Scientific Foundation SPIROSKI, Skopje, Republic of Macedonia
Open Access Macedonian Journal of Medical Sciences. 2022 Mar 14; 10(C):1-6.
https://doi.org/10.3889/oamjms.2022.8808
eISSN: 1857-9655
**Category:** *A - Basic Sciences*
**Section:** *Biochemistry*

OPEN ACCESS

# Prevalence of Vitamin D Deficiency and Insufficiency in Kosovo Population

Zana Baruti-Gafurri[1], Ardita Kafexholli[2], Bardha Dervishi[2], Rilind Sylaj[3], Krenare Shabani[3], Dijon Musliu[3]*

[1]*Clinic of Medical Biochemistry, University Clinical Center, Faculty of Medicine, University of Prishtina, Prishtina, Kosovo;* [2]*Faculty of Medicine, University of Prishtina, Prishtina, Kosovo;* [3]*Department of Anatomy, Faculty of Medicine, University of Prishtina, Prishtina, Kosovo;*

**Edited by:** Slavica Hristomanova-Mitkovska
**Citation:** Baruti-Gafurri Z, Kafexholli A, Dervishi B, Sylaj R, Shabani K, Musliu D. Prevalence of Vitamin D Deficiency and Insufficiency in Kosovo Population. Open-Access Maced J Med Sci. 2022 Mar 14; 10(C):1-6. https://doi.org/10.3889/oamjms.2022.8808
**Keywords:** 25(OH)D; Vitamin D insufficiency; Vitamin D deficiency
**Corresponding author:** Dijon Musliu, MD, PhD, Assistant of Anatomy, Faculty of Medicine University of Prishtina, 10000 Prishtina, Kosovo. E-mail: Dijon.musliu@uni-pr.edu
**Received:** 29-Jan-2022
**Revised:** 01-Mar-2022
**Accepted:** 04-Mar-2022

**Funding:** This research did not receive any financial support
**Competing Interest:** The authors have declared that no competing interest exists


**Abstract**

**BACKGROUND:** Vitamin D deficiency is a global health problem, but it is not known about its status in the Kosovo population.

**AIM:** The purpose of this study is to determine the status of Vitamin D deficiency and insufficiency in our population.

**MATERIALS AND METHODS:** Data collection was done from January 2020 to July 2021, during which period blood samples were collected. The sampling was done for 769 selected subjects and statistical data (frequency, mean values, and standard deviation) have been analyzed for 25-hydroxyvitamin D [25(OH)D] concentration. They were categorized by age group, gender, and level of 25(OH)D. The prevalence and percentage of Vitamin D deficiency and insufficiency in the study population were evaluated.

**RESULTS:** The mean concentration of 25(OH)D in the serum of the study group was 18.3 ng/ml. The mean value was significantly lower for females when compared for that of males (17.89 and 19.58 ng/ml, respectively), with $p < 0.0035$, but there was no significant difference between age groups. The level of 25(OH)D less than 20 ng/ml was observed in 62% of the cases in our study population with a slight difference between female (63.6%) and male (57.2%) group. The age group of >60 had 25(OH)D deficiency in 62.3% of cases when compared to other age group categories. Vitamin D deficiency was present in 20.2% of cases; meanwhile, its insufficiency was present in 41.9% of cases. Vitamin D deficiency was observed in 21.1% of females and 17.1% of males, while 42.4% of females, respectively, and 40.1% of males had Vitamin D insufficiency.

**CONCLUSION:** The mean values of 25(OH)D in the study population are relatively low, which corresponds to significant Vitamin D deficiency and insufficiency in all age groups, and which may also have serious implications for their overall health.

## Introduction

Vitamin D and its metabolites are well known for their role in calcium homeostasis and bone mineralization process. In the past, it was believed that a significant proportion of the problems caused by Vitamin D deficiency were rickets in children and osteomalacia and osteoporosis in adults [1], [2], [3]. Now, the role of Vitamin D is known better and it has been described that its deficiency is not only associated with skeletal diseases but also with cardiovascular disease [4], [5], cancer [6], [7], [8], and infection [9], [10].

Vitamin D deficiency is also associated with autoimmune diseases including type 1 diabetes, insulin resistance and beta-cell dysfunction, rheumatoid arthritis, and multiple sclerosis [11], [12], [13]. As well, data suggest that the antimicrobial response is dependent on Vitamin D [14]. Another prospective study has documented an increase in mood after Vitamin D intake and a reduced risk of cancer [15]. Thus, Vitamin D administration has helped and reduced the incidence of these diseases as well as the mortality rate [16], [17], [18].

Regular administration of Vitamin D is recommended as daily intake is good for bone health. Vitamin D administration in amounts of 200IU/day is recommended from birth to age 50, then 400 UI/day for ages 51–70 and over 71 years 600 UI/day [19].

Taking into consideration, the above-mentioned data on the importance of Vitamin D and its deficiency, we came up with an idea of our study to observe to what extent we have Vitamin D levels in our population.

The purpose of this study is to determine the status of Vitamin D deficiency and insufficiency in our population.

## Materials and Methods

We collected our data from January 2020 until July 2021, from the patients who presented at the Clinic of Medical Biochemistry at the University Clinical Center of Kosova and Akumed Laboratory. Our study population includes 769 subject aged between 1 and

89 years, where the concentration level of 25(OH)D was measured.

The subjects were divided by gender and categorized in four age groups, as follows: Age group 1–19 years, 20–39 years, 40–59 years, and age group >60 years.

To determine Vitamin D levels, we have used the electrochemiluminescence method in the Roche Diagnostic Elecsys 2010 system. This assay is for the quantification of 25-hydroxyvitamin D in human serum and plasma, and is used as an auxiliary method in assessing Vitamin D sufficiency, deficiency, and insufficiency. Blood sampling was performed in the morning. Blood was taken with a closed system on Sarstedt monovette and then, serum was separated. Serum Vitamin D is stable for 8 h at 18–25°C, 4 days at 2–8°C, and 24 weeks at −20°C. The working method of this test is based on three incubations (I: Incubation of 15 μL of serum sample and pre-treatment reagent 1 and 2; II: Incubation of samples pre-treated with ruthenium Vitamin D-binding protein; and III: Incubation with streptavidin and biotin) and aspiration of mixed reaction, removal of substances unrelated to ProCell/ProCell M. After this, voltage is applied to electrodes which involves chemiluminescence emission and is measured by photomultiplier. In the end of this procedure, we obtain the result.

For statistical processing of our data, we have used InStat3 and we have done ANOVA for data comparison.

Initially, we calculated the percentage of cases that were below the reference values of vitamin 25(OH)D as per sex and age group. Then, it was calculated the overall prevalence of Vitamin D deficiency and insufficiency, as well we calculated the prevalence according to gender and age group.

The mean values of Vitamin D [25(OH)D] levels were calculated for all mentioned groups and then were compared by sex and age group.

## Results

We have classified patients based on serum 25(OH)D cutoff values as follows: Normal serum levels of Vitamin D-25(OH)D of our study subjects are considered to be 30–70 ng/ml. Serum Vitamin D-25(OH)D values of 20–30 ng/ml are considered as Vitamin D insufficiency. Serum Vitamin D-25(OH)D values below 20 ng/ml are considered as Vitamin D deficiency.

The mean age of the study group is 46.55 years with a significant difference between the mean age of females and males (47.41 and 43.88 years, respectively). The two-tailed $p = 0.0208$ is considered statistically significant.

The mean value of 25(OH)D vitamin is 18.30 ng/ml with a statistically significant difference ($p < 0.0352$) between the mean 25(OH)D values of females (17.89 ng/ml) and males (19.58 ng/ml) (Table 1).

However, when the age group comparison took place, we found no statistically significant difference in mean values of 25(OH)D vitamin, although there was a gradual decrease in 25(OH)D vitamin level. Thus, the age group of 1–19 years had the mean values of 25(OH)D=20.56 ng/ml, the age group of 20–39 years had 25(OH)D=18.82 ng/ml, age group of 40–59 years had 25(OH)D=17.95 ng/ml, and the age group of older than 60 years had the average value of 25(OH)D=17.66 ng/ml.

The values of vitamin 25(OH)D compared to referent levels are shown in Figure 1. It was found that 88.3% of our study subjects had Vitamin D levels below normal values. There was difference in percentages between males and females having 25(OH)D values below the normal level (89.0%, respectively, and 86.1%). The same Figure 2 shows 25(OH)D values for the age groups compared to the referent level. From this, we can reckon that the prevalence of insufficiency and deficiency for the age groups of 1–19 years and >60 years is really high at 87.9%.

Except reference levels, we have analyzed Vitamin D insufficiency and deficiency in our population group with 25(OH)D values below 20 ng/ml considered as deficient and values of 25(OH)D between 20 and 30 ng/ml considered as insufficient.

About 62.7% of the subjects are Vitamin D deficient, while Vitamin D insufficient is 25.6% of our subjects. It is evident that Vitamin D deficiency is mostly found in the age group of 40–59 years (65.9%), concurrently, the least deficient is the age group of 1–19 years presenting with only 6.1%. The high prevalence of Vitamin D insufficiency was found in the age group of 1–19 years in 30.3% of cases and in the age group of 20–39 years in 28.3% of cases.

There was a gender difference between

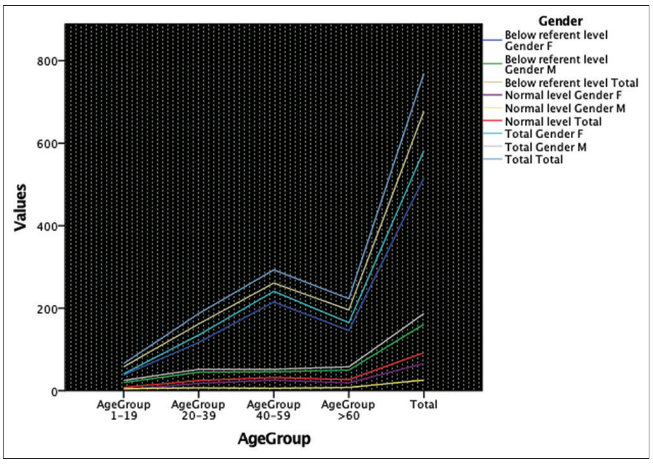


*Figure 1: Gender and age group values of 25(OH)D as per referent level*

subjects below the reference level of vitamin 25(OH) D values in all age groups with the age group of 1–19 years (females 92.7% and males 7.3%) being the most prominent difference. About 64.3% of women and 57.8% of men are deficient in Vitamin D. According to gender and age group, we have found that the highest prevalence of Vitamin D deficiency among women and men is in the age group of 40–59 years old, with 66.4% of females in this age group being Vitamin D deficient and 63.5% of males in this group being deficient. The least deficient age groups were 1–19 years and 20–39 years, but in the same age groups, we observed the biggest difference between genders. The cross-tabulation below represents our findings graphically.

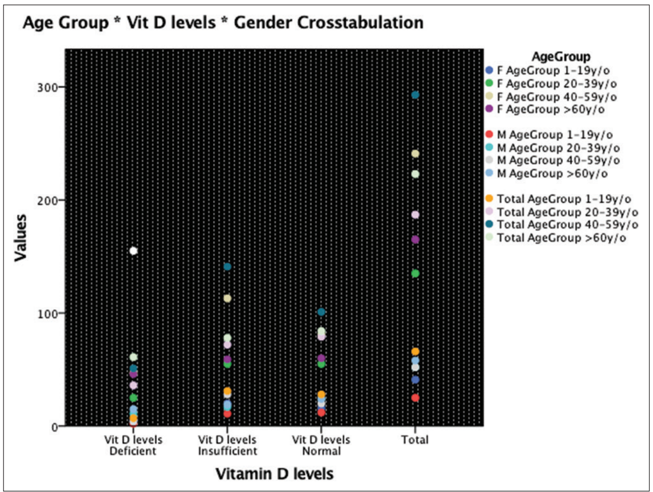


*Figure 2: Gender and age group in relation to Vitamin D levels*

Vitamin D insufficiency was more common in males than in females when all age groups were compared. About 28.3% of males were Vitamin D insufficient, concurrently, 24.7% of females were Vitamin D insufficient. While in every age group, the insufficiency was more prominent in males, it was only in the age group of 1–19 years where the female percentage of vitamin D insufficiency was higher.

Table 2 shows the cross-tabulation for number of subjects in each of our study category, gender, and age group as layered for Vitamin D levels.

## Discussion

Vitamin D deficiency is diagnosed by measuring the concentration of calcidiol (25-hydroxyvitamin D) in the blood, which is a precursor to the active form of 1,25-dihydroxyvitamin D (calcitriol). According to a systematic review, the following categories were set for hypovitaminosis D: Normal values 75–250 nmol/L (30–100 ng/mL) and insufficiency values 25–74 nmol/L (10–29.6 ng/mL) [20]. 1.0 nmol/L equals 0.4 ng/mL according to “Dietary Supplement Fact Sheet: Vitamin D” [21].

**Table 1: Statistical parameters for Vitamin D values as per gender**

| No. | Statistical parameters | Total | Female | Male |
|---|---|---|---|---|
| 1 | No of Patients | 769 | 582 | 187 |
| 2 | Mean | 18.30 | 17.89 | 19.58 |
| 3 | Std. deviation | 9.56 | 9.58 | 9.40 |
| 4 | Lower 95% CI | 17.63 | 17.11 | 18.23 |
| 5 | Upper 95% CI | 18.98 | 18.67 | 20.93 |
| | p-value | | p<0.0352 | |
| Referent value of Vitamin D 30–70 ng/ml | | | | |

The two-tailed P = 0.0352 is considered statistically significant.

It has been calculated that normal Vitamin D values are when we have the concentration of 25(OH) D ≥75 nmol/L (>30 ng/ml) [22]. Concentration levels 50–75 nmol/L (20–30 ng/ml) are considered as Vitamin D insufficiency. 25(OH)D values <50 nmol/L(<20 ng/L) are considered as Vitamin D deficiency and these levels have negative bone repercussions. 25(OH) D values <30 nmol/L (<12 ng/ml) are assessed as severe Vitamin D deficiency, whereas 25(OH)D values <20 nmol/L (<8 ng/ml) cause serious disorder of bone metabolism (rickets or osteomalacia) and myopathy. We have done our classification of Vitamin D normal values as well as insufficiency and deficiency based on the above-mentioned data and the data of other authors [23], [24], [25], [26], [27].

**Table 2: Cross-tabulation for gender, age groups, and Vitamin D Levels**

| Gender | | | | Vitamin D classification | | | Total |
|---|---|---|---|---|---|---|---|
| | | | | Deficient | Insufficient | Normal | |
| F | Age group | 1–19 | Count | 5 | 20 | 16 | 41 |
| | | | % | 4.1% | 8.1% | 7.5% | 7.0% |
| | | 20–39 | Count | 25 | 55 | 55 | 135 |
| | | | % | 20.3% | 22.3% | 25.9% | 23.2% |
| | | 40–59 | Count | 47 | 113 | 81 | 241 |
| | | | % | 38.2% | 45.7% | 38.2% | 41.4% |
| | | >60 | Count | 46 | 59 | 60 | 165 |
| | | | % | 37.4% | 23.9% | 28.3% | 28.4% |
| | Total % | | Count | 123 | 247 | 212 | 582 |
| | | | 100.0% | 100.0% | 100.0% | 100.0% | |
| M | Age group | 1–19 | Count | 2 | 11 | 12 | 25 |
| | | | % | 6.3% | 14.7% | 15.0% | 13.4% |
| | | 20–39 | Count | 11 | 17 | 24 | 52 |
| | | | % | 34.4% | 22.7% | 30.0% | 27.8% |
| | | 40–59 | Count | 4 | 28 | 20 | 52 |
| | | | % | 12.5% | 37.3% | 25.0% | 27.8% |
| | | >60 | Count | 15 | 19 | 24 | 58 |
| | | | % | 46.9% | 25.3% | 30.0% | 31.0% |
| | Total % | | Count | 32 | 75 | 80 | 187 |
| | | | 100.0% | 100.0% | 100.0% | 100.0% | |
| Total | Age group | 1–19 | Count | 7 | 31 | 28 | 66 |
| | | | % | 4.5% | 9.6% | 9.6% | 8.6% |
| | | 20–39 | Count | 36 | 72 | 79 | 187 |
| | | | % | 23.2% | 22.4% | 27.1% | 24.3% |
| | | 40–59 | Count | 51 | 141 | 101 | 293 |
| | | | % | 32.9% | 43.8% | 34.6% | 38.1% |
| | | >60 | Count | 61 | 78 | 84 | 223 |
| | | | % | 39.4% | 24.2% | 28.8% | 29.0% |
| | Total % | | Count | 155 | 322 | 292 | 769 |
| | | | 100.0% | 100.0% | 100.0% | 100.0% | |

Vitamin D insufficiency and deficiency are associated with suboptimal health. The prevalence of

Vitamin D insufficiency and deficiency maybe in a rise and population-based trends are uncertain. We have tried to evaluate the prevalence of Vitamin D insufficiency and deficiency in Kosovo population, having in mind that the prevalence data of Vitamin D in our population and the subgroups are limited.

It has been documented that there is a high worldwide prevalence of Vitamin D deficiency that may require public health actions [28].

Data on Vitamin D prevalence are important for the development of public health policies and reduce the risk for potential health consequences of an inadequate Vitamin D status [29].

Our study included 769 cases or 0.03% of the Kosovo population (approx. 1.7 million inhabitants). We calculated the mean value of 25(OH)D and evaluated Vitamin D deficiency and insufficiency in our population, similar to the study of 32,252 persons or 0.01% of the American population (221 million inhabitants) [30], as well similar to the 0.019% of Canadian population [31].

The aim of our research was to measure the rate of Vitamin D insufficiency and deficiency in the Kosovo population and to assess the differences by age and sex. This study also had limitations because it failed to analyze other Vitamin D-related phenomena that were associated with the season, sunlight exposure, and diet.

The mean value of 25(OH)D was 18.3 ng/ml, with minimum and maximum values between 3.0 and 68.0 ng/ml in our research subjects. In 195 studies conducted in 44 countries involving more than 168,000 participants, mean values of 25(OH)D differed significantly across studies (ranging from 4.9 nmol/l to 136.2 nmol/l), where 37.3% of studies reported average Vitamin D values below 50 nmol/l or 20 ng/mL [29].

A study which took place in the United States was done at two different time periods (including 18.883 and 13.369 participants, respectively), with the aim to determine the mean values for all those included. The mean value of 25(OH)D was 30 ng/ml, respectively, and 24 ng/ml in the two period times (1994–1998 and 2001–2004). The same study found gender differences in mean values of 25(OH) D for females at 28 ng/mL and for males at 32 ng/mL [30]. We have reported similar results in our study as well.

Studies in the Canadian population report for mean values of 25(OH)D concentrations at 67.7 nmol/L (27.08 ng/mL) [31]. In our study population, the mean values of 25(OH)D concentrations were 18.3 ng/mL.

Vitamin D status in Europe varies by gender, season, and skin pigmentation. As observed in various studies, serum 25(OH)D level is higher in North Europe than in South Europe and higher in West Europe than in East Europe [32], [33].

Multicenter studies report high levels of 25(OH) D in North Europe 25 years ago [34]. High levels of 25(OH)D in Norway and Sweden are probably due to high consumption of fatty fish. Low levels of Vitamin D in Spain, Italy, and Greece could be due to increased pigmentation of the skin and avoidance of sunlight penetration [35].

Low levels of 25(OH)D are found in various regions of Asia, for example, in Asian part of Russia [36], in Mongolia [37], in China, and in India, meanwhile, Vitamin D status was better in Malaysia and Japan [38], [39].

Vitamin D deficiency is more common in vulnerable groups, especially in pregnant women and their newborns [40], [41], [42]. Higher risk of low levels of Vitamin D was observed in dark-skinned women and their newborns, as well lower levels were observed in obese and adolescent children [43], [44].

Low levels of Vitamin D in children and adolescents may be due to reduced intake of Vitamin D3 (e.g., minor bowel disorders), reduced synthesis, or increased degradation of 25(OH)D or 1.25 (OH) 2D (e.g., chronic liver or kidney disease) [45].

The elders have lower levels of Vitamin D synthesis in the skin, especially those living in a nursing home who are rarely exposed to the sun [46].

It is pointed out that Vitamin D deficiency has a high prevalence rate worldwide, and not only in the risk groups such as young children, pregnant women, the elderly, and immigrants but also in other groups who are not exposed to the sun, have pronounced skin pigmentation, those who use sun protect lotions, or use cloths that cover the whole body, and poor diets with fish and dairy products [35].

We found that the prevalence of Vitamin D deficiency in our study was 89.4% for the age group of 40–59 years. Studies conducted in other countries show lower prevalence of 25(OH)D for similar group (43.3%) [47]. The mean value of 25(OH)D in the 1–19 age group was 20.56 ng/ml. Similar data are reported by other authors [47] who reported mean values of 25(OH) D vitamin at 25.82 ng/ml. The mean value of 25(OH)D in subjects older age groups is steadily declining. The age group of 20–39 years recorded mean values of Vitamin D at 18.82 ng/ml, age group of 40–59 years recorded values at 17.95 ng/ml, and the eldest age group over 60 years recorded values of 25(OH)D at 17.66 ng/ml.

## Conclusion

The mean values of 25(OH)D in our study group are low which correspond to Vitamin D deficiency and insufficiency in all age groups. Our findings suggest that there is a need for public health intervention and health promotion to prevent further decline of Vitamin D values which may have serious implications for population overall health. There is a need for continuous and seasonal Vitamin D levels measurement in our population as well-conducting studies which would find association between Vitamin D deficiency and related health problems.

## References

1. Hasegawa Y, Miyai K, Takeda R. Updates on rickets and osteomalacia: Pathogenesis and pathophysiology of rickets.

Clin Calcium. 2013;23(10):1405-12.
PMid:24076637

2. Berry JL, Davies M, Mee AP. Vitamin D metabolism, rickets, and osteomalacia. Semin Musculoskelet Radiol. 2002;6(3):173-82. https://doi.org/10.1055/s-2002-36714
3. Bikle DD. Role of Vitamin D, its metabolites, and analogs in the management of osteoporosis. Rheum Dis Clin North Am. 1994;20(3):759-75.
PMid:7984788
4. Giovannucci E, Liu Y, Hollis BW, Rimm EB. 25-hydroxyvitamin D and risk of myocardial infarction in men. Arch Intern Med. 2008;168(11):1174-80. https://doi.org/10.1001/archinte.168.11.1174
5. Dobnig H, Pilz S, Scharnagl H, Renner W, Seelhorst U, Wellnitz B, *et al.* Independent association of low serum 25-hydroxyvitamin D and 1,25-dihydroxyvitamin D levels with all-cause and cardiovascular mortality. Arch Intern Med. 2008;168(12):1340-9. https://doi.org/10.1001/archinte.168.12.1340
PMid:18574092
6. Giovannucci E, Liu Y, Rimm EB, Hollis BW, Fuchs CS, Stampfer MJ, *et al.* Prospective study of predictors of Vitamin D status and cancer incidence and mortality in men. J Natl Cancer Inst. 2006;98(7):451-9. https://doi.org/10.1093/jnci/djj101
PMid:16595781
7. Garland CF, Garland FC, Gorham ED, Lipkin M, Newmark H, Mohr SB, *et al.* The role of Vitamin D in cancer prevention. Am J Public Health. 2006;96(2):252-61. https://doi.org/10.2105/AJPH.2004.045260
PMid:16380576
8. Lin J, Manson JE, Lee IM, Cook NR, Buring JE, Zhang SM. Intakes of calcium and Vitamin D and breast cancer risk in women. Arch Intern Med. 2007;167(10):1050-9. https://doi.org/10.1001/archinte.167.10.1050
PMid:17533208
9. Cannell JJ, Vieth R, Umhau JC, Holick MF, Grant WB, Madronich S, *et al.* Epidemic influenza and Vitamin D. Epidemiol Infect. 2006;134(6):1129-40. https://doi.org/10.1017/S0950268806007175
PMid:16959053
10. Laaksi I, Ruohola JP, Tuohimaa P, Auvinen A, Haataja R, Pihlajamäki H, *et al.* An association of serum Vitamin D concentrations <40 nmol/L with acute respiratory tract infection in young Finnish men. Am J Clin Nutr. 2007;86(3):714-7. https://doi.org/10.1093/ajcn/86.3.714
PMid:17823437
11. Harkness LS, Bonny AE. Calcium and Vitamin D status in the adolescent: Key roles for bone, body weight, glucose tolerance, and estrogen biosynthesis. J Pediatr Adolesc Gynaecol. 2005;18(5):305-11. https://doi.org/10.1016/j.jpag.2005.06.002
PMid:16202933
12. Chiu KC, Chu A, Go VL, Saad MF. Hypovitaminosis D is associated with insulin resistance and B cell dysfunction. Am J Clin Nutr. 2004;79(5):820-5. https://doi.org/10.1093/ajcn/79.5.820
PMid:15113720
13. Holick MF. Vitamin D: Importance in the prevention of cancers, Type 1 diabetes, heart disease, and osteoporosis. Am J Clin Nutr. 2004;79(3):362-71. https://doi.org/10.1093/ajcn/79.3.362
PMid:14985208
14. Zhang C, Qiu C, Hu FB, David RM, van Dam RM, Bralley A, *et al.* Maternal plasma 25-hydroxyvitamin D concentrations and the risk for gestational diabetes mellitus. PLoS One. 2008;3(11):e3753. https://doi.org/10.1371/journal.pone.0003753
PMid:19015731
15. Bodnar LM, Catov JM, Simhan HN, Holick MF, Powers RW, Roberts JM. Maternal Vitamin D deficiency increases the risk of preeclampsia. J Clin Endocrinol Metab. 2007;92(9):3517-22. https://doi.org/10.1210/jc.2007-0718
PMid:17535985
16. Fuller KE. Low birth-weight infants: The continuing ethnic disparity and the interaction of biology and environment. Ethn Dis. 2000;10(3):432-45.
PMid:11110360
17. Liu PT, Stenger S, Li H, *et al.* Toll-like receptor triggering of Vitamin D-mediated human antimicrobial response. Science. 2006;311(5768):1770-3. https://doi.org/10.1126/science.1123933
PMid:16497887
18. Lappe JM, Travers-Gustafson D, Davies KM, Recker RR, Heaney RP. Vitamin D and calcium supplementation reduces cancer risk: Results of a randomized trial. Am J Clin Nutr 2007;85(6):1586-91. https://doi.org/10.1093/ajcn/85.6.1586
PMid:17556697
19. Autier P, Gandini S. Vitamin D supplementation and total mortality: A meta-analysis of randomized controlled trials. Arch Intern Med. 2007;167(16):1730-7. https://doi.org/10.1001/archinte.167.16.1730
PMid:17846391
20. Avenell A, Cook JA, Maclennan GS, Macpherson GC. Vitamin D supplementation to prevent infections. Age Ageing. 2007;36(5):574-7. https://doi.org/10.1093/ageing/afm091
PMid:17702768
21. Martineau AR, Wilkinson RJ, Wilkinson KA, Newton SM, Kampmann B, Hall BM, *et al.* A single dose of Vitamin D enhances immunity to mycobacteria. Am J Respir Crit Care Med. 2007;176(2):208-13. https://doi.org/10.1164/rccm.200701-007OC
PMid:17463418
22. Standing Committee on the Scientific Evaluation of Dietary Reference Intakes Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride. Washington, DC: National Academy Press; 1999. p. 250-87.
23. Stroud ML, Stilgoe S, Stott VE, Alhabian O, Salman K. Vitamin D a review. Aust Fam Physician. 2008;37(12):1002-5.
PMid:19142273
24. National Institutes of Health. “Dietary Supplement Fact Sheet: Vitamin D”. National Institutes of Health; 2007.
25. Holick MF. Vitamin D deficiency. N Engl J Med. 2007;357(3):266-81. https://doi.org/10.1056/NEJMra070553
PMid:17634462
26. Lips P. Which circulating level of 25-hydroxyvitamin D is appropriate? J Steroid Biochem Mol Biol. 2004;89-90:611-4. https://doi.org/10.1016/j.jsbmb.2004.03.040
PMid:15225848
27. Holick MF. Vitamin D status: Measurement, interpretation, and clinical application. Ann Epidemiol. 2009;19(2):73-8. https://doi.org/10.1016/j.annepidem.2007.12.001
PMid:18329892
28. Pilz S, Zittermann A, Trummer C, Theiler-Schwetz V, Lerchbaum E, Keppel MH, *et al.* Vitamin D testing and treatment: A narrative review of current evidence. Endocrine Connections. 2019;8:R27-43. https://doi.org/10.1530/EC-18-0432
PMid:30650061
29. Hilger J, Friedel A, Herr R, Rausch T, Roos F, Wahl DA, *et al.* A systematic review of vitamin D status in populations worldwide. Br J Nutr. 2014;111(1):23-45. https://doi.org/10.1017/S0007114513001840

PMid:23930771

30. Ginde AA, Liu MC, Camargo CA Jr. Demographic differences and trends of Vitamin D insufficiency in the US population, 1988-2004. Arch Intern Med. 2009;169(6):626-32. https://doi.org/10.1001/archinternmed.2008.604
PMid:19307527
31. Langlois K, Greene-Finestone L, Little J, Hidiroglou N, Whiting S. Vitamin D status of Canadians as measured in the 2007 to 2009 Canadian health measures survey. Health Rep. 2010;21(1):47-55.
PMid:20426226
32. Melhus H, Snellman G, Gedeborg R, Byberg L, Berglund L, Mallmin H, *et al.* Plasma 25-hydroxyvitamin D levels and fracture risk in a community-based cohort of elderly men in Sweden. J Clin Endocrinol Metab 2010;95(6):2637-45. https://doi.org/10.1210/jc.2009-2699
PMid:20332246
33. Laktasic-Zerjavic N, Korsic M, Crncevic-Orlic Z, Kovac Z, Polasek O, Soldo-Juresa D. Vitamin D status, dependence on age, and seasonal variations in the concentration of Vitamin D in Croatian postmenopausal women initially screened for osteoporosis. Clin Rheumatol. 2010;29(8):861-7. https://doi.org/10.1007/s10067-010-1409-3
PMid:20204667
34. Van der Wielen RP, Lowik MR, van den BH, de Groot LC, Haller J, Moreiras O, *et al.* Serum Vitamin D concentrations among elderly people in Europe. Lancet. 1995;346(8969):207-10. https://doi.org/10.1016/s0140-6736(95)91266-5
PMid:7616799
35. van Schoor NM, Lips P. Worldwide Vitamin D status. Best Pract Res Clin Endocrinol Metab. 2011;25(4):671-80. https://doi.org/10.1016/j.beem.2011.06.007
PMid:21872807
36. Bakhtiyarova S, Lesnyak O, Kyznesova N, Blankenstein MA, Lips P. Vitamin D status among patients with hip fracture and elderly control subjects in Yekaterinburg, Russia. Osteoporosis Int. 2006;17(3):441-6. https://doi.org/10.1007/s00198-005-0006-9
PMid:16328605
37. Fraser DR. Vitamin D-deficiency in Asia. J Steroid Biochem Mol Biol. 2004;89-90(1-5):491-5. https://doi.org/10.1016/j.jsbmb.2004.03.057
PMid:15225826
38. Rahman SA, Chee WS, Yassin Z, Chan SP. Vitamin D status among postmenopausal Malaysian women. Asia Pac J Clin Nutr. 2004;13(3):255-60.
PMid:15331337
39. Nakamura K. Vitamin D insufficiency in Japanese populations: From the viewpoint of the prevention of osteoporosis. J Bone Miner Metab. 2006;24:1-6. https://doi.org/10.1007/s00774-005-0637-0
PMid:16369890
40. Sachan A, Gupta R, Das V, Agarwal A, Awasthi PK, Bhatia V. High prevalence of Vitamin D deficiency among pregnant women and their newborns in Northern India. Am J Clin Nutr. 2005;81(5):1060-4. https://doi.org/10.1093/ajcn/81.5.1060
PMid:15883429
41. Ginde AA, Sullivan AF, Mansbach JM, Camargo CA Jr. Vitamin D insufficiency in pregnant and non-pregnant women of childbearing age in the United States. Am J Obstet Gynaecol. 2010;202(5):436-8. https://doi.org/10.1016/j.ajog.2009.11.036
PMid:20060512
42. Bowyer L, Catling-Paull C, Diamond T, Homer C, Davis G, Craig ME. Vitamin D, PTH and calcium levels in pregnant women and their neonates. Clin Endocrinol (Oxf). 2009;70(3):372-7. https://doi.org/10.1111/j.1365-2265.2008.03316.x
PMid:18573121
43. Mansbach JM, Ginde AA, Camargo CA Jr. Serum 25-hydroxyvitamin D levels among US children aged 1 to 11 years: Do children need more Vitamin D? Pediatrics. 2009;124(5):1404-10. https://doi.org/10.1542/peds.2008-2041
PMid:19951983
44. Prentice A. Vitamin D deficiency: A global perspective. Nutr Rev. 2008;66(10 Suppl 2):S153-64.
45. Munns C, Zacharin MR, Rodda CP, Batch JA, Morley R, Cranswick NE, *et al.* Prevention and treatment of infant and childhood Vitamin D deficiency in Australia and New Zealand: A consensus statement. Med J Aust. 2006;185(5):268-72. https://doi.org/10.5694/j.1326-5377.2006.tb00558.x
PMid:16948623
46. Portela ML, Monico A, Barahona A, Dupraz H, Gonzales-Chaves MM, Zeni SN. Comparative 25-OH-vitamin D level in institutionalized women older than 65 years from two cities in Spain and Argentina having a similar solar radiation index. Nutrition. 2010;26(3):283-9. https://doi.org/10.1016/j.nut.2009.04.022
PMid:19819110
47. Larijani B, Hossein-Nezhad A, Feizabad E, Maghbooli Z, Adibi H, Ramezani M, *et al.* Vitamin D deficiency, bone turnover markers and causative factors among adolescents: A cross-sectional study. J Diabetes Metab Disord. 2016;15:46. https://doi.org/10.1186/s40200-016-0266-2
PMid:27752482