ORIGINAL ARTICLE

Prevalence of gestational diabetes mellitus, insulin resistance and associated risk factors among pregnant women in a tertiary health setting in Calabar, Nigeria

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Abstract

Background: Gestational Diabetes Mellitus (GDM) is a common undiagnosed feature in many pregnant women in the tropics. Many of these undiagnosed women later progress to type 2 diabetes mellitus. This condition affects many pregnancies, and its prevalence is increasing worldwide. Understanding the pathophysiology and increasing the likelihood of identifying women at risk of GDM is vital to effective prevention and optimal treatment. *Aims and Objectives:* To assess the prevalence of GDM and insulin resistance in susceptible pregnant women with a view to identifying the risk factors associated with these conditions among women Attending Antenatal Care (ANC) clinic at the University of Calabar Teaching Hospital (UCTH), Calabar. *Material and Methods:* One hundred and eighty women pregnant women between 24–28 weeks of gestation attending ANC at UCTH Calabar were enrolled as participants in this study. Ethical approval and informed consent were taken from the women who participated in the study, and were administered oral glucose tolerance test after an overnight fast. Fasting samples for plasma insulin, triglyceride, and total cholesterol were collected as well. Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) and beta-cell function (HOMA-β) were both derived from the fasting plasma glucose and insulin. A well-structured questionnaire containing general information on demographic characteristics, socioeconomic status, and obstetric and gynaecological characteristics was filled up for each participant.Statistical analyses were done to assess the prevalence and the associated risk factors. *Results:* A prevalence of 37.7% was observed for GDM. The majority of the women with GDM were > 25 years of age (79.4%), married (93.9%), educated (tertiary 66.7%, secondary 32.8%), employed (70.6%), and resided in the urban area (72.2%). Most were either overweight (38.3%) or obese (38.9%). Most of the women with GDM were primigravida (40%) and para 1 (37.3%), had previous caesarean section (52.8%), previous preterm delivery (95.4%), and previous stillbirth (45.8%). Based on risk factor assessment, ironically, 45.6% (majority) of women with GDM were of low risk, 29.5% of average risk, and 13.2% of high risk. The prevalence of insulin resistance among participants, as indicated by various biomarkers, was significant: Fasting Plasma Glucose (FPG) 30.6%, fasting plasma insulin 41.1%, triglycerides 11.1%, total cholesterol 51.1%, and insulin resistance index (HOMA-IR) 67.8%. FPG (p = 0.000) and HOMA-IR (p = 0.004) were found to be significantly associated with the development of GDM among the women. *Conclusion:* A high prevalence of GDM (37.7%) and insulin resistance was found among the antenatal population in UCTH Calabar. HOMA-IR and FPG were significantly related to the development of GDM. And several socio-demographic factors (based on jobs and careers) were linked to this association.

Keywords: Pregnancy, Insulin, Resistance, Predictors, Prevalence, HOMA-IR, HOMA-Beta, gestational diabetes

Introduction

Gestational Diabetes Mellitus (GDM) is any degree of glucose intolerance with onset or occurrence first during pregnancy [1-3]. The World Health Organization (WHO) defines it as carbohydrate intolerance resulting in hyperglycemia of varying severity with onset or initial detection during pregnancy [4]. This definition applies irrespective of whether insulin is used or the condition persists after pregnancy [4]. This also acknowledges the fact that patients can have conditions in which there was an already previously undiagnosed diabetes mellitus, an index, or they may have developed diabetes concurrently with pregnancy. GDM usually resolves after delivery, and whether symptoms subside after pregnancy is also inconsequential to the diagnosis [2, 5]. In subjects with normal pregnancy, insulin resistance tends to increase in the late second trimester to levels that would approximate what is obtainable in type 2 diabetes mellitus. Most women remain normoglycemic as a result of adequate beta-cell compensation with increased insulin secretion. However, GDM develops if the beta-cell compensation is inadequate for the degree of insulin resistance and hepatic glucose production [6-9].

Regarding the estimated number of cases of hyperglycemia in pregnancy, Africa is second to South-East Asia, and more than 90% of cases are estimated to occur in low- and middle-income countries [10]. GDM is the commonest cause of hyperglycemia in pregnancy, accounting for about 90% of all diabetes during pregnancy [5, 11]. Generally, GDM patients have few symptoms and it is usually diagnosed by screening at 24-28th week of pregnancy. It is a public health concern currently affecting a large proportion of the female population with both short and long-term consequences for the fetus/neonate and the mother [12]. Depending on the ethnic population studied and the diagnostic criteria used, it has been reported that GDM complicates 1%-14% of all pregnancies worldwide, and its incidence has been on the dramatic increase [12-14]. Offspring of mothers with GDM are at increased risk for diabetes and childhood obesity [12-13, 19-20].

Established risk factors known to cause GDM include women of African, Hispanic, Native American, and South or East Asian origins, obesity with a Body Mass Index (BMI) $\geq$ 30 kg/m2, maternal age > 25 years, antecedent maternal weight of $\geq$ 90 kg, and multiparity. Certain outcomes in a previous pregnancy are also believed to be predictive, including antecedent unexplained stillbirth, perinatal death, fetal macrosomia (birth weight $\geq$ 4 kg), congenital malformation, recurrent miscarriages, and hypertension in pregnancy or previous GDM. Other risk factors include recurrent glycosuria in current pregnancy (2 or more episodes of glycosuria on routine urinalysis), family history of diabetes mellitus, presee of polynchydramnios, or multiple gestations.

Despite numerous studies on the pathogenesis of GDM, its pathophysiology is not fully known and is still clouded with a lack of consistent conclusions. It is known that GDM is a heterogeneous pathophysiological state in which the main mechanism is dysfunction of pancreatic beta-cells, manifesting itself in the course of pregnancy with increasing Insulin Resistance (IR) [19-20]. At present, it is generally believed that GDM is connected with increased IR with a pathogenesis similar to type 2DM, but the specific etiology is not clear yet with any unified understanding [17-18]. The endocrine change is an absolute or relative deficiency of insulin secretion, mainly a glucose metabolism

disorder. Pancreatic beta-cell dysfunction is associated with IR, and the pathogenesis of this IR seen in GDM is similar to what is observed in type 2 diabetes mellitus [19]. Recognized risk factors for GDM include women of African, Hispanic, Native American, and South or East Asian origins, obesity with a Body Mass Index (BMI) $\geq$ 30 kg/m2, maternal age > 25 years, antecedent maternal weight of $\geq$ 90 kg, and multiparity. Certain outcomes in a previous pregnancy are also believed to be predictive, including antecedent unexplained stillbirth, perinatal death, fetal macrosomia (birth weight $\geq$ 4 kg), congenital malformation, recurrent miscarriages, and hypertension in pregnancy or previous GDM. Other risk factors include recurrent glycosuria in current pregnancy (2 or more episodes of glycosuria on routine urinalysis), family history of diabetes mellitus, presence of polyhydramnios, or multiple gestations [2, 13, 15-16].

The overall aim of this research was to assess the prevalence of both GDM and IR and to determine the associated risk factors and predictors among pregnant women in Calabar.

Material and Methods

The study was a cross-sectional descriptive study as it established the role of biomarkers of IR in predicting the occurrence of GDM among the antenatal population at UCTH Calabar. This study was carried out at the antenatal clinic of the University of Calabar Teaching Hospital (UCTH), Calabar, Cross River State, in the South-south geopolitical area of Nigeria. Cross River State has a population of about 2.8 million people. Calabar is the capital city of Cross River state and has a population of 371,022, and the occupation of people is predominantly civil service, trading, and farming [21]. UCTH is a tertiary healthcare facility located in Calabar Municipality of Cross River State. It is a referral center for government/public and private hospitals, providing health care services to the over 3 million people within the state and its environs. The target population was pregnant women between 24-28 weeks of gestation being cared for at the antenatal clinic of the facility (UCTH Calabar).

Sample size determination: Using a GDM prevalence of 14% from an initial study [11], the prevalence was used to determine the sample size using the Leshie-Kish formula [22], illustrated below

$n = Z^2 pq/D^2$

A total of 185 participants were recruited for the study.

All consenting pregnant women at gestational ages between 24-28 weeks were included while known diabetic pregnant women, pregnant women on medications likely to alter glucose metabolism, e.g., steroids, sulfonylureas, protease inhibitors, and beta agonists, very ill patients, participant who did not give consent, and multiple pregnancy were excluded.

Tools for data collection: Data for the study were collected at the booking visit using a structured pre-coded questionnaire. The socio-demographic data of the clients were obtained by use of the questionnaire. The presence of risk factors and symptoms, e.g., obstetrics and gynecological history, past history of GDM, or family history of diabetes mellitus and hypertension, was also evaluated. At the end of the questionnaires, the clients were stratified based on their risk, i.e., clients were placed in either high, average, or low risk for GDM as classified by the 5th International Conference for GDM. Results of the 1-step, 75-g, 2-hour Oral Glucose Tolerance Test (OGTT) (Table II) were determined.

Collection of blood sample: After obtaining

consent and ascertaining an overnight fast, samples of blood were collected aseptically. This involved swabbing the located venous site (commonly at the cubital fossa), followed by the use of a 10 ml syringe to collect a 7 ml blood sample by backflow pressure. Of this, 5 ml was placed into a pre-numbered plain sample bottle for fasting insulin and lipid analysis, while 2 ml was placed into a sample bottle containing fluoride oxalate for fasting glucose analysis.

This was subsequently followed by the administration of 75 g of oral glucose diluted in 300 ml of clean water. Thereafter, 1-hour and 2-hour blood samples (2 mL each) were collected and placed into sample bottles containing fluoride oxalate for 1-hour and 2-hour glucose analysis, respectively. Collected samples were sent to the Chemical Pathology laboratory for proper analysis.

Assay methodology: At the laboratory, the collected samples were centrifuged at 12,000 rpm at room temperature for 10 minutes. This separated the blood cells from the plasma. The glucose oxidase method was used to assay glucose. Enzyme-Linked Immunosorbent Assay (ELISA) was used for the assay of human insulin. The Homeostatic Model Assessment for IR (HOMA-IR) is a measure of IR and was calculated thus:

HOMA-IR = {Fasting glucose (mmol/L)} × {Fasting insulin (mIu/L)} / 22.5

OR

{Fasting glucose (mg/dL)} × {Fasting insulin (mIu/L)} / 4

Biochemical measurements: Parameters such as body mass index (BMI) = weight (kg) / height (m^2) were calculated. Determination of Fasting Plasma Glucose (FPG) levels, Fasting Plasma Insulin (FPI) level, total cholesterol, and triglyceride, determination of HOMA-IR was obtained from the equation, HOMA-IR (Fasting Glucose x Fasting Insulin) / 22.5(Glucose in mmol/L). Determination of Beta-cell Function (HOMA-β) was calculated from this equation: HOMA-β = (20 x Fasting Insulin) / (Fasting Glucose - 3.5) (% β-cell function)

Data analysis

The data obtained were entered into an Excel spreadsheet and later input into Statistical Package for Social Sciences (SPSS) version 23.0 for data cleaning and analysis. Univariate analysis was done to describe the data and presented in frequencies, percentages, and mean ± standard deviation. Bivariate analysis of biomarkers of IR was carried out using the chi-square test statistics (or Fisher's Exact Test where appropriate) for categorical variables; and student's t-test for continuous variables to assess their relationships with GDM. A p-value < 0.05 and a 95% confidence interval were set as the level of significance. Variables that were significant in bivariate analysis were subjected to multivariate analysis to determine the predictors of GDM.

Results

The 75-g OGTT was interpreted in line with the WHO criteria for the diagnosis of GDM. Individuals with hyperglycemia indicative of diabetes outside of pregnancy were excluded. The WHO, 2016 (as integrated from the 2013 WHO diagnostic criteria) [22].

Socio-demographic characteristics

Table 1 shows the socio-demographic characteristics of study participants. A total of 180 pregnant women participated in the study, out of which 39 (20.6%) were aged 25 years and below, while 143 (79.4%) were aged above 25 years. The mean age of study participants was 29.7 ± 5.1 years. More than two-thirds, 169 (93.9%) were married; two-thirds, 120 (66.7%) attained tertiary education while 59 (32.8%)

attained a maximum of secondary education. While 82 (45.6%) were self-employed, 45 (25.0%) had formal employment and 48 (26.7%) were unemployed. Most husbands of respondents were civil servants (46.7%), and businessmen (33.8%). The majority were urban dwellers, 153(85%).

Relationship between socio-demographic characteristics and GDM

Table 2 represents the relationship between socio-demographic characteristics and GDM. The prevalence of GDM was higher among rural dwellers compared with urban dwellers (50.0% versus 33.1%), and the difference was statistically significant ($p = 0.036$). The number of people who had GDM was higher among those aged more than 25 years compared to those aged 25 years and below (38.5% versus 35.1%), although the difference was not statistically significant ($p = 0.710$). More married women had GDM as compared to single women (37.9% versus 36.4%), though the difference was not statistically significant ($p = 1.000$). GDM was more common among respondents with a primary level of education compared with those who attained secondary or tertiary education (100.0%, 35.6% and 38.3% respectively), although differences were not statistically significant ($p = 0.494$). Again, there was no statistically significant relationship between GDM and husbands' profession ($p = 0.411$).

Relationship between obstetrics and gynaecological characteristics / events and GDM

Table 3 shows the relationship between obstetrics and gynaecological characteristics and GDM. Primigravidas (40.0%) accounted for the highest proportion of those with GDM, followed by primiparas (37.3%), then multiparas (36.2%), although the relationship did not show statistical

Table 1: Socio-demographic characteristics of study participants

Demographic characteristics	Frequency (Percentage)
Age group/years	
≤25	37 (20.6%)
>25	143 (79.4%)
Mean ± SD	29.7/5.1
Marital status	
Single	11 (6.1%)
Married	169 (93.9%)
Educational level	
Primary	1 (0.6%)
Secondary	59 (32.8%)
Tertiary	120 (66.7%)
Employment status	
Self-employed	82 (45.6%)
Formal employment	45 (25.0%)
Unemployed	48 (26.7%)
Student	5 (2.8%)
Spouses' profession	
Civil servant	84 (46.7%)
Businessman	61 (33.9%)
Petty trader	1 (0.6%)
Manual Labourer	3 (1.7%)
Others	21 (11.7%)
No response	10 (5.6%)
Current residence	
Rural	50 (27.8%)
Urban	130 (72.2%)

significance ($p = 0.922$). There was a significant relationship between history of caesarean section and GDM ($p = 0.038$). The proportion of GDM was higher among those who had had a caesarean section compared with those who had not had a caesarean section (52.8% versus 34.0%). The proportion of study participants with GDM was higher among those with a history of stillbirth compared to those with no such history (45.8% versus 35.1%), but the difference was not statistically significant ($p = 0.191$). The history of macrosomia was not significantly related to GDM ($p = 0.379$). Similarly, there was no significant relationship between GDM status and delivery before 37 weeks ($p = 0.106$), past history of elevated blood pressure ($p = 0.898$), history of glucose in urine ($p = 0.107$), and history of ever being diagnosed of diabetes ($p = 1.000$).

BMI and blood pressure of study participants

Table 4 shows that 39 (21.7%) had normal BMI, 69 (38.3%) were overweight, and 70 (38.9%) were obese. Mean BMI was $28.6 + 4.8$ Kg/m2 and fell within the range of overweight. More respondents had normal systolic and normal diastolic blood pressure values.

Relationship between risk factors classification and GDM among study participants

Table 5 shows the relationship between risk factor classification and GDM among study participants. The proportion of those in the high-risk category was higher among the respondents with GDM than those without GDM (13.2% versus 8.9%), while those in the low-risk category had a higher proportion among the GDM-negative women than GDM-positive women (61.6% versus 45.6%). Although GDM positivity worsens with increasing risk classification among pregnant women, the relationship was found not to be statistically significant in this study.

Prevalence of insulin resistance among study participants

Table 6 shows the prevalence of IR among study participants using biomarkers for IR. The prevalence of those with abnormal FPG is 55 (30.6%), while abnormal FPI was found among 74 (41.1%). Regarding IR index, 122 (67.8%) had significant IR (> 2.9), 26 (14.4%) had early IR (> 1.9), 11(6.1%) had optimal IR (less than 1), while 21 (11.7%) had normal values ($> 0.5\text{-}1.4$). Total cholesterol values was normal/desirable among 24 (13.3%), borderline high among 64 (35.6%) and high among 92 (51.1%). Triglycerides level was normal in 119 (66.1%), borderline high in 41 (22.8%) and high in 20 (11.1%) of the participants.

Relationship between risk factors classification and GDM among study participants

Table 7 shows the relationship between risk factor classification and GDM among study participants. The proportion of those in the high-risk category was higher among the respondents with GDM than those without GDM (13.2% versus 8.9%), while those in the low-risk category had a higher proportion among the GDM-negative women than GDM-positive women (61.6% versus 45.6%). Although GDM positivity worsens with increasing risk classification among pregnant women, the relationship was found not to be statistically significant in this study.

Discussion

In this study, the prevalence of GDM was found to be 37.7%. Depending on the population charac-

Table 2: Relationship between socio-demographic characteristics and GDM

Variable	GDM Positive n (%)	GDM Negative n (%)	Total	Chi-square test	*p*
Age group/years					
≤25	13 (35.1%)	24 (64.9%)	37 (100.0%)	0.138	0.710
>25	55 (38.5%)	88 (61.5%)	143 (100.0%)		
Marital status					
Single	4 (36.4%)	7 (63.6%)	11 (100.0%)	FET, 0.010	1.000
Married	64 (37.9%)	105 (62.1%)	169 (100.0%)		
Educational level					
Primary	1 (100.0%)	0 (0.0%)	1 (100.0%)	FET, 1.685	0.494
Secondary	21 (35.6%)	38 (64.4%)	59 (100.0%)		
Tertiary	46 (38.3%)	74 (61.7%)	120 (100.0%)		
Employment status					
Self-employed	32 (39.0%)	50 (61.0%)	82 (100.0%)	FET, 2.093	0.594
Formal employment	14 (31.1%)	31 (68.9%)	45 (100.0%)		
Unemployed	19 (39.6%)	29 (60.4%)	48 (100.0%)		
Student	3 (60.0%)	2 (40.0%)	5 (100.0%)		
Husband's profession					
Civil servant	31 (36.9%)	53 (63.1%)	84 (100.0%)	FET, 3.887	0.411
Businessman	21 (34.4%)	40 (65.6%)	61 (100.0%)		
Petty trader	1 (100.0%)	0 (0.0%)	1 (100.0%)		
Labourer	2 (66.7%)	1 (33.3%)	3 (100.0%)		
Others	10 (47.6%)	11 (52.4%)	21 (100.0%)		
Current residence					
Rural	25 (50.0%)	25 (50.0%)	50 (100.0%)	4.400	0.036*
Urban	43 (33.1%)	87 (66.9%)	130 (100.0%)		

FET = Fisher's Exact Test

Table 3: Relationship between obstetrics and gynaecological events and GDM

Variable	GDM Positive n (%)	GDM Negative n (%)	Total	Chi-square test	*p*
Parity					
Primigravida	20 (40.0)	30 (60.0)	50 (100.0)	0.163	0.922
Primipara	31 (37.3)	52 (62.7)	83 (100.0)	-	-
Multipara	17 (36.2)	30 (63.8)	47 (100.0)	-	-
Mean parity	1.0 ± 0.7	1.0/0.8	-	T-Test, 0.528	0.598
History of stillbirth / early NND					
Yes	22 (45.8)	26 (54.2)	48 (100.0)	1.713	0.191
No	46 (35.1)	86 (64.9)	132 (100.0)	-	-
History of congenital anomaly					
Yes	1 (100.0)	0 (0.0)	1 (100.0)	FET,1.681	0.374
No	66 (37.1)	112 (62.9)	178 (100.0)	-	-
History of macrosomic babies					
Yes	8 (30.8)	18 (69.2)	26 (100.0)	0.773	0.379
No	59 (39.9)	89 (60.1)	148 (100.0)	-	-
Past caesarean section					
Yes	19 (52.8)	17 (47.2)	36 (100.0)	0.307	0.038*
No	49 (34.0)	95 (66.0)	144 (100.0)	-	-
Any delivery before 37 weeks					
Yes	62 (95.4)	3 (4.6)	65 (100.0)	FET, 5.138	1.06
No	0 (0)	1 (100.0)	1 (100.0)	-	-
Past history of elevated BP?					
Yes	7 (38.9)	11 (61.1)	18 (100.0)	0.017	0.898
No	59 (37.3)	99 (62.7)	158 (100)	-	-
History of glucose in urine?					
Yes	5 (71.4)	2 (28.6)	7 (100.0)	FET, 3.441	0.107
No	62 (32.7)	107 (63.3)	169 (100)	-	-
Previous diagnosis of diabetes mellitus					
Yes	1 (50.0)	1 (50.0)	2 (100.0)	FET, 0.124	1.000
No	67 (37.9)	110 (62.1)	177 (100)	-	-

FET = Fisher's Exact Test

Table 4: BMI and blood pressure of study participants

Variable	Frequency (Percentage)
BMI category (Kg/m^2)	
Underweight	2 (1.1%)
Normal weight	39 (21.7%)
Overweight	69 (38.3%)
Obese	70 (38.9%)
Mean BMI/SD	28.6 $\pm$ 4.8
Systolic BP (mmHg)	
Normal	148 (82.2%)
Abnormal	32 (17.8%)
Mean SBP/SD	114.4 $\pm$14.5
Diastolic BP (mmHg)	
Normal	141 (78.3%)
Abnormal	39 (21.7%)
Mean DBP/SD	67.8 $\pm$10.4

teristics, screening method, and diagnostic criteria, the global prevalence varies widely, from 1% to 28% [23]. Ewenighi *et al.* got a prevalence of 4.8% while a prevalence of 6.4% was recorded in Qatar by Al-Kuwary *et al.* [12]. The high prevalence observed in this study can be attributed to the socioeconomic status (based on jobs and careers), and ethnicity of the participants, in addition to the diagnostic criteria (WHO) employed. The high prevalence in this study was consistent with the prevalence of 36.6% demonstrated in a population-based cross-sectional study of 13,627 women in Saudi Arabia [4] and 37.7% found in a Norway [24] study. In a recent African study, Sumaiya *et al.* also recorded a prevalence of 31.7% among 262 pregnant women in a case-cohort study in Johannesburg [25]. In the risk stratification in early pregnancy for GDM by Harrison *et al.* [7], 23% of women were diagnosed with GDM based on the Australian Diabetes in Pregnancy Society (ADIPS) criteria, while 30% were diagnosed based on the International Association of Diabetes and Pregnancy Study Group (IADPSG) criteria. In a study by Jenum *et al.* in Oslo, Norway, 13.0% was found using the WHO criteria and 31.5% with the IADPSG criteria [24]. High prevalence of GDM in less wealthy countries is consistent with studies from Asia and Africa. Substantial heterogeneity has been found among studies using different screening methods [23]. The commonly employed method for GDM screening in Africa is the two-hour 75g OGTT with glucose reference ranges as stipulated by the WHO, 2016 (Table 1).

The prevalence of IR among participants of the present study was evaluated by using different biomarkers of IR. The prevalence of abnormal FPG was found to be 30.6%. This is higher than the 16.2% that was found to be the overall prevalence of FPG in pregnancy, shown by Msollo *et al.* in a study of 468 pregnant black African women in Tanzania [26]. Increased FPG is a direct result of IR because of decreased sensitivity to the glucose-lowering effect of insulin. The discrepancies seen in the studies mentioned may be a reflection of the heterogeneous nature of glucose and fat metabolism as influenced by various factors like diet, BMI, lifestyle, physical activity, ethnicity, and the cut-off value of FPG based on the criteria used. The prevalence of abnormal FPI in this study was

Table 5: Relationship between risk factors classification and GDM among study participants

Risk Factor classification	GDM Positive n (%)	GDM Negative n (%)	Total n (%)	Chi-square test	p
Low risk	31 (45.6%)	69 (61.6%)	100 (55.6%)	4.410	0.110
Average risk	28 (41.2%)	33 (29.5%)	61 (33.9%)	3.623	0.163
High risk	9 (13.2%)	10 (8.9%)	19 (10.6%)	1.917	0.383

Table 6: Prevalence of insulin resistance among study participants

Biomarkers of insulin resistance	Frequency (Percentage)
Fasting plasma glucose	
Normal (<5.1 mmol/L)	125 (69.4%)
Abnormal (5.1-6.9 mmol/L)	55 (30.6%)
Fasting plasma insulin	
Normal (≤25 mIu/L)	106 (58.9%)
Abnormal (>25 mIu/L)	74 (41.1%)
Insulin resistance index	
Normal (0.5-1.4)	21 (11.7%)
Optimal (<1)	11 (6.1%)
Early insulin resistance (>1.9)	26 (14. 4%)
Significant insulin resistance	122 (67.8%)
Total cholesterol	
Desirable (<5.2 mmol/L)	24 (13.3%)
Borderline high (5.2-6.2 mmol/L)	64 (35.6%)
High (>6.2 mmol/L)	92 (51.1%)
Triglycerides	
Normal (<1.7 mmol/L)	119 (66.1%)
Borderline high 1.7-2.2 mmol/L	41 (22.8%)
High (>2.2 mmol/L)	20 (11.1%)

observed to be 41.1%. This is lower than the findings by Catalano *et al*., who found a significant 65% increase in insulin concentrations, while Amit *et al*. observed that the mean FPI levels were 61% higher in the early third trimester [27]. These findings suggest that there is a progressive rise in insulin secretion as pregnancy advances, indirectly signifying an increase in IR as the pregnancy advances.

A higher prevalence of GDM was observed with increasing educational level. This could be because of the higher age of majority the women. This was consistent with the study by Rajput *et al*. [14] in a tertiary care hospital in Haryana, India, where a significantly higher prevalence of GDM was observed with increasing educational level. More than half of the women (53.65%) had secondary and tertiary levels of education and were residing in urban areas in a Nigerian study carried out by Chukwunyere *et al*. [2] in Abeokuta, Southwestern Nigeria. This was attributed to the location of the health facility used for the study. In discordance with the finding of this study, Innes *et al*. found an inverse association between the educational level of the pregnant women and GDM. In another study carried out in Italy by Bo *et al*., high levels of maternal education were found to be associated with reduced risks of GDM, compared to less educated women. This was attributed to higher rates of overweight and obesity among women with low education and socioeconomic status (based on jobs and careers).

The majority of the women in the present study (67.8%) had a significant HOMA-IR. Amit *et al*. showed a significant rise in HOMA-IR in women at the 2nd and 3rd trimesters of pregnancy. In a similar and recent cross-sectional study carried out in the Arusha region, Tanzania, by Msollo *et al*. [26], a lower prevalence of 21% was seen among 230 randomly selected pregnant women not known to have diabetes before pregnancy. IR is the condition in which there is a decrease in the action of insulin on body tissues at a normal concentration of plasma insulin. This can be a result of a number of factors, such as the defective molecular structure of insulin, defective receptor functioning, or defective signal transduction pathway. Women with increased HOMA-IR are prone to develop pre-eclampsia and GDM. These conditions are both associated with an increase in the expression of TNF-α and other inflammatory markers, which cause IR. In analyzing the relationship between the biomarkers of IR and the development of GDM among the participants of this present study, the results indicated some significant correlations. The mean FPG and HOMA-IR were significantly higher among the participants with GDM ($p = 0.000$ and 0.004, respectively). This corroborated with a Polish study by Sok *et al*., which showed that HOMA-IR, FPG, FPI, as well as insulin dose required per day, increased in GDM. Georgiou *et al*. demonstrated a significantly higher concentration of FPG ($p < 0.001$) and HOMA-IR ($p < 0.004$) in women with GDM [28]. These results are consistent with the general opinion that chronic IR lies at the core of the development of the most common form of β-cell dysfunction present in GDM [21]. This provides a unique opportunity to study the early pathogenesis of the condition and develop interventions to prevent the disease. In some other studies, GDM was closely linked with high IR in

affected individuals, and many contributory or associated risk factors as outlined above [29-30].

Conclusion

The prevalence of GDM among pregnant women in Calabar is high. This unusually high prevalence calls for concern and may be due to some peculiar factors in this environment that are yet to be explained fully. However, modified lifestyle, among other parameters, is top on the list and should be studied in detail. A global study is necessary to give a wider view of this subject.

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