Can the Vitamin D Needs of the North American Public Be Met By Current Supplementation and Fortification Practices in the Absence of Sun Exposure?

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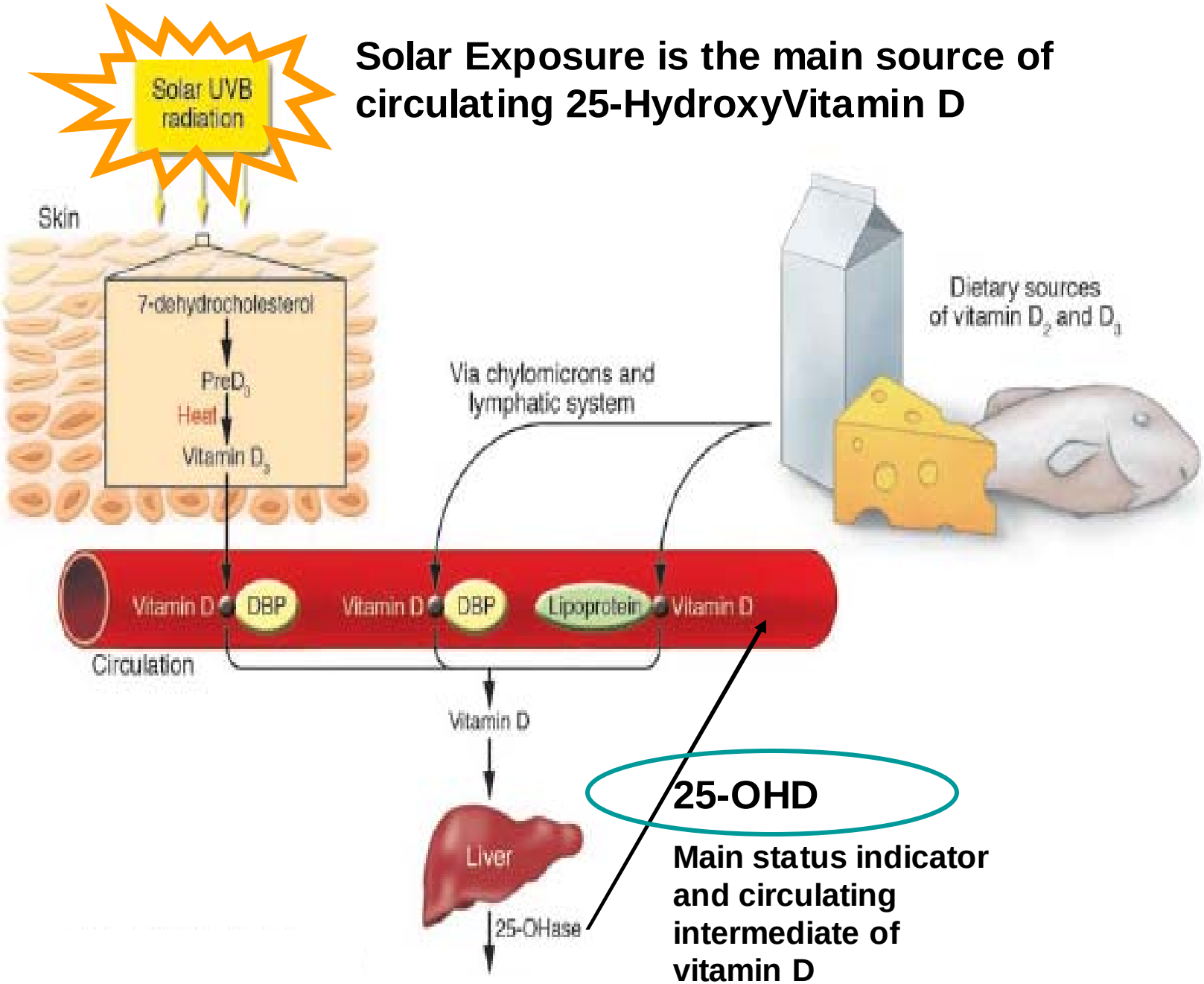
Solar Exposure is the main source of circulating 25-HydroxyVitamin D



Modified from: Holick, M.F. (2006) J. Clin Invest. 116:2062-2072

1997 Dietary Guidelines Vitamin D: DRI

- **Adequate Intake (AI) :**
  - <1 to 50 years -- 5 µg/d or 200 IU
  - 51 to 70 years -- 10 µg/d or 400 IU
  - 71 to 90 years -- 15 µg/d or 600 IU
  - Pregnancy/Lactation -- 5 µg/d or 200 IU
- **Tolerable Upper Level (UL):**
  - 0 to 1 year - - 25 µg/d or 1000 IU
  - 1 to 90 years - - 25 µg/d or 1000 IU

1993 FDA Labeling Guidelines : RDI/DV

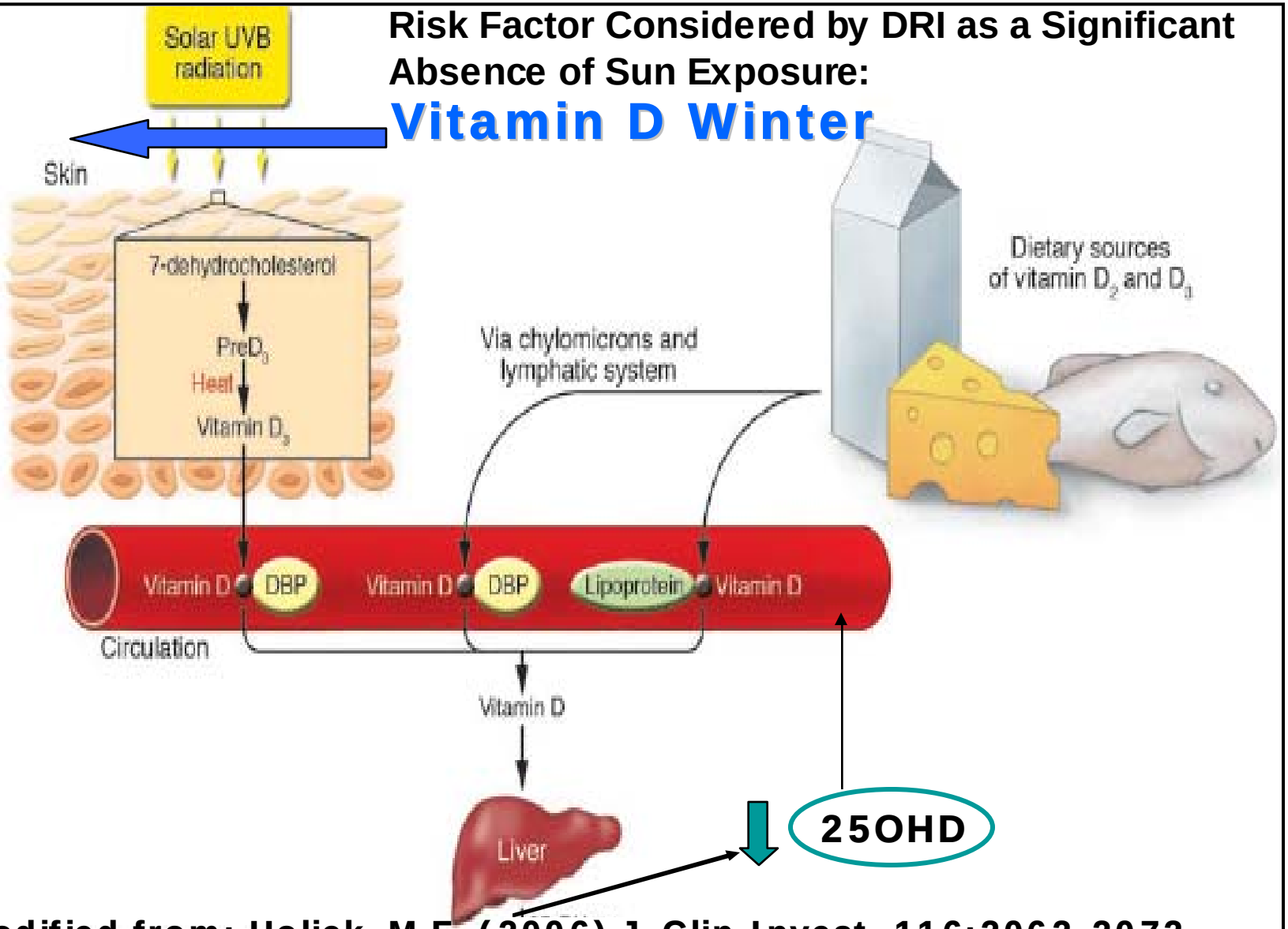
- **Reference Daily Intake (RDI)**
- **Daily Value - - 10 µg or 400 IU**

For many North Americans poor vitamin D status resulting from inadequate sun exposure, can not be optimized to

levels associated with disease prevention by current food fortification or dietary supplement use that follow the DRI's.

Risk Factor Considered by DRI as a Significant Absence of Sun Exposure:

Vitamin D Winter

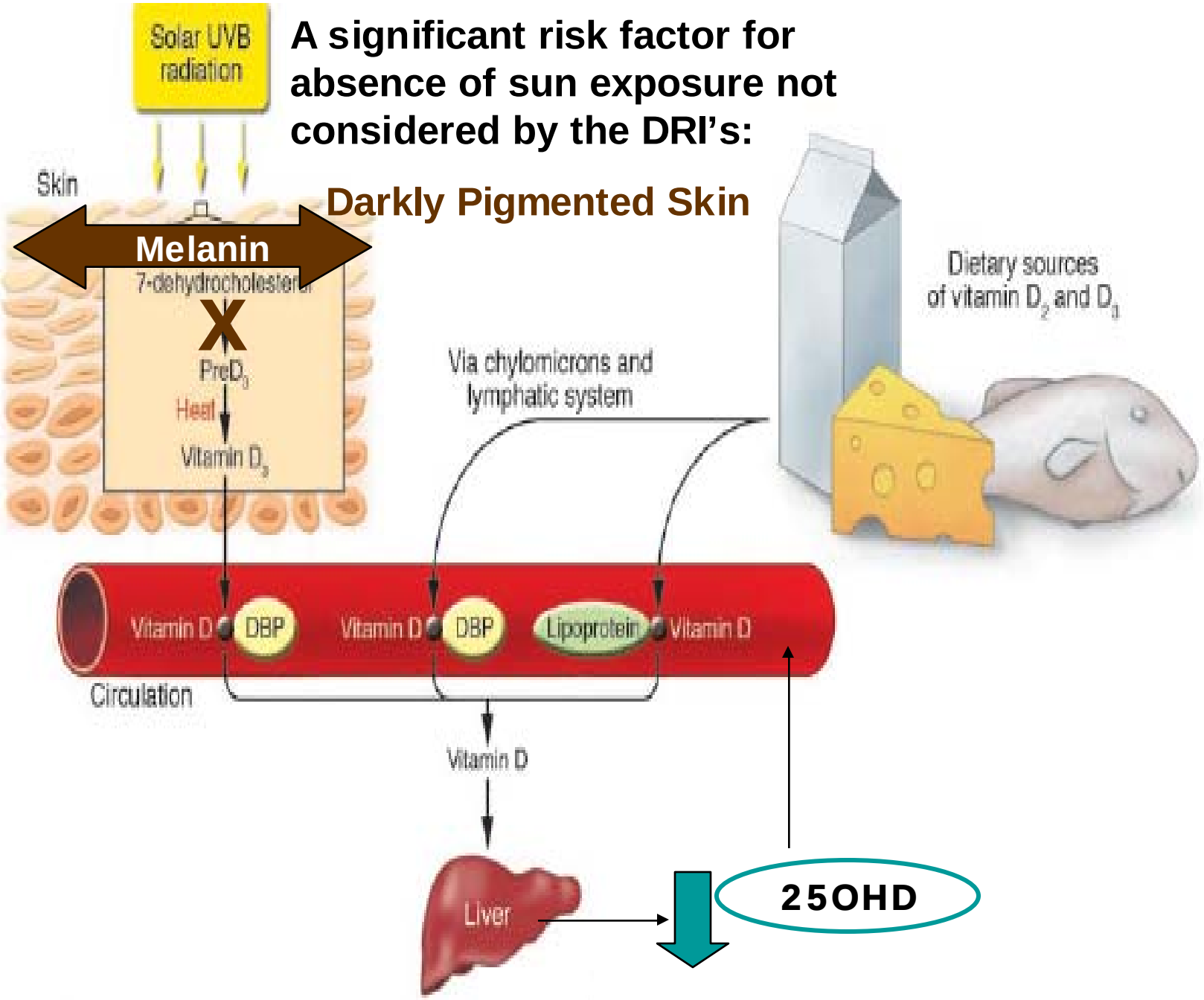


Modified from: Holick, M.F. (2006) J. Clin Invest. 116:2062-2072

Effects of Latitude and Season: Cities of Vitamin D Winter¤

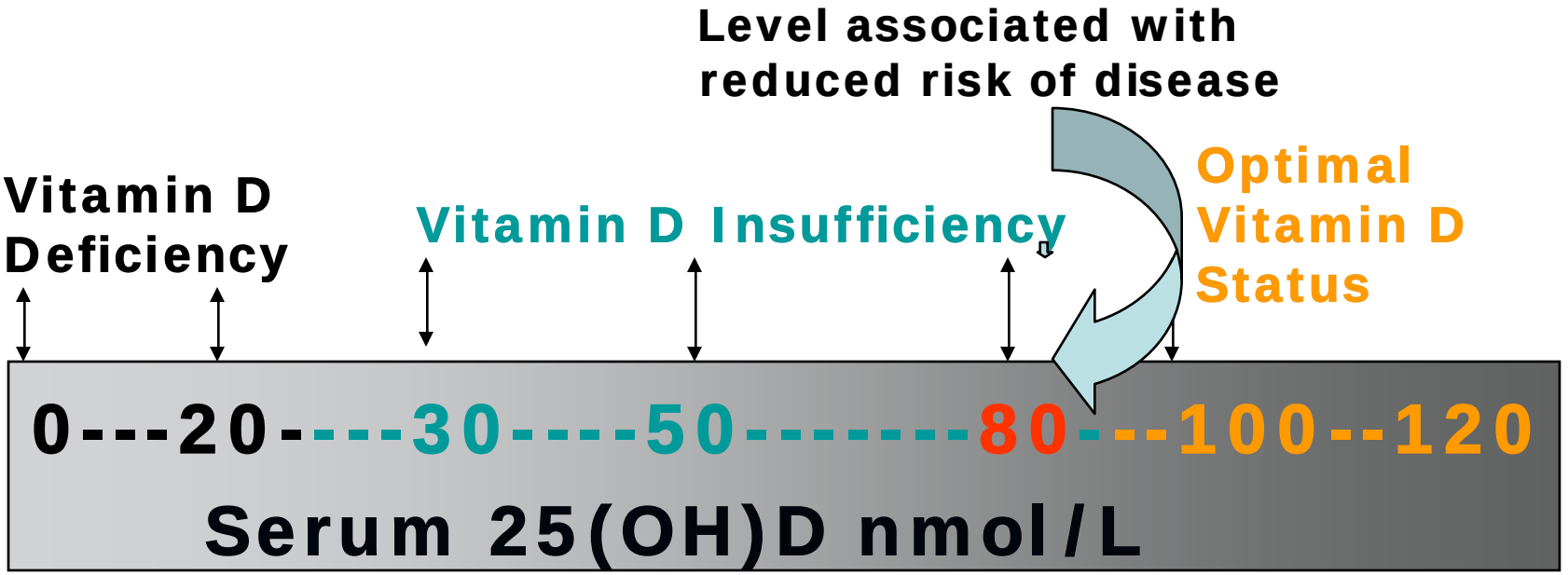
A significant risk factor for absence of sun exposure not considered by the DRI's:

Darkly Pigmented Skin



Modified from: Holick, M.F. (2006) J. Clin Invest. 116:2062-2072

Measurement of Vitamin D Status

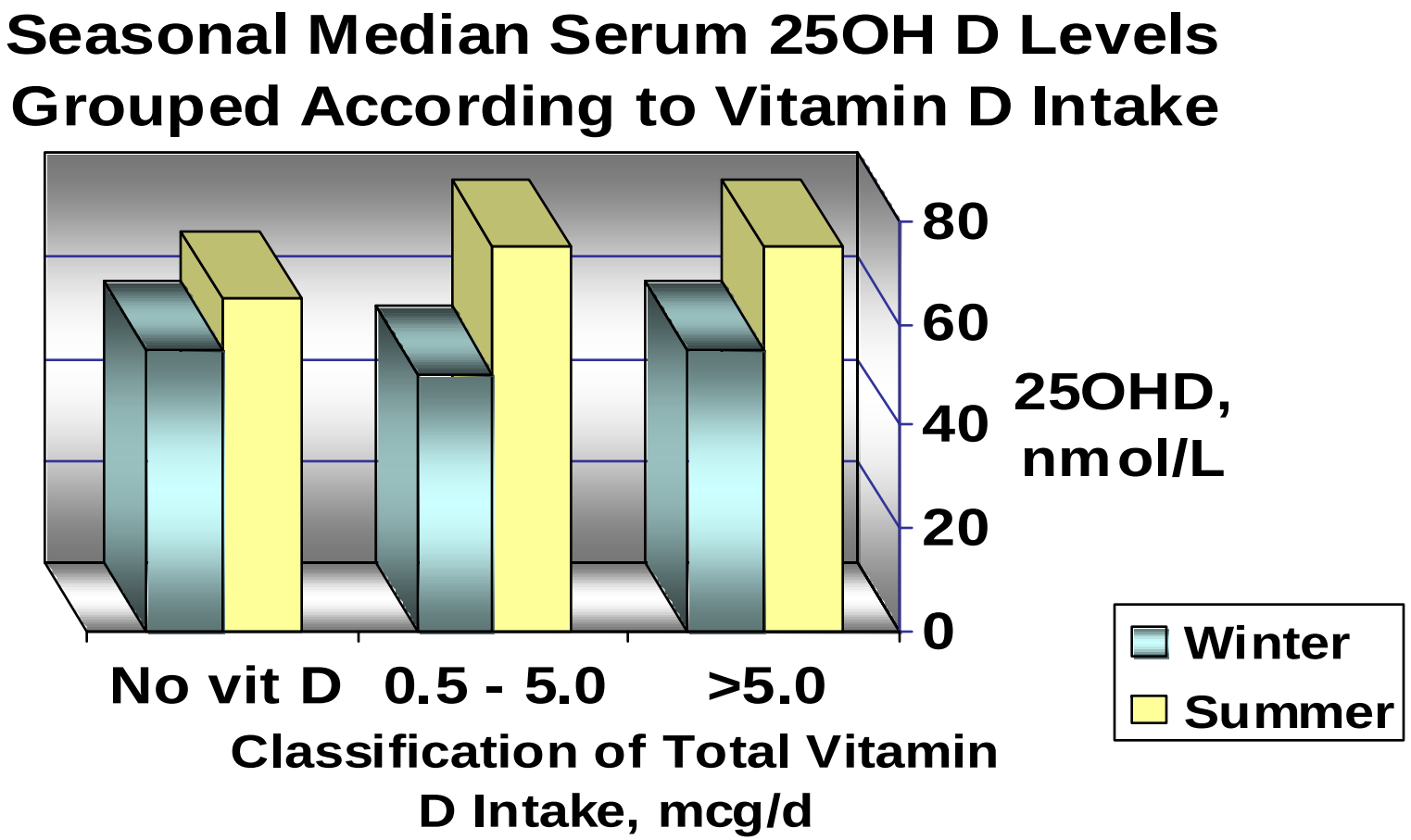


Insufficiency Cut-off Values:

37.5 nmol/L
40.0 nmol/L
50.0 nmol/L
80.0 nmol/L

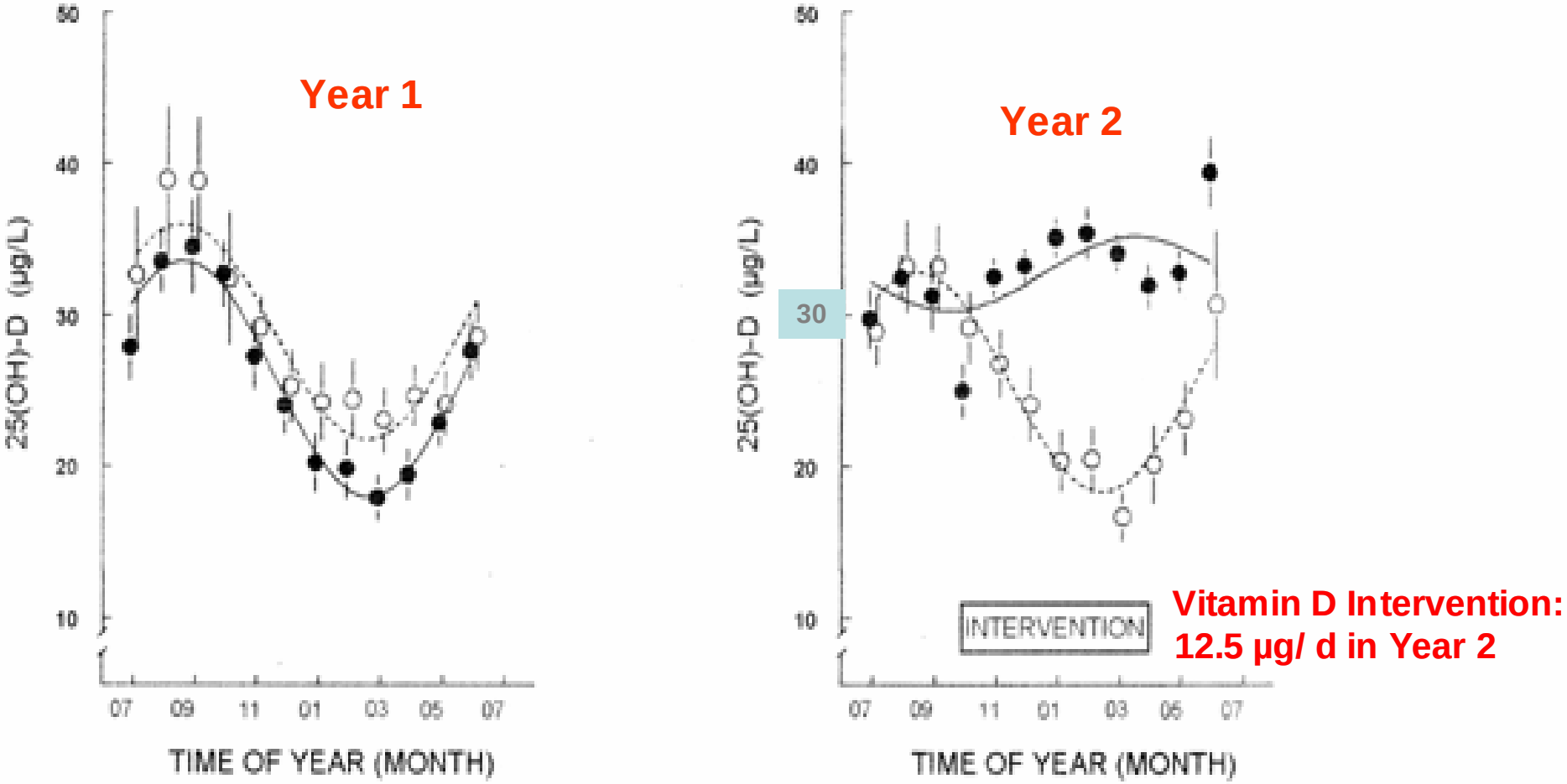
Adapted from: Heaney, R.P. (2003) AJCN. 78:912-919.

Adequate Vitamin D Intake Does Not Prevent Wintertime Vitamin D Insufficiency in Young Canadian Women



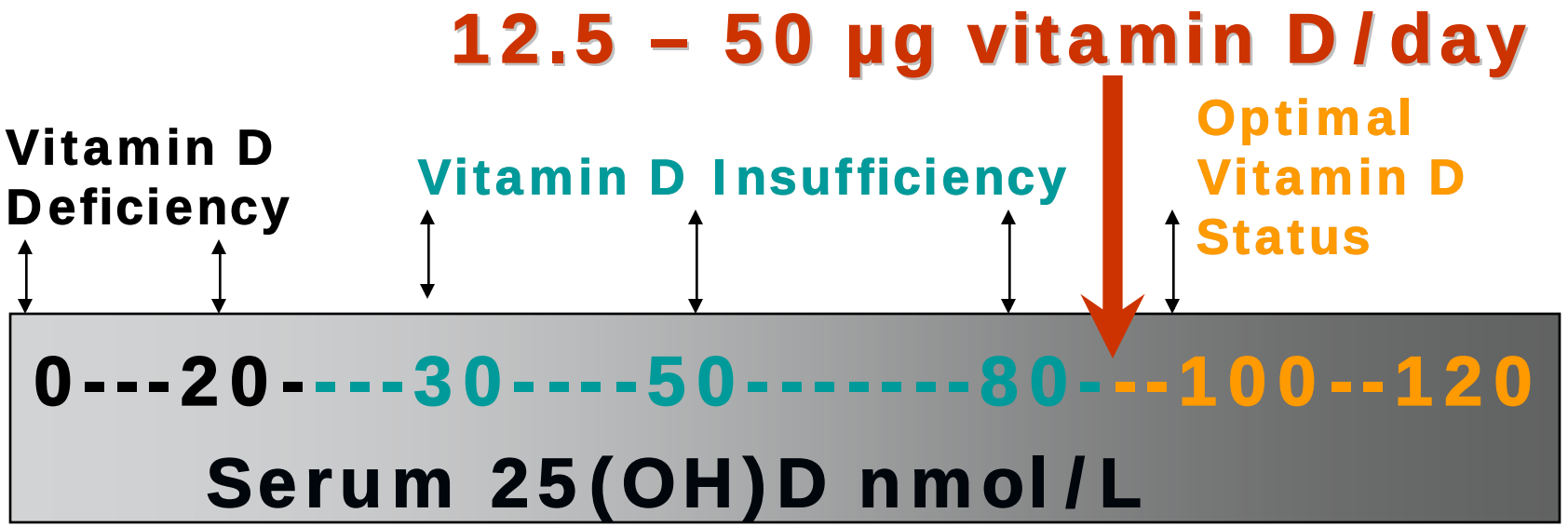
Source: Vieth et al.(2001) European J. of Clin. Nutr.,55:1091-7.

Efficacy of 12.5µg Vitamin D to Maintain 25OHD with Seasonal Sun Exposure in a Northern Latitude

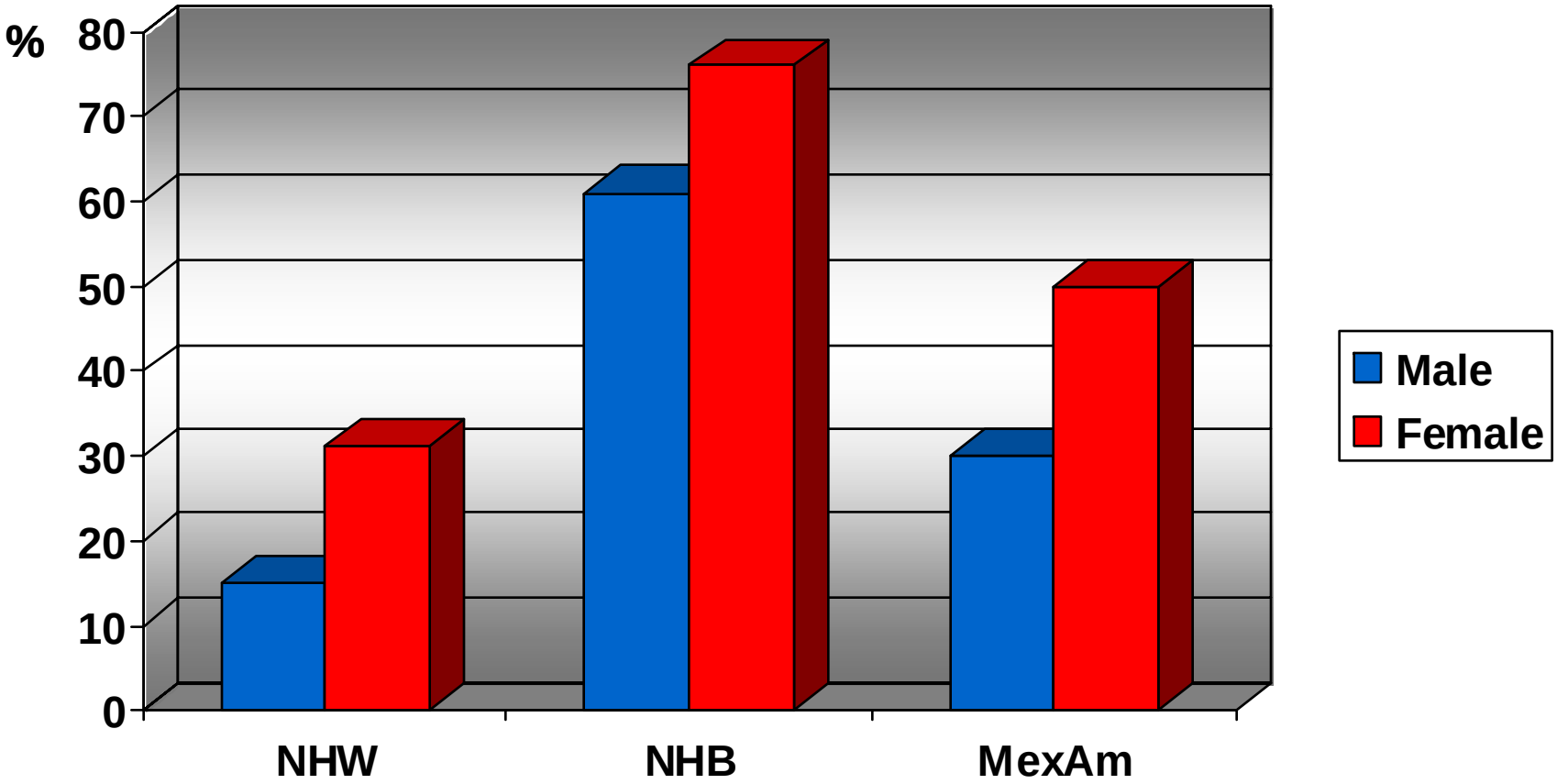


Source: Meier et al.,(2004) JBMR

Vitamin D Intake Needed to Maintain 25OHD Levels Associated with Reduced Risk of Disease

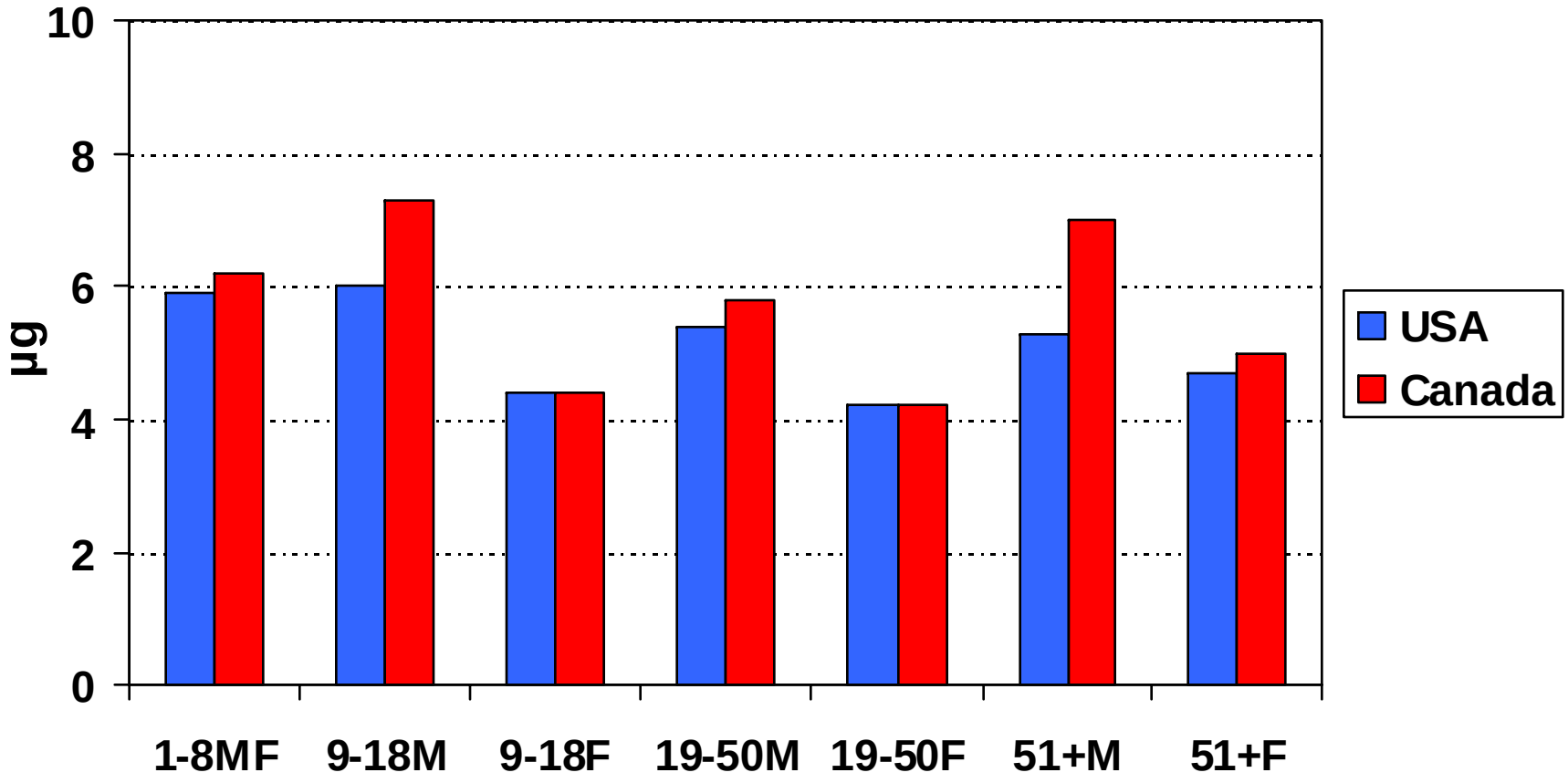


Prevalence of Insufficiency
% with < 50 nmol/L Serum 25OH D by Race/ Ethnicity, Age 30-59y



Source: Looker, Dawson Hughes, Calvo, Gunter, Sahyoun, (2002) Serum 25-hydroxyvitamin D status of adolescents and adults in two seasonal subpopulations from NHANES III. Bone ;30:771-777.

Vitamin D Intakes from Foods



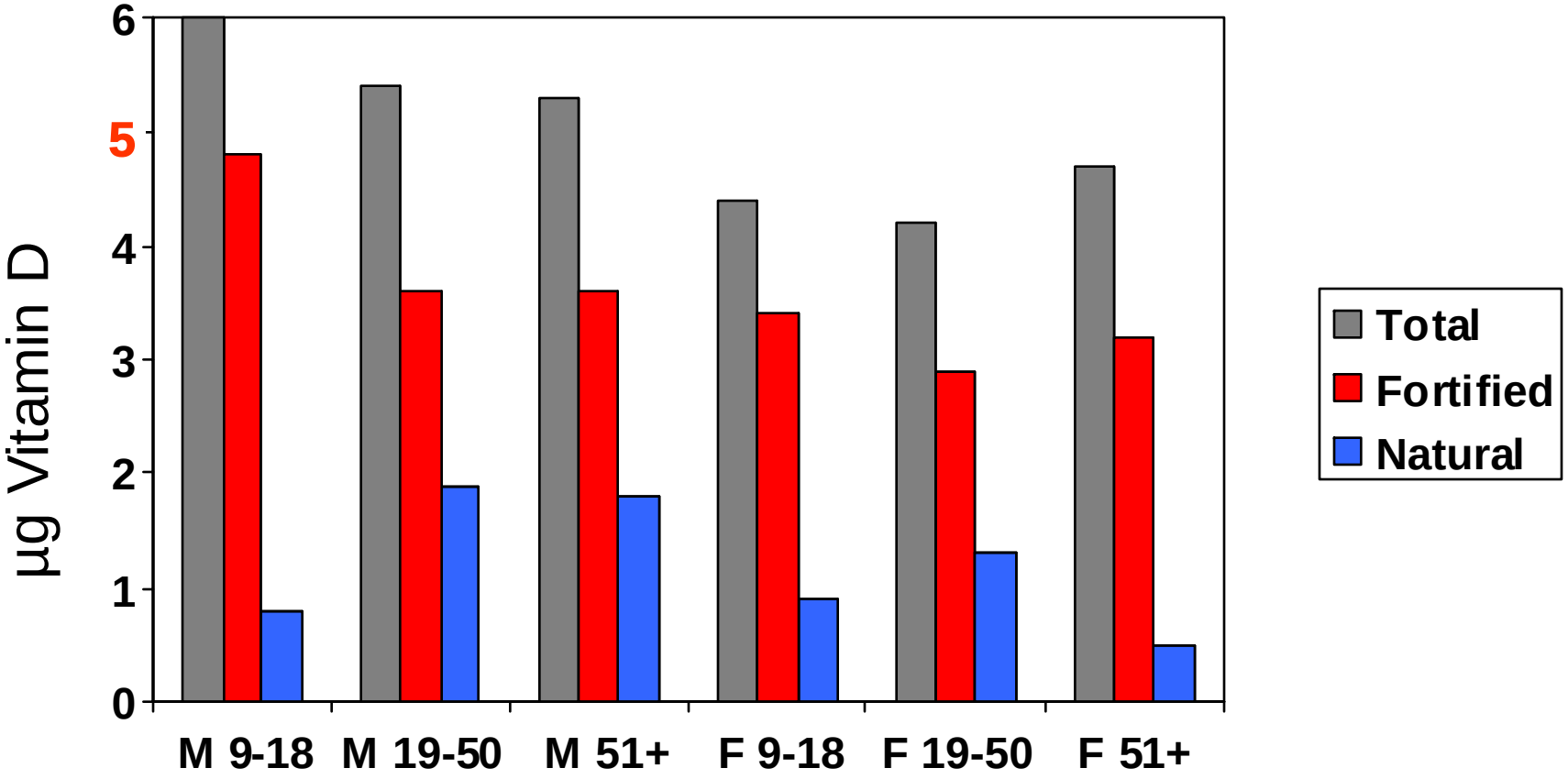
#CCHS 2004 data: Vatanparast et al.; NHANES 2000-01 Moore et al

Food Sources of Vitamin D

Natural sources	
Salmon	
Fresh, wild (3.5 oz)	About 600–1000 IU of vitamin D_3
Fresh, farmed (3.5 oz)	About 100–250 IU of vitamin D_3 or D_2
Canned (3.5 oz)	About 300–600 IU of vitamin D_3
Sardines, canned (3.5 oz)	About 300 IU of vitamin D_3
Mackerel, canned (3.5 oz)	About 250 IU of vitamin D_3
Tuna, canned (3.6 oz)	About 230 IU of vitamin D_3
Cod liver oil (1 tsp)	About 400–1000 IU of vitamin D_3
Shiitake mushrooms	
Fresh (3.5 oz)	About 100 IU of vitamin D_2
Sun-dried (3.5 oz)	About 1600 IU of vitamin D_2
Egg yolk	About 20 IU of vitamin D_3 or D_2
Exposure to sunlight, ultraviolet B radiation (0.5 minimal erythemal dose)†	About 3000 IU of vitamin D_3
Fortified foods	
Fortified milk	About 100 IU/8 oz, usually vitamin D_3
Fortified orange juice	About 100 IU/8 oz vitamin D_3
Infant formulas	About 100 IU/8 oz vitamin D_3
Fortified yogurts	About 100 IU/8 oz, usually vitamin D_3
Fortified butter	About 50 IU/3.5 oz, usually vitamin D_3
Fortified margarine	About 430 IU/3.5 oz, usually vitamin D_3
Fortified cheeses	About 100 IU/3 oz, usually vitamin D_3
Fortified breakfast cereals	About 100 IU/serving, usually vitamin D_3

Source: Holick, M.F. (2007) Vitamin D Deficiency. NEJM.357:266-281.

Vitamin D Intake from Fortified Food and from Natural Sources NHANES (1999-2000)



Sources: Calvo and Whiting (2006) and Moore et al. (2005) J Nutrition

Vitamin D Fortification of Food in CANADA

Category of Food	Required/ Optional	Maximum Level in Food IU (µg)/100g
Milk, cow	required	42 (1.0)
Milk, plant-based	required	42 (1.0)
Margarine	required	530 (8. 2)

Source: Calvo, Whiting and Barton (2004) AJCN; 80:1710S-1716S.

Vitamin D Fortification of Food in the USA

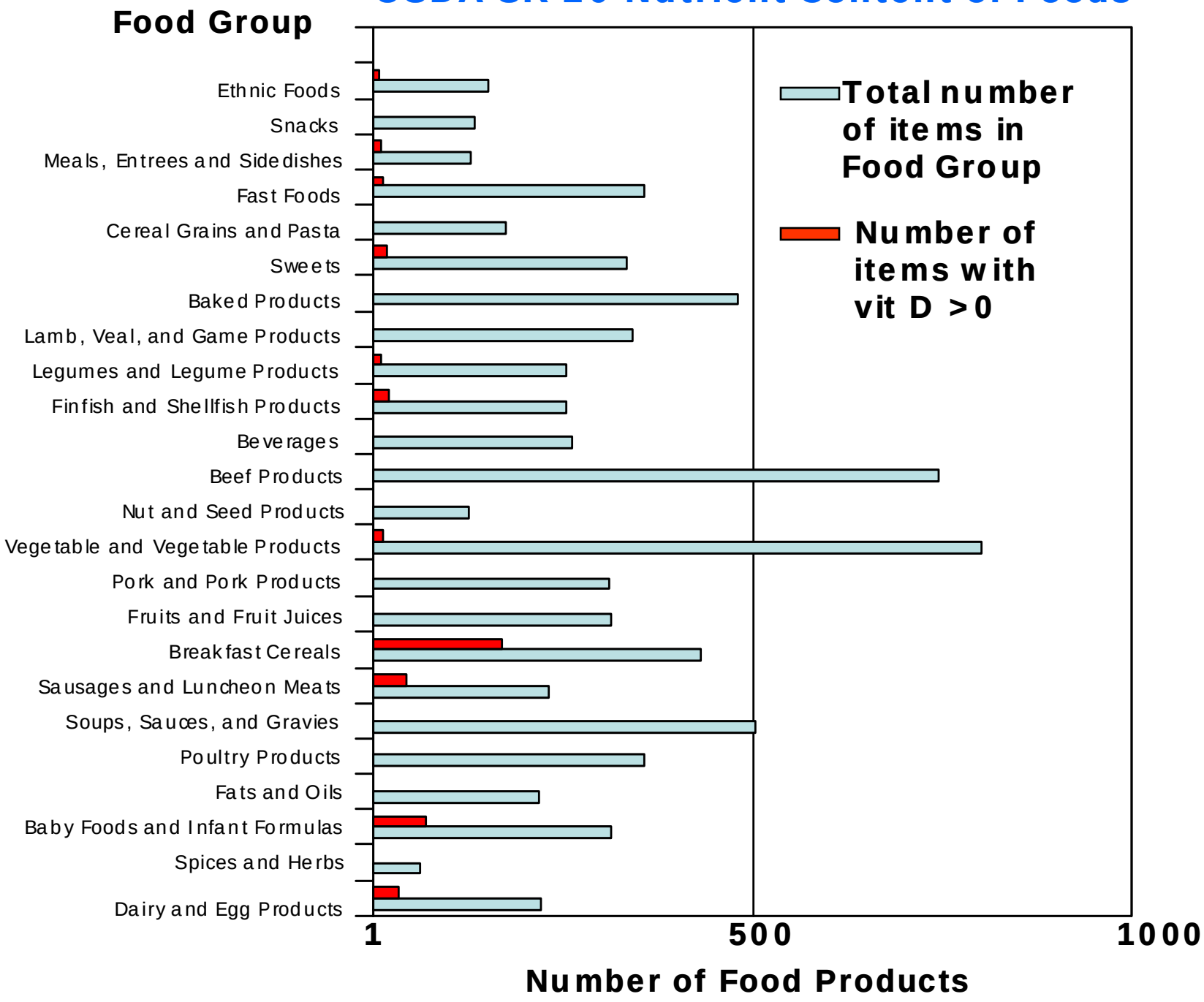
21CFR 184.1950 (b) (2)

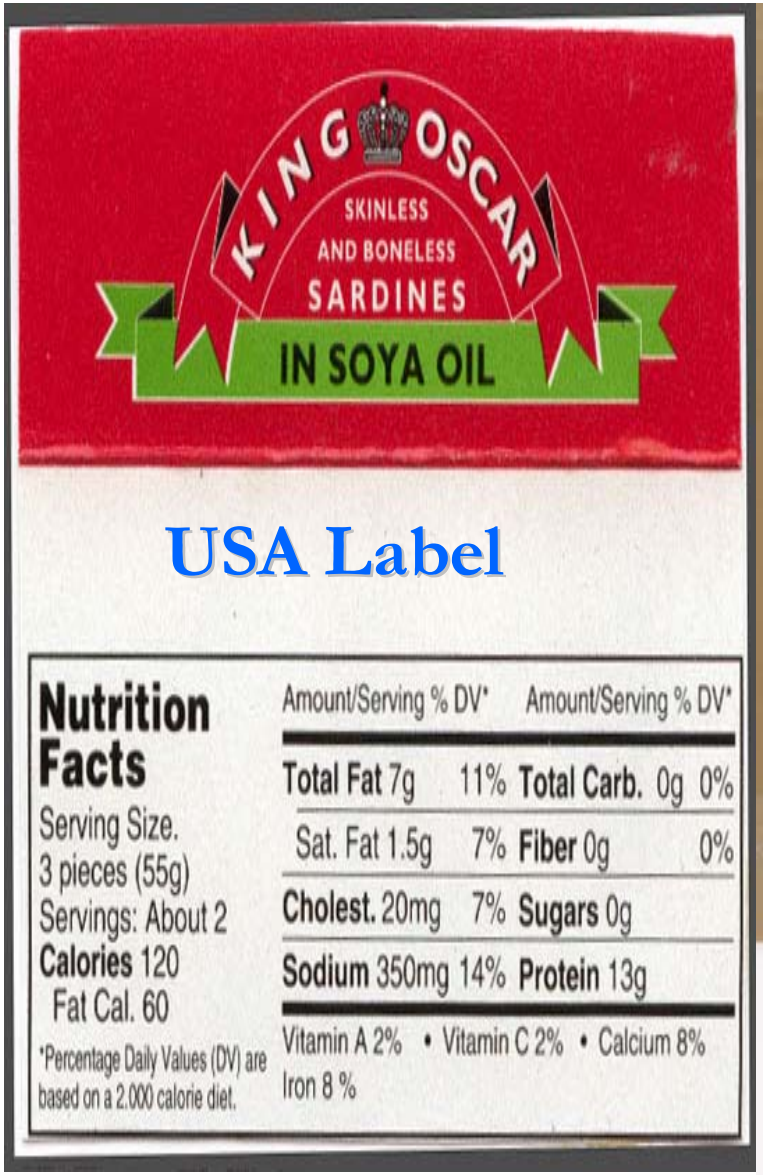
Category of Food in Food	Required/ Optional level	Maximum IU (µg)/100g
Breakfast cereals	optional	350 (8.7)
Grain products and pastas	optional	90 (2.2)
Milk, non-fortified	optional	42 (1.0)
Milk, fortified	required	42 (1.0)
Milk products	optional	89 (2.0)
Margarine	optional	330 (8.2)
Calcium fortified fruit juice	optional	40 (1.0

Source: Calvo, Whiting and Barton (2004) AJCN; 80:1710S-1716S.

Foods Commonly Misunderstood to be Naturally Rich in or Fortified With Vitamin D

USDA SR 20 Nutrient Content of Foods





USA Label

Nutrition Facts

Serving Size.
3 pieces (55g)
Servings: About 2
Calories 120
Fat Cal. 60

*Percentage Daily Values (DV) are based on a 2,000 calorie diet.

Amount/Serving	% DV*	Amount/Serving	% DV*
Total Fat 7g	11%	**Total Carb.** 0g	0%
Sat. Fat 1.5g	7%	**Fiber** 0g	0%
Cholest. 20mg	7%	**Sugars** 0g	
Sodium 350mg	14%	**Protein** 13g	

Vitamin A 2% • Vitamin C 2% • Calcium 8%
Iron 8 %

Nutrition Facts
Valeur nutritive
Serving Size 1 can (92 g drained)
Portion 1 boîte (92 g égouttée)
Calories 190

Amount / Teneur	% DV / % VQ*
Fat / Lipides 12 g	18 %
Saturated / saturés 2.5 g + Trans / trans 0 g	12 %
Omega-6 / oméga-6 3 g	
Omega-3 / oméga-3 1.5 g	
Monounsaturated / monoinsaturés 5 g	
Cholesterol / Cholestérol 110 mg	

Amount / Teneur	% DV / % VQ*
Sodium / Sodium 260 mg	11 %
Potassium / Potassium 290 mg	8 %
Carbohydrate / Glucides 0 g	0 %
Fibre / Fibres 0 g	0 %
Sugars / Sucres 0 g	
Protein / Protéines 20 g	

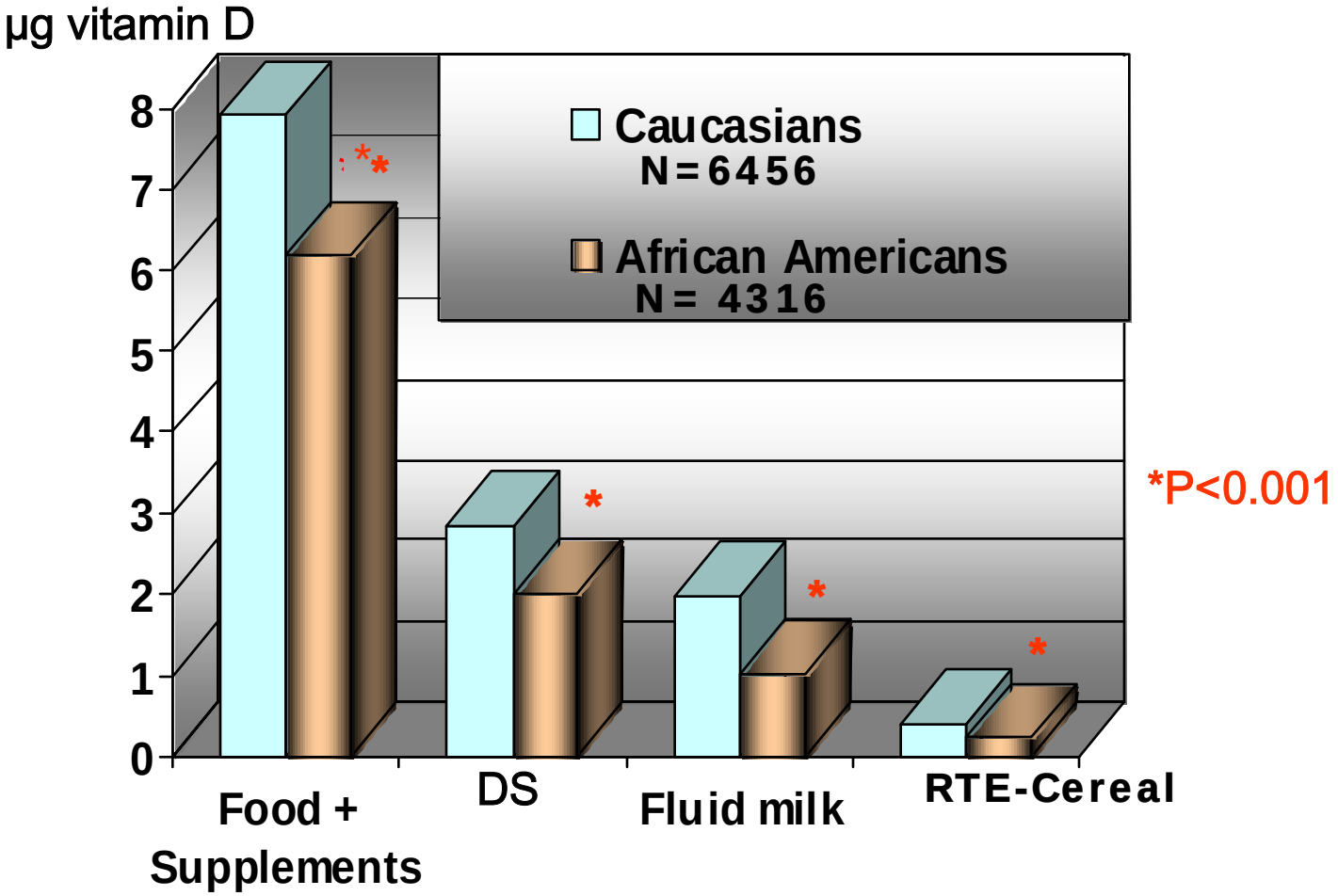
% DV / % VQ*	
Vit A	2 %
Vit C	2 %
Calcium	25 %
Iron / Fer	15 %
Vit D	110 %

* DV = Daily Value / VQ = valeur quotidienne

Canadian Label

Lack of Consistency in Vitamin D Content Labeling or Use of Fortification Options

African Americans Consume Less Vitamin D from Current Main Fortified Food Staples and Dietary Supplements



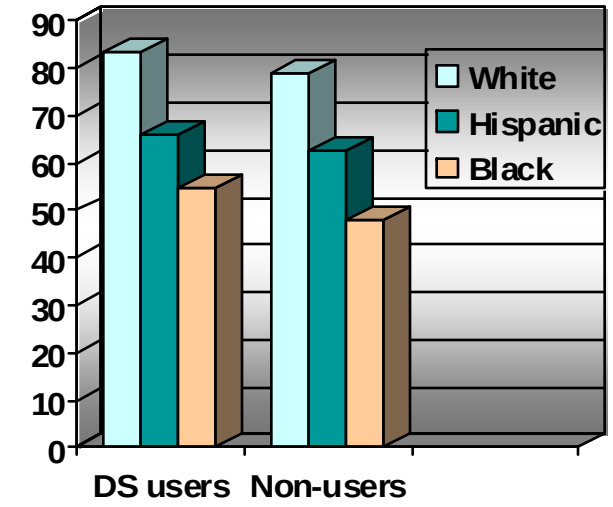
Source: Whiting and Calvo (2006) J. Nutr.136:1114-1116.

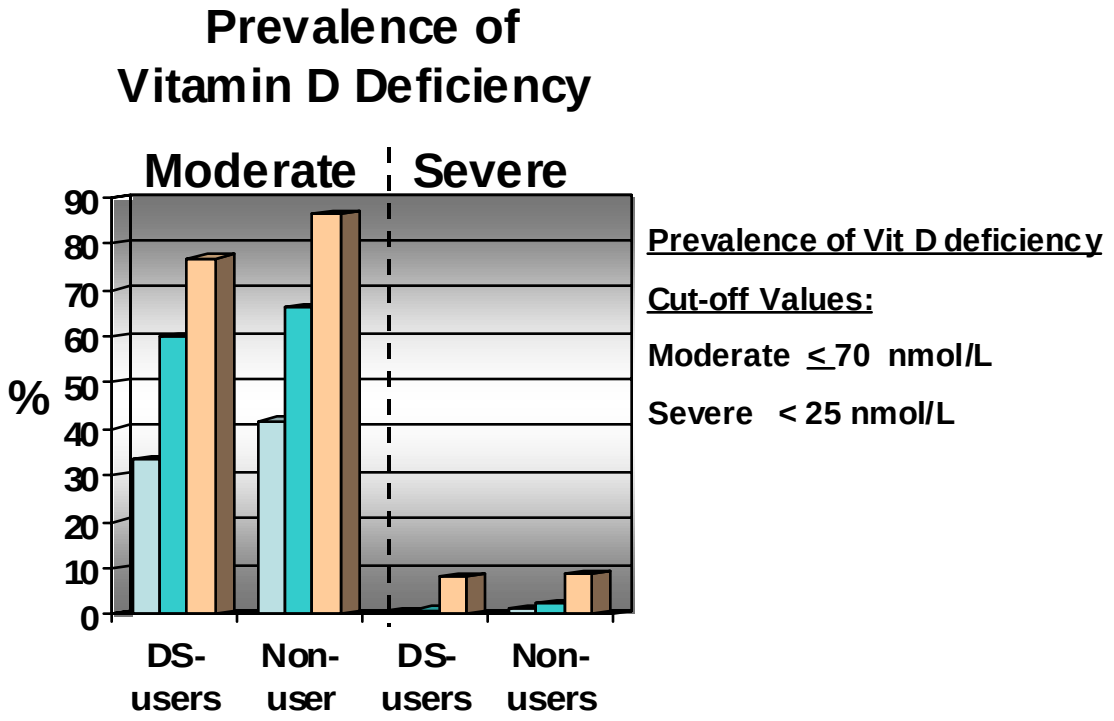
Median Vitamin D Intakes: African Americans

Subject	DRI AI	Food Alone (μg/d)	Food and Supplements
Females, *y*			
6-11	5	4.8	5.6
12-19	5	3.5	3.8
20-49	5	2.8	3.5
>50	10-15	3.3	4.0
Males, y			
6-11	5	5.5	6.1
12-19	5	4.7	4.9
20-49	5	3.7	4.2
<50	10-15	3.4	3.8

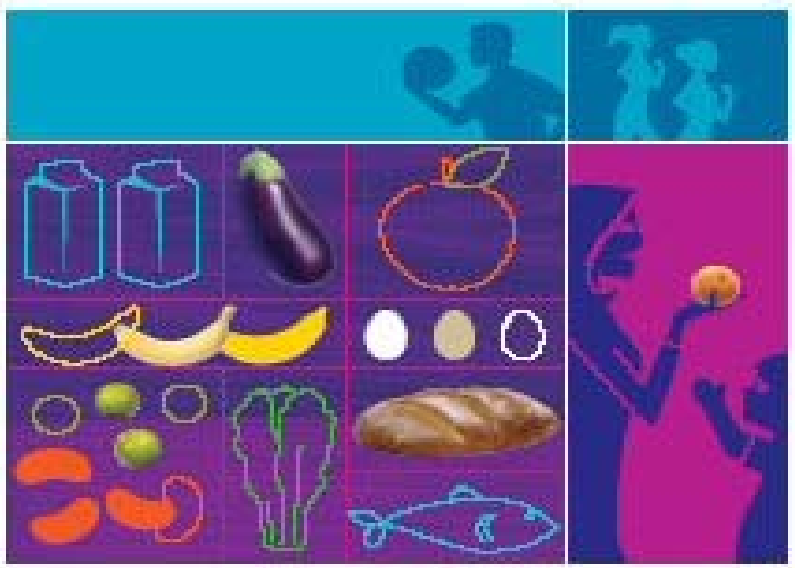
Source: Calvo, Whiting and Barton (2004) AJCN;80:1710S-1716S

Race/Ethnic Differences in the Effect of Dietary Supplement Use on 25OHD Levels and Prevalence of Moderate/Severe Vit D Deficiency





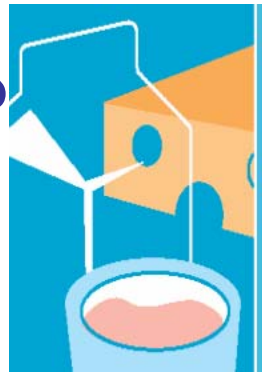
Source: Taureen, N., Martins, D., Zadshir, A. Pan, D., Norris, K.C. (2005) The impact of routine vitamin supplementation on serum levels of 25OHD among the general adult population and patients with chronic kidney disease. Ethn Dis. 15, S5-102-S5-106.



Dietary Guidelines
for Americans
2005

Vitamin D Content

~300 IU



Get your calcium-rich foods. Get 3 cups of low-fat or fat-free milk–or an equivalent amount of low-fat yogurt and/or low-fat cheese (1½ ounces of cheese equals 1 cup of milk)–every day. For kids aged 2 to 8, it's 2 cups of milk. If you don't or can't consume milk, choose lactose-free milk products and/or calcium-fortified foods and beverages.

~100 IU

Make half your grains whole. Eat at least 3 ounces of whole-grain cereals, breads, crackers, rice, or pasta every day. One ounce is about 1 slice of bread, 1 cup of breakfast cereal, or ½ cup of cooked rice or pasta. Look to see that grains such as wheat, rice, oats, or corn are referred to as "whole" in the list of ingredients.

~200 IU

Go lean with protein. Choose lean meats and poultry. Bake it, broil it, or grill it. And vary your protein choices–with more fish, beans, peas, nuts, and seeds.

- **Key Recommendations for Specific Population Groups**
- ***Older adults, people with dark skin, and people exposed to insufficient ultraviolet band radiation (i.e., sunlight).***

Consume extra vitamin D from vitamin D-fortified foods and/or supplements.

~400 IU

Vitamin D Intake from Dietary Supplement Use

- **Vitamin D content range:**

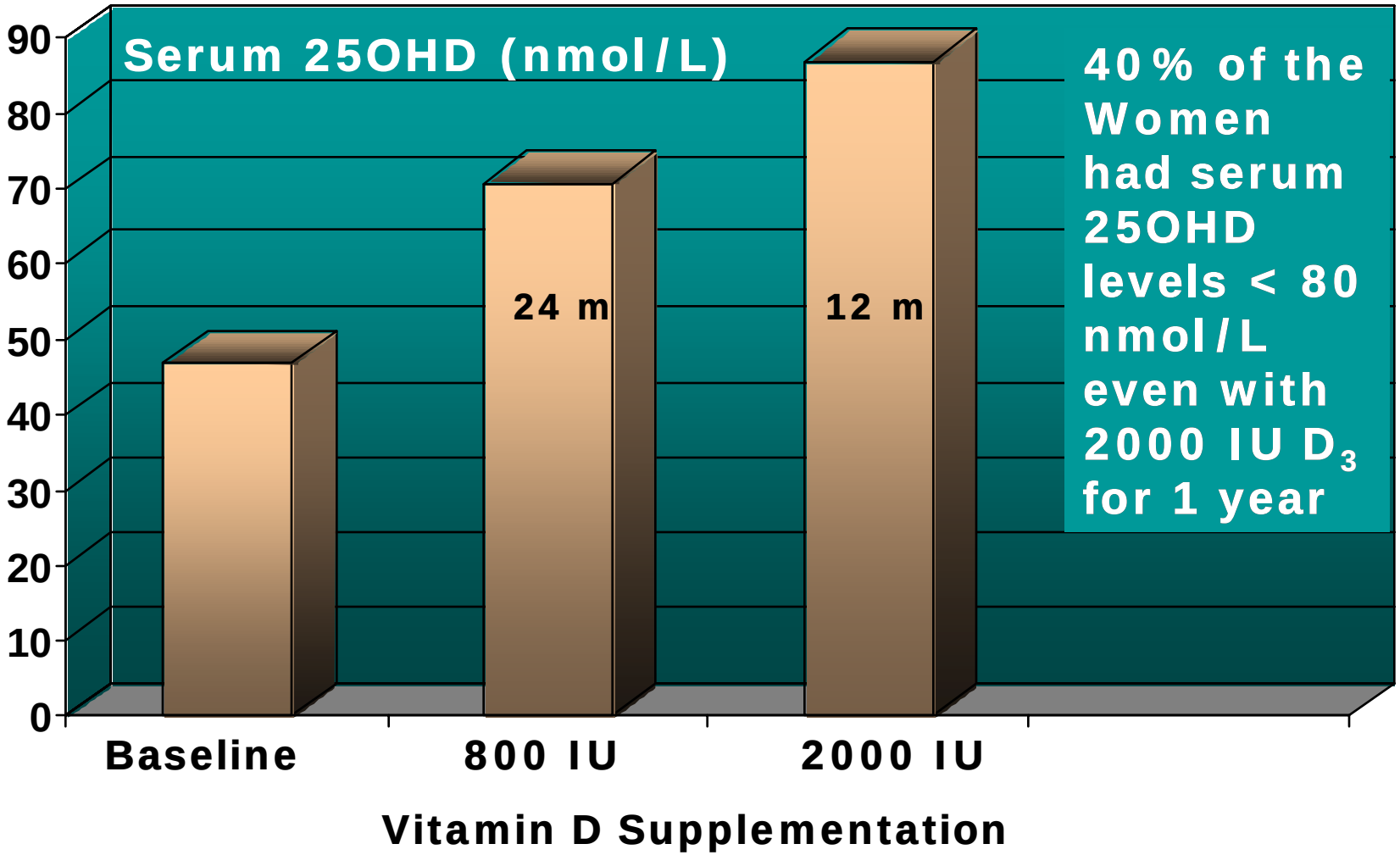
Adult: 200-400 IU/tablet

Children: 400 IU/tablet

- **Upper Limit: 2000 IU/dose (50 µg/daily dose)**

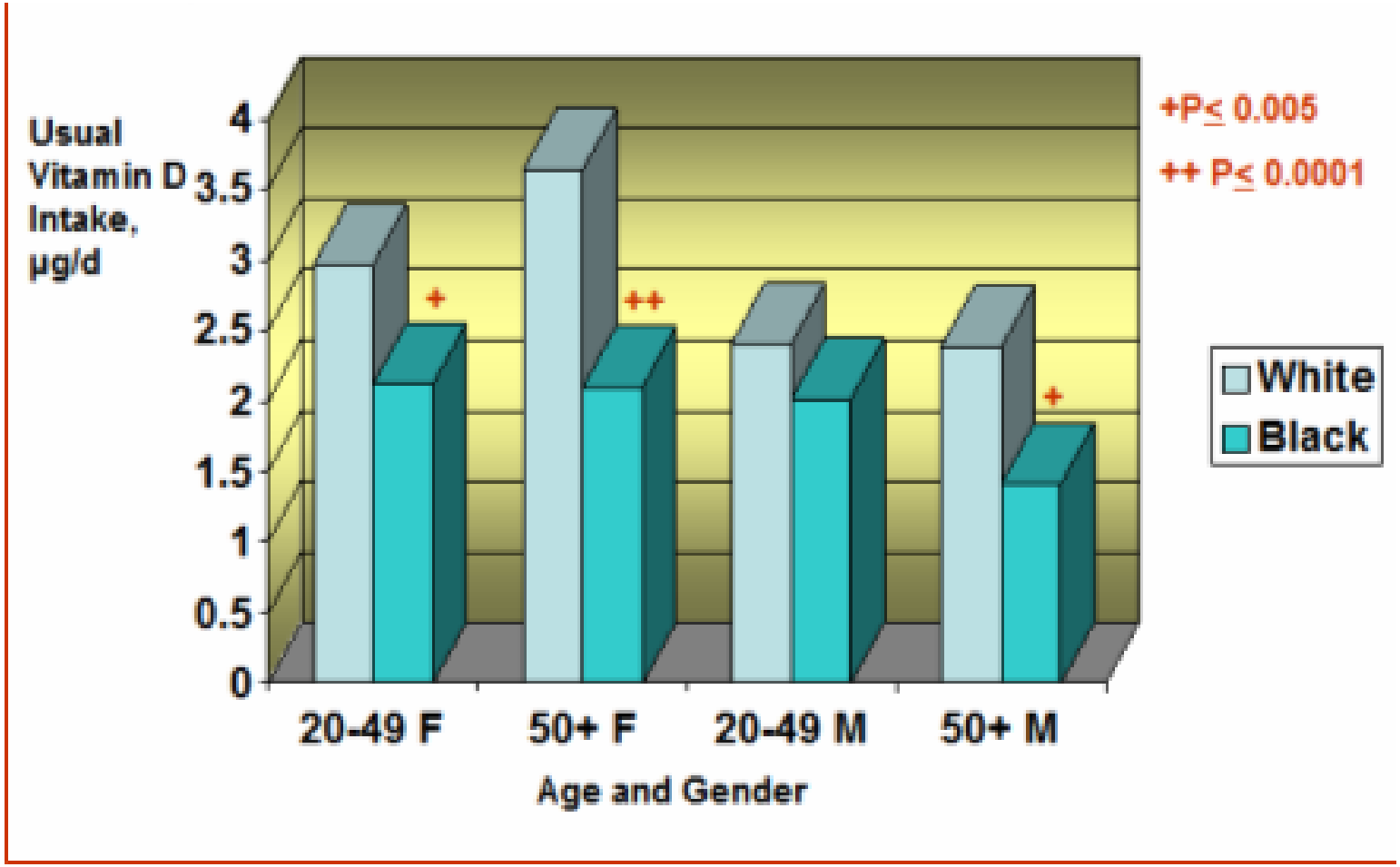
UL limits content of Vitamin D

Poor Efficacy of Vitamin D Supplementation in African American Postmenopausal Women in Northern Latitudes



Source: Aloia et al. A Randomized Controlled Trial of Vitamin D_3 Supplementation in African American Women. Arch Intern Med 2005;165:1618-1623.

Usual Vitamin D Intake from Supplements in African-American and Caucasian Adults NHANES III 1988-1994



Source: Calvo and Barton, 2005

Vitamin D Usual Intake Status NHANES III (1988-1994)

- **Globally, North Americans have the highest vitamin D intakes from both fortified food and supplements:**

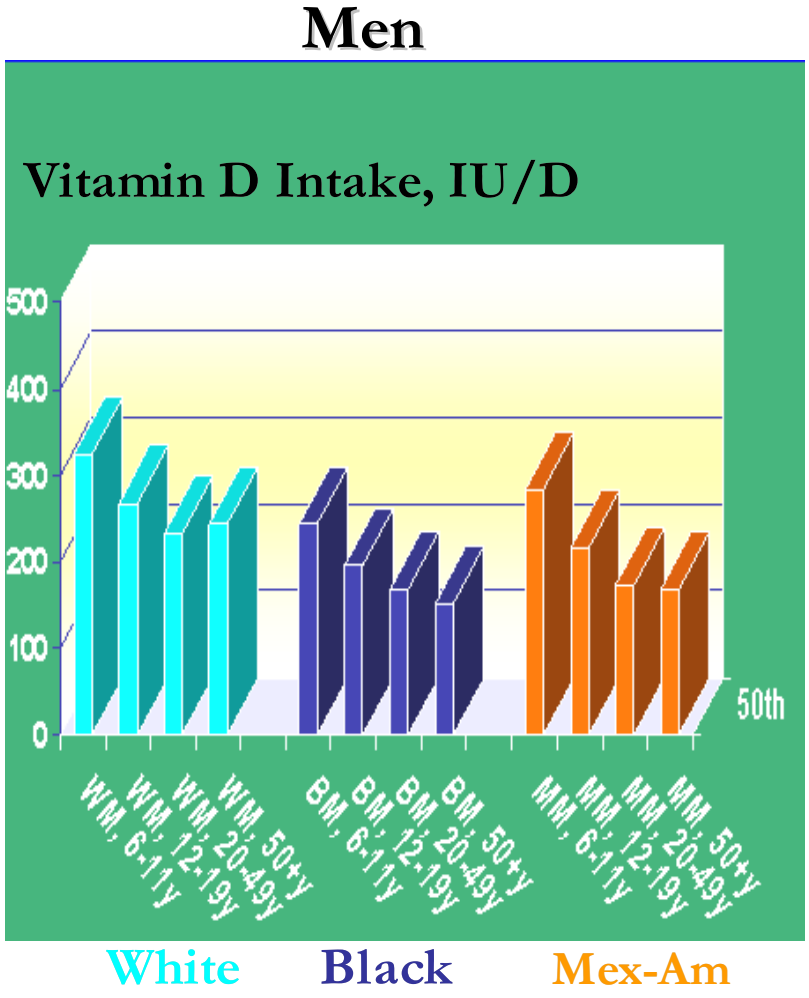
Age group	Mean intake (µg/d)
6-11 y	8.02 F, 9.07 M
12-19 y	6.19 F, 7.88 M
20-49 y	6.97 F, 7.66 M
50+y	7.97 F, 7.84 M

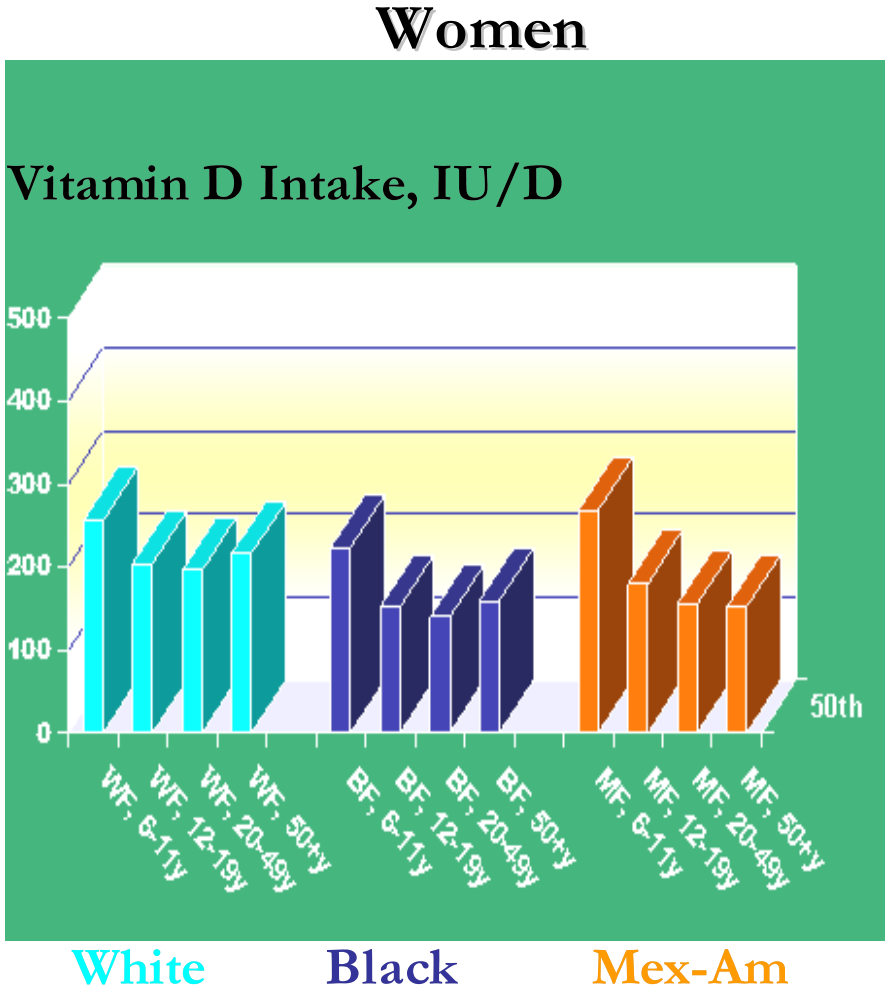
- **Use of dietary supplements are associated with increases in daily vitamin D intakes of approximately 2 to 3 µg**

Source: Calvo, Whiting and Barton (2005) J. Nutr. 135:310-316.

50th Percentile Usual Intakes of Vitamin D

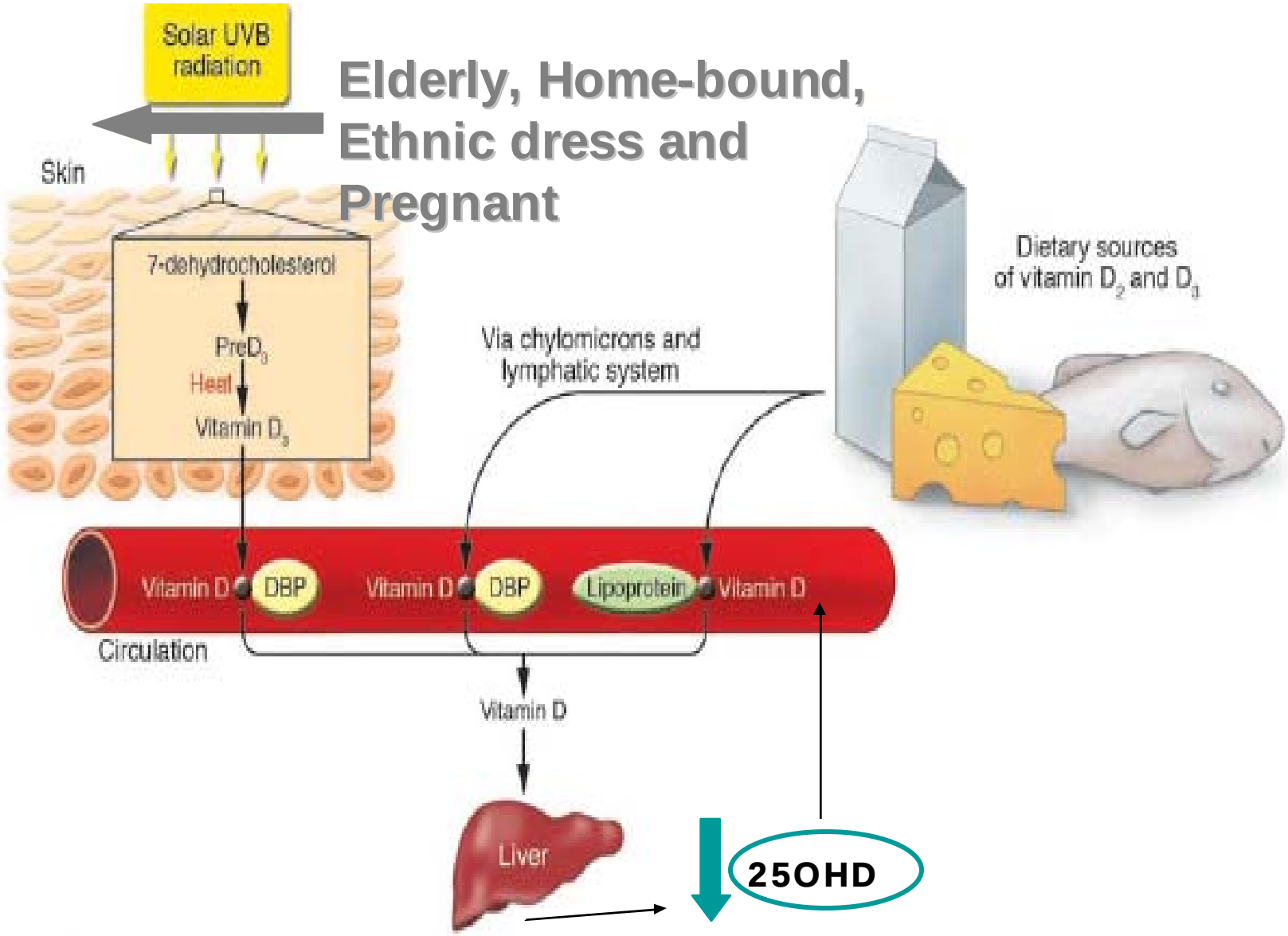
NHANES III: FOOD Plus SUPPLEMENTS





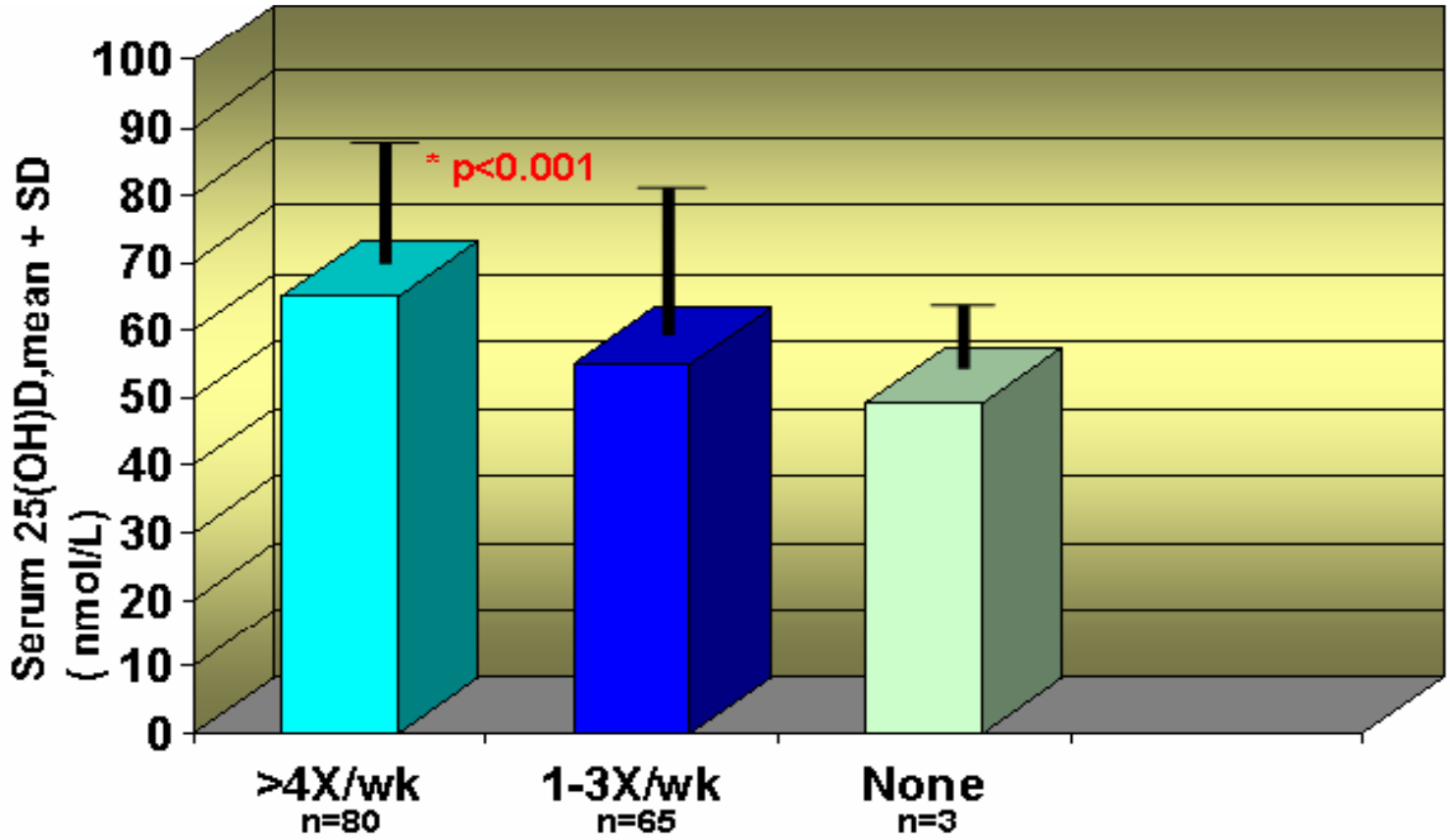
Calvo, Whiting, & Barton. Am J Clin Nutr. 2004; 80: 1710s-6s.

Additional Risk Factors for a Significant Absence of Sun Exposure



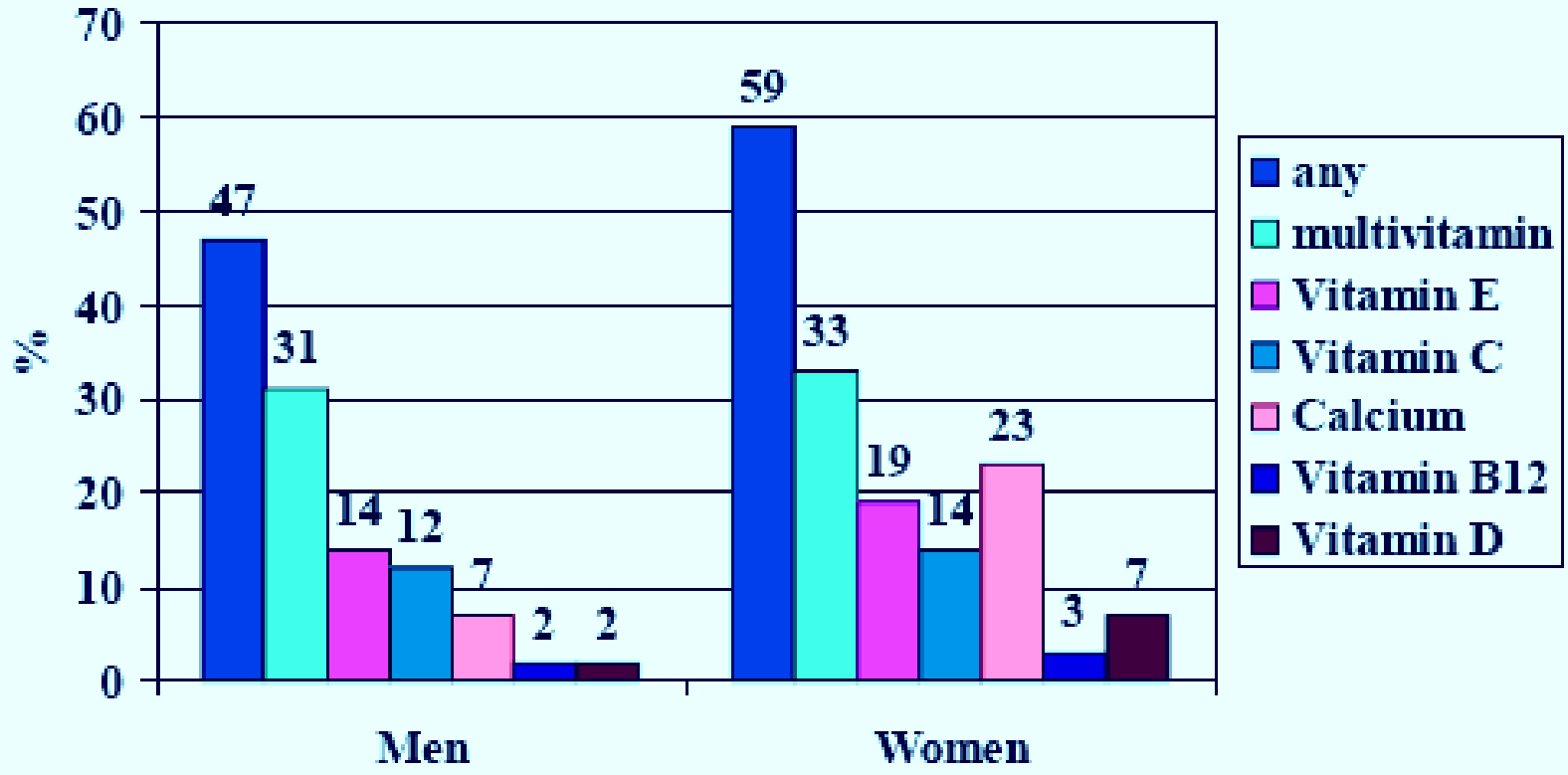
Modified from: Holick, M.F. (2006) J. Clin Invest. 116:2062-2072

Japanese Women Maintain Healthy 25OHD Serum Levels Even in Winter by Frequent Fish Consumption



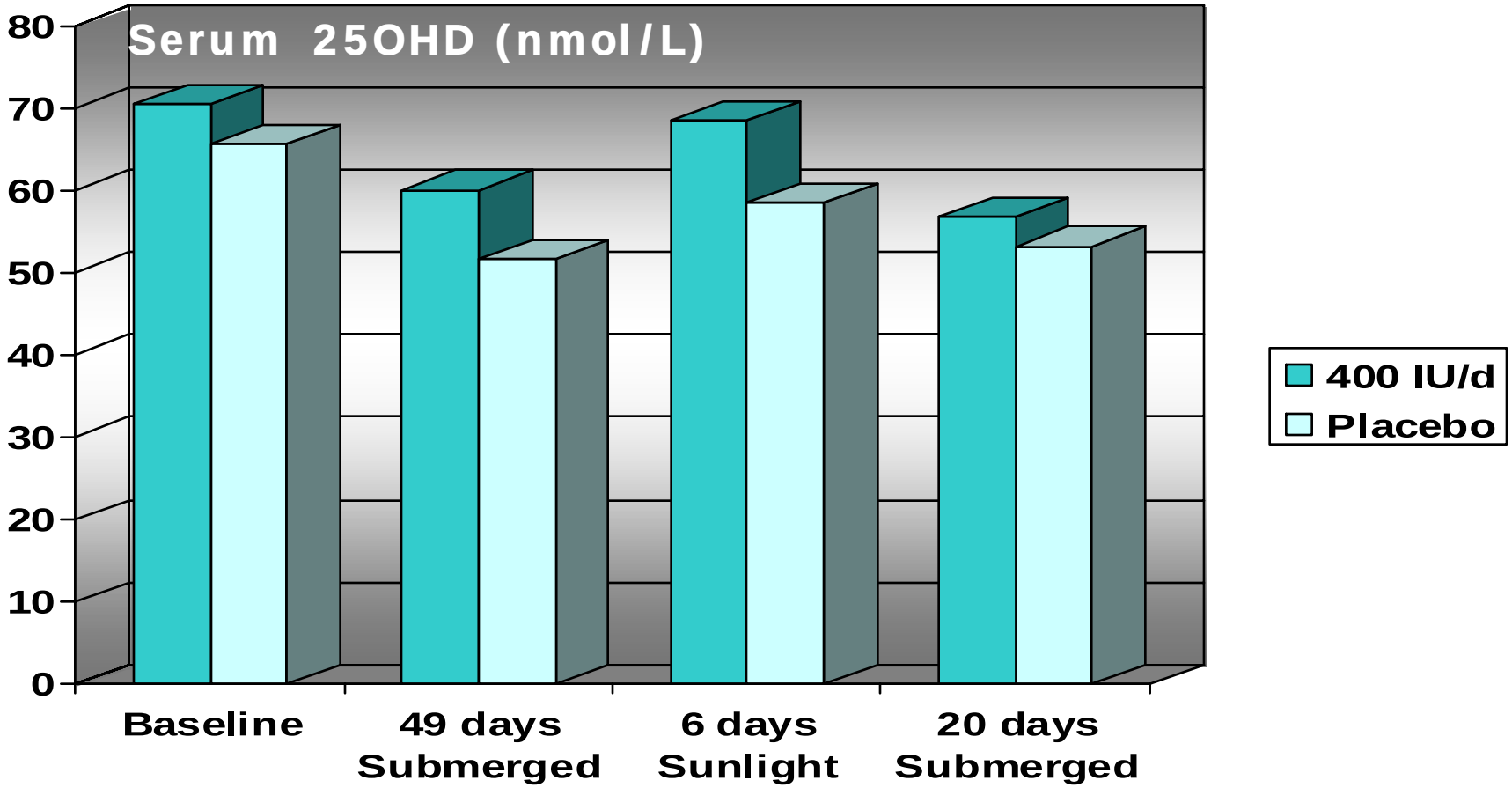
Source: Nakamura et al., (2000) Am. J. Clin Nutr. 71:1160-1165

Supplement Use (%) by Older Adults in the Slone Survey (1998-99, 65 + y)



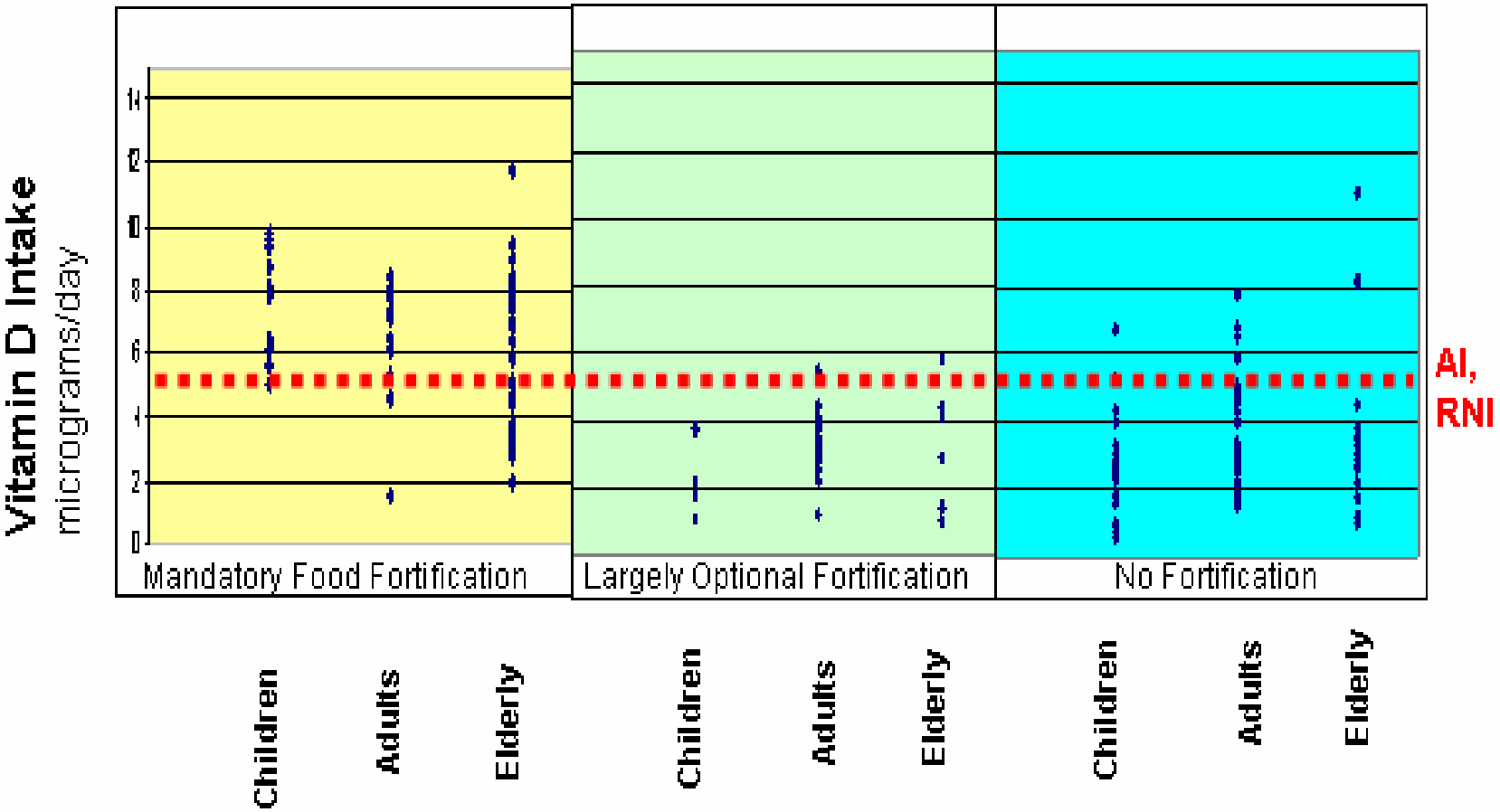
From: Kaufman DW et al. JAMA 2002;287:337-344. N: Men=243; women=351

Independent of Race, Vitamin D Supplements Can Not Maintain Adequate Status in the Complete Absence of Sunlight



Source: Dupless et al. Vitamin D Supplementation in Underway Submariners. Aviat Space Environ Med. 2005; 76:569-575.

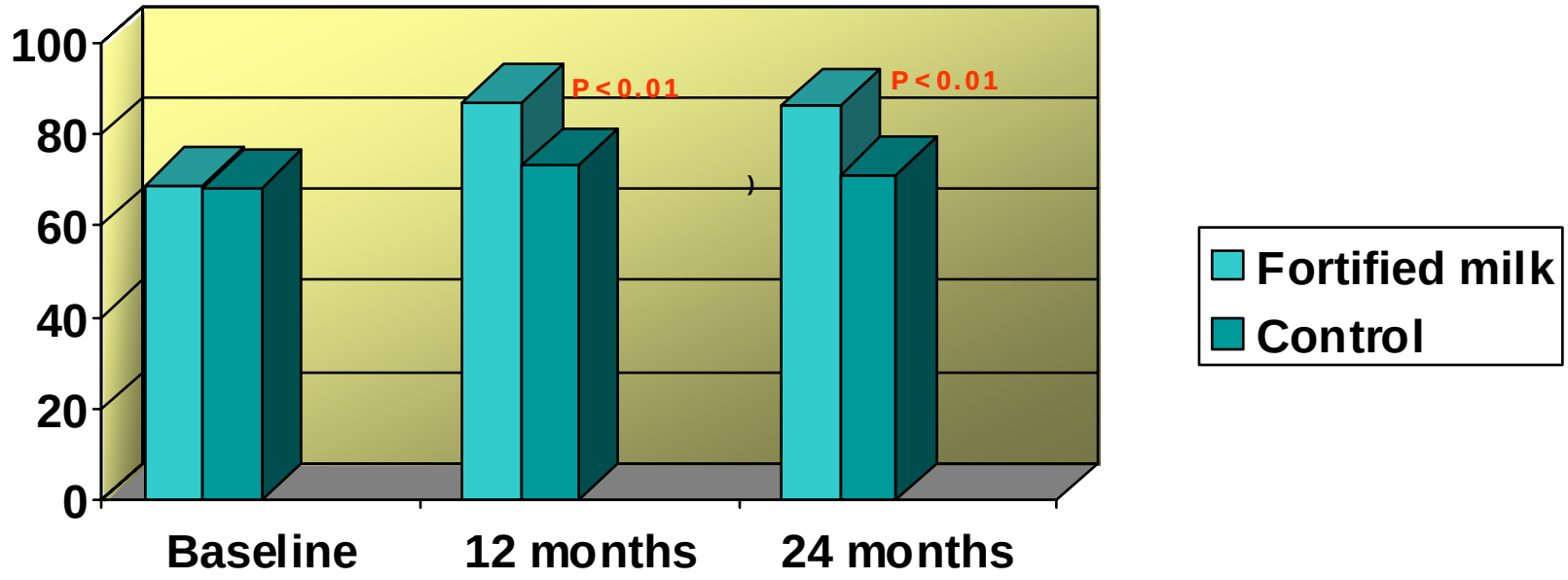
Global Perspective: Importance of Food Fortification to Vitamin D Intake



Source: Calvo, Whiting & Barton. Vitamin D Intake: A Global Perspective of Current Status. J Nutrition 2005;135:310-316.

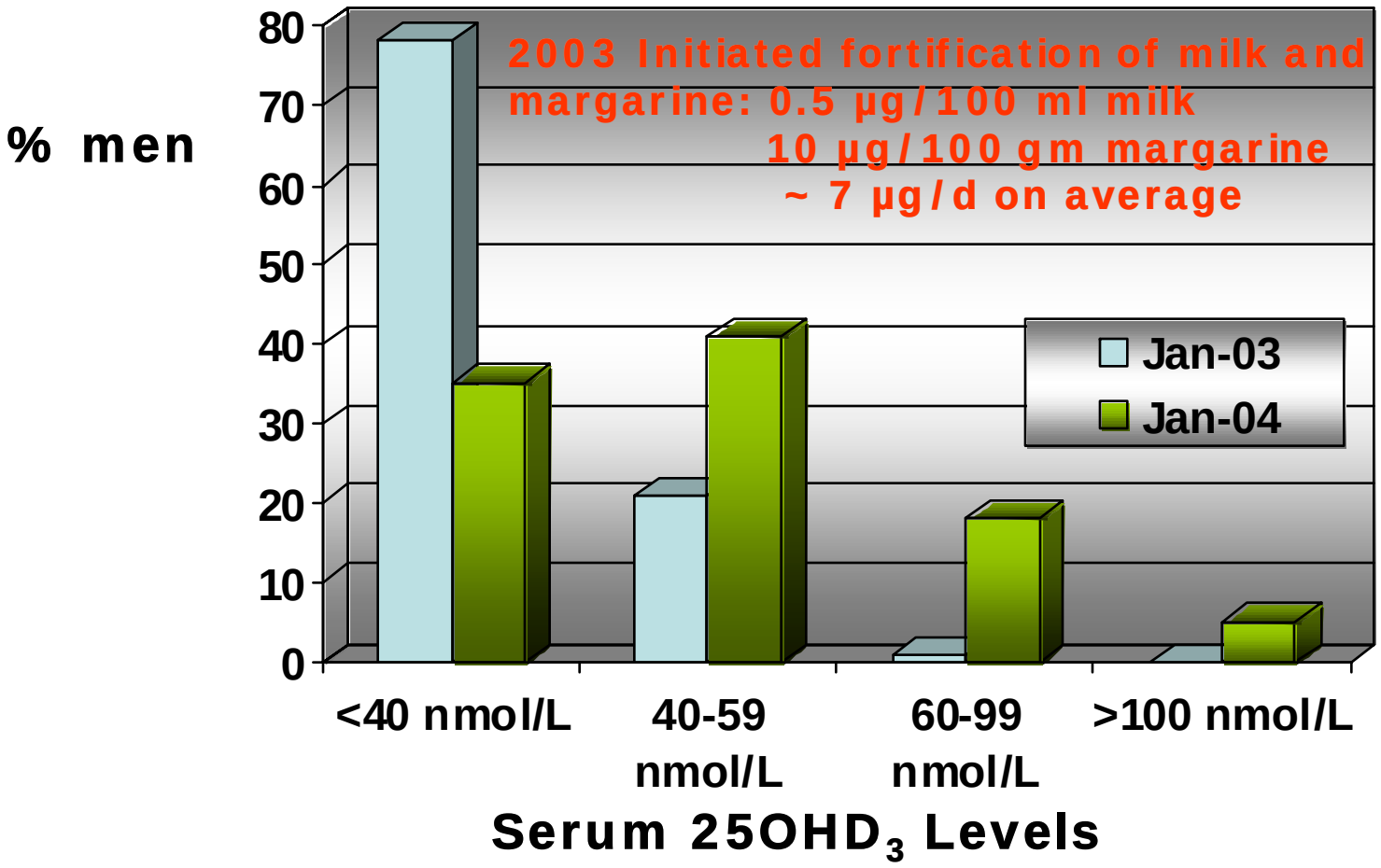
Evidence Supporting Efficacy of Vitamin D Fortification of Milk In Tropical Malaysia

Serum 25OHD levels (nmol/L) at baseline 12 and 24 months supplementation with vitamin D fortified milk (10 mcg/50g milk powder)

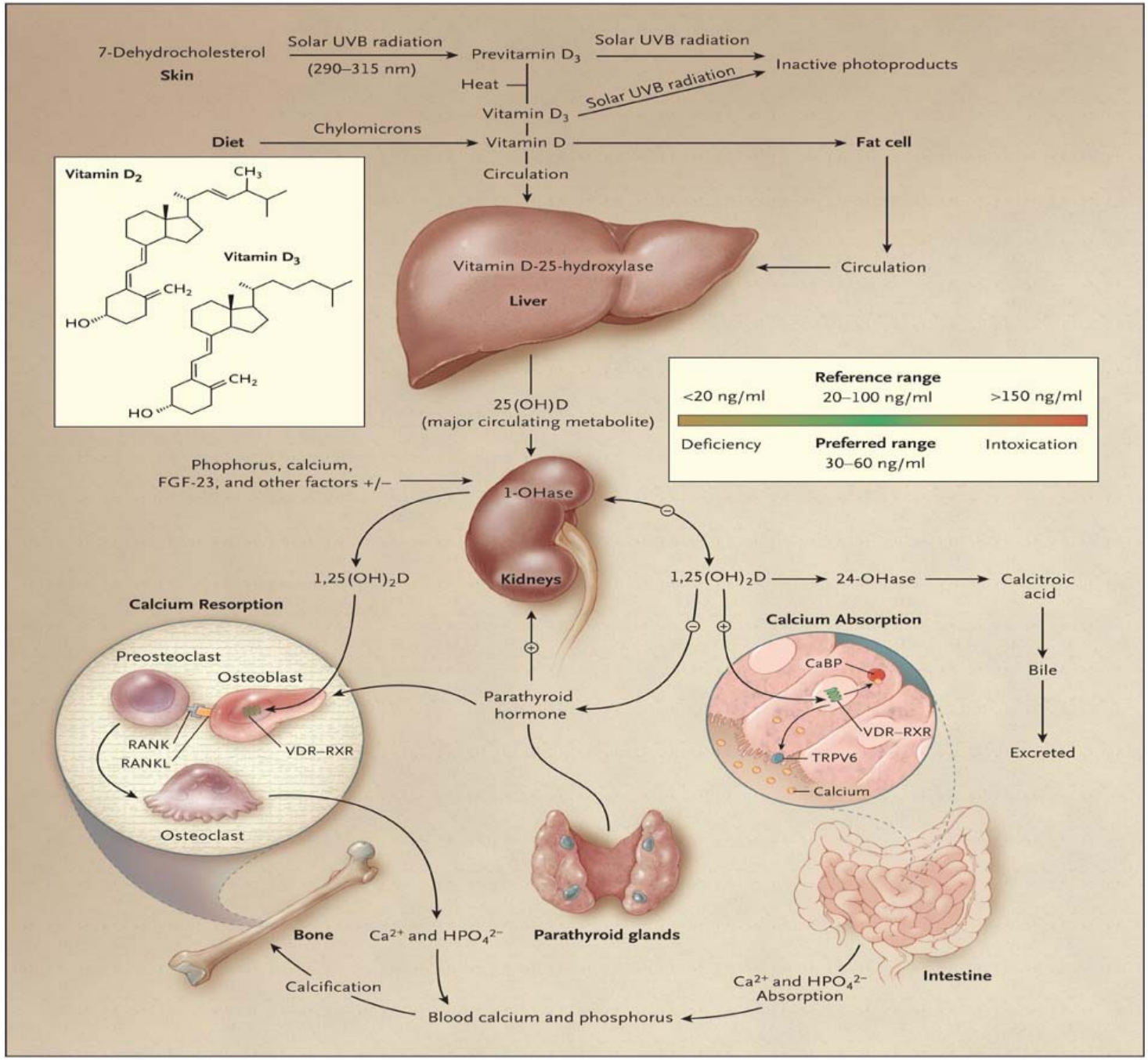


Source: Chee, et al. The effect of milk supplementation on bone mineral density in postmenopausal Chinese women in Malaysia. Osteoporosis International. 2003;14:828-834.

Milk and Margarine Vitamin D Fortification 2003 Public Health Policy in Finland



Source: Laaksi, et al. Vitamin Fortification as Public Health Policy: Significant Improvement in Vitamin D Status in Young Finish Men. Eur J Clin Nutrition. 2006; 1-4.



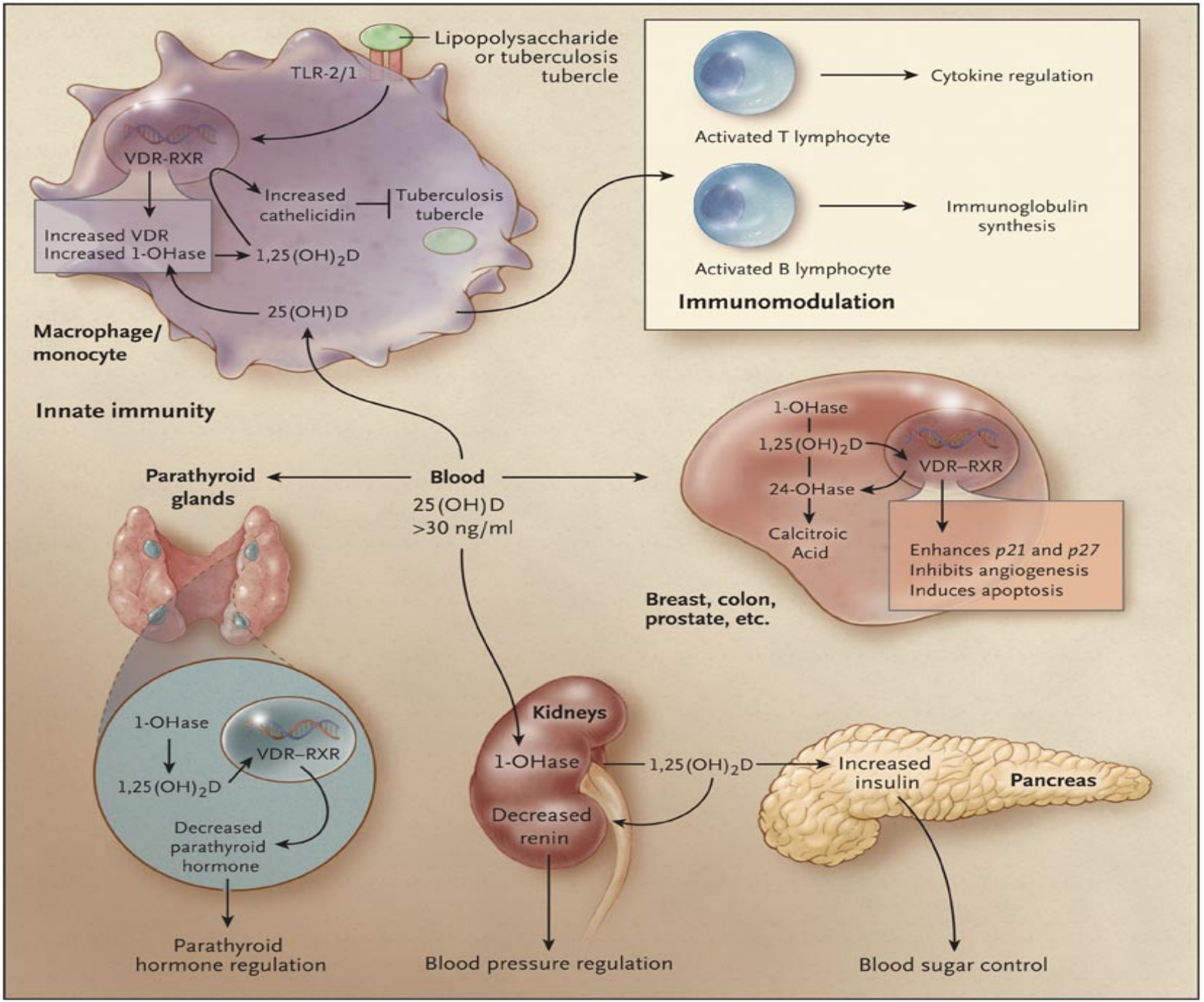


Table 1. Dietary, Supplemental, and Pharmaceutical Sources of Vitamins D_2 and D_3.*

Source	Vitamin D Content
Natural sources	
Salmon	
Fresh, wild (3.5 oz)	About 600–1000 IU of vitamin D_3
Fresh, farmed (3.5 oz)	About 100–250 IU of vitamin D_3 or D_2
Canned (3.5 oz)	About 300–600 IU of vitamin D_3
Sardines, canned (3.5 oz)	About 300 IU of vitamin D_3
Mackerel, canned (3.5 oz)	About 250 IU of vitamin D_3
Tuna, canned (3.6 oz)	About 230 IU of vitamin D_3
Cod liver oil (1 tsp)	About 400–1000 IU of vitamin D_3
Shiitake mushrooms	
Fresh (3.5 oz)	About 100 IU of vitamin D_2
Sun-dried (3.5 oz)	About 1600 IU of vitamin D_2
Egg yolk	About 20 IU of vitamin D_3 or D_2
Exposure to sunlight, ultraviolet B radiation (0.5 minimal erythemal dose)†	About 3000 IU of vitamin D_3
Fortified foods	
Fortified milk	About 100 IU/8 oz, usually vitamin D_3
Fortified orange juice	About 100 IU/8 oz vitamin D_3
Infant formulas	About 100 IU/8 oz vitamin D_3
Fortified yogurts	About 100 IU/8 oz, usually vitamin D_3
Fortified butter	About 50 IU/3.5 oz, usually vitamin D_3
Fortified margarine	About 430 IU/3.5 oz, usually vitamin D_3
Fortified cheeses	About 100 IU/3 oz, usually vitamin D_3
Fortified breakfast cereals	About 100 IU/serving, usually vitamin D_3
Supplements	
Prescription	
Vitamin D_2 (ergocalciferol)	50,000 IU/capsule
Drisdol (vitamin D_2) liquid supplements	8000 IU/ml
Over the counter	
Multivitamin	400 IU vitamin D, D_2, or D_3‡
Vitamin D_3	400, 800, 1000, and 2000 IU

* IU denotes international unit, which equals 25 ng. To convert values from ounces to grams, multiply by 28.3. To convert values from ounces to milliliters, multiply by 29.6.

† About 0.5 minimal erythemal dose of ultraviolet B radiation would be absorbed after an average of 5 to 10 minutes of exposure (depending on the time of day, season, latitude, and skin sensitivity) of the arms and legs to direct sunlight.

‡ When the term used on the product label is vitamin D or calciferol, the product usually contains vitamin D_2; cholecalciferol or vitamin D_3 indicates that the product contains vitamin D_3.

Source: Holick, M.F. (2007) NEJM:357:266-281.