

# Relationship between Serum Vitamin D Status and Gestational Diabetes Mellitus

Bushra Jabbar Hamarashid<sup>1</sup>, Atiya Kareem Mohammed<sup>2</sup>

<sup>1</sup>PhD. Student, Diabetes and Endocrine Center, General Teaching Hospital, <sup>2</sup> Assistant. Prof. Dr., Maternal Neonatal Nursing, College of Nursing, University of Sulaimani

## Abstract

**Background** The association between vitamin D deficiency and risk of gestational diabetes mellitus (GDM) are proposed by several studies. Gestational diabetes mellitus complicates nearly 1% to 28% of all pregnancies and had an adverse effect for both mother and offspring. Vitamin D deficiency is one of the modified risk factors that can be corrected in the pre-conceptual period.

**Objectives** The current study aims to investigate and compare the serum levels of 25-hydroxyvitamin D<sub>3</sub> in pregnant women with GDM and non-GDM control subjects.

**Methods** In a descriptive study plasma 25-hydroxyvitamin D was assessed in a 100 women with GDM and it was compared to 162 non-GDM at gestational age above 24 weeks that was conducted in the Maternity Teaching Hospital in Sulaimani city from December 2018 to January 2019. The study used face-to-face interviews to collect the data through a specific written questionnaire. At the same time serum vitamin D state was examined using the Roche Elecsys vitamin D<sub>3</sub> assay.

**Results** There were no statistical significant differences found between two groups of GDM and non-GDM. The result of the study showed that the prevalence of vitamin D deficiency higher in the GDM group (77.0%) compares to non-GDM group (68.5%). The study found that socioeconomic state (p-value=0.069), body mass index (p-value=0.038), education (p-value=0.000), residency (p-value=0.000), age at marriage (p-value=0.023), gravida (p-value=0.014), and para (p-value=0.001), was significantly different between two groups of GDM and non-GDM.

**Conclusion** Overall, results imply that the vitamin D deficiency more prevalent among GDM group compare to non-GDM group, but the differences was not statically significant.

**Key words:** Serum, Vitamin D, Gestational Diabetes Mellitus

## Introduction

Several metabolic changes occur during pregnancy to allow optimum glucose transport from the mother to the fetus via the placenta. This change in the metabolism during pregnancy is not harmful, but when the environmental risk factors impose effect to this change, causing some abnormality such as GDM. Moreover, in the third trimester of pregnancy as a result of pregnancy hormone especially human placental lactogen, insulin resistance may develop<sup>1</sup>. Gestational diabetes mellitus (GDM) defined as carbohydrate intolerance with variable severity with onset or first diagnosis during pregnancy,

which applies regardless using insulin for the treatment or hyperglycemia remains after pregnancy<sup>2</sup>. GDM can have adverse effect for both the mother and the offspring (3). Most common complications associated with GDM for the mother are: high risk of pre-eclampsia, cesarean section, postpartum hemorrhage (PPH), polyhydramnios and increased risk of type two diabetes mellitus (T2DM) later on, the studies also showed that GDM increased the risk of metabolic syndrome<sup>4</sup>. In terms of offspring morbidity, GDM increase the risk of premature delivery, large for gestational age (LGA), hypoglycemia, hypocalcemia, hypomagnesemia, polycythemia and respiratory distress syndrome (5). Estimating the

prevalence of GDM remains matter because of the differences in the diagnosis criteria. The worldwide incidence of GDM estimated at between 3 and 5%, and reached 14% in the united state. The prevalence of GDM predicted to elevate because of the increase in the prevalence of associated risk factors<sup>6</sup>. Several risk factors associated with GDM have been defined such as; advance age<sup>3</sup> 35 years, family history of T2DM, hypertension, history of GDM and body mass index (BMI) more than 30 kg/m<sup>2</sup><sup>7</sup>.

Many studies carried out concerning if there any relationship between GDM and vitamin D deficiency<sup>4,5,9</sup>.

Vitamin D is one of the fat-soluble vitamins, which play an important role in calcium regulation to maintain good health state. There are two sources of vitamin D; vitamin D<sub>2</sub> (ergocalciferol) that comes from dietary sources such as fatty fish, cod-liver oil and egg yolk and vitamin D<sub>3</sub> (cholecalciferol) that produced in human skin via exposure of skin to ultra violet B (UVB). The conversion of pre-vitamin D<sub>3</sub> to its active form 1,25-dihydroxy vitamin D takes place in the skin, kidney and liver by the activity of enzymes<sup>10</sup>.

The studies proposed that vitamin D deficiency might play a role in pathology of a numbers of diseases other than skeletal problem such as diabetes mellitus, cancers and multiple sclerosis<sup>11</sup>.

Pregnant women are more at the risk of vitamin D deficiency and the evidence showed that vitamin D deficiency during pregnancy may affect pregnancy and pregnancy outcome such as; increased risk of GDM, pre-eclampsia, pre-term birth and post partum depression<sup>12</sup>.

The results of the studies concerning the effect of vitamin D deficiency in development of GDM are not consensus. The relationship between vitamin D level and GDM in the literature is not completely clear. In the study, which carried out by Farrant et al, the association between vitamin D state and risk of GDM studied<sup>13</sup>. They reported that 66% of the pregnant women had hypovitaminosis D, and despite many women being prescribed vitamin D and calcium in early pregnancy, but there were not differences in the incidence of GDM between both groups of GDM and non-GDM.

In the matched case-control study of 54 women with GDM and 39 women with IGT compared with 111 women in control group without GDM. Serum vitamin D concentration among GDM group at weeks of 24-28 was significantly lower compare to control group. They reported in the GDM group 83% were had hypovitaminosis D, while in non-GDM group 71% were deficient in vitamin D (14).

The current study looked at the serum vitamin D concentration in pregnant women with GDM and compares it to the control group of pregnant women without GDM, to find if there any association between vitamin D deficiency and risk of GDM in Sulaimani city.

## Methods

### *Study area:*

A descriptive analytic study was study was carried out at Gestational Diabetes Center, Maternity Teaching Hospital in Sulaimani city.

### *Study population*

262 pregnant women who are beyond their 24 weeks of gestation and belong to different age groups. The study was conducted between the December 2018 to January 2019. Inclusion criteria for selection of pregnant women were to be with gestational age more than 24 weeks. The study excludes pregnant women with pre-pregnancy BMI more than 35 and pregnant age more than 40 years old. In the group of GDM, 100 g oral glucose tolerance test (OGTT) was performed to confirm gestational diabetes. Finally, the total of 262 pregnant women recruited in the study. The Ethical Committee of the university of Sulaimani approved this study.

### *Data collection*

Data collection was performed by direct interviews with the study participants. For this, a questionnaire was constructed which surveyed the socio-demographic characteristics and previous obstetric history.

The blood sample was drowned from the participants on the day of the interview and centrifuged at 5000 r/m for 5 minutes, followed by separation of the serum that stored at -80°C in freeze until they defrosted for measurement of serum 25 dehydroxyvitamin D. In this study vitamin D level categorized into three groups

of sufficiency (more than 30ng/mL), insufficiency (between 20ng/mL and 30 ng/mL) and deficiency (less than 20ng/mL).

The validity ascertained through a pane; group of 12 experts and reliability calculated by using the correlation coefficient that was  $r=0.884$  (statistically adequate). A pilot study applies to groups of 20 pregnant women visiting maternity teaching hospital.

Statistical analysis: the data were analyzed using SPSS version 23.0 software program with the significance level set at (0.05).

## Results

In total, 262 pregnant women participated in the current study. In the table one socio-demographic variables of both groups presented. The majority of the sample in the GDM group were aged at 30 to 39 years old which were 54% of the total samples, and 41 % of the were aged between 20-29 years old. The mean and standard deviation of the age in the GDM group was 30.10, 4.94 respectively. On the other hand, in the non- GDM group the age range of 20-29 years old was the majority of the age group with 54.3% of total participants and 44.9% of participants were in the age of 30-39 years old. Mean and standard deviation of age in the non-GDM group were (28.33, 5.03) respectively.

Regarding the blood group in both groups of GDM and non-GDM the majority of the samples have an O<sup>+</sup> blood group with 39.0% in GDM group and 38.9% in the non-GDM group. 26.0% and 25.3% of the participants had A<sup>+</sup> Blood group in GDM and non-GDM group respectively.

As it is shown in the table one, the majority of the samples (68.0%) in the GDM group were in the middle class by socioeconomic class, whereas, this range was 80.2% in the non-GDM group. 8.0% of the GDM group and 6.2% of the non-GDM group were in the higher socioeconomic class. There was a statistically significant socioeconomic difference between two groups of GDM and non-GDM at a p value of 0.069.

According to the body mass index tool for estimating ideal body weight, the majority of respondents in the GDM group (47.0%), were overweight and only 34.0% of them were having normal weight. Moreover, the mean and standard deviation of the body mass index equals (26.80, 4.62) respectively. Also in non-GDM group majority (43.2%) of the total respondents were overweight and just 26.5% of them had normal weight. There was a statistical significant difference in BMI of groups in p value of 0.038.

Regarding employment variable, 75.0% of GDM samples and 79.6% of non-GDM was non-employed.

The majority of the participants in the GDM (36.0%) and in non-GDM (53.1%) group had a secondary school graduate. 32.0% of GDM and 27.2% of non- GDM had higher education. 5.0% were illiterate in GDM group and 0.6% in non-GDM group were illiterate or other education. The p value showed that education was significantly different between GDM and non-GDM group (Table 1).

The majority of the participants in both groups were living in the urban places that were 63% in the GDM and 95.7% in the non-GDM group, this difference was significant at p-value 0.000.

**Table (1): socio-demographic characteristics of pregnant women with and without GDM**

Variables	Items	GDM (n=100) PERCENT	Non-GDM (n=162) PERCENT	Total	P value
Age classes	Age Class Less than 20 years	3 (3%)	6 (3.70)	9	0.139
	20- 29 years	41(41%)	88(54.3%)	129	
	30- 39 years	54(54)	67(44.9)	121	
	40 years and more	2(2%)	1(0.61%)	3	
	Mean ± S.D	30.10 ± 4.95	28.33±5.03		

**Cont... Table (1): socio-demographic characteristics of pregnant women with and without GDM**

Blood group	Blood group				0.990
	A <sup>+</sup>	26(26%)	41(25.3%)	67	
	B <sup>+</sup>	19(19%)	31(19.1%)	50	
	AB <sup>+</sup>	8 (8%)	13(8.0%)	21	
	O <sup>+</sup>	39(39%)	63(38.9%)	102	
	A <sup>-</sup>	3(3%)	4(2.5%)	7	
	B <sup>-</sup>	2(2%)	2(1.2%)	4	
	AB <sup>-</sup>	0 (0%)	0(0.0%)	0	
Socioeconomic status	O <sup>-</sup>	3 (3%)	8(4.9%)	11	0.069
	Low class	24 (24%)	22(13.6%)	46	
	Middle class	68 (68%)	130(80.2%)	198	
Body mass index	High class	8 (8%)	10(6.2%)	18	0.038
	Underweight	1 (1%)	11(6.8%)	12	
	Normal	34 (34%)	43(26.5%)	77	
	Overweight	47 (47%)	70(43.2%)	117	
	Obese	11 (11%)	32(19.8%)	43	
	Morbid obese	7 (7%)	6(3.7%)	13	
Education	Mean ± S.D	26.80 ± 4.62	26.59 ± 4.72		0.000
	Illiterate	5 (5%)	1(0.6%)	6	
	Read and write	8 (8%)	4(2.5%)	12	
	Primary school graduate	18 (18%)	26(16.0%)	44	
	Secondary school graduate	36 (36%)	86(53.1%)	122	
	Higher education	32 (32%)	44(27.2%)	76	
Residency	Others	1 (1%)	1(0.6%)	2	0.000
	Urban	63 (63%)	155(95.7%)	218	
	Suburban	33 (33%)	5(3.1%)	38	
Occupation	Rural	4 (4%)	2(1.2%)	6	0.381
	Employee	25 (25%)	33(20.4%)	58	
	Non-Employee	75 (75%)	129(79.6%)	204	

Table one compares the association between socio-demographic characteristics of both group and significance of the association. The p value was significant at p value less than 0.05.

The obstetric characteristics of the GDM and non-GDM group are presented in the table two. The majority of the samples in the GDM group had aged at marriage between 20 to 29 years, which were 65.0% of the total participants. Likewise, in the non-GDM group majority of participations were getting married between 20 to 29 years, which were 74.7% of the total samples. Those who got married at age of 30 years and over were merely 10.0% of the total samples in GDM group and (2.5%) in non-GDM group. The differences between two groups reported as significant at p value 0.023.

It is indicated that in GDM group, the majority of the participants (54.0%) were in 20 to 29 weeks of gestational age with mean and standard deviation of (29.47, 4.70) respectively. Similarly, in the non-GDM group, 56.2% of the total participation were in 20 to 29 and 43.8% of them were in 30 to 39 weeks of gestational

age with the mean and standard deviation of (29.89, 4.18) respectively. They were significantly different at p vale of 0.085.

23.0% of the total samples in the GDM group had gravida of one and 77.0% of them had more than one pregnancy. Also in non-GDM group, 37.7% of the total samples had gravida of one and 62.3% of them more than one of gravida. The mean and standard deviation were (1.96, 1.06) respectively.

Regarding the number of delivered babied in GDM group, 68.0% of the total participations had a Para one or less and 32.0% of them more than one. In non-GDM group, 85.2% had Para number equal to one or less and 14.8% of them had para number more than one (Table 2).

**Table (2): obstetric characteristic of pregnant women with and without GDM.**

Variables	Items	GDM (n=100) PERCENT	Non-GDM (n=162) PERCENT	Total	P value
Age at marriage	Less than 20 years	25 (25%)	37(22.8%)	62	0.023
	20- 29 years	65 (65%)	121(74.7%)	186	
	30 years and over	10 (10%)	4(2.5%)	14	
Gestational age	Less than 20 Weeks	3 (3%)	0(0%)	3	0.085
	20- 29 Week	54 (54%)	91(56.2%)	145	
	30- 39 Week	43 (43%)	71(43.8%)	114	
Gravida	Equal to one	23 (23%)	61(37.7%)	84	0.014
	More than one	77 (77%)	101(62.3%)	178	
Para	One and less	68 (68%)	138(85.2%)	206	0.001
	More than one	32 (32%)	24(14.8%)	56	

Table two compare the association between obstetric characteristics of the both group and significance of the association. The p value was significant at p value less than 0.05.

As illustrated in the table 3, 77.0% of the total participations had deficient level of vitamin D, 13.0% of them had an insufficient level of vitamin D and 10.0% of them had sufficient level of vitamin D. Moreover, the mean and standard deviation of the vitamin D class is (9.12, 4.87) respectively in deficient level; (24.81, 2.86) respectively in insufficient level and (47.05, 18.65) respectively in sufficient level (Table 3).

**Table (3): Vitamin D state of GDM group**

Vitamin D class	Frequency	%	Mean	S. D
Deficient	77	77.0	9.12	4.87
Insufficient	13	13.0	24.81	2.86
Sufficient	10	10.0	47.05	18.65
Total	100	100.0		-

Table three shows the serum 25(OH) levels data expressed as frequency, percent (%) and mean. Vitamin D < 20 ng/ml considered deficient, between 20 ng/ml and 30 ng/ml considered insufficient and optimum levels above 30. Differences were considered statistically significant at p < 0.05.

In the non-GDM group, 68.5% of the total participations were on the deficient level of vitamin D, 20.4% of them were in insufficient level of vitamin D and 11.1% of them were had sufficient level of vitamin D. Moreover, the mean and standard deviation of the vitamin D class is (10.50, 4.93) respectively in deficient level; (24.42, 2.78) respectively in insufficient level and (48.98, 21.38) respectively in group of sufficient level (Table 4).

**Table (4): Vitamin D state of non-GDM group**

Vitamin D class	Frequency	%	Mean	S. D
Deficient	111	68.5	10.50	4.93
Insufficient	33	20.4	24.42	2.78
Sufficient	18	11.1	48.98	21.38
Total	162	100.0		-

Table four shows the serum 25(OH) levels data expressed as frequency, percent (%) and mean. Vitamin D < 20 ng/ml considered deficient, between 20 ng/ml and 30 ng/ml considered insufficient and optimum levels above 30. Differences were considered statistically significant at p < 0.05.

There were no statistical significant differences found between vitamin D state of two groups of GDM and non-GDM (Table 5).

**Table (5): Comparism between Vitamin D state of GDM group and non-GDM group**

Vitamin D status	GDM (n=100) Frequency (%)	Non-GDM (n=162) Frequency (%)	P-value
Deficiency	77.0 (77.0%)	111(68.5%)	0.263
Insufficiency	13.0(13.0%)	33(20.4%)	
Sufficiency	10.0(10.0%)	18(11.1%)	

Table five compares the vitamin D state in a group of women with GDM and without GDM. The difference is significant when p value less than 0.05.

### Discussion

The primary focus of this work was to compare serum 25(OH)D concentration between women with and without GDM. The current study found that hypovitaminosis D was more prevalent among GDM group compared to non- GDM group, but the difference in the serum vitamin D state was not significant. Moreover, socioeconomic state, body mass index, education, residency, age at marriage, gravida and para was significantly different between two groups of GDM and non-GDM.

The similar finding, reported by the study that investigate the association between vitamin D state and risk of GDM in Sulaimani city<sup>15</sup>. They reported that the mean of serum 25-hydroxyvitamin D concentration was lower in the group of GDM compared to non- GDM group with no statistically differences.

Observational study among South Asian population found high prevalence of vitamin D deficiency among pregnant women (16,9&10). The studies reported the several risk factors of GDM such as advanced maternal age, high BMI, parity, family history of diabetes and previous history of GDM.

In a double- blind, randomized controlled trial the effect of low dose and high dose vitamin D supplementation on glucose metabolism in pregnant women studied. The women with plasma 25-hydroxyvitamin D less than 32ng/mL and gestational age less than 20 are randomized to get a high dose of vitamin D (5000 IU/day) (n=89) and recommended pregnancy dose of 400 IU per day (90) until end of pregnancy. By the end of study twelve women (13%) in low dose group and seven women (8%) in high dose group develop GDM. Therefore, high dose of vitamin D supplementation for 14 weeks does not improve glucose level in pregnancy<sup>17</sup>.

Among observational studies, several studies showed the association between hypovitaminosis D and risk of type two diabetes mellitus (T2DM) and GDM. The studies suggest that vitamin D deficiency may

change glucose homeostasis during pregnancy<sup>18</sup>

Vitamin D level of pregnant women measured in the cohort study before gestational age of 16 weeks. Elevation of the vitamin D state of the pregnant women results in reduction in incidence of hyperglycemia in 24 to 28 weeks of gestation<sup>18</sup>.

In the review that concerned the effect of vitamin D deficiency in the development of GDM, eligible studies collected from the databases and the result reported that there is a possibility that vitamin D deficiency increase the risk of the gestational diabetes mellitus. Because of the differences in the study projects and differences in the several aspects of the studies is not logical to make a definitive conclusion<sup>19</sup>.

Serum 25-hydroxyvitamin D compared between three groups of pregnant women of GDM, non- GDM and impaired glucose tolerance test. The study which carried out by Soheilykhah et al, select 204 case s between 24-28 weeks of pregnancy and excluding cases with pre-gestational diabetes, multiple pregnancies, fetal abnormalities, chronic diseases, hypertension and history of using an anticonvulsive drug. The cases of GDM identified as having two abnormal reading of OGTT out of four, and cases of impaired glucose tolerance (IGT) defined as having just one abnormal OGTT. Vitamin D status compared between three groups. The result of the study showed that the groups of GDM and IGT had a significant lower serum vitamin D level compare to normal group. Serum vitamin D level had no any correlation with age, BMI and parity<sup>20</sup>.

In a double blind, randomized controlled trail, the impact of vitamin D supplementation on markers of glucose metabolism examined in Asian women with the history of GDM and vitamin D deficiency. In the study 26 participants received 400 IU of vitamin D and other group received placebo. OGTT test of 75g and biochemistry profile examined at the baseline and 6 month after pregnancy. The result of the study showed that 4000IU of vitamin D for the six months safely return vitamin D level and improved beta-cell function and improves metabolic state<sup>21</sup>

Ultraviolet B can be considered as the main source of vitamin D, however, the studies showed high prevalence of vitamin D deficiency among population in

the countries with plenty of sunshine<sup>16</sup>. There are some factors which work as a barrier to get enough vitamin D from the sunshine including time of the day, season, geographical region, skin pigmentation and sun cream<sup>22</sup>.

In conclusion, the results of the studies are inconclusive and have no clear outcome regarding the association between vitamin D deficiency and risk of GDM. However, because of the high prevalence of vitamin D deficiency in the area, randomized control trials may give a more reliable and accurate result.

**Financial Disclosure:** There is no financial disclosure.

**Conflict of Interest:** None to declare.

**Ethical Clearance:** All experimental protocols were approved under the Diabetes and Endocrine Center and all experiments were carried out in accordance with approved guidelines.

## References

1. Debnath A, Gupta M, Jain S, Kumari S, Biswas T, Ray S, et al. Hypovitaminosis D is associated with gestational diabetes mellitus. *J Clin Diagnostic Res.* 2017;11(10):QC01–3.
2. Muthukrishnan J, Dhruv G. Vitamin D status and gestational diabetes mellitus. *Indian J Endocrinol Metab* [Internet]. 2015;19(5):616. Available from: <http://www.ijem.in/text.asp?2015/19/5/616/163175>
3. Saxena R, Saxena R. Diabetes Mellitus and Gestational Diabetes. *An Evidence-Based Clin Textb Obstet Gynaecol MRCOG-2.* 2018;25:147–147.
4. Moore LE. *Diabetes in Pregnancy.* Springer International Publishing; 2018. 47–54 p.
5. Di Cianni G, Volpe L, Lencioni C, Miccoli R, Cuccuru I, Ghio A, et al. Prevalence and risk factors for gestational diabetes assessed by universal screening. *Diabetes Res Clin Pract.* 2003;62(2):131–7.
6. Ashwal E, Hod M. Gestational diabetes mellitus: Where are we now? *Clin Chim Acta* [Internet]. 2015;451:14–20. Available from: <http://dx.doi.org/10.1016/j.cca.2015.01.021>
7. Anna V, Van Der Ploeg HP, Cheung NW, Huxley RR, Bauman AE. Sociodemographic correlates of the increasing trend in prevalence of gestational diabetes mellitus in a large population of women between 1995 and 2005. *Diabetes Care.* 2008;31(12):2288–93.
8. Lu M, Xu Y, Lv L, Zhang M. Association between vitamin D status and the risk of gestational diabetes mellitus: a meta-analysis. *Arch Gynecol Obstet.* 2016;293(5):959–66.
9. Kazemi A, Sharifi F, Jafari N, Mousavinasab N. High Prevalence of Vitamin D Deficiency among Pregnant Women and their Newborns in an Iranian Population. *J Women's Heal.* 2009;18(6):835–9.
10. Vitamin D metabolism - Lehmann - 2010 - *Dermatologic Therapy* - Wiley Online Library.pdf.
11. Zemleni J, Suttie JW, Gregory J, Stover P. *HANDBOOK OF VITAMINS* [Internet]. Fifth Edition. Zemleni J, Suttie JW, Gregory J, Stover P, editors. London, New York, Boca Raton : Taylor & Francis Group; 2014. 51–79 p. Available from: <http://www.taylorandfrancis.com>
12. Amegah AK, Klevor MK, Wagner CL. Maternal Vitamin D insufficiency and risk of adverse pregnancy and birth outcomes: A systematic review and meta-analysis of longitudinal studies. *PLoS One.* 2017;12(3):1–22.
13. Farrant HJW, Krishnaveni G V, Hill JC, Boucher BJ, Fisher DJ, Noonan K, et al. Vitamin D insufficiency is common in Indian mothers, but is not associated with gestational diabetes or variation in newborn size. 2009;646–52.
14. Maghbooli Z, Hossein-Nezhad A, Mirzaei K, Karimi F, Besharati A, Omidfar K, et al. Association between retinol-binding protein 4 concentrations and gestational diabetes mellitus and risk of developing metabolic syndrome after pregnancy. *Reprod Sci.* 2010;17(2):196–201.
15. Bushra J. Hamarashid and Atiya K. Mohammed, 2020, Comparing parity, socio-demographic and serum vitamin D among pregnant women with and without GDM. *Medico Legal Update.* Volume. 20, No. 4.
16. Al-Faris NA. High prevalence of vitamin D deficiency among pregnant saudi women. *Nutrients.* 2016;8(2):6–15.
17. Yap C, Cheung NW, Gunton JE, Athayde N, Munns CF, Duke A. Vitamin D Supplementation and the Effects on Glucose Metabolism During

- Pregnancy : A Randomized Controlled Trial. 2014;37(January):1837–44.
18. Weinert LS, Silveiro SP. Maternal–Fetal Impact of Vitamin D Deficiency: A Critical Review. *Matern Child Health J.* 2014;19(1):94–101.
  19. Amraei M, Mohamadpour S, Sayehmiri K, Mousavi SF, Shirzadpour E, Moayeri A. Effects of vitamin D deficiency on incidence risk of gestational diabetes mellitus: A systematic review and meta-analysis. *Front Endocrinol (Lausanne).* 2018;9(FEB):1–11.
  20. Rashidi M. Incidence of gestational diabetes mellitus in pregnant women. 2014;(December 2010).
  21. Yeow TP, Lim SL, Hor CP, Khir AS, Mohamud WNW, Pacini G. Impact of vitamin D replacement on markers of glucose metabolism and cardio-metabolic risk in women with former gestational diabetes - A double-blind, randomized controlled trial. *PLoS One.* 2015;10(6):1–16.
  22. Holick MF, Chen TC. Vitamin D deficiency: A worldwide problem with health consequences. *Am J Clin Nutr.* 2008;87(4):1080–6.