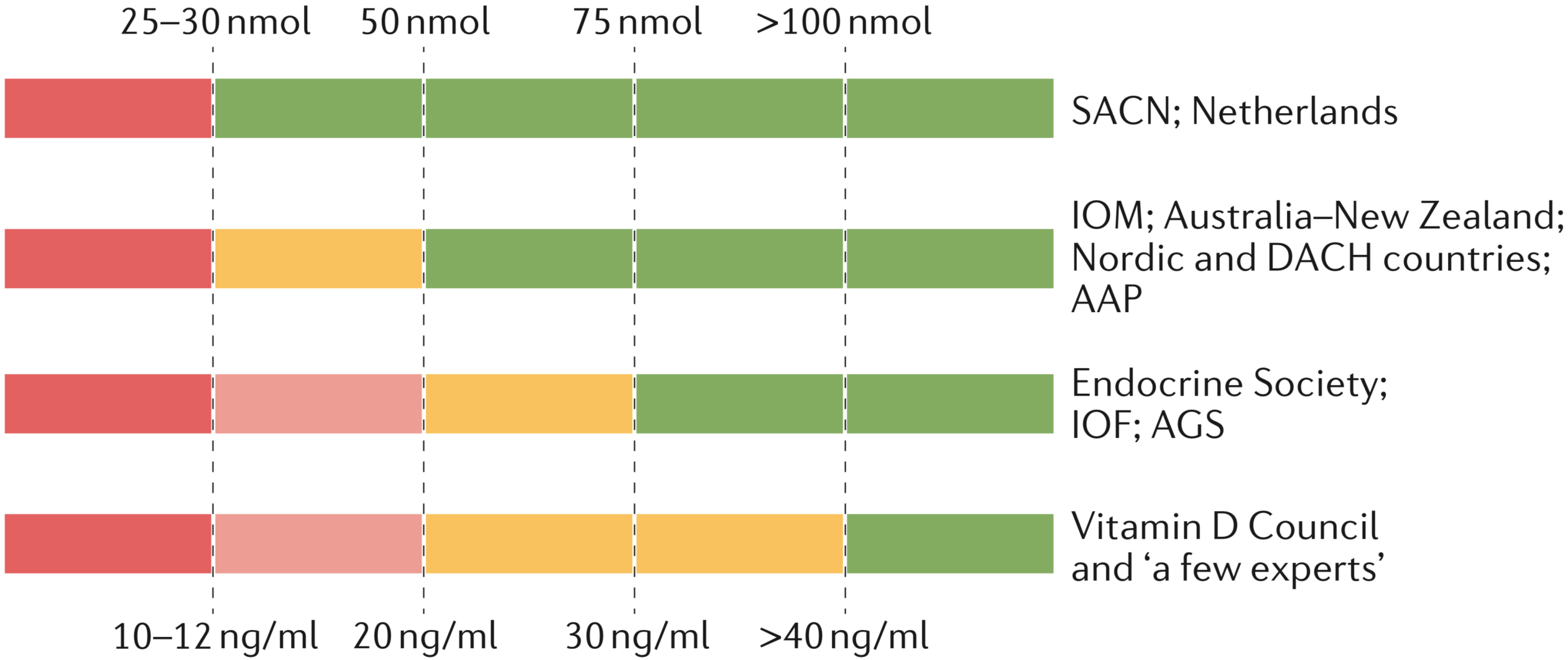



HS (high school); MVMM (multivitamin/multimineral); data are weighted to be nationally representative; adults are defined as those aged ≥20 years.

# Vitamin D Status of US Adults
## By IOM serum 25(OH)D cut points




Schleicher et al., Am J Clin Nutr. 2016 Aug;104(2):454-61. doi: 10.3945/ajcn.115.127985.

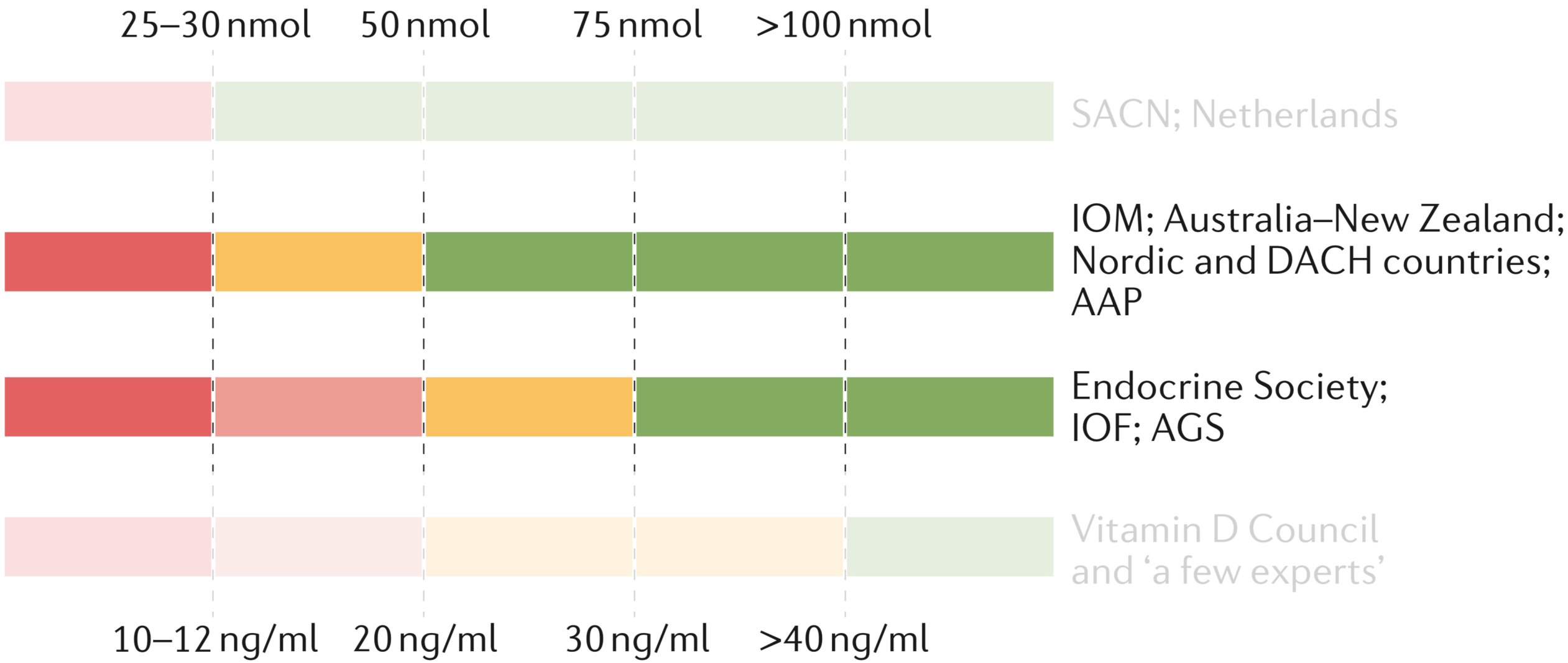



**Red** denotes a state of severe deficiency (danger) that must be corrected without exception.

**Orange** denotes a state of mild deficiency (modest concern), in which intervention is desirable.

**Green** denotes a state of sufficient supply that does not benefit from additional supplementation.

Bouillon R. Nat Rev Endocrinol. 2017 Aug;13(8):466-479. doi: 10.1038/nrendo.2017.31.




**Red** denotes a state of severe deficiency (danger) that must be corrected without exception.

**Orange** denotes a state of mild deficiency (modest concern), in which intervention is desirable.

**Green** denotes a state of sufficient supply that does not benefit from additional supplementation.

Due to concern around **widespread inadequate intake** in the US, vitamin D has been deemed **a nutrient of interest in public health**.

- - -

Vitamin D has been classified as a **chronically under-consumed nutrient** whose low intake can adversely affect health outcomes.

It is plausible that population-wide improvements in vitamin D status could help reduce the incidence or severity of chronic disease and their associated economic burden.

- - -

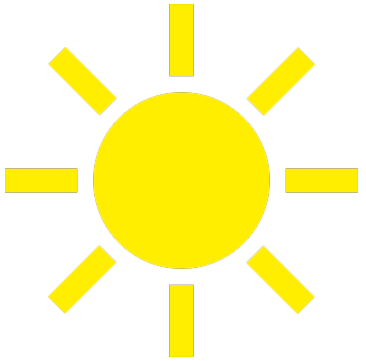
To this end, there are many modifiable lifestyle factors that could be targeted to improve vitamin D status.

Grant, Whiting, Schwalfenberg, Genuis, & Kimball, 2016

# Modifiable Lifestyle Factors Influencing Vitamin D Status

Diet

Supplement Use

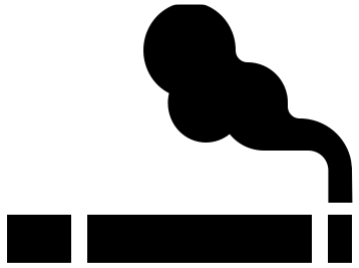


UV Exposure

Body Composition

Physical Activity

Alcohol Intake



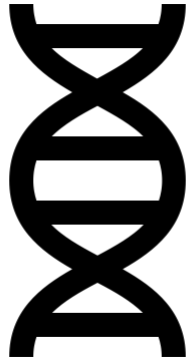
Smoking Habits

Sleep Habits

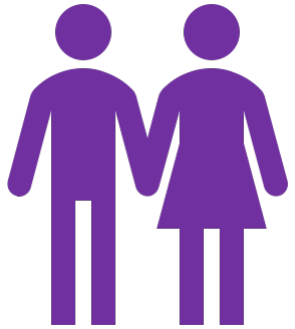
# Non-Modifiable Lifestyle Factors Influencing Vitamin D Status

Season

Latitude/Altitude

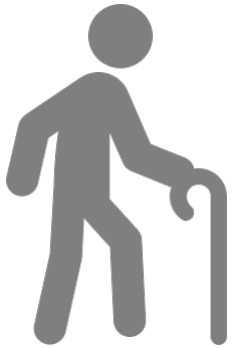


Genetics

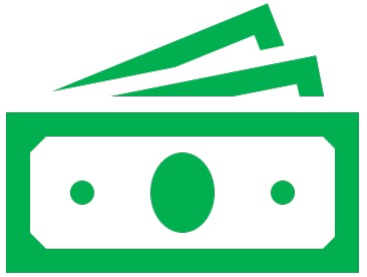


Sex


Skin Pigment



Age



Income

Education

- Many observational studies have examined select modifiable lifestyle determinants of vitamin D status in the US population
  - The majority have also included other modifiable factors with the aim of identifying at-risk populations

- Few observational studies have attempted to comprehensively examine the effects of modifiable lifestyle factors alone on vitamin D status

- Such an analysis may help shed light on which factors carry the greatest influence on vitamin D status

- These findings may help to inform future observational studies or clinical trials, aid in the creation of screening tools, or help inform healthcare practitioners approach to promoting lifestyle interventions for their patients

Daraghmeh et al., 2016; Forrest & Stuhldreher, 2011; Gupta, Brashear, & Johnson, 2012; Liu et al., 2018; Nesby-O'Dell et al., 2002; Rajan, Weishaar, & Keller, 2017; Weishaar, Rajan, & Keller, 2016

# Purpose

- This initial analysis of National Health and Nutrition Examination Survey (NHANES) data will help identify which modifiable lifestyle factors significantly contribute to predicting vitamin D status.

# Research Question

- Do modifiable lifestyle factors predict vitamin D status in adults?
  - $H_o$ : The modifiable lifestyle variables do not predict vitamin D status
  - $H_a$ : The modifiable lifestyle variables do predict vitamin D status

# Research Methods

- Retrospective initial analysis using cross-sectional public-use data from the NHANES 2013–2014 cycle

# Research Methods

- Two dependent variables were selected for separate testing
  The DV was the only factor that differed between models
  - Primary Analysis: Serum vitamin D (IOM cut points)
    - Vitamin D deficient or inadequate (<50.0 nmol/L)
    - Vitamin D sufficient (≥50.0 nmol/L)
  - Secondary Analysis: Serum vitamin D levels (Endocrine Society cut points)
    - Vitamin D deficient or inadequate (≤75.0 nmol/L)
    - Vitamin D sufficient (>75.0 nmol/L)

# Research Methods

- Control variables were selected based on their:
  - Documented potential influence on serum vitamin D
  - Because they are non-modifiable lifestyle factors

1. Age in years at screening
2. Annual household income
3. Education level
4. Gender
5. Household food security
6. Race/Ethnicity
7. The time period of vitamin D blood draw

# Research Methods

- IVs were selected based on their:
  - Documented potential influence on serum vitamin D
  - Because they are modifiable lifestyle factors
  - Sufficient response rates for analysis

# Research Methods

- Order of IV entry into the model was determined via:
  - Justification from the current literature
  - Response rate for the variable
- Automated method: documented concerns with regression models employing stepwise algorithms delivering potentially biased results
  - $R^2$ values are biased high, SE of estimates too small, CI too narrow, p-values too low, collinearity problems exacerbated
- Each IV was entered one by one and only remained if model significantly improved

Harrell Jr., 2015; Flom et al., 2007

1. Total vitamin D (D2 + D3) (mcg) intake
2. Takes vitamin D containing supplement?
3. Frequency of milk consumption (30 days)
4. Lifetime milk consumption regularity
5. Average fat intake (g)
6. Average energy intake (kcal)
7. Min outdoors 9am–5pm, weekly avg
8. Stay in the shade?
9. Sunscreen use?
10. Wear a long-sleeved shirt?
11. Waist circumference (cm)
12. Body Mass Index (kg/m$^2$)
13. Total calcium (mg) intake
14. Takes calcium-containing supplement?
15. Smoked at least 100 cigarettes?
16. Avg number drinks/day
17. Binge drinking frequency
18. 12-month alcohol drinking freq
19. Avg physical activity (MET-hrs/wk)
20. Avg min of sedentary activity/day
21. Usual hours of sleep
22. Self-assessed health of the diet
23. Self-assessed general health

# Research Methods

## INCLUSION CRITERIA

- Valid serum 25(OH)D measure
- Aged 20 years or older
- Day 1 & 2 24-hour dietary recall both completed, are reliable, and met minimum criteria
- Household interviewed and Mobile Examination Center (MEC) examined
- Not currently pregnant
- No health conditions that may interfere with vitamin D absorption or metabolism
  - e.g., kidney/liver/intestinal diseases, celiac disease, IBD, Crohn's, etc.
- Not currently taking medications that may interfere with vitamin D absorption or metabolism
  - e.g., systemic steroid users, anticonvulsants, corticosteroids, PTH, PTHrP, thyroid hormone, etc.

# Research Methods

**POPULATION**

- The study subsample was taken from an initial sample of 14,332 NHANES participants
- 3,679 participants met this study's inclusion criteria
  - Provided a weighted sample of 188.4 million participants

# Research Methods

- A binary multiple logistic regression was performed to assess which modifiable lifestyle factors could aid in predicting vitamin D status

# ANALYSIS

- Box-Tidwell procedure
  - All continuous IVs were linearly related to the logit of the DV for both analyses
- Collinearity
  - No evidence of collinearity in tolerance values or VIFs
- Influential cases
  - None identified via Cook's distance
- Outliers
  - Standardized residuals examining variables with SDs ±2.50
  - 48 cases in the IOM analysis and 54 in the ES analysis
  - After removing cases, both models were significantly improved ($P < .001$)
- No imputation methods were used for any variable

# Descriptive Statistics of Included Participants (Weighted #, %)

| | | |
|---|---|---|
| **Age** | | |
| Mean (SD) | 45.61 (17.08) | |
| | | |
| **Sex** | | |
| Male | 98,073,403.10 | 52.1% |
| Female | 90,295,061.89 | 47.9% |
| | | |
| **Race/Ethnicity** | | |
| Mexican American | 19,736,000.53 | 10.5% |
| Other Hispanic | 10,106,182.97 | 5.4% |
| Non-Hispanic Black | 21,853,943.38 | 11.6% |
| Non-Hispanic Asian | 10,442,041.88 | 5.5% |
| Other Race - Including Multi-Racial | 5,974,468.91 | 3.2% |
| Non-Hispanic White | 120,255,827.33 | 63.8% |
| | | |
| **Education level** | | |
| 1st–8th grade | 7,540,616.11 | 4.0% |
| 9–11th grade & 12th w/ no diploma | 19,055,251.62 | 10.1% |
| HS graduate/GED or equivalent | 40,084,345.14 | 21.3% |
| Some college or AA degree | 61,658,546.00 | 32.8% |
| College graduate or above | 59,906,900.77 | 31.8% |

| | | |
|---|---|---|
| **Annual household income** | | |
| $0 to $4,999 | 2,455,702.79 | 1.4% |
| $5,000 to $9,999 | 4,988,646.73 | 2.8% |
| $10,000 to $14,999 | 7,543,408.15 | 4.3% |
| $15,000 to $19,999 | 8,427,446.84 | 4.8% |
| $20,000 to $24,999 | 13,130,669.72 | 7.5% |
| $25,000 to $34,999 | 15,896,581.95 | 9.1% |
| $35,000 to $44,999 | 17,884,077.83 | 10.2% |
| $45,000 to $54,999 | 14,726,651.43 | 8.4% |
| $55,000 to $64,999 | 11,599,005.57 | 6.6% |
| $65,000 to $74,999 | 8,814,001.35 | 5.0% |
| $75,000 to $99,999 | 19,499,593.95 | 11.1% |
| $100,000 and Over | 50,537,969.65 | 28.8% |
| | | |
| **Household food security category** | | |
| HH full food security | 143,430,724.23 | 76.8% |
| HH marginal food security | 15,839,954.81 | 8.5% |
| HH low food security | 16,682,124.44 | 8.9% |
| HH very low food security | 10,835,940.85 | 5.8% |

# RESULTS: IOM

- Of 24 IVs tested, six significantly improved the model
- 2,605 valid cases were included in the final regression
  - Weighted subsample size of 125.8 million
- The regression model was statistically significant (P <.001) and remained significant when a Bonferroni correction was applied (P <.001).

| IOM Analysis Model Results | | | | |
|---|---|---|---|---|
| **Source** | **df** | **Wald Chi-Square** | **Sig.** | **Bonferroni Sig.** |
| (Corrected Model) | 15.00 | 3,066.505 | <.001 | <.001 |
| (Intercept) | 1.00 | 11.122 | <.001 | <.001 |
| | | | | |
| Control variables | | | | |
| Age | 1.00 | 9.481 | .002 | .002 |
| Gender | 1.00 | .278 | .598 | .598 |
| Race/Ethnicity | 5.00 | 166.490 | <.001 | <.001 |
| Education level | 4.00 | 1.301 | .861 | 1.000 |
| Annual household income | 11.00 | 75.905 | <.001 | .051 |
| Season of vitamin D blood draw | 1.00 | 15.927 | <.001 | <.001 |
| Amount of food consumed (24-hr recall) | 4.00 | 6.976 | .137 | .162 |
| Household food security category | 3.00 | 3.353 | .340 | .281 |
| | | | | |
| Independent variables | | | | |
| Vitamin D (D2 + D3) intake (mcg) | 1.00 | 25.648 | <.001 | <.001 |
| Vitamin D dietary supplement use | 1.00 | 16.294 | <.001 | <.001 |
| Regular milk use 5 times per week? | 2.00 | 3.007 | .222 | .385 |
| Sunscreen use | 4.00 | 1.726 | .786 | .974 |
| Waist Circumference (cm) | 1.00 | 42.204 | <.001 | <.001 |
| Minutes sedentary activity per day | 1.00 | 2.231 | .135 | .135 |

# RESULTS: IOM

| | |
|---|---|
| Variance (%) | |
| Cox & Snell $R^2$ | 31.07 |
| Nagelkerke $R^2$ | 44.65 |
| | |
| Classification (%) | |
| Overall Accuracy | 79.68 |
| Sensitivity | 50.26 |
| Specificity | 91.24 |
| Positive Predictive Value | 69.26 |
| Negative Predictive Value | 82.36 |

# RESULTS: IOM

| Vitamin D dietary supplement use | | | |
|---|---|---|---|
| | | 95% CI | |
| | Exp(B) | Lower | Upper |
| Does not use vitamin D containing supplement | 4.414 | 2.015 | 9.669 |
| Uses vitamin D containing supplement | 1.000[a] | | |

a. Set to zero because this parameter is the reference variable.

# RESULTS: IOM

| Regular milk use 5 times per week? | | | |
|---|---|---|---|
| | | 95% CI | |
| | Exp(B) | Lower | Upper |
| Never been a regular milk drinker | 1.431 | .921 | 2.225 |
| Milk drinking has varied over their life | 1.299 | .847 | 1.994 |
| Been a regular milk drinker for most or all their life | 1.000[a] | | |

a. Set to zero because this parameter is the reference variable.

# RESULTS: IOM

| Sunscreen use | | | |
|---|---|---|---|
| | | 95% CI | |
| | Exp(B) | Lower | Upper |
| **Never** | .956 | .547 | 1.672 |
| **Rarely** | 1.094 | .605 | 1.980 |
| **Sometimes** | 1.276 | .712 | 2.283 |
| **Most of the time** | 1.156 | .644 | 2.075 |

a. Set to zero because this parameter is the reference variable.

# RESULTS: IOM

| | | 95% CI | |
|---|---|---|---|
| | Exp(B) | Lower | Upper |
| **Vitamin D (D2 + D3) intake (mcg)** | .925 | .895 | .956 |
| **Waist Circumference (cm)** | 1.024 | 1.016 | 1.032 |
| **Minutes sedentary activity per day** | 1.001 | 1.000 | 1.001 |

a. Set to zero because this parameter is the reference variable.

# RESULTS: Endocrine Society

- Of 24 IVs tested, seven significantly improved the model
- 2,655 valid cases were included in the final regression
  - Weighted subsample size of 128.1 million
- The regression model was statistically significant (P <.001) and remained significant when a Bonferroni correction was applied (P <.001)

| Endocrine Society Analysis Model Results | | | | |
|---|---|---|---|---|
| **Source** | **df** | **Wald Chi-Square** | **Sig.** | **Bonferroni Sig.** |
| (Corrected Model) | 15.000 | 622.652 | <.001 | <.001 |
| (Intercept) | 1.000 | 66.611 | <.001 | <.001 |
| | | | | |
| Control variables | | | | |
| Age | 1.000 | 3.173 | .075 | .075 |
| Gender | 1.000 | 7.409 | .006 | .006 |
| Race/Ethnicity | 5.000 | 101.009 | <.001 | <.001 |
| Education level | 4.000 | 1.478 | .831 | 1.000 |
| Annual household income | 11.000 | 22.139 | .023 | .117 |
| Season of vitamin D blood draw | 1.000 | 4.816 | .028 | .028 |
| Amount of food consumed (24-hr recall) | 4.000 | 6.213 | .184 | .248 |
| Household food security category | 3.000 | 1.325 | .723 | .825 |
| | | | | |
| Independent variables | | | | |
| Vitamin D (D2 + D3) intake (mcg) | 1.000 | 10.835 | .001 | .001 |
| Vitamin D dietary supplement use | 1.000 | 8.910 | .003 | .003 |
| Regular milk use 5 times per week? | 2.000 | .759 | .684 | .794 |
| Fat intake (g) | 1.000 | .605 | .437 | .437 |
| Wear a long-sleeved shirt? | 4.000 | 13.491 | .009 | .279 |
| Smoked at least 100 cigarettes in lifetime? | 1.000 | 3.362 | .067 | .067 |

# RESULTS: Endocrine Society

| | |
|---|---|
| Variance (%) | |
| Cox & Snell $R^2$ | 21.20 |
| Nagelkerke $R^2$ | 30.40 |
| | |
| Classification (%) | |
| Overall Accuracy | 78.13 |
| Sensitivity | 93.18 |
| Specificity | 40.21 |
| Positive Predictive Value | 79.69 |
| Negative Predictive Value | 70.08 |

# RESULTS: Endocrine Society

| Vitamin D dietary supplement use | | | |
|---|---|---|---|
| | | 95% CI | |
| | Exp(B) | Lower | Upper |
| Does not use vitamin D containing supplement | 2.030 | 1.224 | 3.367 |
| Uses vitamin D containing supplement | 1.000[a] | | |

a. Set to zero because this parameter is the reference variable.

# RESULTS: Endocrine Society

| Regular milk use 5 times per week? | | | |
|---|---|---|---|
| | | 95% CI | |
| | Exp(B) | Lower | Upper |
| Never been a regular milk drinker | 1.234 | .727 | 2.095 |
| Milk drinking has varied over their life | 1.080 | .771 | 1.513 |
| Been a regular milk drinker for most or all their life | 1.000[a] | | |

a. Set to zero because this parameter is the reference variable.

# RESULTS: Endocrine Society

| Wear a long-sleeved shirt on sunny days? | | | |
|---|---|---|---|
| | | 95% CI | |
| | Exp(B) | Lower | Upper |
| Never | .464 | .188 | 1.144 |
| Rarely | .651 | .236 | 1.797 |
| Sometimes | .790 | .304 | 2.050 |
| Most of the time | .811 | .264 | 2.491 |

a. Set to zero because this parameter is the reference variable.

# RESULTS: Endocrine Society

| Smoked at least 100 cigarettes in lifetime? | | | |
|---|---|---|---|
| | | 95% CI | |
| | Exp(B) | Lower | Upper |
| Yes | 1.425 | .944 | 2.150 |
| a. Set to zero because this parameter is the reference variable. | | | |
| No | 1.000[a] | | |

# RESULTS: Endocrine Society

| How healthy is the diet? | | | |
|---|---|---|---|
| | | 95% CI | |
| | Exp(B) | Lower | Upper |
| **Poor** | 1.880 | .787 | 4.490 |
| **Fair** | 1.602 | .910 | 2.821 |
| **Good** | 1.545 | 1.011 | 2.360 |
| **Very good** | 1.376 | .783 | 2.419 |

a. Set to zero because this parameter is the reference variable.

# RESULTS: Endocrine Society

| | | 95% CI | |
|---|---|---|---|
| | Exp(B) | Lower | Upper |
| **Vitamin D (D2 + D3) intake (mcg)** | .976 | .961 | .991 |
| **Fat intake (g)** | .998 | .993 | 1.003 |

a. Set to zero because this parameter is the reference variable.

# Comparison of Model Predictors

| IOM Model | Endocrine Society Model |
|---|---|
| **Common Predictors** | |
| Total vitamin D ($D_2$ + $D_3$) intake | |
| Vitamin D dietary supplement use | |
| Regular milk use 5 times per week for most of your life? | |
| | |
| **Unique Predictors** | |
| Waist circumference | Wear a long-sleeved shirt for sun protection? |
| Minutes sedentary activity per day | Smoked at least 100 cigarettes in lifetime? |
| Sunscreen use | How healthy is your diet (self-rated) |
| | Total fat intake |

# STRENGTHS

- Controlled for numerous potential confounders
- Used 2 automated multi-pass 24 hour recalls for dietary intake
- Used gold-standard LC-MS/MS measures for serum 25O(H)D
- Employed standardized questionnaires and lab assessment practices
- Corrected for multiple comparisons
- Comprehensively assessed lifestyle variables that may affect vitamin D status
- Followed the recommendations of the Strengthening the Reporting of Observational Studies in Epidemiology—Nutritional Epidemiology guidelines for reporting nutritional epidemiology and dietary assessment research

# LIMITATIONS

- Data are cross-sectional
- Model over-fit is possible
- Use of a single NHANES data cycle, limiting external validity
- Unable to account for some factors that can affect vitamin D production
  - Skin pigmentation, latitude, altitude, weather conditions, living environment, genetic variation, type of vitamin D, indoor tanning, etc.
- Many variables rely on subjective memory-based recall
  - Omissions, inaccurate, or false reporting may be residual confounders
- 24-hr recall food database does not account for 25(OH)D content in foods
  - May increase reported intakes by 69–116 IU/day
- Single 25(OH)D measure may led to certain degree of misclassification

Taylor et al., 2014

# LIMITATIONS

- **Non-significant individual predictors -** significantly improve the model, given the other variables. Included in the final model for the following reasons
  - Primary aim of the study was to build a predictive model as opposed to an explanatory one
  - Model becomes significantly worse with their removal, decreasing predictive accuracy. Indicates their inclusion may be providing a critical adjustment or affecting the parameters of other IV's
  - Previous literature suggests some variables have larger, significant effects on vitamin D status than seen in our model. Thus, their non-significance is of interest, but may be due to the limitations of the dataset tested

- Acknowledge the predictive capability of these variables may be considered preliminary
- Their inclusion may cause some overfitting of the models

- Variables will need to be further tested using a larger dataset

Harrell Jr., 2015; Flom et al., 2007

# FUTURE RESEARCH

- An expanded analysis using a similar framework could be conducted by combining multiple NHANES data cycles
- Would have greatly enhanced external validity and allow for appropriately powered subgroup analyses not viable in the present study
- Combining NHANES 2007–2014 would produce an estimated sample size of 12,000–16,000 participants
- By combining multiple NHANES cycles, an adequate sample size from which additional variables could be tested may yield further insight into their influence on vitamin D status

# CONCLUSIONS

- The present study explored the link between modifiable lifestyle factors and their ability to predict vitamin D status in a large, heterogeneous population taken from a representative sample of US adult residents

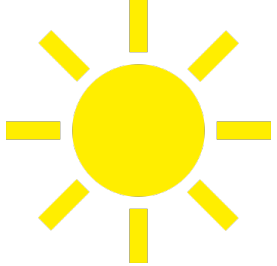
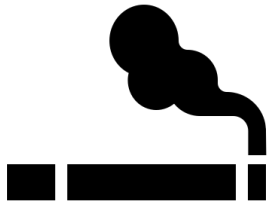
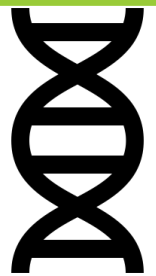
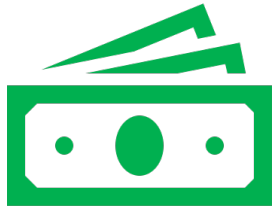
- The results of this study have replicated some of the findings of previous works on lifestyle predictors of vitamin D status, adding additional confirmation of their utility, and given further insight into potential, less-studied predictors which may warrant further investigation

# CONCLUSIONS

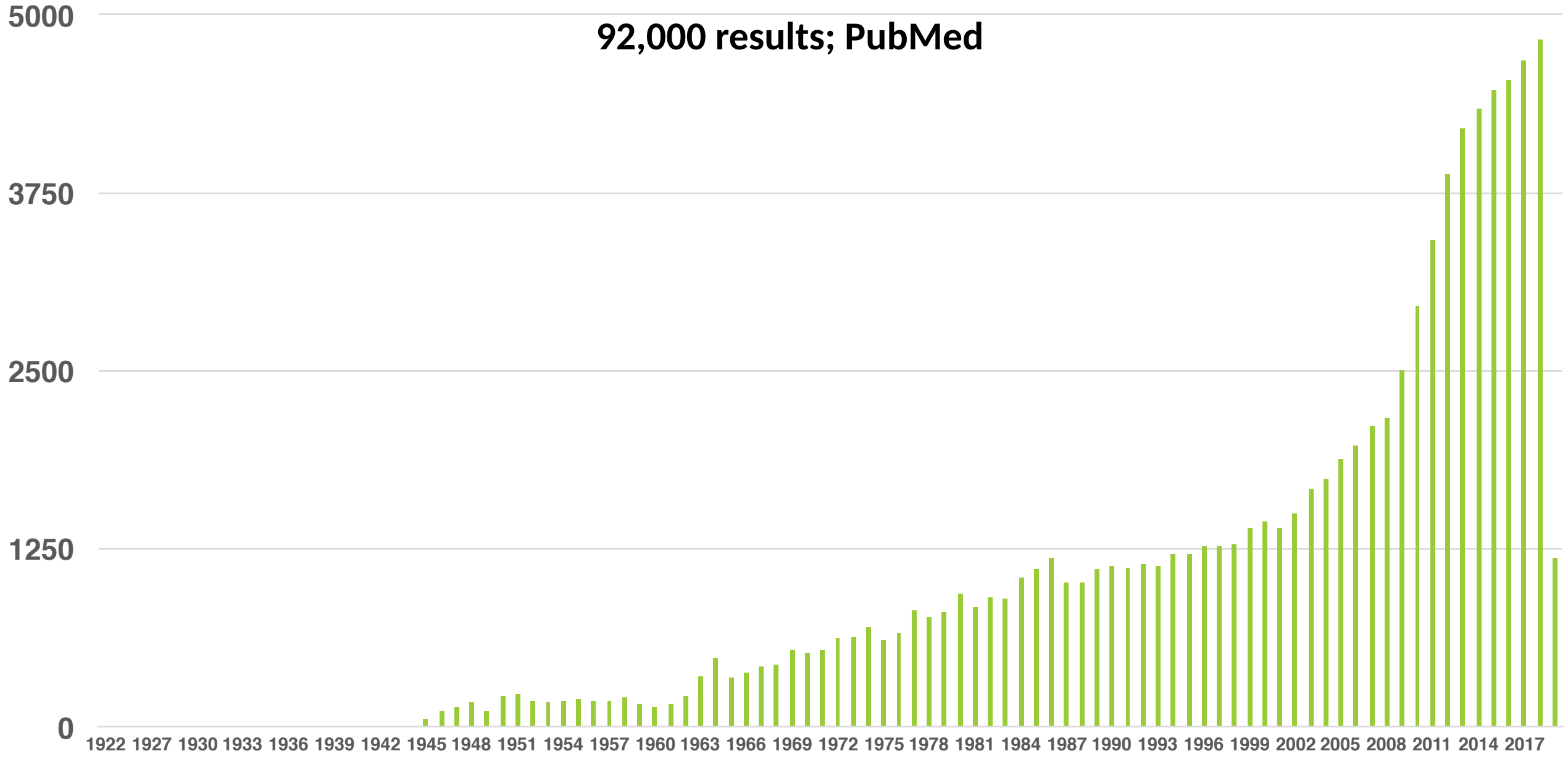
- A follow-up study combining multiple NHANES cycles is needed to confirm the results seen here and to provide greater external validity
- Given the high prevalence of US adults not achieving adequate vitamin D status (~60.99 million), identifying modifiable factors which carry the greatest influence on vitamin D status may help to:
  - Inform future observational studies or clinical trials
  - Aid in the creation of screening tools
  - Help in the development of interventions for at-risk populations
  - Help inform healthcare practitioners approach to lifestyle interventions

# METHOD

**Custom tool for tracking literature review searches**

| | | | |
|---|---|---|---|
|  |  |  |  |
| Diet | Supplement Use | UV Exposure | Body Composition |
|  |  |  |  |
| Physical Activity | Alcohol Intake | Smoking Habits | Sleep Habits |
|  |  |  |  |
| Season | Latitude/Altitude | Genetics | Sex |
|  |  |  |  |
| Skin Pigment | Age | Income | Education |

# Number of Vitamin D related publications/year



# PROBLEM

- Built-in search string creation and tracking tools are cumbersome, time consuming
- Software-based solutions
  - Expensive
  - Not primary purpose
  - Feature is buried, not easily accessible
- Limited by software/webapp functions

## Quick Start Guide

# Search Builder for PubMed/Embase Version 1.0



**Description:** Search Builder 1.0 is a tool for user-defined search strategy text strings that can easily be copied and pasted into PubMed (MEDLINE) and Embase.

**To use Search Builder 1.0, follow this Quick Start Guide, with a real example of a systematic review search on "Risk of Ischemic Stroke in People with Migraine Headaches"**

**Step 1:** Open PubMed (pubmed.gov) or Embase (embase.com) in you internet browser. Click on "Advanced" to optimize the search. ("Advanced" not mandatory, but highly recommended)

**Step 2:** In the Tab bar (bottom of the screen), select the **PubMed** or **Embase** sheet.

| Column A | Column B | Column C | Column D | Column E | Column F | | | |
|---|---|---|---|---|---|---|---|---|
| **PubMed** *Enter Search Terms Below* | ***Category/Limit*** Select from list, or enter free text **Sort** | ***Quotes?*** Yes or Blank = No | ***Appearance in Search String*** (Column **locked**; edit columns A thru C to change) | ***PubMed Field Code*** Select from list, or enter free text | ***Use Term?*** No or Blank = Yes | **Create String** | | **Copy Search String** |
| migraine headache | 2-Intervention/Exposure | Yes | "migraine headache" | [tw] | | | OR | ("migraine headache"[tw] OR headache[MeSH Terms]) AND ("cerebrovascular disorders"[MeSH Terms] OR stroke[MeSH Terms]) NOT (review[pt]) AND (english[la]) AND (humans[All Fields]) |
| severe headache | 2-Intervention/Exposure | yes | "severe headache" | [All Fields] | no | | | |
| headache | 2-Intervention/Exposure | | he | | | | ) AND ( | |
| headach* | 2 | | he | | no | | | |
| cerel | | | "cerebrova | ] | | | OR | |
| strok | | | s | ] | | | | |
| tia | | | | | no | | | |
| trans | 4-Outcome | | transient ischemic attack | [All Fields] | no | | | |
| ische | 4-Outcome | Y | | [MeSH Terms] | no | | | |
| revie | limit-EXCLUDE-article | | | [pt] | | | | |
| english | limit-language | | | [la] | | | | |
| humans | limit-species | | | [All Fields] | | | | |

**Step 3.** Enter a search term in column A.

Use the **Tab** or **Right-Arrow** button to go from left to right.

**Step 4.** In column B, choose a category or limit for your term from the dropdown menu, or write your own. Sort using the "Sort" button.

**Step 5.** In column C, add quotes to keep a keyword phrase together by typing Yes.
Default: Blank = No

**Step 6.**
Nothing to enter in Column D.

In column E, pick a Field Code.
**For Field Code tips, see below**

**Step 7.** Repeat steps 3-6 and populate your list of search terms.

**Step 8:** When you are satisfied by your search term list:
1) Click "Sort" to organize your terms by category.
2) Click "Create String" to make your search string.
3) To exclude a term from your string, type "No" in Column F.
4) Click "Create String" or "Copy Search String" again!
5) Go to PubMed/Embase and hit Ctrl-V to paste your string.

**FIELD CODE TIPS (COLUMN E):**

**TIP:** PubMed--choose Medical Subject Heading [MeSH], title word [tw], title/abstract [tiab], language [la], publication type [pt], limit, or All Fields [All Fields]. Confirm MeSH terms at ncbi.nlm.nih.gov/mesh.

**TIP:** Embase--choose explosion "/exp", synonym "/syn", title/abstract ":ti,ab", or limit. Beware: synonym terms can be very broad and introduce many false hits. It is best to look at the synonym list in the Emtree record to manually identify additional search terms . Emtree terms can be found at embase.com/emtree. Additional Field Codes can be found in the Embase help menu.

**A Novel Search Builder To Expedite Search Strategies For Systematic Reviews**

BB Kamdar et al., 2015
International Journal of Technology Assessment in Health Care

Lit Search Tracker

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Share

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | **Categorty** | **String** | **Compare** | **Differences** | **Date Searched** |
| 2 | **NHANES** | (Vitamin D[mh] C | | | |
| 3 | String 1 | (Vitamin D[mh] C | ☑ | (NHANES OR "national health and nutrition examination" ( | 1/28/2019 |
| 4 | String 2 | (Vitamin D[mh] C | ☑ | (america OR american OR americans OR USA OR "unitec | 1/29/2019 |
| 5 | String 3 | | ☐ | | |
| 6 | | | | | |
| 7 | **Supplement Use** | (Vitamin D[mh] C | | | |
| 8 | String 1 | (Vitamin D[mh] C | ☐ | | 1/30/2019 |
| 9 | String 2 | | ☐ | | |
| 10 | String 3 | | ☐ | | |
| 11 | | | | | |
| 12 | | | | | |
| 13 | | | | | |
| 14 | | | | | |
| 15 | | | | | |
| 16 | | | | | |

Tracking NHANES Supplement Use

| | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | TERM | * | QUOTES | FIELD | OPERATOR | | JOIN OPERATOR | | TERM | * | QUOTES | FIELD | OPERATOR |
| 2 | | | | | OR | | AND | | | | | | OR |
| 3 | Vitamin D | ☐ | ☐ | MeSH Terms | OR | | | | NHANES | ☐ | ☐ | Text Words | OR |
| 4 | Vitamin D deficiency | ☐ | ☐ | MeSH Terms | OR | | | | national health a | ☐ | ☑ | Text Words | OR |
| 5 | vitamin d | ☐ | ☑ | Text Words | OR | | | | Nutrition Surveys | ☐ | ☐ | MeSH Terms | |
| 6 | vitamin d3 | ☐ | ☑ | Text Words | OR | | | | | ☐ | ☐ | | |
| 7 | vitamin d2 | ☐ | ☑ | Text Words | OR | | | | | ☐ | ☐ | | |
| 8 | cholecalciferol | ☐ | ☐ | Text Words | OR | | | | | ☐ | ☐ | | |
| 9 | ergocalciferol | ☐ | ☐ | Text Words | OR | | | | | ☐ | ☐ | | |
| 10 | calcitriol | ☐ | ☐ | Text Words | OR | | | | | ☐ | ☐ | | |
| 11 | dihydrotachysterol | ☐ | ☐ | Text Words | OR | | | | | ☐ | ☐ | | |
| 12 | hydroxycholecalciferols | ☐ | ☐ | Text Words | OR | | | | | ☐ | ☐ | | |
| 13 | 25-hydroxyvitamin | ☐ | ☐ | Text Words | OR | | | | | ☐ | ☐ | | |
| 14 | calciferol | ☐ | ☐ | Text Words | OR | | | | | ☐ | ☐ | | |
| 15 | cholecalciferol | ☐ | ☐ | Text Words | OR | | | | | ☐ | ☐ | | |
| 16 | alfacalcidol | ☐ | ☐ | Text Words | OR | | | | | ☐ | ☐ | | |
| 17 | alphacalcidol | ☐ | ☐ | Text Words | OR | | | | | ☐ | ☐ | | |
| 18 | 25-hydroxyvitamin D | ☐ | ☐ | Text Words | OR | | | | | ☐ | ☐ | | |
| 19 | 25(OH)D | ☐ | ☐ | Text Words | OR | | | | | ☐ | ☐ | | |
| 20 | 25OHD | ☐ | ☐ | Text Words | OR | | | | | ☐ | ☐ | | |
| 21 | 1,25-dihydroxyvitamin D | ☐ | ☐ | Text Words | OR | | | | | ☐ | ☐ | | |
| 22 | 1,25(OH)2D | ☐ | ☐ | Text Words | OR | | | | | ☐ | ☐ | | |
| 23 | 1-25-dihydroxyvitamin D | ☐ | ☐ | Text Words | OR | | | | | ☐ | ☐ | | |
| 24 | 1-25(OH)2D | ☐ | ☐ | Text Words | | | | | | ☐ | ☐ | | |

Lit Search Tracker

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| | A | B | C | D | E |
|---|---|---|---|---|---|
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| 8 | String 1 | (Vitamin D[mh] C | ☐ | | 1/30/2019 |
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| 11 | | | | | |
| 12 | | | | | |
| 13 | | | | | |
| 14 | | | | | |
| 15 | | | | | |
| 16 | | | | | |

Tracking NHANES Supplement Use

## Your query

Type a PubMed or Ovid MEDLINE query in the box above to see its translations. Show me an example

- PubMed — any search box
- Ovid Medline / Ovid Embase — any search box
- Cochrane Library — use search manager box
- Embase — any search box
- Web of Science — any search box
- CINAHL — any search box
- PsycInfo — any search box
- Scopus — use advanced search box

## Your query

Vitamin D[mh] OR Vitamin D deficiency[mh] OR "vitamin d" OR "vitamin d3" OR "vitamin d2" OR cholecalciferol OR ergocalciferol OR calcitriol OR dihydrotachysterol OR hydroxycholecalciferols OR 25-hydroxyvitamin OR calciferol OR cholecalciferol OR alfacalcidol OR alphacalcidol OR "25-hydroxyvitamin D" OR "25(OH)D" OR "25OHD" OR "1,25-dihydroxyvitamin D" OR "1,25(OH)2D" OR "1-25-dihydroxyvitamin D" OR "1-25(OH)2D"

AND

NHANES OR "national health and nutrition examination" OR Nutrition Surveys[mh]

### PubMed

any search box

### Ovid Medline / Ovid Embase

any search box

### Cochrane Library

use search manager box

([mh "Vitamin D"] OR [mh "Vitamin D deficiency"] OR "vitamin d" OR "vitamin d3" OR "vitamin d2" OR cholecalciferol OR ergocalciferol OR calcitriol OR dihydrotachysterol OR hydroxycholecalciferols OR 25-hydroxyvitamin OR calciferol OR cholecalciferol OR alfacalcidol OR alphacalcidol OR "25-hydroxyvitamin D" OR 25(OH)D OR 25OHD OR "1,25-dihydroxyvitamin D" OR 1,25(OH)2D OR "1-25-dihydroxyvitamin D" OR 1-25(OH)2D)

AND

(NHANES OR "national health and nutrition examination" OR [mh "Nutrition Surveys"])

# http://crebp-sra.com/#/polyglot

**Center for Research In Evidence-Based Practice (CREBP)**
**Bond University**