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Low Maternal Vitamin D and Calcium Food Intake during Pregnancy Associated with Place of Residence: A Cross-Sectional Study in West Sumatran Women, Indonesia

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Abstract

BACKGROUND: There is a high prevalence of vitamin D deficiency in pregnancy worldwide, and variable availability of vitamin D-rich foods may affect the adequacy of vitamin D food intake in different regions.

AIM: We analysed the relationship between place of residence and maternal food intake of vitamin D and calcium in West Sumatra, Indonesia.

METHODS: This cross-sectional study was conducted in 203 pregnant women. Data collection was carried out in four districts in West Sumatra – two in coastal locations and two in mountainous locations – with subjects divided into groups based on their place of residence. The dietary intakes of pregnant women were assessed through a semi-quantitative food-frequency questionnaire (SQ-FFQ).

RESULTS: The means of maternal vitamin D and calcium food intake were 7.92 ± 5.26 µg/day and 784.88 ± 409.77 mg/day, respectively. There were no reports of vitamin D supplement intake during pregnancy. A total of 86.7% and 89.7% of the study subjects had low vitamin D and calcium food intake status, respectively. There was a significant association between maternal vitamin D intake and place of residence (p = 0.02) and significant different mean levels of vitamin D food intake with the place of residence (9.04 vs 6.55 µg/day; p = 0.01). Mothers who had higher education levels had adequate calcium food intake (p = 0.015; OR: 0.295; 0.116–0.751).

CONCLUSION: Low maternal vitamin D and calcium food intake were found to be common in West Sumatra, Indonesia and their differed between those residents in mountainous and in coastal areas.

Introduction

Vitamin D deficiency and insufficiency during pregnancy is a global public health problem. According to our recent studies, the pregnant Indonesian women investigated had inadequate vitamin D and calcium intakes [1], [2], [3]. Adequacy of food intake during pregnancy determines the adequacy of maternal nutrition, and in terms of vitamin D intake, foods rich in this nutrient are not as common as other vitamin sources. Recent studies showed that low vitamin D food intake during pregnancy was positively but weakly correlated with maternal serum vitamin D level (25-hydroxyvitamin D) [4]. Our previous studies had no association between vitamin D and calcium food intake status. However, pregnant women who had low vitamin D levels were 60-70% in the inadequate vitamin D and calcium food intake status. There were 30-40% of pregnant women in the normal vitamin D level [5]. Vitamin D and calcium food intake were extremely low during the first trimester of pregnancy with more than 90% of inadequate vitamin D and calcium food intake status [6]. This high number of inadequate status for both vitamin D and calcium food intake status might due to the quantity of supplementation and intake of vitamin D-fortified food policies during pregnancy. The limited availability of such foods and the difficulty of accessing them are challenges for people in meeting their daily vitamin D requirements.

Dietary sources of vitamin D can be obtained from natural or fortified foods such as dairy products, fish and supplements [7]. However, the main source of vitamin D is exposure to sunlight, and lifestyle changes such as limited sunlight exposure resulting from the full coverage of the skin by clothing, use of sunscreen/sunblock and lack of outdoor physical activities may restrict sun exposure [8], [9]. Vitamin D helps to maintain calcium homeostasis and a healthy, mineralised skeleton, making it important in the process of foetal development. It can also affect the activity of the immune system, cell proliferation and differentiation and insulin cell synthesis, and is thus one of the essential micronutrients for maintaining maternal and foetal health during pregnancy [10]. Several previous studies have reported that pregnant women with vitamin D deficiency are at risk of low birth weight babies, preterm births, autoimmune disorders such as type I diabetes mellitus [8], [9], [10], [11], [12] and impaired blood vessel function. The latter may lead to pre-eclampsia, which is a common cause of maternal death [16].

There are some areas of debate about adequate food intake of vitamin D and optimal vitamin D food intake levels. The recommended food intake of vitamin D varies by country: in Scandinavia, all pregnant women are advised to take 10 mcg/day to maintain an adequate level of vitamin D food intake. It is estimated that the food intake of vitamin D-rich foods at this level may maintain a serum 25OHD level of 25 nmol/L [17]. In contrast, Indonesia's recommended dietary allowance (RDA) for vitamin D food intake level is 15 mcg/day [18]. Calcium also plays an important role in foetal growth during pregnancy and vitamin D assists the absorption of calcium in the small intestine. Thus, the fulfilment of vitamin D and calcium food intake requirements are important for foetal development during pregnancy [19]. Place of residence is one of the factors which determines the availability of food. It is easier for pregnant women who live in coastal areas to access vitamin D-rich foods in seafood such as fatty fish (mackerel, tuna, salmon and sardines), fish oil, oysters, prawns and cod liver oil than for those who live in mountainous areas. A recent study showed that 37% of vitamin D food intake source was coming from seafood, followed by starchy, meat, eggs, dairy, and sweet and pastry foods [4].

This study analysed the relationship between place of residence and maternal intake of vitamin D and calcium in West Sumatra, Indonesia.

Methods

Study design and participants

Of 215 initial candidates for this cross-sectional study, 203 were enrolled while 12 refused to participate, giving a total enrolled cohort of 203. This cross-sectional study was conducted between September and December 2016 in two coastal districts (Pariaman and Pasaman Barat) and two mountainous areas (Solok and Tanah Datar) of West Sumatra, Indonesia. This study was part of The Vitamin D Pregnant Mother (VDPM) cohort study [6]. Inclusion criteria for the women taking part were as follows: (1) > 28 weeks of pregnancy attending routine antenatal reviews in the primary health service; (2) no history of taking any kind of drug that could interact with vitamin D and calcium metabolism; (3) absence of chronic disease; (4) living in close proximity to the research area; and (5) agreement to participate in the study.

Solok, Tanah Datar, Pariaman and Pasaman Barat are distinct districts of West Sumatra which demonstrate variety concerning geography, social life, eating habits and living conditions. Pariaman and Pasaman Barat are located on the the Indian Ocean coast at altitudes of between 0 and 15 m above sea level. According to the Indonesia Directorate of Meteorology, the average daily temperature in these locations varies between 20°C and 26°C. Fish consumption rates are higher in coastal areas such as these, as fish is relatively abundant. In contrast, Solok and Tanah Datar are located in a mountainous area of West Sumatra. The study protocol was reviewed and approved by the local ethics committee at the Faculty of Medicine, Andalas University, Indonesia (No: 108/KEP/FK/2016) and written informed consent was obtained from all participants before their recruitment and their identity anonymity was preserved.

Data collection

Participants gave written informed consent and were then asked to complete two questionnaires: one addressing socio-demographic characteristics and the other a validated semi-quantitative food-frequency questionnaire (SQ-FFQ). Anthropometric data such as maternal body weight and height without shoes were measured to the nearest 0.1 kg and 0.1 cm, respectively. Pre-pregnancy BMI was calculated as weight (kg)/height $(m)^{2,}$ and then participants were categorised into four groups based on current World Health Organization classifications: underweight (BMI < 18.5), normal (BMI 18.5 – 24.99), overweight (BMI 25 – 29.99) and obese (BMI 30 or higher) [20]. The questionnaires collected information regarding age, educational level, marital status, occupation, family income, drug history, maternal health history and dietary behaviour, and blood pressure was recorded using a sphygmomanometer.

Dietary assessment

Dietary intake was assessed using a semi-quantitative food-frequency questionnaire (SQ-FFQ) developed and validated by Lipoeto [21]. This questionnaire was adapted for Minangkabau food habits. Minangkabau people, also known as *Minang*, comprise an ethnic group indigenous to the Minangkabau Highlands of West Sumatra. The validated SQ-FFQ gathered information on foods fortified with vitamin D, natural foods rich in vitamin D and dietary supplements, and referenced more than 223 general food items available in West Sumatra, including potential sources of vitamin D. Daily energy and nutritional intakes were calculated and compared with RDAs for pregnant women [15]. Based on their calcium and vitamin D intakes, the pregnant women were divided into two groups: inadequate intake (< 15 μg/day) and adequate intake (≥ 15 μg/day) for vitamin D and inadequate intake (< 1300 mg/day) and adequate intake (≥ 1300 mg/day) for calcium.

Statistical analysis

All data were analysed using IBM SPSS Statistics for Windows (SPSS version 23.0, IBM Inc., Chicago, IL, USA). Descriptive analysis was presented as frequency and percentage for categorical variables and as mean and standard deviation (SD) for continuous variables to show respondents' characteristic measurements. Continuous variables with normal distribution were presented as mean ± SD. Student *t*-test and chi-square test were used to test the relationship between place of residence and vitamin D and calcium intake levels. The level of significance was set at $p < 0.05$ to determine the relationship.

Results

Participant characteristics

The study group comprised of 203 women above 28 weeks of pregnancy. Table 1 shows the socio-demographic and anthropometric data for the subjects. Ages varied from 16 to 45 years old, with a mean age of 29.96 ± 6.13 years. The mean gestational week was 31.77 ± 3.4 in the coastal area group and 31.90 ± 3.6 in the mountainous area group. Many of the subjects were high school graduates (47.3%), and more than 70% were housewives. Mean monthly income was Rp 3,179,000 ± 340,000, with 142 (70%) earning above the average minimum wage of Rp 1,800,000 and 61 (30%) earning below it. Most of the subjects (138) were multiparous (68%), with the remaining 65 (32%) being nulliparous.

Table 1: Socio-demographic and anthropometric data for participants (n = 203)

Variables		Value (%)	Mean ± SD
		Socio-demographic data	
Age in years			29.96 ± 6.13
a.	< 20	5 (2.480)	
b.	20-29	92 (45.32)	
c.	30-34	53 (26.10)	
d.	≥35	53 (26.10)	
Parity			
a.	Nulliparous	65 (32)	
b.	Multiparous	138 (68)	
Working status			
a.	Housewife	143 (70.40)	
b.	Non-housewife	60 (29.60)	
Monthly income, Rp			3,179,000 ± 340,000
a.	≥ Minimum wages	142 (70)	
b.	< Minimum wages	61 (30)	
Education level			
a.	< High school	72 (35.40)	
b.	≥ High school	131 (64.60)	
Physical activity			7.252 ± 0.826
a.	Low	23 (11.30)	
b.	Medium	79 (38.90)	
c.	High	101 (49.80)	
		Anthropometric data	
Height (cm)			152.74 ± 5.370
a.	≥ 145	194 (95.60)	
b.	< 145	9 (4.40)	
Pre-pregnancy weight (kg)			51.03 ± 9.380
Weight (kg)			61.05 ± 10.110
Pre-pregnancy BMI (kg/m^2)			21.85 ± 3.727
a.	Underweight (< 18.50)	37 (18.20)	
b.	Normal (18.50–22.99)	91 (44.80)	
c.	Pre-obese (23.00–	35 (17.20)	
	24.99)	30 (14.80)	
d.	Obese I (25.00–29.99)	10 (4.90)	
e.	Obese II (≥ 30)		
Weight gain (kg)			10.01 ± 5.265
MUAC (cm)			26.93 ± 3.459
a.	Low (< 23.50)	27 (13.30)	
b.	Normal (23.50–25.00)	38 (18.70)	
c.	Obese (> 25.00)	138 (68)	
Average blood pressure			
a.	Systolic		115.60 ± 12.04
b.	Diastolic		74.52 ± 8.69

SD: standard deviation; BMI: body mass index; MUAC: mid-upper arm circumference.

Anthropometric characteristics

The means (SD) of height, weight, BMI, weight gain during pregnancy, mid-upper-arm circumference (MUAC) and systolic and diastolic blood pressures were 152.74 ± 5.370 cm, 61.05 ± 10.11 kg, 21.85 ± 3.727 kg/m^2, 10.01 ± 5.265 kg, 26.93 ± 3.459 cm, 115.60 ± 12.04 mmHg and 74.52 ± 8.69 mmHg, respectively. Based on MUAC measurements, 18.5% of the pregnant women were classified as underweight, 19.7% as normal and more than 60% as obese.

Dietary intake of pregnant women

The mean (± SD) values for the intake of vitamin D and calcium were 7.92 ± 5.26 mcg/day and 782.67 ± 408.84 mg/day, respectively. The mean daily energy intake for the pregnant women was 2,443.77 ± 479.996 kcal, 106.33 ± 30.789 g of protein, 109.56 ± 26.092 g of fat and 266.577 ± 57.977 g of carbohydrates. The percentages of RDAs intake of pregnant women are presented in Table 2.

Table 2: Dietary intake of subjects (n = 203)

Variables	Min-max	Mean ± SD	RDA*	%RDA
Energy (kcal)	1,577.97–3,484.23	2,443.77 ± 479.996	2,550	95.8
Total carbohydrate (g)	137.07–440.42	266.577 ± 57.977	363	73.2
Total protein (g)	54.37–198.52	106.33 ± 30.789	79	134
Total fat (g)	56.08–180.29	109.56 ± 26.092	85	128
Calcium (mg)	181.73–2,993.79	784.88 ± 409.77	1,300	60
Vitamin D (μg)	0.39–29.28	7.92 ± 5.26	15	52.8

RDA: recommended dietary allowance. *RDA adopted from Indonesia Ministry of Health [18].

Percentages of RDAs consumed were 60% for calcium, 52.8% for vitamin D, 95.8% for energy, 134% for protein, 128% for fat and 73.2% for carbohydrates. None of the pregnant women in the study consumed vitamin D supplements during pregnancy.

Nutrient intake data were compared with RDAs for pregnant women. Energy, total protein and total fat intakes were adequate (≥ 77% of RDA) while calcium, vitamin D and total carbohydrate intake were inadequate (< 77% of RDA) [18]. This study found that more than half of the pregnant women had inadequate intakes of vitamin D (86.7%) and calcium (89.7%). We did not find any subjects took vitamin D as their dietary supplements during pregnancy. Means (± SD) of vitamin D and calcium intake were 7.92 ± 5.26 μg/day and 784.88 ± 409.77 mg/day, respectively.

Association between the place of residence and maternal intake of vitamin D and calcium

Comparison of mean dietary intakes of vitamin D and calcium in pregnant women based on place of residence is shown in Table 3. Maternal vitamin D intake compared to the place of residence is significantly different (p = 0.001), with the average of vitamin D intake being higher for those living in coastal areas than in mountainous areas. In contrast, although the average intake of calcium in the coastal areas is higher than in the mountainous areas, the difference, at p = 0.09, is not significant.

Table 3: Association between the place of residence and vitamin D and calcium intake (n = 203)

Variables	Place of residence		Odds ratio (95% CI)	P-value
	Coastal (%)	Mountainous (%)		
Vitamin D intake (μg)*	9.04 ± 5.92	6.55 ± 3.92		0.001
Vitamin D status**			0.306 (0.118–0.794)	0.02
Adequate (≥ 15 μg/day)	21 (18.80)	6 (6.60)		
Inadequate (< 15 μg/day)	91 (81.20)	85 (93.40)		
Calcium intake (mg)*	812.385 ± 434.840	751.043 ± 376.263		0.09
Calcium intake status **			0.583 (0.225–1.513)	0.37
Adequate (≥ 1,300 mg/day)	14 (12.50)	7 (7.70%)		
Inadequate (< 1,300 mg/day)	98 (87.50)	84 (92.30)		
Energy (kcal)*	2476.26 ± 490.63	2406.70 ± 467.69		0.329
Carbohydrate (g)*	297.86 ± 89.87	273.94 ± 76.93		0.046
Fat (g)*	119.90 ± 37.26	113.60 ± 30.42		0.195
Protein (g)*	118.03 ± 42.38	107.62 ± 30.87		0.044

Analysis of the relationship between place of residence and vitamin D and calcium intake found that 18.8% of the pregnant women in the coastal areas had adequate vitamin intake levels compared with only 6.6% in the mountainous areas. Thus, inadequate intake of vitamin D is more common in mountainous areas (93.4%) than in coastal areas (81.2%). Our study results showed that the intake of maternal vitamin D was significantly associated with place of residence (p = 0.02; OR: 0306; 95% CI: 0.118 to 0.794). In contrast, calcium intake and place of residence had no significant relationship (P = 0.37; OR: 0583; 95% CI: 0.225 to 1.513), but adequate intake of calcium is more common in coastal areas than in mountainous areas, at 12.5% and 7.7%, respectively.

Discussion

To our knowledge, this is the first study to investigate the relationship between place of residence and maternal vitamin D and calcium intake in the population of West Sumatra. The study found that the level of maternal vitamin D intake was associated with place of residence, in that women who lived in mountainous areas had less adequate vitamin D intake than those who lived in coastal areas. In contrast, we found no association between maternal calcium intake and place of residence, but we did find that women who lived in both locations had inadequate intake. High prevalence of low vitamin D and calcium intake need to be considered by health services because of the vital role of these nutrients in foetal growth and development. Our findings, if replicated in further studies, may have significant public-health implications for raising awareness about the need to fulfil nutritional needs during pregnancy, especially in terms of micronutrients such as vitamin D and calcium, to maintain a healthy pregnancy.

Vitamin D and calcium are essential nutrients for the human body throughout life [22]' and inadequate vitamin D intake may reduce calcium absorption in the intestine while low calcium intake can greatly increase vitamin D catabolism [23], [24]. This study has shown that an inadequate intake of vitamin D and calcium is a serious health problem for pregnant women in West Sumatra, Indonesia, that must be addressed. Based on the recommended level suggested by the Ministry of Health in Indonesia [18], almost 90% of pregnant women in our study had inadequate intakes of vitamin D and calcium. The standard recommendation for dietary allowances applied in Indonesia of 15 μg/day is the same as that used by the US Institute of Medicine [25].

The prevalence of inadequate intake of vitamin D and calcium found in this study is similar to the results of other recent research in Indonesia. A study conducted into healthy first-trimester pregnant women (n = 143) living in Jakarta showed that intake of vitamin D and calcium in pregnant women was below RDAs by 100% and 97.9%, with an average intake of vitamin D and calcium of 1.1 μg and 433.3 mg, respectively [3]. These average intakes of vitamin D and calcium were thus even lower than in this present study.

Two additional studies in women of childbearing age in North Sumatra and West Sumatra showed that more than 80% had inadequate vitamin D intake, with an average intake of vitamin D being between 5.24 and 7.29 μg/day [5], [26]. Another study reported that there was no significant association between the intake of vitamin D and body mass index in adult women aged 20 – 50 years [27]. A systematic review of three different studies into the nutritional status of pregnant women in Indonesia found that the average calcium intake of pregnant women was 45%

– 80% below the estimated average requirement (EAR). The average values for calcium intake in these studies were 536.23 mg, 614.41 mg and 360 mg, respectively [28].

Our findings indicate a significant difference between the average intake of vitamin D and calcium of pregnant women who live in coastal and of those living in mountainous areas. However, no significant differences were found in calcium intake between those living in these contrasting areas. Thus, only the status of vitamin D intake was found to differ significantly. Research conducted in North Sumatra has reported that vitamin D intake was significantly different between urban and rural groups, and these findings match those of the present study because they are similarly based on an environmental divided between coastal areas, which are urban, and mountainous areas, which are predominantly rural [29]. The effects of lifestyle choices can also be among several risk factors in determining the dietary intake of pregnant women. Pregnant women's choices related to physical activity, food habits, clothing style, occupation and the daily use of sunscreen can affect their quality of food intake and exposure to sunlight [29], [30].

Place of residence plays an important role in dietary health, in this case, because women who live in coastal areas tend to have better access to food sources rich in vitamin D such as fish or seafood than women who live in mountainous areas [29], [31], [32]. Also, a cardiovascular cohort study (MESA) conducted by Franco et al. at the Baltimore site of the Multi-Ethnic Study of Atherosclerosis showed that family economic status, as seen from the aspect of the average minimum wage, is associated with vitamin D intake. Reasons for this include difficulty in accessing healthy food sources, consumer buying power and the availability of food [33]. Women who live in low-income communities have less available income to purchase healthy foods because prices in their neighbourhoods exceed their incomes. The prices of food sources rich in vitamin D such as fish and dairy products tend to be especially high in such markets [34], [35]. This present study shows that pregnant women living in coastal areas have better consumption of vitamin D-rich foods than those in mountainous areas, but that their intake is still inadequate.

More than 80% of vitamin D is obtained through the synthesis in the skin from sunlight exposure, with the remaining 20% being obtained from the diet [23]; however, in this study, the frequency of sunlight exposure was not measured. The daily activities of Indonesian women feature limited exposure to sunlight due to the wearing of full-length dress and veils, sunscreen application and a tendency to avoid sunlight exposure during pregnancy. Changes in lifestyle, such as reducing outdoor activities, increasing the use of sheltered transportation and increased consumption of fast food, also reduce sunlight exposure [26]. A recent study among 160 third-trimester pregnant women in West Sumatra reported that living in mountainous areas and having low levels of physical activity were significantly associated with low vitamin D intake [5]. Very low intake of vitamin D contributes to the high prevalence of hypovitaminosis for vitamin D found in immigrant East Asian women living in Sydney [36]. In the study, subjects had 9.04 ± 5.92 mcg/day of vitamin D intake, and this is below the 15 mcg/day EAR [25]. Also, this study revealed an average calcium intake by women during pregnancy of 784.88 ± 409.77 mg/day, a level which is significantly below the RDA (60.37% of RDA).

Vitamin D intake is a predictor of circulating levels of 25OHD, and regular use of prenatal multivitamins increases vitamin D levels in pregnant women [37]. The role of vitamin D should not be underestimated: during the preconception period, vitamin D intake affects IVF success; during pregnancy, vitamin D is involved in the bone formation of the foetus through increasing absorption of calcium in the intestines and influencing systemic immune functions (adaptive and innate) vital to the function of the placenta and nephrogenesis; and in the perinatal period, vitamin D affects early life immunomodulation [38]. Also, our previous findings reported that maternal vitamin D intake was associated with blood pressure levels in the third trimester [1], and Shin et al. suggested that inadequate vitamin D intake during pregnancy is related to low neonatal birth weight and shorter infant height [39]. In light of these contributions to healthy foetal development and maternal health, additional intake of vitamin D from supplements may be important to meet the recommended dietary levels for pregnant women.

There are some limitations to this study. Firstly, we consider the number of subjects to be insufficient to represent vitamin D intake in the wider community, and this small sample size did not represent all of West Sumatra vitamin D and calcium food intake status. Secondly, the use of SQ-FFQ must be validated for measuring serum levels for vitamin D and calcium to ensure more accurate findings. Thirdly, we were not accounted for some confounding variables such as sunlight exposure, vitamin D from supplementation, and vitamin D-fortified foods which has an impact on maternal vitamin D status and vitamin D intake. Finally, the identified relationship may have been stronger if the study had been designed as a cohort or randomised clinical trial and a higher level of statistical analysis. In the future studies, the association between maternal vitamin D and calcium intake and pregnancy outcomes needs to be considered and involving more holistic approach which could be explaining clearer the association between vitamin D and calcium food intake status on pregnancy health outcomes.

In conclusion, low maternal vitamin D and calcium intake are common in West Sumatra, Indonesia. Vitamin D and calcium intake may differ between those residents in mountainous and coastal areas. Adult women should understand the importance of vitamin D and calcium supplementation for meeting their daily needs and should be aware of proper food sources for these nutrients. Further large studies are required to confirm our findings before considering strategies for the implementation of vitamin D supplementation programs in Indonesia. Our results demonstrated that strategies for promoting the increase of vitamin D and calcium food sources and support for reducing a high prevalence of vitamin D deficiency status in the Indonesian population.

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