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The Association between Maternal Serum Vitamin D Levels and Gestational Diabetes Mellitus among Filipino Patients: A Cross-Sectional Study

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Abstract

Objectives. To determine the association between low maternal serum vitamin D and gestational diabetes mellitus (GDM) among Filipino women in St. Luke's Medical Center, Quezon City.

Methodology. A cross-sectional study involving pregnant women at outpatient clinics in a tertiary hospital in the Philippines. Simultaneous testing for fasting blood sugar, 75g oral glucose tolerance test and serum vitamin D was done. Participants were classified as GDM versus non-GDM, and normal versus low serum vitamin D. Univariate and multivariate statistics were done to determine relationship between vitamin D and GDM.

Results. Of 211 included women, 198 (93.8%) had low vitamin D levels, and 56 (26.5%) had GDM. Vitamin D was significantly higher in the GDM group (21.0±8.1 vs 18.8±5.3 ng/mL, *p*=0.0189). The proportion of women with low vitamin D levels was significantly higher among those without GDM (96.1% vs 87.5%, OR=0.28, p=0.029]. After adjusting for age, parity, history of GDM and pre-pregnancy BMI, no significant association was observed (adjusted OR=0.66, *p*=0.522). No correlation was seen between vitamin D and FBS (r=0.28, *p*=0.095), 1-hour post-75 g OGTT (r=0.26, *p*=0.643), and 2-hour post-75 g OGTT (r=0.28, *p*=0.113).

Conclusion. There was an association found between maternal serum vitamin D level and GDM in the univariate analysis, but none was evident after adjusting for possible confounders. The unanticipated high prevalence of low vitamin D levels among pregnant Filipinos needs to be verified in future studies.

Key words: gestational diabetes mellitus, gestational diabetes, vitamin D deficiency

INTRODUCTION

Gestational Diabetes Mellitus (GDM)

GDM is defined by the American Diabetes Association (ADA) as diabetes diagnosed in the second or third trimester of pregnancy that is not clearly either type 1 or type 2 diabetes.[1] Its occurrence, like type 2 diabetes mellitus, is increasing reaching a global prevalence of 15% to 20%,[2] while locally in the Philippines, it was reported to be at 14%.[3] It carries the risk of adverse maternal, fetal and neonatal outcomes including increased birth weight above the 90th percentile, as well as a higher incidence of neonatal hypoglycemia and primary cesarean section demonstrated in the large-scale multinational cohort study called The Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study.[4] Other reported risks increased by GDM are the development of preeclampsia and dystocia, and the predisposition of both the mother and offspring to develop obesity, type 2 diabetes mellitus and the metabolic syndrome. Recognized risk factors in the development of GDM include advanced maternal age, obesity, ethnicity, family history of diabetes, and a previous history of abnormal glucose metabolism and polycystic ovarian syndrome. Parity per se was not found to have any direct link to GDM appearance.[5] Recently, vitamin D was identified as a potential contributor to its occurrence.

Vitamin D and its Extra-skeletal Effects

There is gaining interest in the role of vitamin D in diabetes mellitus. Studies found that its function extends beyond calcium and bone metabolism. It was demonstrated in animal models to improve pancreatic exocrine function and insulin sensitivity.[6] Calcitriol or 1,25$(OH)_2$D, the form of vitamin D produced in the kidneys, was shown in animal models to have effects on the synthesis, secretion, and actions of insulin.[7,8] It enhances insulin-dependent glucose transport by inducing insulin receptor expression.

Pregnancy and Vitamin D

Physiologic changes in vitamin D metabolism during pregnancy are still incompletely understood. Studies showed an increase in vitamin D binding proteins by 7% to 152% [9,10,11,12] as well as serum 1,25$(OH)_2$D by 104% to 134% with minimal effect on serum 25(OH)D.[13,14]

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Serum 1,25$(OH)_2$D levels are expected to return to pre-pregnancy levels by weeks 8 to 10 postpartum. Both forms of vitamin D cross the placenta to the growing fetus, the latter theorized to be the predominant metabolite.[15]

There is still a lack of consensus on the definition of normal vitamin D levels among pregnant women. Based on the systematic review by the Institute of Medicine (IOM), serum 25(OH)D levels below 20 ng/mL (50 nmol/L) are considered insufficient.[16] The Endocrine Society Clinical Practice Guidelines define vitamin D insufficiency as 25(OH)D levels of >20 ng/mL (50 nmol/L) and <30 ng/mL (75 nmol/L), and vitamin D deficiency as levels ≤20 ng/mL.[17] The National Institute for Health and Clinical Excellence guidelines, on the other hand, define vitamin D insufficiency as 25(OH) D levels less than 10 ng/mL (25 nmol/L).[18] However, these cutoff values are based on optimal levels in maintaining skeletal health in the general population. There remains the need to establish a normal range among pregnant women.

GDM and Vitamin D

In gestational diabetes mellitus, vitamin D acts as a potential immunosuppressant that downregulates the expression of pro-inflammatory marker such as TNF-α and IL-2.[19] Many observational studies found an association between low maternal levels of serum vitamin D and GDM. A case-control study done in Istanbul by Parildar et al., (2013) among 44 pregnant women with GDM and 78 non-GDM pregnant women showed a lower mean serum vitamin D level among GDM patients (14.3±8.2 ng/ml) versus that of controls (23.2±8.3 ng/ml, p=0.001). Vitamin D deficiency (defined as vitamin D of ≤20 ng/mL) prevalence was 56.8% among GDM patients and 35.8% among non-GDM patients.[20] Another nested case-control study by Wen et al.,(2017) which included 4718 pregnant women from China, 1280 of whom were diagnosed with GDM, found that maternal serum 25(OH)D were significantly lower in women with GDM [42.4 (34.5, 54.0) nmol/L] compared to controls [44.4 (36.0, 58.8) nmol/L, p<0.001]. Seventy percent of women with GDM had vitamin D <50 nmol/L compared to 60.5% in the control group.[21]

There were other studies, however, that found no significant link between the two conditions. Makgoba et al., (2011) conducted a case-control study in Europe involving 248 women in the first trimester of pregnancy, 90 of whom developed GDM. They found no correlation between mean vitamin D levels among those with GDM (18.9±10.7 ng/ml) versus those without GDM (19.0±10.7, p=0.874), even after adjustment for possible confounders (p=0.784).[22] A case-control study by Pleskacova et al., (2015) among 47 pregnant women with GDM and 29 healthy controls measured mid-gestational and early postpartum vitamin D levels. They found a high prevalence of vitamin D deficiency in both groups (95.7% in women with GDM, 93.1% in controls), but mean levels were not significantly different [28.5 (21.0, 34.0) nmol/L in women with GDM, 31.7 (24.0, 40.0) in controls; p>0.05].[23]

Meta-analyses and systematic reviews aimed to absolve these conflicting data. One done by Aghajafari (2013) on the role of vitamin D in pregnancy included 31 studies published between 1980 and 2012, 10 studies of which had gestational diabetes as the outcome, with a total of 687 cases and 3425 controls. They reported that low vitamin D levels were associated with GDM [pooled odds ratio (OR)=1.49, (1.18-1.89)] with no evidence of heterogeneity (I^2=0%).[24] Participants in this meta-analysis, however, included Americans, Asians, Europeans, Canadians and Middle Easterners. There was no representative study for Southeast Asians.

A recently published article by Hu et al., (2018) pooled data from 29 observational studies which included 28982 participants, with more than half being Asian of Chinese and Korean descent, 4634 of whom were diagnosed with GDM. It was demonstrated that low levels of vitamin D significantly increased the risk for GDM by 39% (pooled OR=1.39, [1.20, 1.60]) albeit with moderate heterogeneity (I^2=50.2%, p=0.001). Vitamin D levels were significantly lower among patients with GDM compared with controls with a pooled effect of -4.79 (-6.43, -3.15) nmol/L and significant heterogeneity (I^2=65.0%, p<0.001).[2]

Several limitations of these meta-analyses may hinder the applicability of results in the Filipino population. These include the observational nature of included studies, as well as the diversity of study populations in terms of ethnicity with inadequate representation of Southeast Asians. Other confounders that were not considered were adiposity and laboratory techniques in the measurement of serum 25(OH)D. In this light, local data is needed to assess its applicability in the Filipino community.

The current guidelines of the American College of Obstetrics and Gynecology (ACOG)[25] and World Health Organization[26] do not recommend routine screening for vitamin D deficiency among pregnant women, except those who are considered high risk – only then would screening and treatment be initiated. Current knowledge points toward a possible link between GDM and low maternal vitamin D levels, but the challenge lies in its translation to clinical recommendation whether achieving optimal levels of vitamin D can actually prevent GDM and its associated sequelae. Establishing an association between the two conditions among Filipinos can pave the way for future local studies on causality and benefit of vitamin D screening and correction in pregnant patients to prevent GDM, in the hope of ultimately improving maternal and fetal outcomes in the country.

This study aimed to determine the association of low levels of maternal serum vitamin D levels and GDM among Filipino patients in St. Luke's Medical Center, Quezon City.

METHODOLOGY

This was a single-center study. Target population included both social service and private outpatients in St. Luke's Medical Center, Quezon City, a private tertiary hospital in the Philippines, from April 2019 to January 2020. Table 1 enumerates the inclusion and exclusion criteria of participants.

Description of Study Procedure

This was a cross-sectional study involving pregnant women seen at both private and social service outpatient clinics at St. Luke's Medical Center, Quezon City from April 2019 to January 2020.

Table 1. Eligibility criteria

Inclusion criteria
• Pregnant Filipino women above 18 years old
Exclusion criteria
• Pregnant women who fulfill diagnostic criteria for diabetes mellitus before 24 weeks age of gestation • Pregnant women with: ◦ History of type 1 or type 2 diabetes mellitus prior to pregnancy ◦ Multifetal pregnancy ◦ Use of artificial reproductive technology ◦ Fetal abnormalities ◦ Chronic liver or renal failure ◦ Parathyroid or bone metabolism abnormalities ◦ Malignancy

Consent was obtained from obstetricians and endocrinologists to screen their patients for inclusion in this study. All pregnant women who were in their second or third trimester scheduled to undergo FBS and 75 g OGTT as standard of care, who met eligibility criteria were included in the study. Informed consent was obtained by the study investigator or designated representative during their clinic visit. The study investigator or designated representative gathered demographic information which included age, pre-pregnancy BMI, personal history of abnormal glucose metabolism (prediabetes, impaired glucose tolerance, impaired fasting glucose), previous GDM, history of poor obstetric outcome (including but not limited to macrosomia, fetal demise, spontaneous abortion), and family history of diabetes.

During their scheduled blood draw for FBS and OGTT, blood samples were likewise taken through venipuncture by the medical technologist to measure serum vitamin D levels. These tests were done at the St. Luke's Medical Center laboratory. Patients were then classified as to having GDM and no GDM, as well as to having low and normal vitamin D levels (Figure 1).

Description of Test Procedures

The measurement of total vitamin D was done at St. Luke's Medical Center, Quezon City serology laboratory using an in vitro diagnostic electrochemiluminescent process according to the manufacturer's instructions. Reported deviations are as follows: for concentrations up to 15ng/ml, deviation is ≤1.5 ng/ml; for concentrations >15 ng/ml, deviation is ≤10%.

Diagnosis

The diagnosis of GDM was based on the ADA criteria,[1] and was made when any of the following plasma glucose values were met or exceeded with a 75 g OGTT during the second or third trimester of pregnancy: fasting blood sugar of 92 mg/dl; 1-hour post-OGTT of 180 mg/dl; or 2-hour post-OGTT of 153 mg/dl.

Since there is still a lack of consensus on definitions of vitamin D deficiency and insufficiency among pregnant women, the Endocrine Society Clinical Practice Guideline[17] definition was applied. Patients were classified as having low levels of vitamin D when serum level of total vitamin D was ≤30 ng/ml. Those with low vitamin D levels were further classified as vitamin D insufficient when levels were 21-30 ng/ml, and vitamin D deficient at levels ≤20 ng/ml.

Outcome Measures

The primary outcome of this study was the prevalence of low maternal levels of vitamin D among patients with GDM. The secondary outcomes were the prevalence of vitamin D insufficiency and vitamin D deficiency among patients with GDM, the mean vitamin D level among patients with GDM, and the correlation between FBS and 75g OGTT levels with maternal serum vitamin D levels.

Sample Size Estimation

Based on a level of significance of 5% and a power of 90%, a minimum of 190 patients were required for this study. This was derived from preliminary data from an article by Parildar et al., (2013)[20] which reported a prevalence of 56.8% of vitamin D deficiency among pregnant women with GDM and 35.8% in pregnant women without GDM. Controlling for 2 more variables in the analysis (age, parity), with an additional 10% for each control variable, final sample size required was 228. The computed sample size assumes that the proportion of patients to be assigned to the two groups is equal.

Data Processing and Analysis

Data was processed and encoded using Microsoft Excel. Statistical analysis was done using STATA version 14. Determination of the relationship between maternal serum vitamin D levels and GDM was analyzed using univariate and multivariate statistics. Chi-square test and logistic regression were done in the univariate analysis of qualitative and quantitative independent variables, respectively. Multiple logistic regression was utilized in the multivariate analysis. Crude and adjusted OR and the 95% confidence interval were also calculated. Pearson's r was calculated to determine the correlation of vitamin D and parameters of OGTT. Level of significance was set at $\alpha = 0.05$.

Ethical Considerations

The clinical protocol and all relevant documents were reviewed and approved by the SLMC Institutional Ethics

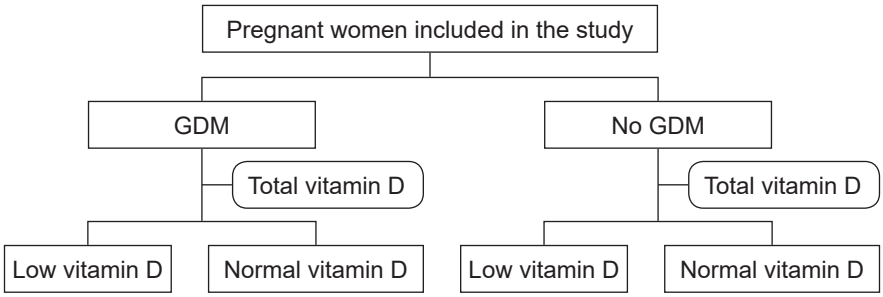

Figure 1. Schematic diagram of study design from time of inclusion of participants.

Table 2. Baseline characteristics

	GDM (n=56, 26.5%)	No GDM (n=155, 73.5%)	*p* value
Age (yrs)	33.2±5.6	28.7±5.2	0
Pre-pregnancy BMI (kg/m^2)	23.0±3.6	22.1±3.6	0.12
Parity n (%)			
Nulliparous	13 (23.2)	71 (45.8)	
1-2 previous deliveries	40 (71.4)	74 (47.7)	0.008
≥3 previous deliveries	3 (5.4)	10 (6.5)	
Previous history of GDM n (%)	14 (25.0)	15 (9.7)	0.004
History of poor obstetric outcome n (%)	4 (7.1)	19 (12.3)	0.292
History of abnormal glucose metabolism n (%)	1 (1.8)	1 (0.6)	0.461
History of polycystic ovarian syndrome n (%)	8 (14.3)	12 (7.7)	0.183
Family history of diabetes n (%)	21 (37.5)	73 (47.1)	0.272
Fasting blood glucose (mg/dL)	93.6±21.3	76.8±7.4	0
75g oral glucose tolerance (mg/dL)			
1st hour (mg/dL)	192.1±34.7	133.6±26.2	0
2nd hour (mg/dL)	162.2±29.0	110.9±21.0	0
Vitamin D level (ng/mL)	21.0±8.1	18.7±5.3	0.0189

Review Committee. As respect to patient confidentiality, anonymity of patient records was ensured by assigning a unique code to each patient. The principal investigators were responsible for the integrity of the data that was recorded. The protection of confidentiality of the data was guaranteed by the manner of dissemination of study results. Written and signed informed consent were obtained and data collection forms were compiled and stored in an envelope. Data was tabulated in Microsoft Excel format and saved in a CD. These will be kept and filed in the Diabetes, Thyroid and Endocrine Center under the Section of Endocrinology for 5 years before they are shredded.

RESULTS

Two hundred eighty-nine pregnant women were screened and gave their consent to be included in this study. However, only 211 complied with the required test procedures and were subsequently included in the analysis. Fifty-six of these women (26.5%) were diagnosed with GDM by ADA criteria, and 155 (73.5%) without GDM. Women with GDM had a significantly higher average age compared to those without GDM (p<0.001). Both groups likewise differed significantly in terms of parity. Majority of those with GDM had 1-2 previous deliveries, while most of those without GDM were nulliparous or had 1-2 previous deliveries (p=0.008). The proportion of women with a previous history of GDM was significantly higher among those with GDM (p=0.004) There was no significant difference between the two groups in terms of pre-pregnancy BMI, history of poor obstetric outcome, abnormal glucose metabolism, PCOS or family history of diabetes. The summary of baseline characteristics is seen in Table 2.

Low vitamin D levels were seen in 198 of the participants, accounting for 93.8% of the entire group. Vitamin D level was significantly higher in the GDM group (21.0±8.1 vs 18.7±5.3 ng/mL, p=0.0189). The proportion of patients with low vitamin D levels was significantly higher among those without GDM [GDM 49 (87.5%) vs no GDM 149 (96.1%)]. Calculating for the odds ratio (OR), having low vitamin D levels was significantly associated with a lower likelihood for GDM (OR=0.28, p=0.029). However, after adjusting for age, parity, history of GDM, and pre-pregnancy BMI no significant association was observed (OR=0.66, p=0.522). The same trend was demonstrated on subgroup analysis of those with vitamin D insufficiency (OR=0.32, p=0.069; adjusted OR=0.55, p=0.433) and vitamin D deficiency (OR=0.27, p=0.025; adjusted OR=0.65, p=0.511). These are summarized in Table 3. No correlation was found between Vitamin D and FBS (Figure 2, r=0.28, p=0.095), 1-hour post 75 g OGTT (Figure 3, r=0.26, p=0.643), and 2-hour post 75 g OGTT (Figure 4, r=0.28, p=0.113).

DISCUSSION

Vitamin D acts as a potential immunosuppressant that downregulates the expression of pro-inflammatory markers which are associated with the development of GDM.[19] It is also known to influence insulin secretion thereby affecting circulating glucose levels.[27] Hence, low concentrations of vitamin D is a potential risk factor for developing GDM. GDM, on the other hand, is associated with several adverse maternal and fetal outcomes including increased birthweight, neonatal hypoglycemia, increased incidence for primary cesarean section, preeclampsia and dystocia, and the predisposition of both the mother and offspring to develop obesity, type 2 diabetes mellitus and the metabolic syndrome.

Table 3. Vitamin D levels among patients with GDM

	GDM (n=56, 26.5%)	No GDM (n=155, 73.5%)	*p* value	Unadjusted OR (95% CI)	*p* value	Adjusted OR *(95% CI)	*p* value*
Normal Vitamin D (n=13)	7 (12.5)	6 (3.9)	0.021	Reference	–	Reference	–
Low Vitamin D (n=198)	49 (87.5)	149 (96.1)		0.28 (0.09-0.88)	0.029	0.66 (0.18-2.36)	0.522
Vitamin D insufficiency (n=59)	16 (69.6)	43 (87.8)	0.061	0.32 (0.09-1.09)	0.069	0.55 (0.12-2.48)	0.433
Vitamin D deficiency (n=139)	33 (82.5)	106 (94.6)	0.018	0.27 (0.08-0.85)	0.025	0.65 (0.18-2.38)	0.511

*adjusted for pre-pregnancy BMI, age, parity and history of GDM

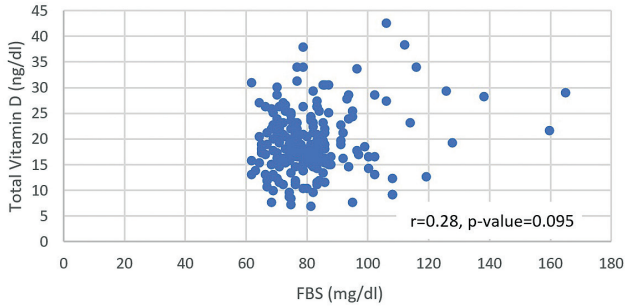

Figure 2. Scatter plot of FBS against total vitamin D.

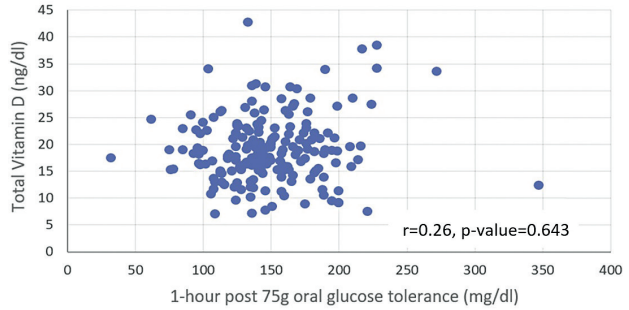

Figure 3. Scatter plot of 1-hour post 75 g oral glucose tolerance against total vitamin D.

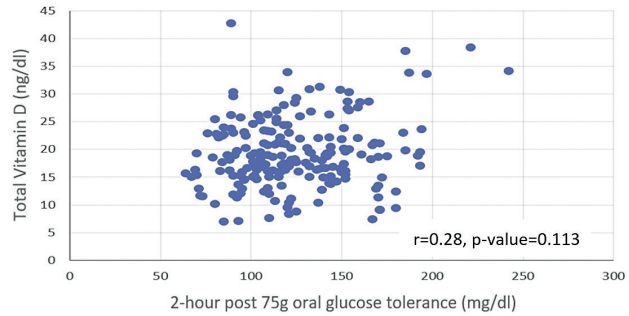

Figure 4. Scatter plot of 2-hour post 75 g oral glucose tolerance against total vitamin D.

In this study, pregnant women diagnosed with GDM had a significantly higher mean age and history of previous GDM, both of which are established risk factors for GDM. Other risk factors for GDM such as BMI, a history of abnormal glucose metabolism, PCOS, family history for diabetes, were not found to have any direct link to GDM appearance in the participants. Increased parity was also seen in the GDM group, although parity per se has not been shown to be a risk factor for its development.[5]

There is still no established cutoff to define normal vitamin D levels among pregnant women. Several ranges have been used to define vitamin D sufficiency,[16,17,18] but these were set on the basis of optimal levels to maintain skeletal health in the general population. There remains the prerequisite to determine the normal range for pregnant women. Employing the cutoffs recommended by the Endocrine Society Clinical practice guidelines to define vitamin D insufficiency (>20 to <30 ng/mL, or >50 to 75 nmol/L) and deficiency (≤20 ng/mL, or ≤50 nmol/L),[17] there was a high overall prevalence of 93.8% for low vitamin D levels among pregnant women included in this study. This is similar to a study on 74 pregnant Czech women which found an overall prevalence of 94.7%.[23] Other studies, however, reported lower rates. An incidence rate of vitamin D deficiency (<50 nmol/L) among 98 pregnant Chinese women was reported at 20.4%.[19] A larger cohort of 4718 Chinese women were found to have a higher prevalence rate of 63.1%[21] with a median 25(OH)D concentration of 43.7 nmol/L. Another study in Nepal involving 79 pregnant women revealed an even higher rate of 81%.[28]

Local data on the prevalence of vitamin D among pregnant Filipino women are still lacking. For the general population, however, the overall prevalence of combined vitamin D deficiency and insufficiency was 48.7%. In the same report, low vitamin D levels were highest in people residing in NCR (54.1%), with a higher prevalence in females (62.5%), in the age group of 20-39 years old (55.5%)[29]– all factors of which were similar to the profile of the women included in this study which could explain the relatively increased rates observed. Avoidance of sun exposure, whether intentional (i.e., to maintain fair skin for aesthetic reasons, to prevent sunburns) or unintentional (i.e., occupation setting mostly indoors) likely contributes to the low vitamin D levels in this population. It is unclear if pregnancy per se contributes to this decrease.

Important to note as well, although not quantified, is that women who were included in this study were already on vitamin D supplementation as part of standard of prenatal care. Yet, there remained a high prevalence of low vitamin D levels. A study by Lau et al., found that among 147 pregnant Australian women on daily vitamin D supplementation of 400 IU or 500 IU, 41% remained vitamin D deficient.[30] This might imply that the amount of supplementation given as standard of care is not enough to augment already low vitamin D levels.

Vitamin D levels were significantly higher among patients with GDM (GDM 21.0±8.1 ng/mL vs no GDM 18.7±5.3 ng/mL, p=0.0189). However, the absolute difference between both groups may be small clinically. Pregnant women with low vitamin D levels were found to have lower odds of having GDM (OR=0.28, p=0.029). These findings contradict the initial hypothesis of this study. To our knowledge, there have been no studies reporting an association between high vitamin D levels and the occurrence of GDM. We attribute this finding to random chance or a type I error, as the initial calculated sample size of 228 was not reached. Furthermore, after adjusting for, age, parity, history of GDM, and pre-pregnancy BMI, no significant association was observed (adjusted OR=0.66, p=0.522). The same finding was true when stratified according to vitamin D insufficient (adjusted OR=0.55, p=0.433) and deficient individuals (adjusted OR=0.65, p=0.511). Similar findings of non-association were reported by previous studies. A study on 76 pregnant Czech women by Pleskacova et al., found a prevalence of vitamin D deficiency of 95.7% among those with GDM and 93.1% among controls (p=NS)[23]. Makgoba et al., studied 248 women and found a rate of 57% among those with GDM versus 62.2% among those without GDM (p=0.502)[22]. However, the results of this current study are in contrast with many other studies including meta-analyses by Aghajafari and Lu. In the former, 10 studies were included in the analysis and it was found that GDM was associated with insufficient vitamin D levels compared with controls (pooled OR=1.49

using random effects model, $I^2 = 0\%$).[24] In the latter which analyzed 20 observational studies that contained a total of 16,515 pregnant women, maternal vitamin D insufficiency was found to be associated with greater risk for GDM (RR=1.45, $p<0.0001$).[31]

The lack of association between GDM and low maternal serum vitamin D levels in this study may be due to the high overall prevalence of low vitamin D levels. Hence, vitamin D levels were plotted against FBS, 1-hour and 2-hour blood glucose post 75 g OGTT. However, still no significant correlations were found. The study by Makgoba et al., found no association between low vitamin D levels and GDM, but found a negative correlation between vitamin D and fasting glucose (p=0.009) and blood glucose 2-hours after a glucose load (p=0.002) at 28 weeks of gestation.[22] Similarly, Burris et al., found an inverse association between vitamin D levels of women in their second trimester and blood glucose levels after a 50 g oral glucose load. However, only 5% of these women developed GDM.[32] Only the study by Soheilykhah among Iranian women found no correlation between vitamin D levels and FBS despite reporting a higher prevalence of vitamin D deficiency among women with impaired glucose tolerance and GDM.[33]

This investigation is limited by a few factors. Many studies have demonstrated a likely link between low maternal serum vitamin D levels and GDM. However, if present, this association is probably very small and may have been diluted by the unanticipated high prevalence of low serum vitamin D levels, which was the reason it was not detected in this study. Given the high rates of low vitamin D levels found in this investigation, a study with a power of 90% and level of significance of 5% will require at least 261 participants to detect if an association indeed exists.

Furthermore, the cutoffs to define vitamin D sufficiency, insufficiency and deficiency were based on levels to maintain skeletal health in the general population. A different level of vitamin D may be required to achieve optimal glycemic control and prevention of GDM among pregnant women. Thus, future studies should aim to determine this threshold.

CONCLUSION

There was an association found between maternal serum vitamin D level and GDM in the univariate analysis but none was evident after adjusting for possible confounders. Given the high prevalence of low vitamin D levels among pregnant Filipino women, the absence of an association between vitamin D and GDM in this study cannot be firmly established. This unanticipated high prevalence of low vitamin D levels needs to be verified in future studies.

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Statement of Authorship
The author certified fulfillment of ICMJE authorship criteria.

Author Disclosure
The author declared no conflicts of interest.

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