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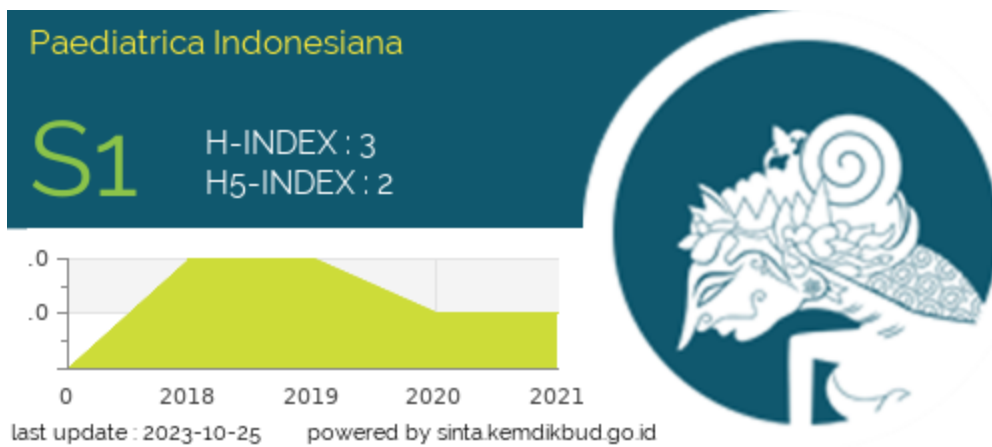
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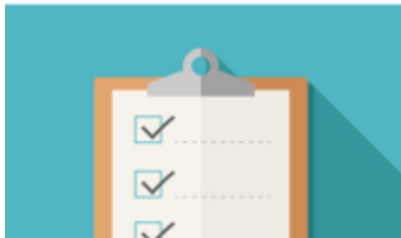
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Vitamin D deficiency in newborns: a tropical paradox

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Nancy Napitupulu,² Juandy Jo,^{4,5}

Abstract

Background Previous studies have shown a ‘tropical paradox’ in Indonesia, where despite being a tropical country with abundant sunlight, a widespread vitamin D inadequacy is observed in various populations. This paradox extends to Indonesian children, who predominantly exhibit low vitamin D levels, yet research specifically investigating vitamin D status in the newborn remains notably limited.

Objective To determine the prevalence of low level of vitamin D and elucidate its correlation with the conditions of newborns in Jakarta, Indonesia.

Methods This retrospective study analyzed data from newborns undergoing assessment at Siloam Hospital Kebon Jeruk, Jakarta, from June 2022 to May 2024. We collected the following data: newborn’s vitamin D level, demographic and clinical characteristics, as well as available maternal data. Serum 25-hydroxyvitamin D [25(OH)D] levels between < 20, 20-29.9 and ≥ 30 ng/mL were classified as deficient, insufficient, and sufficient, respectively. Statistical analyses were used to compare baseline characteristics and outcomes based on vitamin D status.

Results Of the 243 newborns studied, 70.4% were classified as vitamin D deficient, 22.2% as insufficient, and 7.4% as sufficient. Subjects’ median vitamin D level was 15.7 (range 1.2-57.1) ng/mL. No significant difference in vitamin D levels was observed between male and female newborns ($P=0.190$) and between newborns with birthweight <2,500 and the ones with birth weight ≥2,500 grams ($P=0.794$). Vitamin D levels were not significantly different between healthy and sick newborns ($P=0.537$). Maternal vitamin D status was available for only a small proportion (15.6%) of mothers, highlighting the need for further investigation into maternal-newborn vitamin D status.

Conclusion Although a high prevalence of newborn with vitamin D deficiency was observed in our study participants, no significant difference in vitamin D levels was observed between healthy and sick newborns. No correlation was observed between sex or birth weight, and vitamin D levels as well. Future inquiries should explore maternal vitamin D status in greater detail and assess the prolonged health consequences of hypovitaminosis D in newborns. [Paediatr Indones. 2025;66:1-7; DOI: <https://doi.org/10.14238/pi66.1.2025.1-7>].

Keywords: vitamin D deficiency; newborns; Indonesia; prevalence

Vitamin D exerts pleiotropic effects critical to newborns well-being, as well as influencing bone development, immune regulation, and various physiological functions essential for early growth.^{1,2} Despite advancements in diet and health technologies, vitamin D deficiency is emerging as an overlooked global health challenge, spreading quietly across populations worldwide.³ Beyond its well-documented role in calcium regulation and bone metabolism, vitamin D contributes to the regulation of the immune, neurological, and cardiovascular systems.⁴ In adults, a lack of vitamin D has been associated with several disorders, such as diabetes, as well as cardiovascular and various metabolic diseases.⁵

Dietary intake contributes to only a small percentage of the body's vitamin D levels, with the majority being generated in the skin via ultraviolet B (UVB) radiation-induced conversion of the steroid precursor 7-dehydrocholesterol.⁶ However,

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multiple factors influence this endogenous synthesis, including anthropometric status, age, sun exposure duration, skin pigmentation, seasonal variations, and geographical latitude. These factors have exacerbated vitamin D deficiency in both adults and infants, raising concerns about long-term health implications.^{5,6}

During the COVID-19 pandemic, vitamin D garnered heightened attention due to its immunomodulatory properties and potential role in mitigating disease severity.^{7,8} However, despite increased awareness, post-pandemic epidemiological statistics continue to indicate a persistent prevalence of vitamin D inadequacy among newborns. Furthermore, comprehensive investigations on this issue remain limited. Newborn vitamin D deficiency is particularly concerning due to its association with adverse health outcomes, including newborn sepsis,⁹ impaired bone mineralization,⁴ and neurodevelopmental disorders.⁵

Interestingly, Indonesia, a country characterized by abundant sunlight, faces a growing burden of vitamin D deficiency, particularly among newborns and young children.^{10,11} This trend raises critical questions regarding maternal vitamin D status, given that insufficient maternal vitamin D levels during gestation have been recognized as the primary risk factor for newborn vitamin D deficiency. Due to the biological connection between mother and child, insufficient perinatal vitamin D has gained heightened interest in the last two decades, which might have lasting effects on fetal and newborn health.¹² Given these concerns, investigating the prevalence of newborns' vitamin D deficiency is imperative to elucidating its associations with newborn morbidities and identifying effective preventive strategies. Thus we aimed to evaluate the prevalence of vitamin D deficiency among Indonesian newborns and explored its potential associations with newborn health outcomes.

Methods

This study used a retrospective design to assess the level of vitamin D in newborns and potential associations between vitamin D levels and newborn health outcomes. Data were collected from Siloam Hospital Kebon Jeruk, Jakarta, Indonesia, over a two-year period from June 2022 to May 2024.

The study utilized a consecutive sampling

approach, enrolling all eligible newborns who underwent serum vitamin D assessment during the specified timeframe. Inclusion criteria consisted of newborns in whom serum 25-hydroxyvitamin D [25(OH)D] levels were measured within the first days of life and whose guardians provided informed consent at the time of primary data collection.

Serum vitamin D levels were measured on day three post-birth, coinciding with routine hyperbilirubinemia screening in newborns. Venous blood specimens were collected (0.5 mL) and analyzed using an electrochemiluminescence immunoassay (ECLIA) method on a COBAS *e411* analyzer. Where available, maternal vitamin D status was also recorded to assess for potential maternal-newborn correlations. The classification of newborn vitamin D status was defined as deficient if the 25(OH)D was < 20 ng/mL (<50 nmol/L), insufficient if 25(OH)D was 20-29.9 ng/mL (50-74.9 nmol/L), and normal if ≥ 30 ng/mL (≥ 75 nmol/L).¹³

Newborns' data were obtained from two primary sources: the Transition Ward, where clinically stable (i.e. healthy) newborns were, and the neonatal intensive care unit (NICU), where medically compromised (i.e. sick) newborns were closely monitored. Demographic and clinical characteristics, including birth anthropometric measurements, gestational age, and maternal vitamin D status (if documented), were extracted from medical records.

The SPSS for Windows version 26.0 (IBM Corp., Armonk, NY, USA) was used for statistical analyses. Descriptive statistics were utilized to characterize baseline parameters and vitamin D concentrations. Comparisons between vitamin D status and newborn outcomes were performed according to the data distribution using parametric or non-parametric tests. Continuous variables are presented as median with range, due to the non-homogeneous distribution of the data. A significant result ($P < 0.05$) was followed up using the Mann-Whitney test.

Ethical approval was obtained from the Universitas Tarumanagara Ethics Committee. All processes adhered to the Declaration of Helsinki, ensuring confidentiality and complying with ethical standards for research involving human participants.

Results

The study population consisted of 243 newborns whose baseline characteristics are summarized in **Table 1**. Subjects' median gestational age was 38 (range 25-41) weeks and median birth weight was 2,950 (range 840-5,210) grams. The median serum vitamin D level among all newborns was 15.7 (range 1.2-57.1) ng/mL. Males represented 57.2% (n=139) of the study population, while females accounted for 42.8% (n=104). A notable proportion of newborns (107; 44%) required specialized care in the NICU for various health complications. Additionally, 191 (78.6%) newborns had birth weight of $\geq 2,500$ grams, whereas 52 (21.4%) newborns had birth weight below 2,500 grams. Maternal vitamin D status was available for only 15.6% of the participants (38/243 maternal participants).

Of 243 newborns, 171 (70.4%) had deficient vitamin D levels (< 20 ng/mL), while 54 (22.2%) had insufficient levels (20-29.9 ng/mL). Only 18 newborns (7.4%) had sufficient vitamin D levels (≥ 30 ng/mL) (**Table 2**). Taken together, 92.6% of newborn exhibited hypovitaminosis D (deficiency or insufficiency), indicating a high burden of vitamin D inadequacy in this study. The median vitamin D levels among healthy newborns were 16 (range 4.1-57.1) ng/mL, whereas in sick newborns, the levels were 15.2 (range 1.2-47.7) ng/mL. However, the difference in vitamin D levels between healthy and sick newborns was not statistically significant ($P=0.537$) (**Table 3**). No significant difference in vitamin D was observed between male and female newborns (15.2 (range

1.2-34.6) ng/mL vs. 16.1 (range 4.1-57.1) ng/mL, respectively ($P=0.190$). Similarly, birthweight did not significantly correlate with vitamin D levels ($P=0.794$). Newborns with birthweight $< 2,500$ grams had a median vitamin D level of 15.1 (range 5.6-47.7) ng/mL, while those with a birth weight $\geq 2,500$ grams had a median vitamin D level of 15.8 (range 1.2-57.1) ng/mL.

The data on health complications and vitamin D levels in newborns are summarized in **Table 4**. No significant associations were found between vitamin D status and low birth weight, respiratory distress, or perinatal infection.

Discussion

This study reported a high rate of vitamin D inadequacy was observed with 92.6% of participants failing to achieve sufficient levels of this essential nutrient. This high prevalence of vitamin D inadequacy represents the "tropical paradox", as Indonesia, despite being a tropical country with abundant sunlight, nonetheless exhibits widespread deficiency of this vitamin. The high prevalence of vitamin D inadequacy among newborns observed in this study aligns with findings from other tropical regions. For instance, a study conducted at a tertiary care center in India reported an 80% prevalence of vitamin D deficiency among both healthy and sick newborn.¹⁴ Similarly, another investigation from Saudi Arabia documented vitamin D deficiency in 86% of their studied newborn in a tertiary hospital.¹⁵ Despite

Table 1. Characteristics of newborn subjects

Variables	(N=243)
Median gestational age, weeks (range)	38 (25-41)
Median birth weight, grams (range)	2,950 (840-5,210)
Median vitamin D level, ng/mL (range)	15.7 (1.2-57.1)
Sex, n(%)	
Male	139 (57.2)
Female	104 (42.8)
Health condition, n(%)	
Healthy newborn	136 (56)
Respiratory distress	53 (21.8)
Perinatal infection	19 (7.8)
Hyperbilirubinemia	25 (10.3)
Congenital anomaly	7 (2.9)
Others (hypoglycemia, growth faltering, low nutrition intake)	3 (1.2)

being a country with year-round sunlight exposure, Indonesia continues to experience a high burden of vitamin D deficiency.^{10,11,16}

This paradox has been noted in previous studies and may be attributed to several factors, such as the limited food fortification, rural residency with crowded living conditions, air pollution, ultraviolet (UV) index, and skin pigmentation. All of these factors might collectively reduce cutaneous vitamin D synthesis. Furthermore, cultural practices, such as restrictions on outdoor activity, conservatively dressed, and the widespread use of sunscreen, further impede vitamin D production in the skin.^{17,18}

A systematic review also indicated a concerning high pooled prevalence of vitamin D deficiency (61%) among all newborn, which, while widespread even in non-septic infants (43.7%) and those with

sepsis (79.4%).⁹ In the current study, however, no significant differences in vitamin D levels were observed between healthy and sick newborns. This finding may be attributed to the uniformly low vitamin D levels prevalent across the entire newborn in our study, which likely masked any potential significant differences between the two groups.

One key factor contributing to low newborn vitamin D levels is maternal vitamin D deficiency.¹² Previous studies have demonstrated a strong correlation between maternal and fetal vitamin D status. Another systematic review noted a consistent correlation between maternal and newborn vitamin D deficiency across various countries.¹⁹ In Indonesia, Octavianus *et al.*¹¹ reported a hypovitaminosis D prevalence of 78% among pregnant women, while Oktaria *et al.*²⁰ found that 90% of newborns from mothers with vitamin D deficiency also had insufficient vitamin D levels, highlighting a direct relationship. However, maternal vitamin D levels were assessed in only 15.6% newborn of the mothers in our study participants, limiting the strength of the

Table 2. Vitamin D status of newborn subjects

Vitamin D status	(N=243)
Deficient (<20 ng/mL), n(%)	171 (70.4)
Insufficient (20 – 29.930 ng/mL), n(%)	54 (22.2)

Table 3. Analysis of newborn characteristics and vitamin D levels

Variables	(N=243)	Median vitamin D status (range), ng/mL	P value
Newborn status, n(%)			0.537
Healthy	136 (56.0)	16 (4.1-57.1)	
Sick	107 (44.0)	15.2 (1.2-47.7)	
Gender, n(%)			0.190
Male	139 (57.2)	15.2 (1.2-34.6)	
Female	104 (42.8)	16.1 (4.1-57.1)	
Birth weight, n(%)			0.794
<2,500 grams	52 (21.3)	15.1 (5.6-47.7)	
≥2,500 grams	191 (78.7)	15.8 (1.2-57.1)	

Table 4. Analysis of vitamin D status between health conditions of sick newborns

Variables	(N=243)	Vitamin D status			P value
		Deficient (n=171)	Insufficient (n=54)	Sufficient (n=18)	
Birthweight, n(%)					0.980
Normal	191 (78.6)	135 (70.7)	42 (22)	14 (7.3)	
Low*	52 (21.4)	36 (69.2)	12 (23.1)	4 (7.7)	
Respiratory distress, n(%)					0.788
No	184 (75.7)	131 (71.2)	39 (21.2)	14 (7.6)	
Yes	59 (24.3)	40 (67.8)	15 (25.4)	4 (6.8)	
Infection, n(%)					0.828
No	205 (84.4)	143 (69.8)	46 (22.4)	16 (7.8)	
Yes	38 (15.6)	28 (73.7)	8 (21.1)	2 (5.3)	

*Deficient <20 ng/mL; insufficient 20-29.9 ng/mL; sufficient ≥30ng/mL

conclusions (data not shown). Future studies should aim to include maternal vitamin D levels to strengthen the understanding of this association and develop more effective intervention strategies.

Research has consistently documented a widespread vitamin D deficiency among pregnant women in the third trimester living in tropical regions, including Indonesia, despite the high level of sunlight characteristic of these environments. Notably, Indonesia (11° South latitude to 6° North latitude) and Malaysia (1° North latitude to 7° North latitude), neighboring countries situated along the equator, receive substantial solar insolation year-round. Nonetheless, the prevalence of vitamin D deficiency remains exceedingly high (ranging from 45.5% to 82.2%).^{21,22} Cultural and religious practices, such as wearing hijabs or veils that cover most of the body except the face, hands, and feet, significantly diminish dermal exposure to sunlight, thereby elevating the risk of vitamin D insufficiency among women. Beyond Muslim attire, aesthetic ideals favoring fair skin, especially in many East Asian societies, encourage sun-avoidance behaviors, further limiting endogenous vitamin D synthesis. Additional cultural determinants include a preference for skin coverage, societal norms discouraging outdoor exposure, indoor-centric lifestyles, and extensive sun-protection practices such as sunscreen use, foundation with SPF, hats, sunglasses, and umbrellas. These factors may collectively lead to the counterintuitive situation observed in Indonesia, where ample sunlight does not translate into adequate vitamin D levels.^{21,22}

Fauziah et al. reported a pervasive culture of sun-avoidance and skin protection among Indonesian women.²³ A substantial majority (84.3%) reported utilizing long-sleeved clothing to cover their shoulders. Furthermore, the adoption of sunscreen was widespread, with 85.9% of respondents regularly applying products featuring an SPF of 15 or higher, and 68.5% specifically opting for sunscreens offering both UVA and UVB protection.²³

Additionally, the significant rate of vitamin D deficiency among newborns found in this study suggests that similar trends may be observed in other populations, particularly in tropical regions. This raises concerns about potential undiagnosed vitamin D deficiency cases in newborns, which may contribute to adverse health outcomes such as

impaired bone mineralization, immune dysfunction, and neurodevelopmental disorders.²⁴ Therefore, it is crucial for healthcare providers to be more vigilant regarding the occurrence of vitamin D deficiency, particularly in populations at risk such as newborns. Due to the high incidence of vitamin D deficiency in newborns, supplementation should be considered as a preventive measure.¹³

Strategic public health interventions are paramount, particularly in guiding maternal and newborn vitamin D supplementation programs. These efforts should underscore the imperative for supplementation, especially in populations demonstrating a high prevalence of vitamin D deficiency. Specific recommendations stemming from these findings include targeted supplementation that prioritize high-risk populations, such as pregnant women and newborn, particularly in settings where behavioral, cultural, or environmental factors compromise adequate cutaneous vitamin D synthesis. We also recommend conducting larger, well-designed studies to rigorously confirm the association between newborn vitamin D status and pertinent health risks and implement continuous and systematic assessment to ensure the efficacy and impact of supplementation programs. For a holistic perspective, we need to emphasize the broader significance of vitamin D's role in neurodevelopment and the potential benefits of its judicious supplementation. The public health policy also needs strategies to promote awareness and advocate judicious, safe sun exposure practices, particularly during optimal morning hours, while accounting for cultural sensitivities and individual risk factors.

In conclusion, this study highlights the prevalent deficiency of newborn vitamin D levels in Indonesia, emphasizing the need for targeted interventions. Future research should explore maternal vitamin D status in greater detail and assess the long-term health implications of newborn deficiency. The exceptionally high prevalence of deficiency in our study emphasizes a need for targeted strategies to mitigate vitamin D deficiency in newborns, particularly in tropical regions where sunlight exposure is abundant. Public health efforts should focus on increasing awareness, promoting sun exposure, and implementing supplementation programs to mitigate this issue.

Conflict of interest

None declared.

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