Original article

# Association of gestational diabetes mellitus with vitamin D deficiency among Saudi pregnant women: A case-control study

**Zarqa Saleem[1], Aisha Mansoor Ali[2]**
[1]Consultant Obstetrics and Gynecology, Dr Suleiman Habib Hospital, Takhussusi Road, Rehmania, PO Box 11393, Riyadh Saudi Arabia, [2]Consultant Obstetrics and Gynecology, Women Specialized Hospital, King Fahad Medical City, PO Box 59046, Riyadh 11525
***Correspondence to:*** Dr. Zarqa Saleem, Email: asalwa44@yahoo.com

## ABSTRACT

Background: Prevalence of gestational diabetes mellitus (GDM) and 25-hydroxyvitamin D (vitamin D) deficiency is high in Saudi Arabia. Whether GDM is associated with low vitamin D level or not is still under debate, and the literature regarding this association is deficient in Saudi Arabia. GDM is associated with an adverse pregnancy outcome; therefore, the current study was conducted on Saudi pregnant women to evaluate this relationship.

Subjects and methods: This case-control study was conducted in the antenatal clinic at King Fahad Medical City, Riyadh, from February 2015 till February 2017. The Study included 300 pregnant women, of which 100 were GDM cases, and 200 were controls (i.e., without GDM). Cases and control were matched for age, parity, body mass index, gestational age, family history of diabetes mellitus. Vitamin D levels were obtained between 24 to 28 weeks of gestation along with Oral Glucose Tolerance Test (OGTT).

Results: The levels of vitamin D among pregnant Saudi women were sufficient in 13%, insufficient in 51%, and deficient in 36%. It was evident that Vitamin D deficiency (≤25 nmol/L) was associated with 3 times more abnormal OGTT. Patients with vitamin D deficiency had a 2.3 times greater risk for developing GDM than those having normal levels. There was no difference among cases and controls regarding, demographic variables like age parity BMI and previous history of GDM.

Conclusion: An inverse relationship between GDM development and maternal vitamin D deficiency.

Keywords:
Gestational diabetes mellitus; 25-hydroxyvitamin D; Pregnant

## INTRODUCTION

Gestational diabetes mellitus (GDM) is a carbohydrate intolerance that causes hyperglycemia, which should be diagnosed between 24-28 weeks of gestation.[1] The prevalence depends on ethnicity, age, and screening methods.[2] GDM prevalence is increased by many times since 1995, reaching almost 45% worldwide, 36.6% in Saudi Arabia and 17.2% in Pakistan.[2-4] Mechanism of GDM development is still under evaluation but is linked to several factors like maternal age, socioeconomic position, and ethnicity.[5] GDM is associated with complications like macrosomia, birth trauma, shoulder dystocia, preeclampsia, and neonatal hypoglycemia.[6]

Vitamin D deficiency is common in Saudi Arabia, in reproductive age group females, it is approximately 50% while, in the rest of the population (male and female) it is around 60%.[7-9] Vitamin D deficiency is a global problem in pregnancy with prevalence reaching 40-99.5% in Oman, UK, USA, Kuwait, Turkey, Pakistan, urban India, Japan and China.[10-12] It is very high in some regions of India (96%) and Pakistan (99.5%).[11,12] In spite of adequate sunlight exposure, 90% of the cases are due to inactivity, chronic diseases, obesity, genetic factors, and dietary insufficiency.[13,14] Several epidemiological studies suggest a link between low vitamin D levels and an increased risk of gestational diabetes, type 2 DM, osteoporosis, pre-eclampsia, cesarean section, and fetal growth restriction and other adverse pregnancy and neonatal outcomes.[13-22]

The exact mechanism by which GDM develops is not well established. Vitamin D is needed directly by beta cells of the pancreas for insulin secretion.[23] Vitamin D level indirectly affects peripheral insulin receptor sensitivity.[23] In pregnancy, which is complicated by GDM, if associated with vitamin D deficiency it may either start or exaggerate this process by decreasing insulin secretion and sensitivity.[23-25] In literature, it is reported that low vitamin D level is associated with high hemoglobin A1C (HbA1C) levels.[26]

Numerous studies conducted in from around the globe demonstrated contradictory results regarding the association of vitamin D deficiency and GDM.[26-31] In Saudi Arabia, a study has shown a positive association between low vitamin D levels with GDM.[32] Similarly,

**Conflict of interest:** The authors declared no conflict of interest exist.
**Citation:** Saleem Z, Ali AM. Association of gestational diabetes mellitus with vitamin D deficiency among Saudi pregnant women: A case-control study. J Fatima Jinnah Medical Univ. 2019; 13(3): 97-101.

**DOI: https://doi.org/0.37018/jfjmu.v13i3.641**

various studies supported the inverse association between low vitamin D levels and prevalence of GDM.[33] On the contrary, other studies prove no association.[33] Therefore, more studies are needed to confirm this causal relationship. The current study aimed to determine the prevalence of vitamin D deficiency among pregnant Saudi women and to find the association between vitamin D deficiency and GDM.

## SUBJECTS AND METHODS

The study was conducted after taking approval (approval No. 17-247) from the Institutional Review Board (IRB), King Fahad Medical City Riyadh. This case-control study was carried out at Women's Specialized Hospital, King Fahad Medical City, Riyadh, Saudi Arabia, from February 2015 to February 2017. The study included pregnant women with an age range of 18-45 years.

The total sample size was 300 pregnant women, comprising of 100 subjects with GDM (cases) and 200 subjects without GDM (controls). The estimation of the sample size was carried out using PASS 11 software.[34] In a matched case-control study, the probability of exposure among sampled control patients was 0.30, and the correlation coefficient for exposure between matched case and control patients was 0.1. Therefore, a sample of 100 participants (cases) was determined. For each case-patient, a matching sample of 200 participants was also obtained. Which will achieve 80% power to detect an odds ratio of 0.50 versus the alternative of equal odds using a Chi-Square test with a 0.05 significance level.

Three hundred patient's health record was retrieved from the electronic record system of the hospital HIM and CORTEX. Saudi Women who visited for routine antenatal followed up during the study period and were tested between 24-28 weeks of gestation both for vitamin D[21,22] levels and OGTT[35], were later recruited in the study.

Data for OGTT (Oral Glucose Tolerance Test) and serum 25-hydroxyvitamin D [25(OH)D] results performed between 24-28 weeks of gestation were recorded. For serum 25(OH)D concentrations assay, the tests performed using the Roche Cobas e601 Immunoassay Analyzer using the Roche Elecsys vitamin D3 assay (Roche Diagnostics, Mannheim, Germany). Reference ranges used in this study were based on Endocrine Society Guidelines. According to which vitamin D deficiency was defined as levels ≤25 nmol/L, insufficiency as 25–75 nmol/L, and sufficient as 75–200 nmol/L.[21-22] The least required satisfactory serum level of Vitamin D was 75–80 nmol/L.[21-22]

For OGTT, the one-step method was performed to measure plasma glucose with 8 hours of fasting and then 2 hours after drinking a 75 grams OGTT solution, at 24 to 28 weeks of gestation. The diagnosis of GDM was made according to the American Diabetes Association (ADA) criteria, when any one of the following plasma glucose values were exceeded i.e., fasting plasma glucose ≥5.1 mmol/L (≥92 mg/dL) and 2 hours ≥8.5 mmol/L (≥153 mg/dL).[35]

Pregnant women in the study group were matched for age, parity, body mass index (BMI), family history of diabetes mellitus or GDM, and gestational age to the control group on 1:2 ratios. Exclusion criteria included patients with one of the following characteristics: multiple pregnancies, history of diabetes mellitus, history of chronic renal or hepatic disease, autoimmune diseases, and existing malignancies. Study form was completed for every participant's electronic data, including the following information: demographic information like (maternal age, parity), previous history of GDM, history of vitamin D supplementation, family history of DM, and BMI.

Continuous demographic and clinical data were summarized by means and standard deviations (SD). Frequencies and percentages analyzed categorical data. The student t-test / Mann–Whitney U test was applied for non-normal data for the comparison between the groups. Chi-square, Fisher's exact test was used to detect the association between groups and several demographic or study outcome variables. Multivariate analysis was utilized to estimate the odds of having GDM among patients concerning vitamin D status and intake. Software SPSS (Version 22) was considered for all analyses. A p-value of ≤0.05 was considered statistically significant.

## RESULTS

Of the 300 participants, 100 (33.3%) pregnant women had GDM who served as cases while 200 (66.7%) in the control group had no GDM. Among pregnant women with GDM, 34 were less than 25 years of age group, whereas 66 were ≥25 years old. Among them, 38 (38%) were obese, and 79 (79%) of the participants were not taking any vitamin D supplements (Table 1). Moreover, vitamin D deficiency was observed in 49 participants, 43 had insufficient levels, while 8 had sufficient vitamin D levels (Table 2). The mean vitamin D level was 32.07 nmol/L among the cases (Table 1).

Table 1. Demographic, diagnostic and clinical characteristics of the study population

| Characteristics | GDM *n* (%) | Non GDM *n* (%) | p-value* |
|---|---|---|---|
| **Age (years)** | | | |
| < 25 | 34 (34) | 70 (35) | 0.71 |
| ≥ 25 | 66 (66) | 130 (65) | |
| Mean ±SD | 27.10±4.57 | 27.16±4.54 | 0.92 |
| **Parity** | | | |
| Primgravida | 41 (41) | 88 (44) | 0.36 |
| Multigravidas | 59 (59) | 112 (56) | |
| **BMI (kg/m²)** | | | |
| <25 | 46 (46) | 23 (11.5) | <0.001 |
| 25 - 29.9 | 16 (16) | 80 (40) | <0.001 |
| >29.9 | 38 (38) | 97 (48) | 0.08 |
| Mean ±SD | 29.81±6.16 | 30.45±5.51 | 0.37 |
| **Family history of DM** | 60 (60) | 64 (32) | 0.20 |
| **Previous history of GDM** | 22 (22) | 50 (25) | 0.67 |
| **Vitamin D intake** | 21 (21) | 72 (36) | 0.008 |
| **Vitamin D level (nmol/L)** | | | |
| Mean ±SD | 32.07±22.64 | 44.76±28.04 | <0.001 |
| **Antenatal OGTT** | | | |
| Normal | 0.0 | 200 (100) | <0.001 |
| Abnormal | 100 (100) | 0.0 | |
| **GDM results (mmol/L)** | | | |
| FBS (mean ± SD) | 5.25 ± 0.62 | 4.38 ± 0.38 | <0.001 |
| PPBS (median ± IQR) | 9.10 ± 1.85 | 6.00 ± 1.7 | <0.001 |

**Abbreviations: BMI:** body mass index; **DM:** diabetes mellitus; **GDM:** gestational diabetes mellitus; **IQR:** interquartile range; **FBS:** fasting blood sugar; **PPBS:** post-prandial blood sugar; **SD:** standard deviation

*Chi-square, fisher's exact test was used to calculate p-value for categorical variables while, independent sample t-test were used for quantitative variables. A p-value of ≤0.05 was considered as significant.

Among the control group, 70 (34%) pregnant women were from less than 25 years of age, whereas 130 (65%) were ≥25 years of age group. Among them, 88 (44%) women were primigravida. A total of 128 (64%) women were taking vitamin D supplements (Table 1). Moreover, 60 (30%) pregnant women were from vitamin D deficient group, 110 (55%) participants from vitamin D insufficient group, and 31 (16%) patients were from vitamin D sufficient group, respectively (Table 2). The mean vitamin D level was 44.7 nmol/L among the control population (Table 1).

Comparison of cases with controls showed that demographic features including age, parity, BMI, previous history of gestational diabetes, and family history of the diabetes were not statistically different among them (Table 1). Women who took vitamin D supplementation had higher levels of vitamin D compared to those who did not take it (67.6 nmol/L *vs.* 28.4 nmol/L p<0.001). (Table 1) The study also demonstrated that mean serum vitamin D was significantly (p=0.001) lower in the cases versus controls (32.07 nmol/L *vs.* 44.76 nmol/L, respectively) (Table 1).

Out of 300 study subjects, only 39 (13%) had a normal vitamin D level, while 153 (51%) had insufficient levels, and 108 (36%) were deficient. The odds ratio showed that GDM has a significant association (OR (95% CI) 2.3, p=0.001) with vitamin D deficiency (Table 2). That risk of GDM was 2.3 times higher in the vitamin D deficient group as compared to those who had normal levels. A protective effect of vitamin D supplementation was seen in this study (OR 0.47 (95% CI), p-value=0.009) (Table 2).

## DISCUSSION

In this study, only 13% of women had sufficient levels of vitamin D levels while the remaining 87% of women had an insufficient (51%) or frank deficiency (36%). The current study confirmed the previously reported low levels of vitamin D among pregnant women worldwide.[6-12] vitamin D deficiency was reported in 84% women in some parts of Europe.[6]

Like in Saudi Arabia 50-60%[7,8], in Australia, it was 45%[10] in India it was 96%[11], in Pakistan 99.5%[12] and in Korea 46%.[13]

Pregnant women with vitamin D level of <25 nmol/L have a 2.3 times greater risk for GDM as compared to those who have vitamin D level of higher than that. This finding coincides with the previously reported association between low vitamin D levels and GDM.[36-40] Another recent trial was done in China, which favors that vitamin D levels <25 nmol/L, has two folds the risk of GDM, and adverse pregnancy outcome development, rather than the insufficient group.[41]

Table 2. Association of GDM with vitamin D intake and levels

| Characteristics | Total *n* (%) | GDM *n* (%) | Non-GDM *n* (%) | OR (95% CI) | p-value* |
|---|---|---|---|---|---|
| Vitamin D intake | 93 (31) | 21 (21) | 72 (36) | 0.47 (0.27 - 0.83) | 0.009 |
| Vitamin D deficiency (<25nmol/L) | 108 (36) | 49(49) | 60(30) | 2.3(1.39 - 3.77) | 0.001 |
| Vitamin D insufficiency (25-75nmol/L) | 153 (51) | 43 (43) | 110 (55) | 0.62 (0.38 - 1.0) | 0.05 |
| Vitamin D sufficiency (>75nmol/L) | 39 (13) | 8 (8) | 31 (16) | 0.47 (0.20 - 1.07) | 0.06 |

**Abbreviations: OR:** odds ratio; **GDM:** gestational diabetes mellitus; **CI:** confidence interval

* Pearson's Chi-square test was to calculate p-value. A p-values of ≤0.05 was considered as significant.

Literature is deficient for GDM and vitamin D association in the Saudi population. Only one cross-sectional study was done in Saudi Arabia by Al Ajlan et al in 2018. To study Vitamin D and GDM relationship, which used cut off of 50 nmol/L for vitamin D.[32] Our study is conducted with a better design and used different cut off levels for a precise outcome to confirm the findings of Al Ajlan and coworkers. It reinforced the evidence that at lesser levels of vitamin D below 25nmol/L is associated with an increased rate of GDM as well as intrauterine growth restriction and preeclampsia.[22]

Many recent studies reported undesirable pregnancy complications as a result of low vitamin D levels; the fact that highlights, reassessing the value of prescribing vitamin D supplementation for pregnant ladies.[15-22] However, due to data inconsistency, there have not been any clear guidelines for screening and supplementation of vitamin D during pregnancy.[27] The current study has shown a positive association between vitamin D intake and its level in the blood, which in turn is inversely related to the development of GDM. For instance, the odds of having GDM among participants taking vitamin D were almost half of those who are disease-free. Therefore, this emphasizes the need for a robust clinical trial to determine the exact role of vitamin D in pregnancy and test its potential integration into routine antenatal care. The results of the study might be limited by the nature of the study population that entailed only healthy pregnant women who did not have any other co-morbidities. Other co-morbidities may be confounding factors in analysis. Another limitation is that vitamin D levels were measured at a single time in gestation between 24-28 weeks, although vitamin D deficient women followed and treated with vitamin D supplements. A complete follow up during the entire pregnancy would provide a better understanding of the deficiency trend.

## CONCLUSION

Vitamin D deficiency is highly prevalent in Saudi Arabia. This study concludes the inverse relationship between GDM development and maternal vitamin D levels less than 25 nmol/L. More extensive clinical trials are recommended for confirmation of this finding. Further studies are needed to prove the role of vitamin D supplementation in reducing GDM development.

## REFERENCES


1. American Diabetes Association. Classification and diagnosis of diabetes: Standards of medical care in diabetes-2019. Diabetes Care. 2019; 42(Suppl.1):S13–S28. https://doi.org/10.2337/dc19-S002
2. Anna V, Van der Ploeg HP, Cheung NW, Huxley RR, Bauman AE. Sociodemographic correlates of the increasing trend in the prevalence of gestational diabetes mellitus in a large population of women between 1995 and 2005. Diabetes Care. 2008;31(12):2288-93. https://doi.org/0.2337/dc08-1038
3. Alfadhli EM, Alfadhli EM, Osman EN, Basri TH, Mansuri NS, MH, Assaaedi SA, et al. Gestational diabetes among Saudi women: prevalence, risk factors and pregnancy outcomes. Ann Saudi Med. 2015;35(3):222-230. https://doi.org/10.5144/0256-4947.2015.222
4. Fatima SS, Rehman R, Alam F, Madhani S, Chaudhry B, Khan TA. Gestational diabetes mellitus and the predisposing factors. J Pak Med Assoc. 2017;67(2):261-65.
5. American Diabetes Association. Classification and diagnosis of diabetes. Diabetes Care 2017;40 (Suppl 1):S11-S24. https://doi.org/10.2337/dc17-S005
6. Joergensen JS, Lamont RF, Torloni MR. Vitamin D and gestational diabetes: An update. Curr Opin Clin Nutr Metab Care. 2014;17(4):360-7. https://doi.org/10.1097/MCO.0000000000000064
7. Rafique M, Nuzhat A, Jaroudi D. Role of vitamin D deficiency in female infertility and ART. Outcomes J Soc Obstet Gynaecol Pak. 2018; 8(1):29-35.
8. Al-Faris NA. High prevalence of vitamin D deficiency among pregnant Saudi women. Nutrients. 2016; 8(2):77. https://doi.org/10.3390/nu8020077
9. Al-Alyani H, Al-Turki HA, Al-Essa ON, Alani FM, Sadat-Ali M. Vitamin D deficiency in Saudi Arabians: A reality or simply hype: A meta-analysis (2008-2015). J Family Community Med. 2018; 25(1): 1–4. https://doi.org/10.4103/jfcm.JFCM_73_17
10. Perampalam S, Ganda K, Chow KA, Opie N, Hickman PE, Shadbolt B, et al. Vitamin D status and its predictive factors in pregnancy in 2 Australian populations. Aust N Z J Obstet Gynaecol. 2011; 51(4):353-9. https://doi.org/10.1111/j.1479-828X.2011.01313.x
11. Marwaha RK, Tandon N, Chopra S, Agarwal N, Garg MK, Sharma B, et al. Vitamin D status in pregnant Indian women across trimesters and different seasons and its correlation with neonatal serum 25-hydroxyvitamin D levels. Br J Nutr. 2011;106(9):1383-9. https://doi.org/10.1017/S0007114511001170X
12. Nasir JA, Imran M, Zaidi SAA. Pattern of vitamin D among Pakistani pregnant women. J Coll Physicians Surg Pak.

2018;28(3):233-237. https://doi.org/10.29271/jcpsp.2018.03.233
13. Cho GJ, Hong SC, Oh MJ, Kim HJ. Vitamin D deficiency in gestational diabetes mellitus and the role of the placenta. Am J Obstet Gynecol. 2013;209(6):560.e1-8. https://doi.org/10.1016/ j.ajog.2013.08.015
14. Maghbooli Z, Hossein-Nezhad A, Karimi F, Shafaei AR, Larijani B. Correlation between vitamin D3 deficiency and insulin resistance in pregnancy. Diabetes Metab Res Rev. 2008; 24(1):27-32.
15. Kaludjerovic J, Vieth R. Relationship between vitamin D during perinatal development and health. J Midwifery Womens Health. 2010;55(6):550-60. https://doi.org/10.1016/j.jmwh.2010. 02.016
16. Aghajafari F, Nagulesapillai T, Ronksley PE, Tough SC, O'Beirne M, Rabi DM. Association between maternal serum 25-hydroxyvitamin D level and pregnancy and neonatal outcomes: systematic review and meta-analysis of observational studies. Br Med J. 2013;346:f1169. https://doi.org/10.1136/bmj.f1169
17. Clifton-Bligh RJ, McElduff P, McElduff A. Maternal vitamin D deficiency, ethnicity and gestational diabetes. Diabet Med. 2008;25(6):678-84. https://doi.org/10.1111/j.1464-5491.2008.02422.x
18. Moon RJ, Harvey NC, Cooper C. Endocrinology in pregnancy: influence of maternal vitamin D status on obstetric outcomes and the fetal skeleton. Eur J Endocrinol. 2015;173(2): R69-R83. https://doi.org/10.1530/EJE-14-0826
19. Thorne-Lyman A, Fawzi WW. Vitamin D during pregnancy and maternal, neonatal and infant health outcomes: a systematic review and meta-analysis. Paediatr Perinat Epidemiol. 2012;26 Suppl 1:75-90. https://doi.org/10.1111/j.1365-3016.2012.01283.x.
20. Lapillonne A. Vitamin D deficiency during pregnancy may impair maternal and fetal outcomes. Med Hypotheses. 2010;74(1):71-5. https://doi.org/10.1016/j.mehy.2009.07.054
21. Hanley DA, Cranney A, Jones G, Whiting SJ, Leslie WD. Guidelines committee of the scientific advisory council of osteoporosis Canada. Vitamin D in adult health and disease: a review and guideline statement from osteoporosis Canada. CMAJ 2010;182(12): E610-E618. https://doi.org/10.1503/cmaj.080663
22. Ali AM, Alobaid A, Malhis TN, Khattab AF. Effect of vitamin D3 supplementation in pregnancy on risk of pre-eclampsia - Randomized controlled trial. Clin Nutr. 2019;38(2):557-563. https://doi.org/10.1016
23. Wei SQ. Vitamin D and pregnancy outcomes. Curr Opin Obstet Gynecol.2014;26(6):438-447. https://doi.org/10.1097/GCO.0000000000000117
24. Staud R. Vitamin D: more than just affecting calcium and bone. Curr Rheumatol Rep. 2005;7(5):356-364. https://doi.org/10.1007/s11926-005-0020-0
25. Farrant HJ, Krishnaveni GV, Hill JC, B J Boucher, D J Fisher, K Noonan. et al. Vitamin D insufficiency is common in Indian mothers but is not associated with gestational diabetes or variation in newborn size. Eur J Clin Nutr. 2009;63(5):646-652. https://doi.org/10.1038/ejcn.2008.14
26. Kaushal M, Magon N. Vitamin D in pregnancy: A metabolic outlook. Indian J Endocrinol Metab. 2013;17(1):76-82. https://doi.org/10.4103/2230-8210.107862
27. Arnold DL, Enquobahrie DA, Qiu C, Huang J, Grote N, VanderStoep A, et al. Early pregnancy maternal vitamin D concentrations and risk of gestational diabetes mellitus. Paediatr Perinat Epidemiol 2015;29(3):200-210. https://doi.org/10.1111/ppe.12182
28. Muthukrishnan J, Dhruv G. Vitamin D status and gestational diabetes mellitus. Indian J Endocrinol Metab. 2015;19(5):616-619. https://doi.org/10.4103/2230-8210.163175
29. Baker AM, Haeri S, Camargo CA Jr, Stuebe AM, Boggess KA. First trimester maternal vitamin D status and risk for gestational diabetes mellitus: a nested case-control study. Diabetes Metab Res Rev. 2011
30. Makgoba M, Nelson SM, Savvidou M, Messow CM, Nicolaides K, Sattar N. First-trimester circulating 25-hydroxyvitamin D levels and development of gestational diabetes mellitus. Diabetes Care. 2011;34(5):1091-1093. https://doi.org/10.2337/dc10-2264
31. Park S, Yoon HK, Ryu HM, Han YJ, Lee SW, Park BK, et al. Maternal vitamin D deficiency in early pregnancy is not associated with gestational diabetes mellitus development or pregnancy outcomes in Korean pregnant women in a prospective study. J Nutr Sci Vitaminol (Tokyo). 2014;60(4):269-275. https://doi.org/10.3177/jnsv.60.269
32. Al-Ajlan A, Al-Musharaf S, Fouda MA, Aljohani JN, Sheshah E, Ali MA et al. Lower vitamin D levels in Saudi pregnant women are associated with higher risk of developing GDM. BMC Pregnancy Childbirth. 2018;18(1):86. https://doi.org/10.1186/s12884-018-1723-3
33. Nargesi S, Ghorbani A, Shirzadpour E, Mohamadpour M, Mousavi S, Amraei M. A systematic review and meta-analysis of the association between vitamin D deficiency and gestational diabetes mellitus. Biomed Res Ther. 2018;5(3):2078-95.https://doi.org/10.15419/bmrat.v5i3.422
34. Hintze J. Sample size & power Kaysville, Utah, USA: NCSS statistical software; 2011 [cited 2019 December 31]. Available from: http://www.ncss.com/software/pass/procedures/
35. Rani PR, Begum J. Screening and diagnosis of gestational diabetes mellitus, where do we stand. J Clin Diagn Res. 2016;10(4):QE01-QE04. https://doi.org/10.7860/JCDR/2016/17588.7689
36. Alzaim M, Wood RJ. Vitamin D and gestational diabetes mellitus. Nutr Rev. 2013;71(3):158-167. https://doi.org/10.1111/nure.12018
37. Senti J, Thiele DK, Anderson CM. Maternal vitamin D status as a critical determinant in gestational diabetes. J Obstet Gynecol Neonatal Nurs. 2012;41(3):328-338. https://doi.org/10.1111/j.1552-6909.2012.01366.x
38. Vejrazkova D, Vcelak J, Vankova M, Lukasova P, Bradnova O, Kancheva R, et al. Steroids and insulin resistance in pregnancy. J Steroid Biochem Mol Biol 2014; 139:122-129. https://doi.org/10.1016/j.jsbmb.2012.11.007
39. McLeod DS, Warner JV, Henman M, Cowley D, Gibbons K, McIntyre HD. HAPO Study cooperative research group. Associations of serum vitamin D concentrations with obstetric glucose metabolism in a subset of the hyperglycemia and adverse pregnancy outcome (HAPO) study cohort. Diabet Med. 2012;29(8): e199-e204. https://doi.org/10.1111/j.1464-5491.2011.03551.x
40. Mutlu N, Esra H, Begum A, Fatma D, Arzu Y, Yalcin H, et al. Relation of maternal vitamin D status with gestational diabetes mellitus and perinatal outcome. Afr Health Sci. 2015;15(2):523-531. https://doi.org/10.4314/ahs.v15i2.27
41. Wang O, Nie M, Zhang K, Li W, Hu YY, Chen LM, et al. Association between Vitamin D insufficiency and the risk for gestational diabetes mellitus in pregnant Chinese women. Biomed Environ Sci. 2012; 25(4): 399-406. https://doi.org/10.3967/0895-3988.2012.04.004

 