

## Primary source of Vitamin D: sunlight or nutrition?



Bahrul Fikri<sup>1</sup>, Aidah Juliaty<sup>2</sup>, Sam Engels<sup>3</sup>, Azwin Mengindera Putera<sup>1\*</sup>,  
Zahrah Hikmah<sup>1</sup>, Andi Dwi Bahagia Febriani<sup>2</sup>, Sri Hardiyanti Putri<sup>2</sup>,  
Nadirah Rasyid Ridha<sup>2</sup>, Ema Alasiry<sup>2</sup>, Anang Endaryanto<sup>1</sup>, Nasrum Massi<sup>4</sup>,  
Yusrawati<sup>5</sup>, Deasy Irawati<sup>6</sup>, Hamsu Kadrian<sup>6</sup>

### ABSTRACT

This study reviews the existing literature on whether sunlight or nutrition is the main source of vitamin D and explores the factors contributing to vitamin D deficiency in tropical regions. The key findings include urbanization, ethnicity, sun-avoidance, religion, and nutrition as causes for the high prevalence of vitamin D deficiency in tropical areas. While sunlight is considered the main source of vitamin D, factors such as air pollution, sun-avoidance behaviors, and the clothing style of certain religions can limit sunlight absorption. Moreover, limited access to vitamin D-rich foods and low consumption of fortified foods contribute to the deficiency. The study suggests further research on the role of nutrition as a potential main contributor to vitamin D deficiency in tropical areas.

**Keywords:** Vitamin D deficiency, tropical country, main source.

**Cite This Article:** Fikri, B., Juliaty, A., Engels, S., Putera, A.M., Hikmah, Z., Febriani, A.D.B., Putri, S.H., Ridha, N.R., Alasiry, E., Endaryanto, A., Massi, N., Yusrawati., Irawati, D., Kadrian, H. 2024. Primary source of Vitamin D: sunlight or nutrition?. *Bali Medical Journal* 13(1): 458-462. DOI: 10.15562/bmj.v13i1.4958

<sup>1</sup>Department of Child Health, Faculty of Medicine, Universitas Airlangga, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia;

<sup>2</sup>Department of Pediatrics, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia/ DR Wahidin Sudirohusodo Hospital, Makassar, Indonesia;

<sup>3</sup>Faculty of Medical Sciences, Radboud University, Nijmegen, The Netherlands;

<sup>4</sup>Department of Microbiology, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia;

<sup>5</sup>Department of Pediatrics, Faculty of Medicine, Andalas University, Padang, Indonesia;

<sup>6</sup>University of Mataram, West Nusa Tenggara, Indonesia.

\*Corresponding author:

Azwin Mengindera Putera;  
Department of Child Health, Faculty of Medicine, Universitas Airlangga, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia;  
[azwin-m-p@fk.unair.ac.id](mailto:azwin-m-p@fk.unair.ac.id)

Received: 2023-10-14

Accepted: 2023-12-02

Published: 2024-01-09

### INTRODUCTION

Vitamin D is a prohormone that can be used by the human body mainly to facilitate absorption of calcium and phosphorus, among other biological functions, such as its role in cell proliferation and the immune system, although this has been less intensively studied.<sup>1</sup> Vitamin D can be obtained by transforming 7-dehydrocholesterol in the human skin with the aid of UVB light from the sun into provitamin D<sub>3</sub> which immediately transforms into vitamin D<sub>3</sub> through a heat induced reaction. Additionally, it can be acquired through consuming animal derived foods (such as liver, butter, fatty fish, eggs) for vitamin D<sub>3</sub> or mushrooms for vitamin D<sub>2</sub>. This non-active form of vitamin D<sub>2</sub> and D<sub>3</sub>, also called calciferols, is then hydroxylated by the liver with the aid of the enzyme 25-hydroxylase into 25-hydroxyvitamin D, which is usually measured to assess serum vitamin D concentration.<sup>2,3</sup> Consecutively, 25-hydroxyvitamin D is hydroxylated again in the kidneys with the aid of the enzyme 1- $\alpha$ -hydroxylase to obtain the biologically active 1,25-dihydroxyvitamin D. This active form of vitamin D can then bind to vitamin D receptors to manifest biological effects.<sup>4-7</sup>

A deficiency in vitamin D, defined as a serum concentration of <15 ng/L as defined by

the American Academy of Pediatrics, or <20 ng/L as defined by Endocrine society, can lead to various adverse events, such as osteoporosis, rickets, muscle weakness, hypertension, multiple sclerosis, diabetes, tuberculosis, and cancer, among others.<sup>4,5,8</sup>

Currently, vitamin D deficiency is still a very common phenomenon, with a prevalence of 24-40% in the western world and 6-73% in southeast Asia.<sup>9-11</sup> While medical issues such as malabsorption or chronic kidney disease account for some of these cases, a large part is also due to a lack of intake of vitamin D. Therefore, it is important to identify the most important source of vitamin D: sunlight or nutrition.

Many articles have stated that sunlight accounts for 80-90% of vitamin D levels in humans,<sup>12-21</sup> but only a few research has been done into the exact contribution of nutrition to vitamin D concentrations. Most importantly, even though there is an abundance of sunlight in tropical countries all year long, rates of vitamin D deficiency are often still high in these regions, which seemingly directly contradicts the suggestion of sunlight as the primary vitamin D source.

Therefore, in this narrative review we would like to examine current literature about the causes of vitamin D deficiency in tropical countries, as

well as determine whether the primary source of vitamin D is sunshine, or rather nutrition.

## METHODS

Literature research was conducted in order to collect information about the cause of vitamin D deficiency in tropical countries and the primary source of vitamin D. The main database used in this study was PubMed, in which multiple search strings have been applied, including MeSH terms for vitamin D deficiency. Excluding search strings that yielded no relevant articles: (Vitamin D deficiency [Title/Abstract] OR Vitamin D deficiency [MeSH]) AND (tropical [Title/Abstract])

(Vitamin D deficiency [Title/Abstract] OR Vitamin D deficiency [MeSH]) AND (Southeast asia [Title/Abstract]). The Searching filters were within the last 12 years.

Additional articles from other databases were obtained through snowballing. Only articles published between 2010 and 2022 were included, data collection was carried out in July 2022.

Articles were firstly selected based on the title and then filtered based on the abstract. Reasons to exclude articles were limited usability for the topic of the study and unavailability of the full article. Outcomes and conclusions drawn in the articles were considered and combined to draw our own conclusions in this study. No statistical analysis of the outcomes was performed.

## RESULTS

### Articles

Using the search strings mentioned in the material & methods section, initially 106 articles were found, of which 8 were deemed relevant based on the title and abstract. Articles were deemed relevant if they had the source of vitamin D as their main topic and were conducted in a tropical area. One article was excluded because the full article was not available. Finally, 7 articles remained for further analysis.<sup>10,13,22-26</sup>

### Narrative review

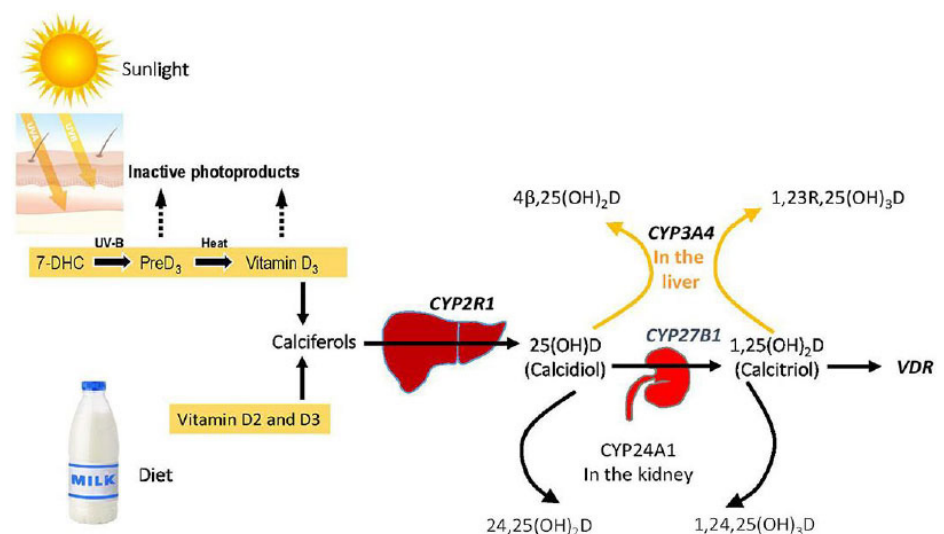
Overall, when considering all articles included, there were multiple causes

mentioned to explain why there can still be such a high prevalence of vitamin D deficiency in tropical countries. All mentioned causes of this phenomenon are connected to the underlying mechanism of Vitamin D metabolism. Even though in theory, problems could occur on the sunlight absorption level, the biological metabolism level, or the Vitamin D receptor level (Figure 1), most found articles only report potential causes regarding either sunlight absorption or nutrition intake.<sup>10,13,22-26</sup> However, these issues on the sunlight absorption level are

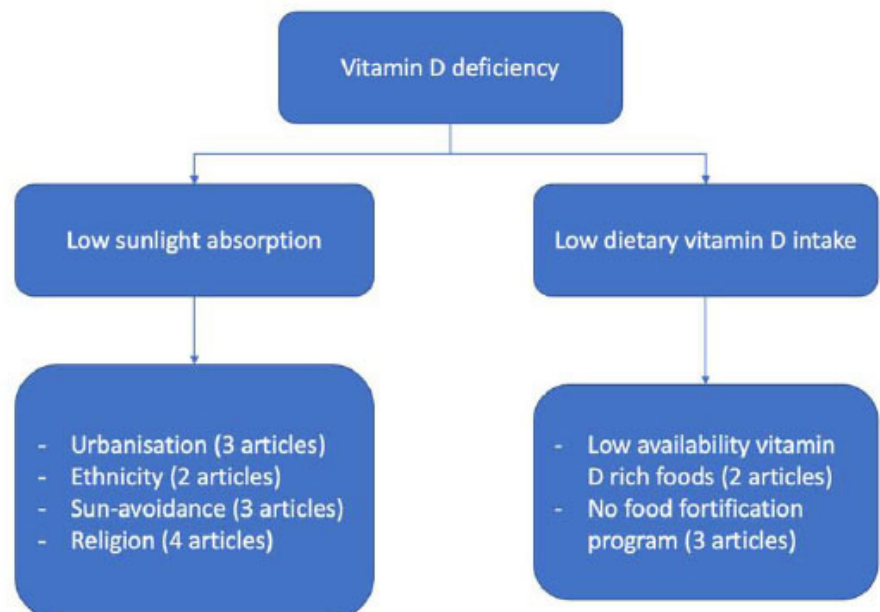
diverse and thus further highlighted below in five key points.

### Urbanization

Three out of seven articles mentioned urbanisation as one of the causes that there is still a high prevalence of vitamin D deficiency in tropical areas.<sup>10,22,23</sup> It was explained that the rate of vitamin D deficiency was much higher or the vitamin D level much lower in urban areas compared to rural areas, and that people living a herder-like lifestyle reportedly often have sufficient levels of vitamin D.<sup>22</sup>



**Figure 1.** The metabolism of vitamin D (7). 7-DHC: 7-dehydrocholesterol. VDR: Vitamin D Receptor.<sup>7</sup>



**Figure 2.** Summary of key findings of the narrative review.

One of the reasons explicitly mentioned why urbanisation was a cause of vitamin D deficiency, was that air pollution absorbs UVB rays, and therefore the actual effective sunshine reaching the population is decreased.<sup>10</sup> An additional reason was that people in urban areas tend to stay indoors more often, especially schoolkids.<sup>22</sup> Additionally, and relatedly, residents with a higher education level also had a higher prevalence of vitamin D deficiency, as they were more likely to study and work indoors and use sun protection.<sup>24,25</sup>

### **Ethnicity**

In tropical areas the population is generally of ethnicity with a darker skin tone compared to non-tropical areas, such as African or Malay. Since a darker skin is also less sufficient in absorbing sunlight for the production of vitamin D, individuals with darker skin may need three times as much sunlight exposure to obtain the same vitamin D levels compared to a person with lighter skin.<sup>10,26</sup> This also decreases the effectiveness of the sunlight present in the country. It was also mentioned that this probably explains why in Malaysia low levels of vitamin D are mostly found in individuals of Malay or Indian ethnicity, compared to those of Chinese ethnicity which generally have a lighter skin type.<sup>26</sup>

### **Sun-avoidance**

Sun avoiding behaviour such as staying inside, covering up and using sunscreen, can limit the absorption of UVB as the skin will not be directly exposed to sunlight.<sup>10,13,26</sup> Therefore, the vitamin D levels will also stay low. It was mentioned that the lack of sun-seeking behaviour may be due to the hot temperatures which would prevent people from going outside more, or the popular beauty standards in some of these areas (particularly southeast Asia) where fair skin is seen as preferable, especially for women.<sup>10</sup> Relatedly, the use of sunscreen was seen more among the female population.<sup>10</sup> In the end, however, the factor that contributed most to the lack of vitamin D, above sunscreen and wearing covering clothing, was staying in the shade.<sup>10</sup>

### **Religion**

Multiple articles mentioned that the high percentage of Muslim population in parts of southeast Asia (notably Malaysia) contributed to the lower levels of vitamin D.<sup>10,23,25,26</sup> The reason mentioned was mainly that Muslim women usually wear a clothing style that covers most of the skin, which limits UVB absorption. It was mentioned that the larger Muslim population in South Thailand, for example, was probably one of the bigger contributors to the difference in vitamin D level between North and South Thailand.<sup>23</sup> This covering clothing style was also mentioned as one of the reasons why being female was considered a risk factor for vitamin D deficiency. According to a national health survey conducted in Thailand, non-Muslims had a mean vitamin D level 10 nmol/L higher than Muslims, although it must be noted that this survey had an overrepresentation of non-Muslims (97%).<sup>10,23</sup>

### **Nutrition**

Another contributor mentioned, although not in much detail, was that in Thailand there are not many vitamin D-rich foods that are consumed daily, and additionally Thailand does not fortify their foods with supplementary vitamin D.<sup>22</sup> Similar problems were mentioned for Brazil, as oily fish and mushrooms are not widely available and not often consumed by the general population, and additionally the use of vitamin D supplements is reportedly very low (6% of the adult population).<sup>13,27,28</sup> It was also mentioned that in Malaysia, there is insufficient baseline data about what foods are fortified and to what extent they are consumed by the population, and they report this being crucial to developing a strategy to tackle the still insufficient vitamin D intake, implying the importance of nutrition to the vitamin D deficiency problem.<sup>26</sup> Also, it was mentioned that the population of the tropical island Hainan experienced especially low rates of vitamin D deficiency, of which reportedly one of the main contributors was the high consumption of oily fish, stressing the importance of nutrition in avoiding low levels of vitamin D.<sup>25</sup> Finally, all key points mentioned in the narrative review can be summarised in one figure, as can be seen in [Figure 2](#).

## **DISCUSSION**

In total, 7 articles were analysed for this narrative review, originating mostly from the PubMed database, in order to find causes for why people living in tropical areas with a year-long abundance of sunlight still suffer from high rates of vitamin D deficiency, and assess the importance of nutrition in this issue.

The key causes found in this review were urbanisation, ethnicity, sun-avoidance, religion, and nutrition, which were all mentioned in multiple articles across this narrative review. However, few articles researched the role of nutrition as a cause for the vitamin D deficiency in tropical areas, and rather regarded it as a possible solution and compensation.

There are various reasons mentioned why there is still a high prevalence of vitamin D deficiency in tropical countries, notably southeast Asia, even if sunlight is the main source of vitamin D for humans. The fact that people in these tropical areas avoid sunlight because of the heat and cannot absorb sunlight as effectively because of their darker skin tone might be factors that neutralise the advantage of having an abundance of sunlight all year long. After all, if the sunlight will not or cannot be effectively used, this advantage is meaningless. However, it must be noted that previous studies reported that even people with darker skin tones should be able to get enough vitamin D from sunlight exposure if they go outside at the right time of the day.<sup>10,29</sup> Therefore, skin tone may be ruled out as one of the main contributors to the issue.

When it comes to urbanisation and religion, these are not factors present only in tropical areas, so this does not necessarily fully explain why these tropical areas have a high prevalence of vitamin D deficiency compared to most western countries.

The last factor, nutrition, is the one that was least researched and often not considered at all. It has rarely been investigated as a possible cause of the vitamin D deficiency prevalence and is mostly mentioned as a possible solution to battle vitamin D deficiency. For future research, it may be wise to consider nutrition and especially malnutrition as a potential main contributor to the



high vitamin D deficiency in areas with abundant sunlight, considering it is one of the two direct sources of vitamin D.

Limitations of this study include its narrative nature that does not allow for statistical analysis, limiting its scientific relevance, however few of the articles included conducted any noteworthy statistical analyses so that it would not be productive to summarise them in this review. Another limitation is that only one database, namely PubMed was used as a source for articles, however through snowballing a wider scope of literature was reached.

The strengths of this study include the inclusion of articles from different tropical areas, such as southeast Asia and Brazil, making the results more generalisable. Studies which are focused on the exact cause of vitamin D deficiency are needed. There could be different causes in different areas.

Further research is warranted to explore the role of nutrition in contributing to this issue, as existing studies have not extensively considered it as a potential cause of vitamin D deficiency, despite it being one of the two exclusive natural sources of vitamin D.

## CONCLUSION

In conclusion, based on current scientific literature, the main reasons behind the high occurrence of vitamin D deficiency in tropical countries can be attributed to urbanization, religious practices, avoidance of sunlight, variations in skin tone, and nutritional factors. Among these factors, sun avoidance, skin tone, and nutrition appear to be specific to these regions. Despite the abundance of sunlight in tropical countries, the prevalence of vitamin D deficiency cannot solely undermine the consensus that sunlight exposure is the primary source of vitamin D.

## ACKNOWLEDGEMENT

We would like to thank Ms. Handayani from NECHRI Laboratory for her support and Ms. Hestiani Saharuddin from the Department of Pediatrics, Hasanuddin University's Faculty of Medicine, for her assistance in editing the manuscript.

## CONFLICT OF INTEREST

The authors declare no conflict of interest in this study.

## ETHICS CONSIDERATION

This review does not require any form of ethical approval.

## FUNDING

The author(s) received no financial support for the research, authorship, and/or publication of this article.

## AUTHORS' CONTRIBUTION

BF responsible for concept of the study, design of the study, definition of intellectual content, manuscript preparation, and guarantor of the study. AJ responsible for definition of intellectual content and manuscript review. SE responsible for literature search and manuscript preparation. AMP, ZH, ADBF, SHP, NRR, EA, AE, NM, Y, DI, and HK responsible for manuscript review.

## REFERENCES

1. Umar M, Sastry KS, Chouchane AI. Role of vitamin D beyond the skeletal function: A review of the molecular and clinical studies. *Int J Mol Sci.* 2018;19(6):1618.
2. Holick MF. Vitamin D status: measurement, interpretation, and clinical application. *Ann Epidemiol.* 2009;19(2):73–8.
3. Jukic AMZ, Hoofnagle AN, Lutsey PL. Measurement of vitamin D for epidemiologic and clinical research: Shining light on a complex decision. *Am J Epidemiol.* 2018;187(4):879–90.
4. Zhang R, Naughton DP. Vitamin D in health and disease: current perspectives. *Nutr J.* 2010;9:65.
5. Roth DE, Morris SK, Zlotkin S, Gernand AD, Ahmed T, Shanta SS, et al. Vitamin D supplementation in pregnancy and lactation and infant growth. *N Engl J Med.* 2018;379(6):535–46.
6. Bikle DD. Vitamin D: Newer concepts of its metabolism and function at the basic and clinical level. *J Endocr Soc.* 2020;4(2):bvz038.
7. Levine MA. Diagnosis and management of Vitamin D dependent rickets. *Front Pediatr.* 2020;8:315.
8. Marshall I, Mehta R, Ayers C, Dhumal S, Petrova A. Prevalence and risk factors for vitamin D insufficiency and deficiency at birth and associated outcome. *BMC Pediatr.* 2016;16(1):208.
9. Amrein K, Scherkl M, Hoffmann M, Neuwersch-Sommeregger S, Köstenberger M, Tmava Berisha A, et al. Vitamin D deficiency 2.0: an update on the current status worldwide. *Eur J Clin Nutr.* 2020;74(11):1498–513.
10. Nimitphong H, Holick MF. Vitamin D status and sun exposure in southeast Asia. *Dermatoendocrinol.* 2013;5(1):34–7.
11. Siddiquee MH, Bhattacharjee B, Siddiqi UR, MeshbahurRahman M. High prevalence of vitamin D deficiency among the South Asian adults: a systematic review and meta-analysis. *BMC Public Health.* 2021;21(1):1823.
12. Cribb VL, Northstone K, Hopkins D, Emmett PM. Sources of vitamin D and calcium in the diets of preschool children in the UK and the theoretical effect of food fortification. *J Hum Nutr Diet.* 2015;28(6):583–92.
13. Mendes MM, Hart KH, Botelho PB, Lanham-New SA. Vitamin D status in the tropics: Is sunlight exposure the main determinant? *Nutr Bull.* 2018;43(4):428–34.
14. Dominguez LJ, Farruggia M, Veronese N, Barbagallo M. Vitamin D sources, metabolism, and deficiency: Available compounds and guidelines for its treatment. *Metabolites.* 2021;11(4):255.
15. Divakar U, Sathish T, Soljak M, Bajpai R, Dunleavy G, Visvalingam N, et al. Prevalence of vitamin D deficiency and its associated work-related factors among indoor workers in a multi-ethnic Southeast Asian country. *Int J Environ Res Public Health.* 2019;17(1):164.
16. Holick MF. Vitamin D: a D-Lightful health perspective. *Nutr Rev.* 2008;66(10 Suppl 2):S182-94.
17. Holick MF, Chen TC. Vitamin D deficiency: a worldwide problem with health consequences. *Am J Clin Nutr.* 2008;87(4):1080S-6S.
18. Holick MF, Binkley NC, Bischoff-Ferrari HA, Gordon CM, Hanley DA, Heaney RP, et al. Evaluation, treatment, and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline. *J Clin Endocrinol Metab.* 2011;96(7):1911–30.
19. Moan J, Porojnicu AC, Dahlback A, Setlow RB. Addressing the health benefits and risks, involving vitamin D or skin cancer, of increased sun exposure. *Proc Natl Acad Sci U S A.* 2008;105(2):668–73.
20. Webb AR, Kift R, Durkin MT, O'Brien SJ, Vail A, Berry JL, et al. The role of sunlight exposure in determining the vitamin D status of the U.K. white adult population. *Br J Dermatol.* 2010;163(5):1050–5.
21. Lips P, van Schoor NM, de Jongh RT. Diet, sun, and lifestyle as determinants of vitamin D status. *Ann N Y Acad Sci.* 2014;1317:92–8.
22. Wakayo T, Belachew T, Vatanparast H, Whiting SJ. Vitamin D deficiency and its predictors in a country with thirteen months of sunshine: The case of school children in Central Ethiopia. *PLoS One.* 2015;10(3):e0120963.
23. Chailurkit L or, Aekplakorn W, Ongphiphadhanakul B. Regional variation and determinants of vitamin D status in sunshine-abundant Thailand. *BMC Public Health.* 2011;11:853.
24. Beer RJ, Herrán OF, Villamor E. Prevalence and correlates of vitamin D deficiency in a tropical setting: results from a nationally representative survey. *Am J Clin Nutr.* 2020;112(4):1088–98.

25. Lin L, Ou Q, Lin L, Zhang H, Chen K, Chen D, et al. Low prevalence of vitamin D deficiency in adult residents in Hainan, the tropical island province of China. *Ann Palliat Med*. 2021;10(5):5580–9.
26. Md Isa Z, Mohd Nordin NR, Mahmud MH, Hashim S. An update on vitamin D deficiency status in Malaysia. *Nutrients*. 2022;14(3):567.
27. Maeda SS, Borba VZC, Camargo MBR, Silva DMW, Borges JLC, Bandeira F, et al. Recommendations of the Brazilian Society of Endocrinology and Metabology (SBEM) for the diagnosis and treatment of hypovitaminosis D. *Arq Bras Endocrinol Metabol*. 2014;58(5):411–33.
28. Maeda SS, Saraiva GL, Kunii IS, Hayashi LF, Cendoroglo MS, Ramos LR, et al. Factors affecting vitamin D status in different populations in the city of São Paulo, Brazil: the São Paulo vitamin D Evaluation Study (SPADES). *BMC Endocr Disord*. 2013;13:14.
29. Setiati S. Vitamin D status among Indonesian elderly women living in institutionalized care units. *Acta Med Indones*. 2008;40(2):78–83.



This work is licensed under a Creative Commons Attribution