e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2025; 17(8); 1135-1140

Original Research Article

Role of HbA1c in Early Diagnosis of Gestational Diabetes Mellitus

Charulata Purbia[1], Pooja Rao[2], Anshu Lohchab[3]

[1]Assistant Professor, Department of Obstetrics and Gynaecology, Pacific Institute of Medical Sciences, Sai Tirupati University, Umarda, Udaipur, Rajasthan, India.

[2]Junior Resident, Department of Obstetrics and Gynaecology, Pacific Institute of Medical Sciences, Sai Tirupati University, Umarda, Udaipur, Rajasthan, India.

[3]Junior Resident, Department of Obstetrics and Gynaecology, Pacific Institute of Medical Sciences, Sai Tirupati University, Umarda, Udaipur, Rajasthan, India.

Received: 01-05-2025 Revised: 15-06-2025 / Accepted: 21-07-2025

Corresponding author: Dr. Pooja Rao

Conflict of interest: Nil

Abstract

Introduction: Gestational diabetes mellitus (GDM) is associated with adverse maternal and neonatal outcomes. Early identification of high-risk women is essential for timely intervention. Hemoglobin A1c (HbA1c) reflects average glycemia over 8–12 weeks and may serve as a practical early screening tool. The objective is to evaluate the utility of first-trimester HbA1c in predicting GDM and its associated maternal and neonatal outcomes.

Materials and Methods: This prospective observational study included 200 high-risk pregnant women attending the antenatal clinic at Pacific Institute of Medical Sciences, Udaipur, Rajasthan, from January 2024 to January 2025. HbA1c was measured in the first trimester, and a 75 g oral glucose tolerance test (OGTT) performed between 24–28 weeks served as the reference standard. Maternal outcomes (pharmacological therapy, mode of delivery, complications) and neonatal outcomes (birth weight, APGAR score, NICU admission) were recorded. Statistical analyses included Chi-square and t-tests, with $p<0.05$ considered significant.

Results: GDM was diagnosed in 171 (85.5%) participants. Women with GDM had significantly higher first-trimester HbA1c (5.75 ± 0.3% vs. 5.27 ± 0.2%, $p<0.001$) and glycaemic indices. A first-trimester HbA1c cut-off of 5.45% predicted GDM with 89.5% sensitivity and 82.8% specificity. Maternal complications such as polyhydramnios, PROM, and hypertensive disorders were more frequent among GDM cases. Neonates of GDM mothers had higher rates of NICU admission (22.8% vs. 6.9%).

Conclusion: First-trimester HbA1c is a reliable and practical early screening tool for predicting GDM in high-risk pregnancies, allowing timely interventions that may improve maternal and neonatal outcomes.

Keywords: Gestational diabetes mellitus, HbA1c, Early screening.

Introduction

Gestational Diabetes Mellitus (GDM) is a form of glucose intolerance first recognized during pregnancy, typically in the second or third trimester. It results from a combination of increased insulin resistance driven by pregnancy hormones and inadequate compensatory insulin secretion by pancreatic β-cells [1]. Insulin resistance intensifies as gestation progresses due to placental hormones such as human placental lactogen, progesterone, and cortisol [2]. This imbalance can lead to maternal hyperglycemia, which, if untreated, is associated with adverse outcomes including preeclampsia, polyhydramnios, and increased rates of cesarean delivery, highlighting the importance of timely diagnosis and management [3]. GDM represents a growing public health challenge, affecting 2.4% to 22.3% of pregnancies worldwide, with substantial regional variation influenced by lifestyle, diet, and genetic predisposition [4]. In Southeast Asia, prevalence rates are among the highest globally, with India reporting rates from 3.8% to over 40% depending on region and diagnostic criteria [5]. Factors such as urbanization, dietary transitions, and reduced physical activity contribute to this rising trend. These disparities underscore the necessity for localized screening strategies and culturally adapted prevention measures to mitigate maternal and neonatal risks [6]. Both non-modifiable and modifiable factors contribute to GDM risk. Advanced maternal age (>35 years), non-Caucasian ethnicity, a family history of type 2 diabetes, and a history of previous

GDM, macrosomia, or stillbirth increase susceptibility [7]. Modifiable factors include pre-pregnancy obesity, excessive gestational weight gain, poor dietary habits, and sedentary lifestyle. Conditions like polycystic ovary syndrome (PCOS) and chronic hypertension further heighten risk, emphasizing the importance of comprehensive maternal risk assessment and early lifestyle interventions to prevent hyperglycemia during pregnancy [8].

Traditional screening methods, including the oral glucose tolerance test (OGTT) performed between 24 and 28 weeks, often delay diagnosis, limiting early intervention opportunities [9]. Hemoglobin A1c (HbA1c) has emerged as a promising early marker, reflecting average glycemia over 8–12 weeks and allowing detection of women at high risk even in the first trimester [10]. Early identification through HbA1c can enable timely dietary counselling, glucose monitoring, and pharmacologic interventions, potentially reducing adverse maternal and neonatal outcomes. In this context, the present study was conducted to evaluate the utility of first-trimester HbA1c in the early prediction of GDM and its associated pregnancy complications.

Materials and Methods

This prospective observational study was conducted in the Department of Obstetrics and Gynecology at Pacific Institute of Medical Sciences (PIMS), Umarda, Udaipur, Rajasthan, from January 2024 to January 2025, after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrolment.

A total of 200 pregnant women attending the antenatal clinic were recruited based on predefined inclusion and exclusion criteria. Inclusion criteria were pregnant women with singleton pregnancies, aged 18–40 years, and less than 13 weeks of gestation, or presence of high-risk factors such as family history of GDM, history of prematurity, fetal loss or intrauterine death (IUD), unexplained neonatal loss, previous congenital anomaly, or history of PCOD (Polycystic Ovarian Disease). Exclusion criteria included known cases of pre-gestational diabetes mellitus, patients with HbA1c > 6.5%, and those with chronic systemic illnesses such as chronic kidney disease, cardiac or respiratory diseases, anemia, or hemoglobinopathies. Relevant demographic and clinical information, including maternal age, body mass index (BMI), and obstetric history, were recorded using a structured proforma.

All participants underwent HbA1c estimation at the time of recruitment. In addition, a standard 75 g oral glucose tolerance test (OGTT) was performed according to the International Association of Diabetes and Pregnancy Study Groups (IADPSG) criteria, which served as the reference diagnostic standard for GDM. Women diagnosed with GDM were managed as per standard institutional protocols, either with dietary modification, oral hypoglycaemic agents, or insulin, depending on glycaemic control.

Maternal outcomes assessed included need for pharmacological intervention, mode of delivery, and obstetric complications. Neonatal outcomes studied were birth weight, APGAR scores, gender distribution, and need for neonatal intensive care unit (NICU) admission. Data were entered into Microsoft Excel and analyzed using SPSS version [26]. Categorical variables were expressed as frequencies and percentages, while associations were assessed using Chi-square test. A p-value <0.05 was considered statistically significant.

Results

The mean age of the study population was 27.8 ± 3.4 years, with an average BMI of 23.16 ± 1.64 kg/m². Nearly half of the participants were primigravida (46%), while 36% were gravida two and 18% gravida three or more. More than half (54%) were nulliparous, whereas 35% had one prior delivery and 11% had two or more. A positive family history of diabetes was observed in 19% of the women (Table 1).

Table 1: Baseline Characteristics of Study Participants (n = 200)

Parameter			Value
Age (years)		**Mean ± SD**	27.8 ± 3.4
BMI (kg/m²)		**Mean ± SD**	23.16 ± 1.64
Gravida status	**G1**	**N (%)**	92 (46%)
	G2	**N (%)**	72 (36%)
	≥ G3	**N (%)**	36 (18%)
Parity	**P0**	**N (%)**	108 (54%)
	P1	**N (%)**	70 (35%)
	≥ P2	**N (%)**	22 (11%)
Family history of diabetes		**N (%)**	38 (19%)

Progressive changes were observed in the glycaemic profile across trimesters. Fasting blood glucose levels declined modestly from the first (98.93 ± 3.79 mg/dL) to the third trimester (94.66 ± 5.52 mg/dL), whereas both 1-hour and 2-hour postprandial values showed a significant upward trend, reaching 183.86 ± 6.42 mg/dL and 156.94 ± 7.35 mg/dL, respectively, in the third trimester. HbA1c also demonstrated a steady rise from 5.68 ± 0.29% in the first trimester to 6.02 ± 0.31% in the third trimester, reflecting progressive deterioration in glycaemic control (Table 2).

Table 2: Glycaemic Profile across Trimesters (n = 200)

Parameter	1st Trimester	2nd Trimester	3rd Trimester
Fasting Blood Glucose (mg/dL)	98.93 ± 3.79	96.20 ± 4.88	94.66 ± 5.52
1-hr Postprandial (mg/dL)	165.42 ± 5.91	174.38 ± 6.15	183.86 ± 6.42
2-hr Postprandial (mg/dL)	142.16 ± 7.42	148.94 ± 8.82	156.94 ± 7.35
HbA1c (%)	5.68 ± 0.29	5.90 ± 0.33	6.02 ± 0.31

The figure illustrates the overall distribution of women with GDM (85.5%) and without GDM (14.5%), highlighting the predominance of GDM cases within the study population. (Figure 1)

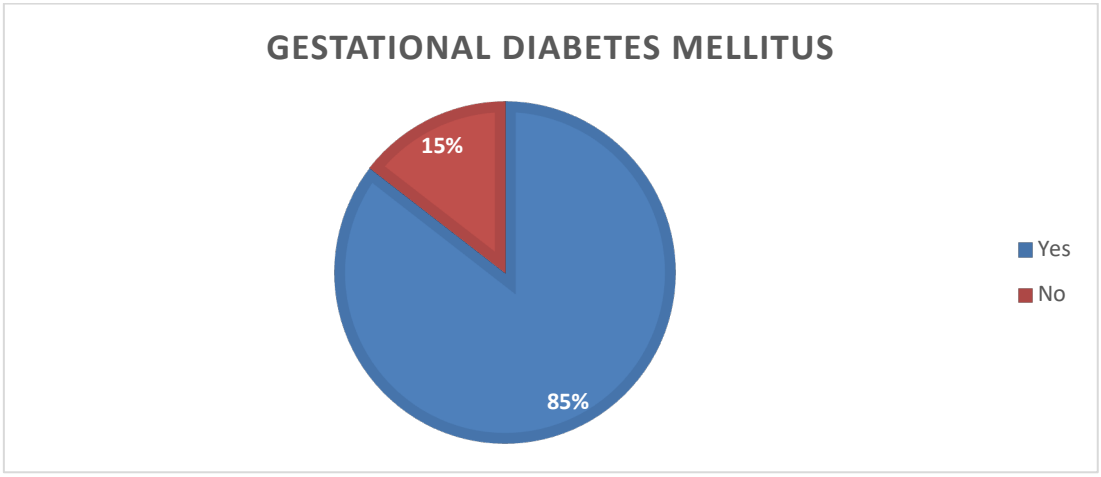

Figure 1: Pie chart showing distribution of GDM and no GDM

When stratified by GDM status, women with GDM (n = 171) had significantly higher BMI and consistently elevated glycaemic indices across all trimesters compared to those without GDM (n = 29). First trimester fasting glucose (99.40 ± 3.5 vs. 96.17 ± 2.8 mg/dL), HbA1c (5.75 ± 0.3 vs. 5.27 ± 0.2%), and postprandial glucose levels were all higher in the GDM group, with differences persisting through subsequent trimesters. Postpartum fasting glucose values, however, showed no significant difference between groups (Table 3).

Table 3: Comparison of Clinical and Biochemical Variables between GDM and Non-GDM Mothers (n = 200)

Variable (Mean ± SD)		No GDM (n = 29)	GDM (n = 171)	t-value	p-value
BMI (kg/m²)		22.10 ± 1.2	23.34 ± 1.5	3.878	<0.001
1st Trimester	**FBS (mg/dL)**	96.17 ± 2.8	99.40 ± 3.5	4.438	<0.001
	1-hr PP (mg/dL)	131.24 ± 6.7	142.15 ± 7.1	7.105	<0.001
	2-hr PP (mg/dL)	118.45 ± 5.9	126.94 ± 6.3	6.191	<0.001
	HbA1c (%)	5.27 ± 0.2	5.75 ± 0.3	10.144	<0.001
2nd Trimester	**FBS (mg/dL)**	92.60 ± 3.2	97.18 ± 3.8	6.196	<0.001
	1-hr PP (mg/dL)	145.33 ± 7.0	158.22 ± 7.6	8.138	<0.001
	2-hr PP (mg/dL)	138.31 ± 7.5	150.74 ± 8.0	8.061	<0.001
	HbA1c (%)	5.36 ± 0.3	5.99 ± 0.4	12.750	<0.001
3rd Trimester	**FBS (mg/dL)**	87.93 ± 4.6	95.80 ± 5.2	8.198	<0.001
	1-hr PP (mg/dL)	172.14 ± 6.0	185.84 ± 6.8	16.134	<0.001
	2-hr PP (mg/dL)	144.97 ± 6.2	158.97 ± 7.1	12.769	<0.001
	HbA1c (%)	5.48 ± 0.3	6.15 ± 0.5	10.302	<0.001
Follow-up FBS (mg/dL)		92.33 ± 3.1	92.99 ± 3.0	0.337	0.737

Among maternal outcomes, a substantial proportion of women with GDM required pharmacological therapy, including oral hypoglycaemics (31.6%) and insulin (21.1%). Rates of cesarean delivery were high in both groups, with preterm cesarean section more frequent in the GDM group (43.9% vs. 27.6%). Maternal complications were varied, with polyhydramnios, intrauterine growth restriction (IUGR), premature rupture of membranes (PROM), and anemia being observed, though the overall distribution was not statistically different between groups (Table 4).

Table 4: Comparison of Maternal Clinical and Obstetric Outcomes in Women with and without GDM (n = 200)

Variable	Category	No GDM (n=29)	GDM (n=171)	χ^2	p-value
Oral Hypoglycaemic use	**Yes**	0 (0.0%)	54 (31.6%)	12.545	0.001
	No	29 (100.0%)	117 (68.4%)		
Insulin use	**Yes**	0 (0.0%)	36 (21.1%)	7.445	0.006
	No	29 (100.0%)	135 (78.9%)		
Mode of delivery	**FTND**	1 (3.4%)	5 (2.9%)	2.713	0.258
	Full-term LSCS	20 (69.0%)	91 (53.2%)		
	Preterm LSCS	8 (27.6%)	75 (43.9%)		
Maternal complications	**Anemia**	2 (6.9%)	3 (1.8%)	16.926	0.110
	PROM	4 (13.8%)	15 (8.8%)		
	IUGR	4 (13.8%)	11 (6.4%)		
	Polyhydramnios	1 (3.4%)	21 (12.3%)		
	Oligohydramnios	2 (6.9%)	8 (4.7%)		
	Wound sepsis	4 (13.8%)	5 (2.9%)		
	Others (APH, UTI, PPH, Postdatism, Shoulder dystocia)	12 (41.4%)	108 (63.2%)		

Neonatal outcomes were comparable between the groups in terms of mean birth weight (3.06 ± 0.5 vs. 3.03 ± 0.4 kg) and gender distribution. Most neonates had an APGAR score of 9, though lower scores (6–8) were noted in a small proportion of infants born to mothers with GDM. NICU admission was more common among neonates of GDM mothers (22.8% vs. 6.9%), though this difference did not reach statistical significance (Table 5).

Table 5: Comparison of Neonatal Outcomes in Women with and without GDM (n = 200)

Variable	Category	No GDM (n=29)	GDM (n=171)	t/χ^2	p-value
Birth Weight	**kg**	3.03 ± 0.4	3.06 ± 0.5	0.274	0.784
Baby gender	**Male**	15 (51.7%)	76 (44.4%)	0.933	0.334
	Female	14 (48.3%)	95 (55.6%)		
APGAR	**6**	0 (0%)	2 (1.2%)	2.553	0.635
	8	0 (0%)	8 (4.7%)		
	9	29 (100%)	161 (94.2%)		
NICU admission	**Yes**	2 (6.9%)	39 (22.8%)	4.806	0.090
	No	27 (93.1%)	132 (77.2%)		

A first-trimester HbA1c cut-off of 5.45% predicted gestational diabetes mellitus with a sensitivity of 89.5% and specificity of 82.8%, indicating its effectiveness as an early screening tool for identifying high-risk women (Table 6).

Table 6: Predictive Value of First-Trimester HbA1c for Gestational Diabetes Mellitus (n = 200)

HbA1c Cut-off (%)	Sensitivity	Specificity
5.45	89.5%	82.8%

Discussion

The present study demonstrates that first-trimester HbA1c is a strong predictive marker for gestational diabetes mellitus (GDM), with a cut-off of 5.45% yielding a sensitivity of 89.5% and specificity of 82.8%. These findings align with previous reports, including Desai et al., who reported a first-trimester HbA1c cut-off of 5.3% with comparable diagnostic performance, and the meta-analysis by Kalaij et al., which confirmed first-trimester HbA1c as a

significant risk factor for GDM (OR 4.36, 95% CI: 3.66–5.20, $p < 0.00001$) [10,11]. Similarly, Sun et al. and Hinkle et al. demonstrated that even modest elevations in early-pregnancy HbA1c are associated with increased GDM risk, supporting the concept that dysglycaemia may begin preconceptionally or in early gestation [12,13].

Collectively, these findings suggest that first-trimester HbA1c measurement can facilitate early identification of high-risk women, enabling timely interventions and improved glycaemic management throughout pregnancy.

Our study also observed progressive glycaemic deterioration across trimesters among women who developed GDM, evidenced by higher fasting blood sugar, postprandial glucose, and HbA1c values compared to non-GDM counterparts ($p < 0.001$). This aligns with prior studies showing increased glycaemic variability in GDM patients over time, including Quah et al. and Gáborová et al., highlighting the need for trimester-specific monitoring and management [14,15]. While our analysis was limited to univariate comparisons, previous multivariate analyses, such as those by Kalaij et al., suggest that HbA1c retains predictive value even after adjusting for BMI, family history, and other confounders, underscoring its potential role in personalized risk assessment and early screening protocols, particularly in resource-limited settings [11].

Regarding management, 31.6% of women with GDM in this study received oral hypoglycaemic agents and 21.1% were treated with insulin, reflecting contemporary trends favoring individualized treatment based on glycaemic severity. This aligns with evidence from Alfadhli, and Nicolaou et al., demonstrating the safety and efficacy of metformin or glyburide in moderate GDM, while insulin remains the standard for severe cases [16,17]. Additionally, the study observed a high rate of cesarean delivery among GDM patients, consistent with global literature, including Inocêncio et al. and Boriboonhirunsarn & Waiyanikorn, which link GDM and insulin therapy to increased LSCS rates [18,19]. These findings underscore the importance of stratifying risk to optimize maternal and neonatal outcomes while avoiding unnecessary surgical interventions.

Finally, while maternal complications such as polyhydramnios and PROM were observed, they did not reach statistical significance, yet align with prior studies highlighting elevated risks in GDM pregnancies [20,21]. Postpartum follow-up at 6 weeks revealed elevated fasting glucose in a subset of women, emphasizing the need for long-term monitoring given the high risk of progression to type 2 diabetes mellitus [22]. Incorporating lifestyle interventions, breastfeeding, and predictive risk models can reduce long-term metabolic complications. Future research should focus on larger, multicentre studies with extended postpartum follow-up, multivariate analyses, and incorporation of lifestyle and socioeconomic factors to refine predictive models and optimize outcomes.

Conclusion

The present study demonstrates that first-trimester HbA1c is a reliable and practical early screening tool for predicting gestational diabetes mellitus (GDM) in high-risk antenatal women. With a cut-off of 5.45%, HbA1c showed high sensitivity (89.5%), specificity (82.8%), and an AUC of 0.84, indicating strong predictive capability for later GDM development. Elevated first-trimester HbA1c levels were significantly associated with abnormal DIPSI and OGTT results, as well as maternal risk factors such as advanced age, multigravida status, obesity, and positive family or obstetric history. Maternal complications—including polyhydramnios, PROM, and hypertensive disorders—and adverse neonatal outcomes such as hypoglycemia, jaundice, and NICU admissions were more frequent among GDM-positive cases. These findings support the integration of first-trimester HbA1c screening into routine antenatal care, enabling early identification, targeted interventions, and improved maternal and neonatal outcomes.

References

1. Plows JF, Stanley JL, Baker PN, et al. The Pathophysiology of Gestational Diabetes Mellitus. Int J Mol Sci. 2018; 19(11):3342.
2. Kampmann U, Knorr S, Fuglsang J, et al. Determinants of Maternal Insulin Resistance during Pregnancy: An Updated Overview. J Diabetes Res. 2019; 2019:5320156.
3. Yang Y, Wu N. Gestational Diabetes Mellitus and Preeclampsia: Correlation and Influencing Factors. Front Cardiovasc Med. 2022; 9:831297.
4. Nakshine VS, Jogdand SD. A Comprehensive Review of Gestational Diabetes Mellitus: Impacts on Maternal Health, Fetal Development, Childhood Outcomes, and Long-Term Treatment Strategies. Cureus. 2023; 15(10):e47500.
5. Chakraborty A, Yadav S. Prevalence and determinants of gestational diabetes mellitus among pregnant women in India: an analysis of National Family Health Survey Data. BMC Womens Health. 2024; 24(1):147.
6. Gordon RD, Kishi A, Brown JA, et al. Rural maternal health interventions: A scoping review and implications for best practices. J Rural Health. 2025; 41(1):e70007.

7. Zhang C, Rawal S, Chong YS. Risk factors for gestational diabetes: is prevention possible? Diabetologia. 2016; 59(7):1385-1390.
8. Langley-Evans SC, Pearce J, Ellis S. Overweight, obesity and excessive weight gain in pregnancy as risk factors for adverse pregnancy outcomes: A narrative review. J Hum Nutr Diet. 2022; 35(2):250-264.
9. Minschart C, Beunen K, Benhalima K. An Update on Screening Strategies for Gestational Diabetes Mellitus: A Narrative Review. Diabetes Metab Syndr Obes. 2021;14:3047-3076.
10. Desai DD, Zutshi DM, Pitre DD. First trimester HbA1c as an early predictor of gestational diabetes mellitus. Int J Clin Obstet Gynaecol. 2023; 7(5):80–7.
11. Kalaij AGI, Dyson NG, Sugiyanto M. First Trimester Glycated Hemoglobin (HBA1C) Level as a Novel Predictor of Gestational Diabetes Mellitus: a Systematic Review and Meta-Analysis. J Asian Med Stud Assoc. 2021; 9(1):1-4.
12. Sun J, Chai S, Zhao X, et al. Predictive Value of First-Trimester Glycosylated Hemoglobin Levels in Gestational Diabetes Mellitus: A Chinese Population Cohort Study. J Diabetes Res. 2021; 2021: 5537110.
13. Hinkle SN, Tsai MY, Rawal S, et al. HbA1c Measured in the First Trimester of Pregnancy and the Association with Gestational Diabetes. Sci Rep. 2018; 8(1):12249.
14. Quah PL, Tan KH, Razali N, et al. Higher mean amplitude of glycaemic excursion in the second trimester of pregnancy is associated with the subsequent development of gestational diabetes mellitus: an observational study. Authorea. 2021.
15. Gáborová M, Doničová V, Bačová I, et al. Glycaemic Variability and Risk Factors of Pregnant Women with and without Gestational Diabetes Mellitus Measured by Continuous Glucose Monitoring. Int J Environ Res Public Health. 2021; 18(7):3402.
16. Alfadhli EM. Gestational diabetes mellitus. Saudi Med J. 2015; 36(4):399–406.
17. Nicolaou V, Soepnel L, Huddle KR, et al. Maternal and neonatal outcomes following the introduction of oral ypoglycaemic agents for gestational diabetes mellitus were comparable to insulin monotherapy in two historical cohorts. South Afr Med J Suid-Afr Tydskr Vir Geneeskd. 2020; 110(2):154–8.
18. Inocêncio G, Braga A, Lima T, et al. Which Factors Influence the Type of Delivery and Cesarean Section Rate in Women with Gestational Diabetes? J Reprod Med. 2015; 60:529–34.
19. Boriboonhirunsarn D, Waiyanikorn R. Emergency cesarean section rate between women with gestational diabetes and normal pregnant women. Taiwan J Obstet Gynecol. 2016; 55(1):64–7.
20. Yeasmin MS, Sultana BT, Nourin NA, et al. Maternal and Perinatal Outcome in Women with Gestational Diabetes Mellitus. Chattagram Maa-O-Shishu Hosp Med Coll J. 2024; 23(1):68–72.
21. Rajashree D, Paunikar VM. Maternal complications of gestational diabetes mellitus. Natl J Physiol Pharm Pharmacol. 2019; 9(11): 1117-1120.
22. Weinert LS, Mastella LS, Oppermann MLR, ete al. Postpartum glucose tolerance status 6 to 12 weeks after gestational diabetes mellitus: a Brazilian cohort. Arq Bras Endocrinol Metabol. 2014; 58(2):197–204.