ORIGINAL ARTICLE

Prevalence and Risk Factors of Vitamin D Deficiency and Insufficiency in Thai Term Newborns

Seewalee Sidafong, MD[1], Supapan Tantracheewathorn, MD[1]

[1] Department of Pediatrics, Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok, Thailand.

Objective: To determine the prevalence of and factors associated with vitamin D deficiency and insufficiency among healthy full-term newborns in Bangkok, Thailand.

Materials and Methods: A cross-sectional study was conducted between July and December 2020 involving 136 pairs of mothers and their newborns. Venous blood samples were collected from mothers and their newborns at 48 to 72 hours postpartum to measure serum vitamin D levels. The maternal demographic, clinical data and vitamin D status were obtained and analyzed to explore associations with the neonatal vitamin D status.

Results: Among the 136 mother–newborn pairs, 17.6% of the mothers exhibited vitamin D deficiency, whereas 32.4% had insufficient levels. Among the newborns, vitamin D deficiency was found in 8.8% and insufficiency in 53.0%. A moderate positive correlation was observed between maternal and neonatal serum vitamin D levels ($r=0.525$, $p<0.001$). Independent risk factors for neonatal vitamin D deficiency and insufficiency included maternal vitamin D deficiency (adjusted odds ratio [AOR]: 25.37; 95% confidence interval [CI]: 2.70 to 238.39), maternal vitamin D insufficiency (AOR: 11.35; 95% CI: 3.60 to 35.81), maternal light-brown skin (AOR: 17.87; 95% CI: 2.40 to 133.07), maternal medium-brown skin (AOR: 7.80; 95% CI: 1.69 to 35.96), and inadequate sun exposure (AOR: 10.27; 95% CI: 1.63 to 64.67).

Conclusion: The present study highlights the high prevalence of vitamin D insufficiency and deficiency among term newborns and their mothers in Bangkok, Thailand. Maternal vitamin D status, skin color, and sun exposure emerged as significant factors of neonatal vitamin D levels. These findings emphasize the critical role of maternal health in shaping the neonatal vitamin D status.

Keywords: Prevalence; Risk factor; Term newborn; Vitamin D deficiency; Vitamin D insufficiency

Received 18 February 2025 | Revised 1 March 2025 | Accepted 12 March 2025

J Med Assoc Thai 2025;108(Suppl.1): S175-81

Website: http://www.jmatonline.com

Vitamin D is a crucial nutrient that plays an essential role in the metabolism of calcium and phosphate, promoting bone health, and it also exhibits many extraskeletal effects[(1,2)]. Vitamin D deficiency is a major public health problem worldwide, affecting individuals across all age groups[(3-5)]. Although Thailand is a tropical country with abundant sunlight, vitamin D deficiency is still prevalent among different populations, including infants, children, pregnant women, and elderly individuals[(6-10)].

The factors that contribute to vitamin D deficiency are multifaceted. One major factor is limited sun exposure resulting from lifestyle changes, such as increased indoor activities and the use of sun protection. In addition, the dietary intake of vitamin D is often insufficient, particularly in populations with low consumption of vitamin D–rich foods, such as fatty fish and fortified products[(11)].

The prevalence of vitamin D insufficiency or deficiency in infants ranges from 20.2% to 69.1%[(3)]. Due to the low vitamin D content in breast milk and inadequate sunlight exposure during infancy, newborns and infants are particularly vulnerable to vitamin D deficiency[(12,13)]. A study conducted at Chonprathan Hospital in Nonthaburi, Thailand, found that 20.2% of newborns had vitamin D deficiency, whereas 69.1% had insufficient levels. Furthermore, the maternal vitamin D status during pregnancy significantly influences neonatal vitamin D levels[(14)].

Because of the high prevalence of vitamin D deficiency in newborns, it is essential to identify at-risk populations and understand the factors contributing to the development of effective prevention strategies. In the present study, we aimed to investigate the prevalence and risk factors associated with vitamin D deficiency in Thai newborns,

Correspondence to:

Tantracheewathorn S.

Department of Pediatrics, Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok 10300, Thailand

Phone: +66-2-2443066

Email: supapan.t@nmu.ac.th

How to cite this article:

Sidafong S, Tantracheewathorn S. Prevalence and Risk Factors of Vitamin D Deficiency and Insufficiency in Thai Term Newborns. J Med Assoc Thai 2025;108(Suppl.1): S175-81.

DOI: 10.35755/jmedassocthai.2025.S01.S175-S181

providing critical insights into a vulnerable population that requires early intervention to prevent long-term health complications.

Materials and Methods

This cross-sectional study was conducted at the Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok, Thailand. The Institutional Review Board of the Faculty of Medicine Vajira Hospital approved the study protocol (COA 143/2562, October 24, 2019).

Sample size estimation

The authors estimated the sample size using the formula, $n = \frac{Z^2_{\alpha/2}(p)(1-p)}{d^2}$ where p represents the prevalence of vitamin D deficiency and insufficiency and d is the margin of error. Based the study by Kansuda et al.[14], which reported a prevalence of 89.3%, the sample size calculation assumed an acceptable margin of error of 6% (d=5.358%) and a significance level of 0.05 (α). The estimated minimum required sample size was 128 participants. To account for potential missing data, the authors enrolled a total of 138 participants in the present study.

Participant recruitment

In accordance with the Declaration of Helsinki, we obtained written informed consent from the mothers before initiating the present study. Inclusion criteria was term neonates (born between 37 and 42 weeks of gestation) with a normal birth weight (2,500 to 4,000 g) and a 5-minute APGAR score of ≥7; and their mothers who had delivered in the hospital between July 1 and December 31, 2020. The exclusion criteria included mother with perinatal morbidities, those unable to read or communicate in Thai, newborns with congenital anomalies, infections, any morbidities, or incomplete assessment of vitamin D level for both mother and newborn.

Data collection

The researcher (S.S.) interviewed the mothers on the second day postpartum in the postpartum ward. The questionnaire comprised personal data of the mothers and newborns including age, pre-pregnancy weight and height, smoking exposure (both active and passive), underlying diseases, duration of daily sun exposure, sunscreen use, intake of vitamin D–rich foods (such as fatty fish [e.g., salmon, tuna, mackerel, and sardines] as well as cod liver oil and mushrooms), vitamin D supplements taken during pregnancy, season of birth, infant sex, and type of feeding.

The duration of sun exposure was defined as any outdoor activity occurring between 10 AM and 3 PM in the previous 3 months. Sun exposure time ≥15 minutes/day was categorized as adequate and <15 minutes/day as inadequate[15]. The intake of vitamin D–rich food was classified as regular (>3 times/week) or not (<3 times/week). The researcher (S.S.) assessed the skin color in the nonexposed areas of the mothers' inner arms using Fitzpatrick skin-type classification[16].

We confirmed the self-reported weight and height of the mothers by reviewing the medical chart. Pre-pregnancy body mass index (BMI) was calculated as weight divided by the square of height (kg/m^2) and categorized into 4 groups as underweight (<18.5 kg/m^2), normal (18.5 to 24.9 kg/m^2), overweight (25.0 to 29.9 kg/m^2), and obese (≥30 kg/m^2[17]. Infant weight was measured using a digital weighing machine (Seca 374), which was calibrated daily. To measure the vitamin D level (serum 25(OH)D), we collected a 1-mL venous blood sample from both mothers and their newborns between 48 and 72 hours postpartum.

Laboratory analyses

The authors measured serum 25(OH)D levels using the electrochemiluminescence immunoassay (ECLIA) method (Elecsys vitamin D total II assay on the Cobas® 8000 e801 analyzer, Roche Diagnostics, Basel, Switzerland), which correlated well with those measured by the CDC vitamin D reference laboratory using liquid chromatography tandem mass spectrometry (r=0.980)[18]. In the ECLIA tests, internal quality controls were included in each batch to ensure accuracy and precision. We defined the vitamin D status based on the serum 25(OH)D level as follows: vitamin D deficiency as <12 ng/mL (<30 nmol/L), insufficiency as 12 to 20 ng/mL (30 to 50 nmol/L), and sufficiency as >20 ng/mL (>50 nmol/L)[19].

Statistical analysis

We conducted all statistical analyses using SPSS version 29® (IBM SPSS Statistics for Windows, IBM Corp., Armonk, NY, 2022). Categorical variables were expressed as numbers (%), and continuous variables were presented as the mean ± standard deviation or median (interquartile range, IQR).

We assessed the association between maternal and neonatal vitamin D levels using the Chi-square or Fisher's exact test as appropriate. Pearson's correlation coefficient was used to evaluate the correlation between these levels. To identify the independent factors associated with neonatal vitamin D status, the factors significant in the univariate analysis were included in a multivariate analysis using logistic regression. A p-value of less than 0.05 was considered statistically significant.

Results

Of the 138 pairs of mothers and their newborns included in the study, we excluded 2 pairs due to missing serum 25(OH)D data for the newborns, resulting in 136 pairs of mothers and newborns included in the analysis. Table 1 shows the characteristics of the 136 mother-newborn pairs. The mean age of the mothers was 27.71±6.24 years, and the mean pre-pregnancy BMI was 23.95±4.40 kg/m^2. The median duration of daily sun exposure was 60 minutes (IQR: 30 to 90 minutes), with 80.9% of mothers were considered adequate sun exposure. Regular intake of vitamin D–rich food was reported in only 8.8% of the mothers, and none had vitamin D supplements during pregnancy. During the study period, which was in the rainy season (July to October) and winter (November to December), 31.6% of newborns were born in the rainy season and 68.4% in winter. The mean gestational age was 39.0±1.0 weeks. The mean birthweight was 3,092.0±317.2 g, and 77.2% of the newborns were exclusively breastfed.

Table 1. Characteristics of the 136 mother-newborn pairs

Characteristics	n	%
Maternal features		
Maternal age (years)		
<25	49	36.0
≥25	87	64.0
Pre-pregnancy BMI (kg/m^2)		
Underweight	8	5.9
Normal	87	64.0
Overweight and obesity	41	30.1
Underlying disease		
No	123	90.4
Yes	13	9.6
Skin color		
Light brown	24	17.6
Medium brown	92	67.7
Dark brown	20	14.7
Sun exposure (min)		
Adequate	110	80.9
Inadequate	26	19.1
Sunscreen product use		
No	102	75.0
Yes	34	25.0
Regular intake of vitamin D-rich food		
No	124	91.2
Yes	12	8.8
Vitamin D supplementation		
No	136	100.0
Yes	-	-
Smoke exposure		
No	87	64.0
Yes	49	36.0
Season of birth		
Summer	-	-
Winter	93	68.4
Rainy	43	31.6
Neonatal features		
Gender		
Male	70	51.5
Female	66	48.5
Type of feeding		
Breast milk	105	77.2
Mixed breast milk and infant formula	31	22.8

Table 2 shows the numbers and percentages of mothers and newborns according to vitamin D status, along with their median vitamin D values. Half (50.0%) of the mothers had sufficient vitamin D levels, 32.4% had insufficient levels, and 17.6% were deficient. The neonatal vitamin D levels were sufficient in 38.2%, insufficient in 53.0%, and deficient in 8.8%.

Table 3 indicates a head-to-head comparison of vitamin D status between mothers and their newborns, demonstrating that maternal vitamin D status significantly affected the vitamin D status of their newborns (p<0.001). Among the newborns born to vitamin D sufficient mothers, none had vitamin D deficiency and 64.7% had vitamin D sufficiency. Conversely, among the newborns born to vitamin D deficient mothers, 33.3% had vitamin D deficiency and only 4.2% had sufficient levels. We noted a direct correlation between maternal and neonatal vitamin D levels, as shown in Figure 1, which illustrates a moderate correlation between the two variables (Pearson correlation coefficient = 0.525, p<0.001).

Table 2. Vitamin D levels and status of mothers and newborns

Vitamin D status	n (%)	Serum 25(OH)D (ng/mL), median (IQR)
Mother		
Deficiency	24 (17.6)	9.8 (8.9 to 11.1)
Insufficiency	44 (32.4)	16.9 (14.3 to 18.4)
Sufficiency	68 (50.0)	25.2 (23.0 to 29.1)
Newborn		
Deficiency	12 (8.8)	9.6 (7.1 to 11.0)
Insufficiency	72 (53.0)	16.5 (14.8 to 18.3)
Sufficiency	52 (38.2)	24.5 (22.0 to 26.7)

Vitamin D status was categorized as follows: deficiency (<12 ng/mL), insufficiency (12 to 20 ng/mL), and sufficiency (>20 ng/mL).

Table 3. Head-to-head comparison of vitamin D status between mothers and their newborns

Maternal vitamin D status; n (%)	Neonatal vitamin D status			p-value
	Deficiency	Insufficiency	Sufficiency	
Deficient	8 (33.3)	15 (62.5)	1 (4.2)	<0.001
Insufficient	4 (9.1)	33 (75.0)	7 (15.9)	
Sufficient	-	24 (35.3)	44 (64.7)	

*Chi-square test, significant level at p-value <0.05

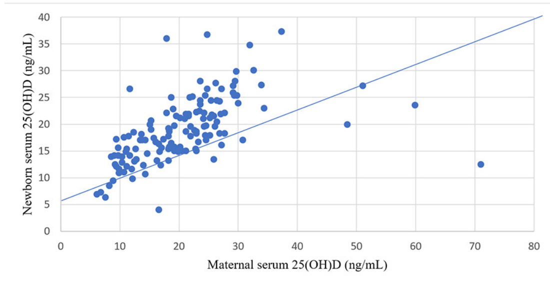

Figure 1. Correlation of serum 25(OH)D concentrations of the mothers and their neonates; r=0.525, p-value <0.001.

Table 4 demonstrates the maternal and neonatal factors associated with neonatal vitamin D status. In the univariate analysis, the factors significantly associated with neonatal vitamin D insufficiency and deficiency included maternal vitamin D insufficiency or deficiency, maternal light or medium-brown skin color, and inadequate sun exposure. These factors remained statistically significant in the multivariate analysis. The authors observed no significant associations between the neonatal vitamin D status and factors such as the season of birth, sunscreen use, maternal intake of vitamin D–rich food, underlying diseases, maternal smoking or exposure to smoking during pregnancy, infant gender, or type of milk feeding at birth.

Discussion

In the present study, we demonstrated that 32.4% of the mothers had insufficient vitamin D levels, whereas 17.6% were deficient. Among the newborns, 53.0% exhibited insufficient vitamin D levels, and 8.8% were classified as deficient. These findings highlight the pervasive issue of inadequate vitamin D among both mothers and their newborns, which is consistent with prior studies conducted in Thailand and other global regions[3,4,14].

The correlation between maternal and neonatal vitamin D levels in the present study (r=0.525) aligns with the findings of Owie et al., who reported a similar correlation (r=0.57)[20]. However, a systematic review and meta-analysis of nine studies reported a higher correlation between maternal vitamin D levels during pregnancy and cord blood concentrations (r=0.70, 95% CI: 0.66 to 0.74)[21]. The lower correlation observed in the present study may be attributed to the differences in the sample collection methods. In this study, we obtained serum 25(OH)D levels from the venous blood of newborns at 48 to 72 hours postpartum, whereas the studies included in the meta-analysis measured vitamin D levels from cord blood, which directly reflects maternal-to-fetal vitamin D transfer. Cord blood sampling likely provides a more immediate representation of the maternal vitamin D status, thereby yielding a stronger correlation. The direct relationship between maternal and neonatal vitamin D levels underscores the significant influence of maternal vitamin D status on neonatal vitamin D levels. Newborns born to mothers with sufficient vitamin D levels were more likely to achieve adequate vitamin D status, whereas those born to mothers with insufficient or deficient levels faced a higher risk of vitamin D inadequacy. These findings emphasize the importance of optimizing maternal vitamin D levels during pregnancy to support neonatal health and decrease the risk of vitamin D deficiency in their newborns.

Our analysis identified factors significantly associated with neonatal vitamin D status including maternal vitamin D status, duration of sun exposure, and maternal skin color. Among these, maternal vitamin D deficiency emerged as the strongest risk factor, which is consistent with the findings from a study conducted in Turkey[22]. Among newborns born to mothers with vitamin D deficiency, nearly all (95.8%) had either vitamin D deficiency or insufficiency, while only 4.2% had sufficient vitamin D levels. In contrast, none of the newborns born to mothers with sufficient vitamin D levels had vitamin D deficiency, and 64.7% exhibited sufficient vitamin D levels. Despite the Ministry of Public Health of Thailand's recommendations of a daily allowance of 600 IU of vitamin D for pregnant women[23], vitamin D supplementation is not included in routine antenatal prescriptions. This was evident in our study, in which none of the mothers received vitamin D supplementation and only 8.8% reported regular consumption of vitamin D–rich foods. Previous studies have demonstrated that maternal supplementation with vitamin D during pregnancy significantly improves maternal serum vitamin D levels and prevents deficiency in both mothers and their newborns[14,24]. Based on these findings, we strongly recommend the incorporation of vitamin D supplementation into antenatal care alongside iron, iodine, and folate to ensure optimal maternal and neonatal vitamin D levels.

Cutaneous synthesis is a primary source of vitamin D in the body. The synthesis of vitamin D in the skin is influenced by multiple factors, including latitude, season, time of day, duration of sun exposure, surface area of the exposed skin, skin pigmentation, type of clothing, and use of sunscreen[11]. With regard to sun exposure, our study identified inadequate maternal sun exposure as an independent risk factor for vitamin D deficiency and insufficiency in their newborns. This finding aligns with previous studies reporting that time spent outdoors during pregnancy significantly influenced both maternal and neonatal vitamin D levels[20,25]. These results underscore the importance of maternal sun exposure in preventing vitamin D deficiency in newborns, warranting further investigation and evaluation. In our study, we found no significant association between the season of birth and neonatal vitamin D status. This lack of seasonal variation

Table 4. The maternal and neonatal factors associated with neonatal vitamin D status

	Newborns with vitamin D insufficiency and deficiency, n (%)	Newborns with vitamin D sufficiency, n (%)	Crude odds ratio (95% CI)	p-value*	Adjusted odds ratio (95% CI)	p-value**
Maternal vitamin D status						
Sufficiency	24 (35.3)	44 (64.7)	1		1	
Insufficiency	37 (84.1)	7 (15.9)	9.69 (3.75 to 25.02)	<0.001	11.35 (3.60 to 35.81)	<0.001
Deficiency	23 (95.8)	1 (4.2)	42.17 (5.36 to 331.82)	<0.001	25.37 (2.70 to 238.39)	0.005
Maternal age				0.084		0.078
<25 years	35 (71.4)	14 (28.6)	1		1	
≥25 years	49 (56.3)	38 (43.7)	0.52 (0.24 to 1.09)		0.39 (0.14 to 1.11)	
Maternal BMI						
Normal	53 (60.9)	34 (39.1)	1		1	
Wasting	6 (75.0)	2 (25.0)	1.93 (0.37 to 10.09)	0.439	1.54 (0.55 to 4.28)	0.412
Overweight and obesity	25 (61.0)	16 (39.0)	1.00 (0.47 to 2.15)	0.995	1.05 (0.12 to 8.93)	0.968
Underlying disease				0.230		0.902
No	78 (63.4)	45 (36.6)	1		1	
Yes	6 (46.2)	7 (53.8)	0.50 (0.16 to 1.56)		0.91 (0.19 to 4.28)	
Maternal skin color						
Dark brown	6 (30.0)	14 (70.0)	1		1	
Medium brown	58 (63.0)	34 (37.0)	3.98 (1.40 to 11.33)	0.010	7.80 (1.69 to 35.96)	0.008
Light brown	20 (83.3)	4 (16.7)	11.67 (2.77 to 49.13)	<0.001	17.87 (2.40 to 133.07)	0.005
Sun exposure				0.017		0.013
Adequate	67 (57.3)	50 (42.7)	1		1	
Inadequate	17 (89.5)	2 (10.5)	6.34 (1.40 to 28.72)		10.27 (1.63 to 64.67)	
Sunscreen use				1.000		0.911
No	63 (61.8)	39 (38.2)	1		1	
Yes	21 (61.8)	13 (38.2)	1.00 (0.45 to 2.22)		0.93 (0.28 to 3.07)	
Vitamin D-rich food intake				0.384		0.198
Adequate	6 (50.0)	6 (50.0)	1		1	
Inadequate	78 (62.9)	46 (37.1)	1.70 (0.52 to 5.57)		3.61 (0.51 to 25.44)	
Vitamin D supplements				-		-
Yes	0	0	-		-	
No	84 (61.8)	52 (38.2)	-		-	
Smoke exposure				0.787		0.943
No	53 (60.9)	34 (39.1)	1		1	
Yes	31 (63.3)	18 (36.7)	1.11 (0.54 to 2.28)		0.96 (0.33 to 2.83)	
Season of birth				0.554		0.559
Rainy	25 (58.1)	18 (41.9)	1		1	
Winter	59 (63.4)	34 (36.6)	1.25 (0.60 to 2.61)		0.72 (0.24 to 2.14)	
Infant gender				0.430		0.162
Male	41 (58.6)	29 (41.4)	1		1	
Female	43 (65.2)	23 (34.8)	1.32 (0.66 to 2.65)		2.06 (0.75 to 5.65)	
Type of feeding				0.720		0.570
Breast milk	64 (61.0)	41 (39.0)	1		1	
Mixed breast milk and infant formula	20 (64.5)	11 (35.5)	1.17 (0.51 to 2.68)		1.43 (0.41 to 4.96)	

* The p-value by Binary logistic regression, significant level <0.05

** The p-value by Binary logistic regression, significant level <0.05, adjusted for all features except maternal vitamin D supplementation

might be explained by Bangkok's geographical location near the equator, where abundant sunlight is available year-round, resulting in minimal seasonal differences in sun exposure.

An unexpected finding in this study was that mothers with dark-brown skin had a reduced risk of vitamin D deficiency and insufficiency in their newborns. This result contrasts with the established understanding that melanin in darker skin acts as a natural sunscreen, inhibiting cutaneous the synthesis of vitamin D and increasing the risk of deficiency[26]. A plausible explanation for this finding could be that mothers with medium-brown or dark-brown skin tones in the present study had greater sun exposure, resulting in higher maternal serum vitamin D levels and consequently a lower risk of deficiency in their newborns. However, to better understand the potential relationship between maternal skin pigmentation, sun exposure, and vitamin D status, this assumption warrants further investigation.

The present study has several notable strengths. First, vitamin D-level data were collected for both mothers and newborns, which enabled a direct comparison and provided valuable insights into the relationship between maternal and neonatal vitamin D status. Because assessments of vitamin D levels are not routinely performed in health care settings due to reimbursement constraints, this approach offers a comprehensive perspective on this important health issue. Second, by measuring the vitamin D levels of newborns a few days after birth, our study provides a more accurate representation of their true vitamin D status, as opposed to cord blood levels, which may be influenced by immediate maternal transfer. Finally, the inclusion of multiple factors in the analysis that potentially influenced vitamin D synthesis strengthens the study's ability to identify key determinants of the neonatal vitamin D status, providing important considerations for future prevention strategies.

On the other hand, certain limitations should be acknowledged. First, we conducted this study at a single institution, potentially limiting the generalizability of the findings to the broader Thai population. Second, the cross-sectional design of this research precludes establishing causality between maternal and neonatal vitamin D levels. Finally, some data on key factors, such as duration of sun exposure, sunscreen use, and intake of vitamin D–rich foods, were self-reported by mothers and may be subject to recall bias. To improve data reliability and to clarify the causal relationships between maternal and neonatal vitamin D status, future longitudinal and multicenter studies incorporating objective data collection methods are necessary.

The high prevalence of vitamin D insufficiency and deficiency that we observed in our study population highlights the urgent need for public health interventions aimed at improving the vitamin D status among pregnant women and their newborns. The significant association between maternal and neonatal vitamin D levels underscores the potential efficacy of maternal supplementation as a strategy for enhancing neonatal vitamin D status. Interventions should focus on promoting adequate sun exposure, encouraging dietary modifications to include vitamin D–rich foods, and incorporating routine vitamin D supplementation during pregnancy and early infancy. These strategies could play a critical role in reducing the burden of vitamin D deficiency in pregnant women and their newborns.

Conclusion

The present study highlights the high prevalence of vitamin D insufficiency and deficiency among term newborns and their mothers in Bangkok, Thailand. Maternal vitamin D status, skin color, and sun exposure emerged as significant factors affecting the vitamin D levels of newborns. These findings emphasize the critical role of maternal health in shaping neonatal outcomes and underscore the need for comprehensive public health initiatives aimed at improving the vitamin D status in this population.

What is already known on this topic?

Vitamin D deficiency and insufficiency are prevalent worldwide.

Maternal vitamin D status is a determinant of neonatal vitamin D levels, as vitamin D is transferred from mother to fetus during pregnancy.

Factors such as sun exposure, skin pigmentation, and dietary intake significantly influence vitamin D synthesis and status.

What this study adds?

The present study highlights a high prevalence of vitamin D insufficiency and deficiency among term newborns and their mothers in Bangkok, Thailand, underscoring a regional public health concern.

Maternal vitamin D status, skin color, and sun exposure were identified as significant predictors of neonatal vitamin D levels.

The findings emphasize the need for targeted public health interventions, including maternal supplementation, dietary modifications, and promotion of adequate sun exposure, to improve maternal and neonatal vitamin D status in tropical regions.

Acknowledgements

The authors would like to express sincere gratitude to the mothers and their newborns who participated in this study and thank Assistant Professor Budsaba Wiriyasirivaj and Witchakorn Ruamtawee for the statistical analyses.

Funding disclosure

The study was funded by Navamindradhiraj University

Research Fund (grant No. 04/2563). Funder does not play any role in the present study.

Conflicts of interest

The authors declare no conflict of interest.

References

1. Castano L, Madariaga L, Grau G, García-Castaño A. 25(OH)Vitamin D deficiency and calcifediol treatment in pediatrics. Nutrients 2022;14:1854. doi: 10.3390/nu14091854.
2. Bouillon R, Marcocci C, Carmeliet G, Bikle D, White JH, Dawson-Hughes B, et al. Skeletal and extraskeletal actions of vitamin D: Current evidence and outstanding questions. Endocr Rev 2019;40:1109-51.
3. Palacios C, Gonzalez L. Is vitamin D deficiency a major global public health problem? J Steroid Biochem Mol Biol 2014;144 Pt A:138-45.
4. Saraf R, Morton SM, Camargo CA Jr, Grant CC. Global summary of maternal and newborn vitamin D status - a systematic review. Matern Child Nutr 2016;12:647-68.
5. Creo AL, Thacher TD, Pettifor JM, Strand MA, Fischer PR. Nutritional rickets around the world: an update. Paediatr Int Child Health 2017;37:84-98.
6. Rojroongwasinkul N, Kijboonchoo K, Wimonpeerapattana W, Purttiponthanee S, Yamborisut U, Boonpraderm A, et al. SEANUTS: the nutritional status and dietary intakes of 0.5-12-year-old Thai children. Br J Nutr 2013;110 Suppl 3:S36-44.
7. Chailurkit LO, Aekplakorn W, Ongphiphadhanakul B. Regional variation and determinants of vitamin D status in sunshine-abundant Thailand. BMC Public Health 2011;11:853. doi: 10.1186/1471-2458-11-853.
8. Kasemsripitak S, Jaruratanasirikul S, Boonrusmee S, Saengkaew T, Sriplung H. Prevalence and risk factors for vitamin D insufficiency in 6-12-month-old infants: a cross-sectional study in Southern Thailand. BMC Pediatr 2022;22:729. doi: 10.1186/s12887-022-03797-y.
9. Reesukumal K, Manonukul K, Jirapongsananuruk O, Krobtrakulchai W, Hanyongyuth S, Chatsiricharoenkul S, et al. Hypovitaminosis D in healthy children in Central Thailand: prevalence and risk factors. BMC Public Health 2015;15:248. doi: 10.1186/s12889-015-1588-6.
10. Pratumvinit B, Wongkrajang P, Wataganara T, Hanyongyuth S, Nimmannit A, Chatsiricharoenkul S, et al. Maternal vitamin D status and its related factors in pregnant women in Bangkok, Thailand. PLoS One 2015;10:e0131126.
11. Chang SW, Lee HC. Vitamin D and health - The missing vitamin in humans. Pediatr Neonatol 2019;60:237-44.
12. 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;96:1911-30.
13. Leerbeck E, Søndergaard H. The total content of vitamin D in human milk and cow's milk. Br J Nutr 1980;44:7-12.
14. Ariyawatkul K, Lersbuasin P. Prevalence of vitamin D deficiency in cord blood of newborns and the association with maternal vitamin D status. Eur J Pediatr 2018;177:1541-5.
15. Cediel G, Pacheco-Acosta J, CastiUo-Durdn C. Vitamin D deficiency in pediatric clinical practice. Arch Argent Pediatr 2018;116:e75-81.
16. Fitzpatrick TB. The validity and practicality of sun-reactive skin types I through VI. Arch Dermatol 1988;124:869-71.
17. World Health Organization. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. World Health Organ Tech Rep Ser 2000;894:i-xii, 1-253.
18. Lim S, Lee K, Woo HY, Park H, Kwon MJ. Evaluation of cobas 8000 analyzer series module e801 analytical performance. Ann Clin Lab Sci 2019;49:372-9.
19. Munns CF, Shaw N, Kiely M, Specker BL, Thacher TD, Ozono K, et al. Global consensus recommendations on prevention and management of nutritional rickets. J Clin Endocrinol Metab 2016;101:394-415.
20. Owie E, Afolabi BB. Vitamin D deficiency in pregnant women and newborns in Lagos, Nigeria. J Obstet Gynaecol 2018;38:616-21.
21. Wong RS, Tung KTS, Mak RTW, Leung WC, Yam JC, Chua GT, et al. Vitamin D concentrations during pregnancy and in cord blood: a systematic review and meta-analysis. Nutr Rev 2022;80:2225-36.
22. Özdemir AA, Ercan Gündemir Y, Küçük M, Yıldıran Sarıcı D, Elgörmüş Y, Çağ Y, et al. Vitamin D deficiency in pregnant women and their infants. J Clin Res Pediatr Endocrinol 2018;10:44-50.
23. Department of Health, Ministry of Public Health, Thailand. Dietary reference intakes for Thais 2020. Nonthaburi: Ministry of Public Health, Thailand; 2020.
24. Aghajafari F, Field CJ, Weinberg AR, Letourneau N. Both mother and infant require a vitamin D supplement to ensure that infants' vitamin D status meets current guidelines. Nutrients 2018;10:429. doi: 10.3390/nu10040429.
25. Wang C, Gao J, Liu N, Yu S, Qiu L, Wang D. Maternal factors associated with neonatal vitamin D deficiency. J Pediatr Endocrinol Metab 2019;32:167-72.
26. Sotunde OF, Laliberte A, Weiler HA. Maternal risk factors and newborn infant vitamin D status: a scoping literature review. Nutr Res 2019;63:1-20.