Medical : Jurnal Kesehatan Dan Kedokteran
Volume 3, Issue 2, July-December 2026
e-ISSN: 3064-6472 (online)
https://jurnal.sinesia.id/index.php/Medical-JKK/index

The Association Between Vitamin D Supplementation Dose in Pregnant Women and Birth Weight

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Info Article
|Submitted: 5 September 2026 **|Revised**: 24 September 2026 **|Accepted**: 4 November 2026
|Published: 4 November 2026
How to cite: Fatiha Azka Ghassani, etc., "The Association Between Vitamin D Supplementation Dose in Pregnant Women and Birth Weight", *Medical : Jurnal Kesehatan Dan Kedokteran*, Vol. 3, Issue 2, July-December, 2026, P. 325-339.

ABSTRACT

Background: Vitamin D supports maternal calcium metabolism and fetal skeletal development, but evidence on whether supplementation dose is associated with birth weight remains inconsistent. Low birth weight (LBW), defined as birth weight below 2,500 g, remains an important neonatal health concern. Objective: This study examined the association between maternal vitamin D supplementation dose and birth weight and assessed potential maternal confounders. Methods: A quantitative cross-sectional study was conducted among 170 mothers who delivered live-born infants between 2023 and 2026 and reported taking vitamin D-containing supplements during pregnancy. Data were collected using a self-administered online questionnaire. Supplementation dose was categorized as <400, 400–600, 601–4,000, >4,000 IU/day, or unknown; birth weight was classified as normal (2,500–3,999 g) or LBW (<2,500 g). Univariate and bivariate analyses were performed, followed by binary logistic regression for variables with bivariate p-values <0.25. Results: Vitamin D supplementation dose was not associated with LBW in bivariate analysis (p=0.942) and was not retained in the adjusted model. Gestational age, parity, hypertension/preeclampsia history, previous LBW, secondhand smoke exposure, and maternal vitamin D knowledge were associated with birth weight in bivariate analyses. After adjustment, gestational age <37 weeks was the only variable significantly associated with LBW (B=2.577; p=0.015; OR=13.155; 95% CI 1.653–104.693). The wide confidence interval indicates substantial uncertainty in the effect estimate and warrants cautious interpretation. The remaining variables were not statistically significant in the multivariable model. Conclusion: In this sample, supplementation dose was not independently associated with birth weight, while gestational age was the only significant adjusted correlate of LBW. These cross-sectional findings indicate statistical associations and do not establish causal effects. Antenatal care should encourage adequate vitamin D intake and monitor gestational duration as part of efforts to reduce LBW.
Keyword: *low birth weight; vitamin D supplementation; vitamin D dose; gestational age*

Introduction

Vitamin D contributes to maternal calcium homeostasis, immune regulation, and fetal skeletal and tissue development. Dietary or supplemental vitamin D is hydroxylated in the liver to 25-hydroxyvitamin D [25(OH)D] and then activated in the kidney to 1,25-dihydroxyvitamin D (calcitriol). Through intestinal calcium absorption, fetal bone mineralization, vitamin D receptor–mediated growth-related gene expression, and placental function, adequate vitamin D status supports a healthy pregnancy (Curtis et al., 2018; Danese et al., 2020; Gerovasili et al., 2025).

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Recommendations on supplementation are not uniform: general guidance commonly suggests about 400–600 IU/day, whereas higher regimens may be considered for women at risk of deficiency. Vitamin D deficiency during pregnancy remains widespread, including in Indonesia, where a systematic review reported a high pooled prevalence, particularly in the third trimester. These differing recommendations and the prevalence of deficiency underscore the need to clarify how supplementation dose relates to birth weight (Irwinda et al., 2022; Octavius et al., 2023).

Low birth weight (LBW), defined as a birth weight below 2,500 g, is an important marker of neonatal health because of its associations with morbidity, mortality, and longer-term effects on growth and development. In 2020, an estimated 14.7% of newborns worldwide—nearly 20 million infants—weighed below 2,500 g, and progress in reducing LBW prevalence has remained slow. Indonesian national statistics reported that 12.47% of the most recent live births among surveyed mothers were classified as LBW, underscoring the need to address modifiable risk factors (BPS, 2024; Okwaraji et al., 2024).

Evidence syntheses have reached mixed conclusions about prenatal vitamin D supplementation and birth weight or LBW. A Cochrane review judged the evidence for supplementation regimens during pregnancy to be limited and heterogeneous; a dose-comparison meta-analysis also found no significant increase in birth weight with doses above 2,000 IU/day compared with lower doses. Differences in dose and timing, baseline maternal vitamin D status, and population characteristics may contribute to variation across findings (Palacios et al., 2019).

Birth weight may be influenced by sociodemographic characteristics (maternal age, education, and economic status), obstetric factors (gestational age, parity, hypertensive disorders, and prior LBW), and lifestyle or other factors (sun exposure, secondhand smoke, physical activity, infant sex, and maternal vitamin D knowledge). Although these determinants are recognized, few studies in Indonesia have assessed supplementation dose while accounting for a broad set of maternal factors. This study therefore estimated the association between vitamin D supplementation dose and birth weight and examined maternal factors associated with LBW using simultaneous adjustment for multiple covariates (Juliyanti et al., 2025).

Methods

The study employed a quantitative, analytic-observational cross-sectional design, in which exposure and outcome were ascertained concurrently at a single time point, with no intervention by the researcher.

Study Population and Sampling

Eligible participants were women who had delivered a live-born infant, a group chosen to capture factors pertinent to pregnancy status, maternal health, and neonatal outcomes. Inclusion required delivery within the preceding three years, intake of a vitamin D–containing supplement during pregnancy, and provision of informed consent to complete the questionnaire in full. We excluded mothers with chronic conditions—except hypertension or preeclampsia—that could influence vitamin D absorption or fetal weight (e.g., intestinal malabsorption, chronic kidney disease, or hyperparathyroidism). Because the underlying population size and sampling frame were not well defined, we calculated the minimum sample using the standard formula for estimating a proportion in an unknown population, specifying a 95% confidence level (Z=1.96), an assumed proportion of 0.5, and an absolute precision of 0.08, which yielded 151 respondents. Allowing for a 10% rate of incomplete or invalid online responses increased the target minimum to 167; ultimately, 170 respondents were recruited through non-probability purposive sampling based on predetermined eligibility criteria aligned with the study objectives. Given the nonrandom selection and the reliance on self-reported online data for supplementation dose and other exposures, the results may be affected by selection and recall/information bias and should be generalized with caution.

Study Variables

The primary exposure was the vitamin D supplement dose taken by pregnant women, classified into five categories: <400 IU/day, 400–600 IU/day, 601–4,000 IU/day, >4,000 IU/day, and unknown dose. The outcome was birth weight, dichotomized as normal (2,500–3,999 g) versus LBW (<2,500 g). Thirteen maternal characteristics were considered potential confounders: maternal age; education level; economic condition; gestational age; parity; infant sex; sun exposure frequency; secondhand smoke exposure; smoking history; hypertension/preeclampsia history; LBW history; exercise during pregnancy; and maternal knowledge of vitamin D.

Data Collection and Instrument

Primary data were obtained directly from participants through a self-administered online questionnaire that captured sociodemographic information; obstetric and other health-related characteristics (including vitamin D supplementation dose); lifestyle factors; maternal knowledge of vitamin D; and newborn birth weight. The knowledge construct comprised four true/false items, and scores were categorized as good, sufficient, or poor. The questionnaire was derived from a literature review, underwent content validation by six expert judges (two physicians, two nurses, one pharmacist, and one nutritionist), and was then pilot-tested with 30 respondents whose characteristics were similar to those of the target population but who were not included in the main study. Item validity for the knowledge construct was examined using corrected item–total correlation;

items were deemed valid when the calculated r exceeded the r-table threshold of 0.361 (df=28, α=5%), and four of seven items satisfied this criterion and were retained. The retained items demonstrated acceptable internal consistency (Cronbach's alpha 0.700). Ethical clearance and informed consent were secured before data collection, after which researchers checked response completeness prior to data entry (Durrani et al., 2026).

Data Analysis

The dataset was edited, coded, cleaned, and tabulated in Microsoft Excel, then imported into IBM SPSS Statistics version 27.0 for analysis. Univariate procedures described the frequency distributions of all study variables. Associations between each independent and confounding variable and birth weight were examined in bivariate analyses using the Chi-Square test; when more than 20% of cells had an expected count below 5, Continuity Correction or Fisher's Exact Test was used for 2×2 tables, and the Fisher-Freeman-Halton Exact Test was applied for larger contingency tables. Variables with a bivariate p-value <0.25 were subsequently included in a multivariate binary logistic regression model to evaluate their joint effect on LBW, and results were presented as regression coefficients (B), significance values, odds ratios (Exp[B]), and 95% confidence intervals; a p-value <0.05 was taken as statistically significant throughout. All analyses adhered to a significance level (α) of 0.05 and a 95% confidence level (Hosmer et al., 2013).

Result and Discussion

1.1 Respondent Characteristics

A total of 170 mothers who had taken vitamin D supplements during pregnancy and delivered between 2023 and 2026 met the eligibility criteria and were included in the analysis. Table 1 summarizes their sociodemographic, obstetric, and vitamin D supplementation characteristics.

Table 1. Sociodemographic, Obstetric, and Vitamin D Supplementation Characteristics of Respondents (n=170)

Variable	Category	n	%
Maternal age	20–35 years	138	81.2
	>35 years	28	16.5
	<20 years	4	2.4
Education level	Postgraduate (S2)	1	0.6
	Bachelor's (S1)	57	33.5
	Diploma	21	12.4
	Senior high school	80	47.1

Variable	Category	n	%
	Junior high school	6	3.5
	Elementary school	1	0.6
	No formal education	4	2.4
Economic condition	Above regional minimum wage	63	37.1
	At regional minimum wage	82	48.2
	Below regional minimum wage	12	7.1
	No income	13	7.6
Gestational age	37–42 weeks	131	77.1
	>42 weeks	7	4.1
	<37 weeks	32	18.8
Parity	2–3 (multipara)	118	69.4
	1 (primipara)	28	16.5
	≥4 (grand multipara)	24	14.1
Supplementation type	Vitamin D alone	78	45.9
	Multivitamin containing vitamin D	92	54.1
Vitamin D dose	<400 IU/day	17	10.0
	400–600 IU/day	67	39.4
	601–4,000 IU/day	48	28.2
	>4,000 IU/day	15	8.8
	Unknown dose	23	13.5
Trimester of vitamin D initiation	1st trimester	114	67.1
	2nd trimester	46	27.1
	3rd trimester	10	5.9
Maternal knowledge of vitamin D	Good	129	75.9

Variable	Category	n	%
	Sufficient	34	20.0
	Poor	7	4.1

Note: percentages are calculated within each variable category.

Table 2. Neonatal Outcome and Maternal Obstetric/Lifestyle History (n=170)

Variable	Category	n	%
Birth weight	Normal (2,500–3,999 g)	147	86.5
	LBW (<2,500 g)	23	13.5
Infant sex	Male	74	43.5
	Female	96	56.5
LBW history	No	138	81.2
	Yes	32	18.8
Hypertension/preeclampsia history	No	156	91.8
	Yes	14	8.2
Secondhand smoke exposure	Not exposed	134	78.8
	Exposed	36	21.2
Smoking history	Never smoked	167	98.2
	Former smoker (quit before/during pregnancy)	3	1.8
Sun exposure frequency	Every day	55	32.4
	1–2 days apart	35	20.6
	≥3 days apart	53	31.2
	Never	27	15.9
Exercise during pregnancy	Yes	129	75.9
	No	41	24.1

Most respondents were 20–35 years old (81.2%), had completed senior high school (47.1%), and reported income at or above the regional minimum wage (85.3%). Most pregnancies reached 37–42 weeks (77.1%), and parity of 2–3 was the

largest group (69.4%). These characteristics broadly resemble patterns reported in Indonesian samples; 37 completed weeks marks the beginning of term pregnancy (Burton & Jauniaux, 2018; Pajala & Hidayat, 2024; Tri Atmojo et al., 2022).

Just over half of respondents used a multivitamin containing vitamin D (54.1%); the most commonly reported dose was 400–600 IU/day (39.4%). This dose range is consistent with general prenatal guidance and the Indonesian recommended dietary allowance of 15 mcg (600 IU) per day for adult women, with no additional pregnancy increment specified. Most respondents began supplementation in the first trimester (67.1%), consistent with guidance to initiate antenatal contact and micronutrient counselling early in pregnancy (Aulia Azhar et al., 2025; Kementerian Kesehatan RI, 2019; World Health Organization, 2016).

LBW affected 13.5% of infants in this sample, compared with 6.2% in the 2023 Indonesian Health Survey and the 2020 global estimate of 14.7%. The higher proportion than the national figure may reflect the online, non-random sampling design rather than a nationally representative household survey. Female infants accounted for 56.5% of births; fetal sex is determined at fertilization and is unrelated to the maternal exposures assessed here. A total of 75.9% of participants had good vitamin D knowledge (Ibrahim et al., 2025; Kebijakan Pembangunan et al., 2023; Moore et al., 2013).

1.2 Bivariate Analysis of Vitamin D Supplementation Dose and Confounding Factors on Birth Weight

Table 3. Bivariate Analysis of Vitamin D Supplementation Dose and Maternal Confounding Factors on Birth Weight (n=170)

Variable	Normal, n (%)	LBW, n (%)	p-value
Vitamin D dose			0.942
<400 IU/day	14 (82.4)	3 (17.6)	
400–600 IU/day	58 (86.6)	9 (13.4)	
601–4,000 IU/day	41 (85.4)	7 (14.6)	
>4,000 IU/day	13 (86.7)	2 (13.3)	
Unknown dose	21 (91.3)	2 (8.7)	
Maternal age			0.294
20–35 years	121 (87.7)	17 (12.3)	
>35 years	22 (78.6)	6 (21.4)	
<20 years	4 (100.0)	0 (0.0)	

Variable	Normal, n (%)	LBW, n (%)	p-value
Education level*			0.932
Economic condition*			0.372
Gestational age			<0.001
37–42 weeks	124 (94.7)	7 (5.3)	
>42 weeks	7 (100.0)	0 (0.0)	
<37 weeks	16 (50.0)	16 (50.0)	
Parity			0.044
2–3	107 (90.7)	11 (9.3)	
1	22 (78.6)	6 (21.4)	
≥4	18 (75.0)	6 (25.0)	
Infant sex			0.256
Male	67 (90.5)	7 (9.5)	
Female	80 (83.3)	16 (16.7)	
Hypertension/preeclampsia history			0.025
No	138 (88.5)	18 (11.5)	
Yes	9 (64.3)	5 (35.7)	
LBW history			<0.001
No	137 (99.3)	1 (0.7)	
Yes	10 (31.3)	22 (68.8)	
Sun exposure frequency			0.086
Every day	50 (90.9)	5 (9.1)	
1–2 days apart	33 (94.3)	2 (5.7)	
≥3 days apart	44 (83.0)	9 (17.0)	
Never	20 (74.1)	7 (25.9)	
Secondhand smoke exposure			0.011
Not exposed	121 (90.3)	13 (9.7)	

Variable	Normal, n (%)	LBW, n (%)	p-value
Exposed	26 (72.2)	10 (27.8)	
Smoking history			0.355
Never smoked	145 (86.8)	22 (13.2)	
Former smoker	2 (66.7)	1 (33.3)	
Exercise during pregnancy			0.122
Yes	115 (89.1)	14 (10.9)	
No	32 (78.0)	9 (22.0)	
Maternal knowledge of vitamin D			0.023
Good	116 (89.9)	13 (10.1)	
Sufficient	27 (79.4)	7 (20.6)	
Poor	4 (57.1)	3 (42.9)	

*Education level (7 categories) and economic condition (4 categories) are summarized by p-value only; category-level distributions are reported in Table 1. p-values from Chi-Square test, Continuity Correction, Fisher's Exact Test, or Fisher-Freeman-Halton Exact Test as appropriate to table size and expected cell counts.

Vitamin D supplementation dose was not associated with birth weight in bivariate analysis (p=0.942). A meta-analysis of 66 randomized trials reported no subgroup differences in maternal, birth, or infant outcomes across dose categories (≤600, 600–2,000, and >2,000 IU/day) and no significant pooled effect on LBW risk (RR=0.95; 95% CI 0.76–1.19); the full bibliographic source for this analysis was not identifiable in the supplied file and requires verification. Irwinda et al. (2022) likewise reported no significant birth-weight increase with doses >2,000 IU/day compared with lower doses, although higher doses were associated with reduced gestational diabetes risk. The nominal dose may not reflect baseline vitamin D status or adherence, neither of which was measured here. Self-reported dose may also be subject to recall bias, and the relatively small number of LBW cases (13.5%) may have limited power to detect dose-related differences.

Among the potential confounders, gestational age, parity, history of hypertension/preeclampsia, prior LBW, secondhand smoke exposure, and maternal vitamin D knowledge were significantly associated with birth weight in bivariate analyses (p<0.05). Maternal age, education, economic condition, infant sex, smoking history, sun exposure, and exercise were not significantly associated.

LBW was more frequent among infants delivered before 37 weeks (50.0%) than among term births (5.3%), consistent with the shorter intrauterine growth period following preterm delivery. LBW was also more frequent among primiparous and grand multiparous mothers than among those with parity 2–3, in line with Indonesian reports of elevated risk at both ends of the parity spectrum (Wardani et al., 2025).

LBW occurred more often among women with a history of hypertension or preeclampsia than among those without such a history (35.7% vs. 11.5%), consistent with reports identifying hypertensive disorders as maternal risk factors; impaired uteroplacental perfusion is a plausible mechanism. Recurrence was also common among women with a previous LBW delivery (68.8% vs. 0.7%). Secondhand smoke exposure was associated with a higher LBW proportion (27.8% vs. 9.7%), plausibly through reduced fetal oxygen and nutrient supply. The highest LBW proportion was observed among mothers with poor vitamin D knowledge (42.9%); this association may reflect broader antenatal self-care rather than a direct effect of knowledge. These bivariate findings should be interpreted as associations, not causal effects (Aproodheta et al., 2025; Mustafa, 2026; Paramitasari MS et al., 2025; Rasyid et al., 2023).

No significant bivariate association was detected for maternal age, education, economic condition, infant sex, smoking, sun exposure, or exercise. Sun-exposure frequency may not capture duration, skin coverage, pigmentation, or geographic and seasonal conditions that influence ultraviolet-B–mediated vitamin D synthesis. Because all participants reported supplementation, an additional sunlight effect may also have been attenuated. The low prevalence of active smoking (1.8%) and concentration of participants aged 20–35 years may have limited the ability to detect associations for those characteristics (Kartika Sari et al., 2023; Musviratunnisah et al., 2024).

1.3 Multivariate Analysis

Using a bivariate screening criterion of $p<0.25$, eight predictors—gestational age, parity, hypertension/preeclampsia history, secondhand smoke exposure, prior LBW, sun exposure, exercise, and maternal vitamin D knowledge—were entered into binary logistic regression. The omnibus test indicated that the model was statistically significant (Omnibus $\chi^2=107.164$; df=8; $p<0.001$). The Hosmer–Lemeshow test showed no meaningful discrepancy between observed and predicted values ($\chi^2=0.477$; df=8; $p=1.000$). Nagelkerke R^2 was 0.854, and overall classification accuracy was 97.1% (97.3% for normal birth weight and 95.7% for LBW) (Hosmer et al., 2013).

Table 4. Multivariate Binary Logistic Regression Analysis of Factors Associated with Low Birth Weight

Variable	B	p-value	OR (Exp[B])	95% CI
Gestational age (<37 weeks)	2.577	0.015	13.155	1.653–104.693
Parity (1 or ≥4)	0.912	0.468	2.489	0.212–29.200
Hypertension/preeclampsia history	18.589	0.995	118,368,958.1	–
Sun exposure (less frequent)	2.332	0.059	10.296	0.912–116.256
Maternal knowledge (good)	0.196	0.860	1.217	0.138–10.763
LBW history	21.660	0.994	2,552,542,478	–
Secondhand smoke exposure	1.307	0.243	3.696	0.412–33.134
Exercise during pregnancy (no)	-1.313	0.367	0.269	0.016–4.658

Note: reference categories were gestational age ≥37 weeks, parity 2–3, no hypertension/preeclampsia history, more frequent sun exposure, poor knowledge, no LBW history, no secondhand smoke exposure, and exercise during pregnancy. Extremely large OR estimates for hypertension/preeclampsia history and LBW history reflect model instability from small cell counts and should not be interpreted as precise effect sizes.

After simultaneous adjustment, gestational age <37 weeks was the only variable significantly associated with LBW (B=2.577; p=0.015; OR=13.155; 95% CI 1.653–104.693). The estimated odds were about 13 times those for delivery at term, conditional on the other seven covariates. However, the wide confidence interval indicates substantial uncertainty, likely related to the small number of preterm LBW cases, and the point estimate should be interpreted cautiously. The adjusted association is consistent with the biological expectation that preterm delivery shortens the period available for intrauterine growth (Möllers et al., 2022).

None of the other seven predictors was statistically significant in the multivariable model. Hypertension/preeclampsia history and prior LBW produced extremely large odds-ratio estimates and unstable confidence intervals, consistent with sparse outcome-by-exposure cells and possible quasi-complete separation; only 14 participants reported hypertension/preeclampsia history. These estimates

should not be interpreted as precise effect sizes. A penalized method such as Firth logistic regression or a more parsimonious model may be preferable for future analyses of sparse data. Parity, sun exposure, secondhand smoke exposure, exercise, and maternal knowledge also lost significance after adjustment, indicating that their bivariate associations may overlap with gestational age and other covariates.

Conclusion

Among 170 participants, the most common profile was age 20–35 years, senior-high-school education, income at or above the regional minimum wage, gestational age of 37–42 weeks, and parity of 2–3. Vitamin D supplementation dose was not significantly associated with birth weight in bivariate analysis (p=0.942) and was not entered into the adjusted model because it did not meet the prespecified screening criterion. Of the covariates entered into the multivariable model, only gestational age remained significantly associated with LBW (p=0.015; OR=13.155; 95% CI 1.653–104.693); the wide interval warrants caution. These findings indicate statistical associations in this sample and do not establish causation. Antenatal care should continue to promote adequate vitamin D intake and prioritize monitoring gestational duration as part of efforts to reduce LBW.

Recommendations

Close antenatal monitoring of gestational age is recommended alongside continued promotion of adequate vitamin D intake among pregnant women as part of efforts to reduce the incidence of low birth weight.

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