Risk factors for Gestational diabetes mellitus among pregnant women attending antenatal clinic in Kisumu City, western Kenya

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Research Article

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Abstract

Background: Globally there is a rapid increase in the prevalence of Gestational diabetes mellitus (GDM) associated with adverse maternal and neonatal outcomes. However, screening for GDM is not part of the standard routine antenatal (ANC) services in Kenya. There is a paucity of data on the factors associated with and predictors of GDM. Therefore, this study sought to determine factors associated with and predictors of GDM among pregnant women in western Kenya.

Methods: A case-control study was conducted from September 2021-October 2022. Using a validated questionnaire, data were obtained from 210 randomly sampled pregnant women attending antenatal clinic at Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH) in Kisumu city, western Kenya. Screening and diagnosis for Gestational Diabetes mellitus was performed using the 2013 World Health Organization (WHO) criteria. Both descriptive and inferential statistical analysis were done in SPSS V.23 using Chi-square (χ^2) test to test for associations and Binary logistic regression analysis to determine predictors of GDM.

Results. Among the 105 GDM cases**,** majority were in 30-34 years age group (51%), overweight with a BMI of 25-29.9 kg/m^2 (56%), had history of hypertension (53%), had hypertensive relatives (64%), had history of glycosuria (64%), were multiparous (69%), had history of cesarean delivery (61%), had history of macrosomic delivery (63%) and had history of neonatal intensive care unit (NICU) admission (53%). Multivariate analysis revealed that living in peri-urban area (adjusted OR [aOR] 3.30, 95%CI: 1.04-11.3, p=0.048), having a diabetic relative (aOR 8.09, 95%CI: 1.44- 73.0, p=0.031), being on iron-folic acid supplementation (IFAS) (aOR 13.0, 95%CI: 4.37-47.8, <0.001), having history of neonatal intensive care unit admission (NICU) (aOR 13.9, 95%CI: 3.45-70.5, p<0.001) and history of caesarean delivery (aOR 5.02, 95%CI: 1.42-19.5, p=0.015) significantly increased the odds of having GDM.

Conclusion: The predictors of GDM include having a diabetic relative, history of cesarean section, NICU admission and being on IFAS. There is need to incorporate GDM screening in the standard ANC services for optimal pregnancy outcomes. Multicenter studies looking at the long term effects of IFAS should be carried out to inform evidence based nutrition interventions during pregnancy.

Introduction

One of the most common non-communicable metabolic deregulation that present as glucose or carbohydrate intolerance of differing severity detected at the start or during pregnancy is Gestational Diabetes Mellitus (GDM) [1]. It is a common pregnancy complication accounting for 90% of all pregnancy complicated by diabetes [2, 3], associated with poor neonatal and maternal outcomes and poses a significant health risk for both the mother and neonates [4, 5]. In 2013, the World Health Organization (WHO) adopted the International diagnostic and screening criteria for GDM that include performing oral glucose tolerance test (OGTT) in a fasting state [1, 6]. Despite the adoption of this criteria, the use of two-step screening and diagnostic methods involving measurement of glucose concentration following 50g

glucose challenge test (GCT) and then again after 100g OGTT is still widely used in various settings [7, 8]. This lack of uniformity in diagnostic and screening protocols has partly contributed to variation in GDM prevalence across regions [8]. The global prevalence of GDM varies from 1–28% depending on the study population genetics, environment and screening methods [5]. Estimates indicate that sub-Saharan Africa (SSA) has a prevalence of 14%, North Africa (24.5%), North America (7%) and Europe (5.4%) [4, 5]. In Africa, there is also geographic variation in GDM prevalence with North Africa having a prevalence of 24.5%, West Africa (14%) and East Africa prevalence of 6% [5]. Moreover, even within East Africa region there is variation in prevalence with Rwanda having a prevalence of 8.3%, Tanzania having a prevalence of 5.9%, Ethiopia a prevalence of 3.7% and western Kenya presenting with a prevalence of 2.6% [2, 4, 5].

Recently, there is a significant shift in public health challenges facing sub-Saharan Africa (SSA) such as increases in incidences of obesity, diabetes and other non-communicable diseases due to changes in lifestyles including lack of physical exercise and/or not eating healthier diets [5]. Developing targeted interventions that will reduce the burden of this problem and result in improvement of both maternal and child health in SSA requires a thorough understanding of the risk factors of non-communicable diseases such as GDM. Although there is a paucity of data on the risk factors for GDM in SSA, previous studies revealed that maternal age, high parity, pregnancy overweight or obesity, family history of diabetes, being hypertensive, previous delivery of macrosomic infants and previous bad obstetric outcomes such as still birth and abortion are important risk factors for GDM [4, 8]. Other potential risk factors includes low or high birth weight, smoking, physical inactivity, stature, socioeconomic factors, under-nutrition during early life and exposure to Human Immunodeficiency virus and Tuberculosis [9].

The Kenyan Ministry of Health has not rolled out screening and treatment of GDM as part of the routine antenatal care (ANC) services. Moreover, to our knowledge the only one study done in Eldoret in Uasin Gishu County, western Kenya, found a GDM prevalence of 2.6% [10]. This study was focused on screening strategies and did not look at the predictors of GDM. Moreover, the lifestyle patterns (in terms of physical activity and dietary habits) in this region are different with that of Kisumu County. The true prevalence and risk factors for GDM in Kenya is not known. Therefore, the purpose of this study was to determine factors associated with and predictors of GDM among pregnant women with GDM in western Kenya. This will help to inform policy change and device evidence-based interventions for prevention, screening and treatment of GDM

Methods

Study design and setting

Our case-control study enrolled pregnant women from ANC clinic of the Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH). The JOOTRH is a level 6 referral and teaching hospital located within Kisumu City in Kisumu County, western Kenya. It serves a varied demography of patients from rural, peri-urban and urban residents in the County and the larger western region of the country. The hospital handles an average of about 40 pregnant women daily who attend antenatal care, maternity and

child health clinics during clinic days (Monday to Friday). Data was collected from participants visiting the hospital for antenatal check-ups. Several services are routinely provided at the clinics including PMTCT, screening for hypertension, malaria, anaemia, venereal diseases and urinary tract infections. The hospital has staff of different carders including consultants, resident doctors, midwives, specialists and nurses

Study population

Pregnant women who attended JOOTRH (antenatal clinic), 18 years or older with singleton pregnancies, between 24- and 32-weeks gestation with a maximal range to 45 weeks, were eligible for inclusion and gave informed written consent. The study involved both new and referral cases from satellite health facilities. The study excluded pregnant women with pre-existing diabetes, and/or taking drugs that would affect blood glucose control or pregnancy outcome, those with incomplete blood glucose values and those unwilling to participate. The study enrolled participants who were categorized as those with GDM (Cases) and those without GDM (Control) groups respectively. The necessary information was collected from the participants through the questionnaire, gynecological files and laboratory examinations.

Study variables

The dependent variable was GDM, the independent variables included anthropometric and sociodemographic data obtained using a structured questionnaire. Socio demographic variables included maternal-age, marital status, residence, educational level, occupational status of the women, monthly income of women and history of chronic infections; Anthropometrical factors included height, pregnancy weight, Body Mass Index (BMI); Obstetric factors such as parity and obstetric history (history of cesarean or macrosomic delivery, abortion, stillbirth, history of miscarriage, history of infertility); Familial risk factors included previous history of GDM, previous history of diabetes and hypertension in first degree relatives; and Bio-chemical factors included history of glycosuria, Fasting blood glucose (FBG) and oral glucose tolerance test (OGTT).

Screening for GDM

All participants who met the inclusion criteria were advised to eat regular diets and fast on the night prior to the appointment day for testing (not to eat anything after 10 o'clock night with exception to water). After which all the participants were given an appointment within 72hours. All appointments were scheduled for 8–10 o'clock in the morning. The participants underwent universal screening by 2 qualified laboratory technicians who performed a laboratory test (Glucose Oxidase method), which was conducted for Fasting blood glucose (FBG) using a capillary whole blood sample from a finger prick drawn aseptically from the participant and measured using a ONE TOUCH FLEX Plus glucometer machine (UK ProPharma Group, Richmond, UK). FBG: 5.1–6.9 mmol/l (92–125 mg/dl), was considered positive and subjected to oral glucose tolerance test (OGTT) two hours after ingestion of 75 gms of glucose dissolved

in 250 ml of water. A blood glucose load of 7.8–11.0 mmol/l (153–199 mg/dl) was considered confirmatory for a GDM case. According to WHO recommendations: (FBG: 5.1–6.9 mmol/L (92–125 mg/dL) and 2-h post 75g oral glucose load 8.5–11.0 mmol/L (153–199 mg/dL). On the same day after diagnosis was completed, participants' both blood pressure and anthropometrical measurements were taken.

Data collection

Face to face interviews of the study participants by trained research assistants were conducted using a validated structured questionnaire. Data was collected for both dependent and independent variables. The data on pregnancy outcomes was captured using a checklist. Additional data such as maternal age and height, gestational age (in weeks) were collected from the mother-baby booklet. All the study participants had the clinic attendance booklets.

Sample size and sampling

Sample size was calculated using formula for comparing two proportions [11]. The sample size was determined based on the proportion of women with obesity (26%), a 95% confidence interval, 5% precision, power of study being (1-β) of 80% and 10% non-response rate. The final sample size was 210 (105 Cases and 105 Controls). A simple random sampling was applied.

Statistical analysis

Pearson Chi-square and Fisher's exact test were used for comparison of categorical variables. Binary regression was performed with all variables with GDM as the dependent variable, yielding crude odds ratios (COR) with 95% Confidence Interval (CI). All binary variables were tried in univariate regression analysis. Variables with *P*-value < 0.25 for the specific outcome were included in multiple regression models with dependent variable for adjusted odds ratios (aOR). *P*-value ≤ 0.05 was considered significant. The statistical analysis was carried out with SPPS (Statistical Package for the Social Sciences, Chicago, Illinois, version 23).

Ethical consideration

The study methods were performed in accordance with relevant guidelines and regulations in the declaration of Helsinki. Ethical approval was sought from Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH) Ethics Review Committee (Approval Number: IERC/JOOTRH/220/2020). Informed consent was sought from all the study participants using an approved consent form. Privacy and confidentiality of the study participants and all raw data was strictly observed.

Results

Sociodemographic characteristics of the study population

The sociodemographic characteristics of study participants with GDM and those without GDM included in the study are given in Table 1. A total of 210 pregnant women (105 cases with GDM and 105 controls without GDM) were enrolled in this study. A majority of participants with GDM were in 30–34 years age group (54, 51%), three quarters were married (79, 75%), over a half had secondary education (54, 52%), overweight with a BMI of 25-29.9 kg/m^2 (59, 56%).

Table 1
Sociodemographic characteristics of the study population

	Gestational Diabetes Mellitus		
Variable	n = 210	Positive n = 105	Negative n = 105
Age in years			
< 25	42(20%)	1(0.9%)	41(39%)
25–29	49 (23.3%)	1 (0.9%)	48 (45.7%)
30–34	70 (33.3%)	54 (51.4%)	16 (15.2%)
≥ 35	49 (23.3%)	49 (46.7%)	0 (0%)
Marital Status			
Married	161 (76.7%)	79 (75.2%)	82 (78%)
Unmarried	49(23.3)	26 (24.8%)	23 (21.9%)
Residence			
Rural	63 (30%)	28 (26.7%)	35 (33.3%)
Urban	85 (40.5%)	39 (37.1%)	46 (43.8%)
Peri-urban	62 (29.5%)	38 (36.2%)	24 (22.9%)
Education level			
None	1 (0.5%)	0 (0%)	1 (1.0%)
Primary	44 (20.9%)	28(26.7%)	16 (15.2%)
Secondary	124 (59%)	54 (51.4%)	70 (66.7%)
Tertiary	41 (19.5%)	23 (21.9%)	18 (17.1%)
Employment status			
Employed	113 (53.8%)	72 (68.6%)	41 (39%)
Unemployed	97 (46.2%)	33 (31.4%)	64 (61%)
BMI			
< 18.5(Underweight)	0 (0%)	0 (0%)	0 (0%)
18.5–24.9(Normal)	83 (39.5%)	18 (17.1%)	65 (61.9%)
25-29.9 (Overweight)	99 (47.1%)	59 (56.2%)	40 (38.1%)
> 30(Obese)	28 (13.3%)	28 (26.7%)	0 (0%)

Gestational Diabetes Mellitus
BMI: Body Mass Index

Clinical characteristics of the study participants

Table 2, shows the clinical and gynecological characteristics of the participants, with the highest proportion had no prior diabetes test (88, 84%), majority had history of hypertension (56, 53%), had hypertensive relatives (67, 64%), had no diabetic relative (65,62%) and had history of glycosuria (67, 64%), multiparous (72, 69%), had history of cesarean delivery (CS) (64,61%), history of macrosomic delivery (66,63%) and history of intensive care unit (ICU) admission (56, 53%). Further most of the women were unemployed (37, 36%).

Table 2
Clinical characteristics of the study participants

	Gestational Diabetes Mellitus		
Variable	n = 210	Positive n = 105	Negative n = 105
Prior diabetes test			
Yes	24 (11.4%)	17 (16.2%)	7 (6.7%)
No	186 (88.6%)	88 (83.8%)	98 (93.3%)
On IFAS			
Yes	144 (68.6%)	99 (94.3%)	45 (42.9%)
No	66 (31.4%)	6 (5.7%)	60 (57.1%)
History of hypertension			
Yes	75 (35.7%)	56 (53.3%)	19 (18.1%)
No	135 (64.3%)	49 (46.7%)	86 (81.9%)
Has hypertensive relative			
Yes	87 (41.4%)	67 (63.8%)	20 (19%)
No	123 (58.6%)	38 (36.2%)	85 (81%)
History of glycosuria			
Yes	67 (32%)	67 (63.8%)	0 (0%)
No	143 (68%)	38 (36.1%)	105 (100%)
Has diabetic relative			
Yes	44 (21%)	40 (38%)	4 (3.8%)
No	166 (79%)	65 (62%)	101 (96.2%)
Parity			
Nulliparous (0)	37(17.6%)	12(11.4%)	25 (23.8%)
Primiparous (1)	53(25.2%)	21(20%)	32(30.5%)
Multiparous (2+)	120(57.1%)	72(68.6%)	48(45.7%)
History of Cesarean delivery			
Yes	77 (36.7%)	64 (61%)	13 (12.4%)
No	133 (63.3%)	41 (39%)	92 (87.6%)

	Gestational Diabetes Mellitus		
Yes	5 (2.4%)	5 (4.8%)	0 (0%)
No	205 (97.6%)	100 (95.2%)	105 (100%)
History of Macrosomic delivery			
Yes	82 (39%)	66 (62.9%)	16 (15.2%)
No	128 (61%)	39 (37.1%)	89 (84.8%)
History of NICU admission			
Yes	63 (30%)	56 (53.3%)	7 (6.7%)
No	147 (70%)	49 (46.7%)	98 (93.3%)

Sociodemographic factors associated with Gestational diabetes mellitus

As shown in Table 3, Pearson Chi-square and Fisher's exact test results revealed the risk of GDM increased with age ($p < 0.001$), with highest prevalence in 30–34 (51%) and ≥ 35 (47%) year-old age groups. We observed an association between the prevalence of GDM with marital status ($p = 0.038$), education level ($p = 0.033$) and employment status ($p < 0.001$). When BMI was considered, a positive association was observed between pregnancy BM1 and GDM ($p < 0.001$). The prevalence of GDM increased with pregnancy BMI. The prevalence was highest in overweight (25-29.9 kg/m^2) group.

Table 3
Sociodemographic factors associated with GDM

	Gestational Diabetes status		
Variable	Positive n = 105	Negative n = 105	χ^2 p-value
Age in years			**< 0.001**
< 25	1(0.9%)	41(39%)	
25–29	1 (0.9%)	48 (45.7%)	
30–34	54 (51.4%)	16 (15.2%)	
≥ 35	49 (46.7%)	0 (0%)	
Marital Status			**0.038**
Married	79 (75.2%)	82 (78%)	
Unmarried	26 (24.8%)	23 (21.9%)	
Residence			0.076
Rural	28 (26.7%)	35 (33.3%)	
Urban	39 (37.1%)	46 (43.8%)	
Peri-urban	38 (36.2%)	24 (22.9%)	
Education level			**0.033**
None	0 (0%)	1 (1.0%)	
Primary	28(26.7%)	16 (15.2%)	
Secondary	54 (51.4%)	70 (66.7%)	
Tertiary	23 (21.9%)	18 (17.1%)	
Employment status			**< 0.001**
Employed	72 (68.6%)	41 (39%)	
Unemployed	33 (31.4%)	64 (61%)	
BMI			**< 0.001**
< 18.5(Underweight)	0 (0%)	0 (0%)	
18.5–24.9(Normal)	18 (17.1%)	65 (61.9%)	
25-29.9 (Overweight)	59 (56.2%)	40 (38.1%)	
> 30(Obese)	28 (26.7%)	0 (0%)	

Gestational Diabetes status
BMI: Body Mass Index

Clinical factors associated with Gestational Diabetes Mellitus

As shown in Table 4, Pearson Chi-square and Fisher's exact test results revealed the risk of GDM was associated with women with history of hypertension ($p < 0.001$), history of hypertensive relative ($p < 0.001$), history of a diabetic relative ($p < 0.001$) and history of glycosuria ($p < 0.001$). GDM was more prevalent in multiparous women ($p < 0.001$), those with history of miscarriage ($p = 0.007$), history of CS ($p < 0.001$), history of macrosomic delivery ($p < 0.001$), history of neonatal intensive care unit admission (NICU) ($p < 0.001$).

Table 4
Clinical factors associated with GDM

	Gestational Diabetes Mellitus		
Variable	Positive n = 105	Negative n = 105	χ^2 p-value
Prior diabetes test			**0.003**
Yes	17 (16.2%)	7 (6.7%)	
No	88 (83.8%)	98 (93.3%)	
On IFAS			**< 0.001**
Yes	99 (94.3%)	45 (42.9%)	
No	6 (5.7%)	60 (57.1%)	
History of hypertension			**< 0.001**
Yes	56 (53.3%)	19 (18.1%)	
No	49 (46.7%)	86 (81.9%)	
Has hypertensive relative			**< 0.001**
Yes	67 (63.8%)	20 (19%)	
No	38 (36.2%)	85 (81%)	
History of glycosuria			**< 0.001**
Yes	67 (63.8%)	0 (0%)	
No	38 (36.1%)	105 (100%)	
Has diabetic relative			**< 0.001**
Yes	40 (38%)	4 (3.8%)	
No	65 (62%)	101 (96.2%)	
Parity			**< 0.001**
Nulliparous (0)	12(11.4%)	25 (23.8%)	
Primiparous (1)	21(20%)	32(30.5%)	
Multiparous (2+)	72(68.6%)	48(45.7%)	
History of miscarriage			**0.007**
Yes	8 (7.6%)	0 (0%)	
No	97 (92.4%)	105 (100%)	

	Gestational Diabetes Mellitus		
History of Cesarean delivery			**< 0.001**
Yes	64 (61%)	13 (12.4%)	
No	41 (39%)	92 (87.6%)	
History of Macrosomic delivery			**< 0.001**
Yes	66 (62.9%)	16 (15.2%)	
No	39 (37.1%)	89 (84.8%)	
History of NICU admission			**< 0.001**
Yes	56 (53.3%)	7 (6.7%)	
No	49 (46.7%)	98 (93.3%)	

Risk factors for Gestational diabetes mellitus

To establish the independence of these variables, we performed binary logistic regression analysis. As shown in Table 5, univariate analysis revealed that women who reside in urban areas (Crude Odds Ratio [cOR] 1.03, 95CI: 0.52–2.02) and peri-urban (cOR 2.10, 95%CI: 1.01–4.48), p < 0.074) were more likely to have GDM relative to those from rural areas. Those who were employed were more likely to have GDM relative to those not employed (cOR 3.91, 95%CI: 2.18–7.15), p < 0.0001). Analysis revealed that those with a diabetic relative were more likely to have GDM relative to those without (cOR 28, 95CI: 8.2–176, p < 0.001), those with hypertensive relative had increased odds of developing GDM (cOR 7.9, 95%CI: 4.2–15.6, p < 0.001), those who had prior diabetes test were more likely to have GDM relative to those without prior diabetes test (cOR 5.8, 95%CI:1.9–25.4, p < 0.001). When parity was considered, those who were primiparous (cOR 1.3, 95%CI: 0.5–3.2, p < 0.001) and multiparous (cOR 3.5, 95%C: 1.6–8.1, p < 0.001) were likely to have GDM relative to those who were nulliparous. Those with history of infertility were more like to have GDM relative to those without although not statistically significant (cOR 2.1, 95%CI: 0.7–7.9, p < 0.22). The results reveal that those with history of hypertension were more likely to have GDM relative to those without (cOR 5.5, 95%CI: 2.9–10.9, p < 0.001). Similarly, those with history of CS delivery (cOR 13, 95%CI: 6.3–29.2, p < 0.001), on IFAS (cOR 21.9, 95%CI: 9.3–60.5, p < 0.001), history of macrosomic delivery (cOR 10.4, 95%CI: 5.3–21.9], p < 0.001, history of NICU admission (cOR 20.1, 95%CI: 8.2–60.6, p < 0.001) were more likely to have GDM relative to those without.

Table 5
Risk factors for Gestational diabetes

	Univariate analysis			Multivariate analysis		
Characteristic	cOR[1]	95% CI[1]	p-value	aOR[1]	95% CI[1]	p-value
Current Residence			0.074			
Rural	*Ref.*	—		*Ref.*	—	
Urban	1.03	0.52, 2.02		0.51	0.15, 1.57	0.200
Peri-Urban	2.10	1.01, 4.48		3.30	1.04, 11.3	0.048
Education Level			0.026			
Primary	*Ref.*	—				
Secondary	0.41	0.19, 0.86				
Tertiary	0.82	0.32, 2.11				
Employment Status			**< 0.001**			
Unemployed	*Ref.*	—		*Ref.*	—	
Employed	3.91	2.18, 7.15		1.70	0.56, 5.15	0.300
Has Diabetic Relative			**< 0.001**			
No	*Ref.*	—		*Ref.*	—	
Yes	28.0	8.20, 176		8.09	1.44, 73.0	**0.031**
Has Hypertensive Relative			**< 0.001**			
No	*Ref.*	—		*Ref.*	—	
Yes	7.9	4.15, 15.6		0.75	0.21, 2.41	0.600
Prior Diabetic Test			**0.001**			
No	*Ref.*	—		*Ref.*	—	
Yes	5.80	1.87, 25.4		2.88	0.47, 20.9	0.300
On IFAS			**< 0.001**			
No	*Ref.*	—		*Ref.*	—	
Yes	21.9	9.33, 60.5		13.0	4.37, 47.8	**< 0.001**
Parity			**< 0.001**			
Nulliparous (0)	*Ref.*	—		*Ref.*	—	

	Univariate analysis			Multivariate analysis		
Primiparous (1)	1.30	0.54, 3.22		0.43	0.12, 1.54	0.200
Multiparous (2 +)	3.54	1.62, 8.08		1.10	0.32, 3.86	0.900
History of Infertility			0.220			
No	*Ref.*	—				
Yes	2.09	0.65, 7.92				
History of hypertension			**< 0.001**			
No	*Ref.*	—				
Yes	5.50	2.89, 10.9				
History of NICU admission			**< 0.001**			
No	*Ref.*	—		*Ref.*	—	
Yes	20.1	8.23, 60.6		13.9	3.45, 70.5	**< 0.001**
History of Macrosomic delivery			**< 0.001**			
No	*Ref.*	—		*Ref.*	—	
Yes	10.4	5.27, 21.9		1.50	0.39, 5.68	0.500
History of caeserean delivery			**< 0.001**			
No	*Ref.*	—		*Ref.*	—	
Yes	13.0	6.26, 29.2		5.02	1.42, 19.5	**0.015**

cOR: crude odds ratio. aOR: adjusted odds ratio, CI: Confidence Interval, IFAS: iron-folic acid supplementation and NICU: neonatal intensive care unit admission

Multivariate analysis revealed that living in peri-urban area was an independent predictor of GDM (adjusted OR [aOR] 3.30, 95%CI: 1.04–11.3, p = 0.048), being employed increased the risk of having GDM (aOR 1.70, 95%CI: 0.56–5.15, p = 0.300) though not statistically significant, having a diabetic relative significantly increased the odds of having GDM (aOR 8.09, 95%CI: 1.44- 73.0, p = 0.031). Although statistically not significant, the analysis revealed that those with prior diabetes test were more likely to have GDM (aOR 2.88, 95%CI: 0.47–20.9, p = 0.300), being on IFAS is an independent predictor of GDM (aOR 13.0, 95%CI: 4.37–47.8, < 0.001), though not statistically significant multiparous women are more likely to have GDM (aOR 1.10, 95%CI: 0.32–3.86, p = 0.900). Further analysis revealed that having history of NICU (aOR 13.9, 95%CI: 3.45–70.5, p < 0.001) and history of caesarean delivery (aOR 5.02, 95%CI: 1.42–19.5, p = 0.015) significantly increased the odds of having GDM. In addition, having history of macrosomic delivery increased the odds of GDM (aOR 1.50, 95%CI: 0.39–5.68, p = 0.500) though not statistically significant.

Discussion

This study examined the risk factors for GDM among pregnant women with GDM in western Kenya with women without GDM as a control. In the present study, 56% of the GDM women were overweight with a BMI of 25-29.9kg/m^2 and 26% were obese with BMI ≥ 30 kg/m^2, whereas 61.9% of women in the control group (without GDM) had normal BMI, 38.1% were overweight. This study found an association between pregnancy BMI and GDM. This is consistent with previous observations linking GDM to maternal BMI [5, 12, 13]. This may be due to suppressed insulin sensitivity among women who are overweight or obese resulting in maternal hyperglycemia or due to lack of physical exercise by overweight and obese women [5]. Significantly the increase in prevalence of overweight among women with pregnancies not complicated by diabetes is of great public health concern as it suggests that there will be rise in GDM cases in the future in this region. Hence, there need for lifestyle interventions such as eating healthier and nutritious food, engaging in physical exercise and early detection of GDM that will ultimately lead to reduction of the risk of being overweight or obese [12, 14].

We found that pregnant women with pregnancies complicated with GDM tend to have advanced age and that advanced maternal age increased the likelihood of having GDM. This finding is in agreement with studies from various countries globally that demonstrated an association between GDM and advanced maternal age [4, 12, 15, 16]. This is probably due to the fact that mothers with advanced maternal age have given birth severally, pregnancy is known to initiate metabolic disorders such as increased insulin resistance and may result in obesity [2]. Poor obstetrical outcomes such as increase risk of CS and GDM is linked to advanced maternal age due to increase fetal growth in hyperglycemic mothers [2]. Hence maternal age should be considered when providing reproductive health care services especially screening for GDM during ANC visits.

The current study found that 61% of the women with GDM had a history of CS delivery in comparison to 12.4% of women without diabetes. This is in line with findings that CS is an adverse pregnancy outcome associated with GDM due to fetal macrosomia [4, 5]. Similar findings of increased rate of operative deliveries among women with pregnancies complicated have been reported [4, 12]. The rise in the CS is a serious public health challenge given that CS is associated with hemorrhage, intra-abdominal adhesion and mortality among pregnant women and development of allergic reaction or poor developmental outcomes in children [6]. Hence there is a need to formulate and implement interventions geared towards reducing the rate of CS. Further analysis revealed that history of CS is a predictor of GDM suggesting that history of CS can be included in the algorithm for identification of pregnant women at high risk for GDM and interventions targeting this population for screening need to be put in place.

This study demonstrated that family history of diabetes increases the odds of having GDM. Similar observation has been reported in Tanzania, Turkey, Iran and USA [2, 5]. Increased risk for GDM has been associated with inheritance of genetic receptor B_3-adrenergic genes linked to weight gain and resistance to insulin from one generation to the next [2, 17]. Moreover, familial inheritance of genetic defects that cause β cell dysfunctions such as deregulated insulin production that lead to hyperglycemia, insulin

intolerance and development of diabetes has been previously demonstrated [6, 17, 18]. Although this study did not look at the genetic factors, these findings suggest family history of diabetes is a predisposing factor to develop GDM and women with this history should be considered to be at high risk and prioritized for screening especially in poor countries where resources for universal screening are unavailable.

To prevent poor pregnancy-related outcomes due to iron and folic deficiencies, the WHO recommends that pregnant women should be given daily iron and folic supplementation (IFAS). Based on this, several countries including Kenya have included IFAS in their ANC service package [19]. However, studies have shown association between IFAS and the likelihood of developing GDM among pregnant women [20, 21], with increased risk associated to taking IFAS for a longer period and/or taking higher doses [21]. More importantly, those using IFAS have higher GDM risk relative to non-users [22]. Similarly, this study also demonstrate that being on IFAS is a predictor of GDM. Although the mechanisms underlying associations between IFAS and GDM is not known, it has been shown that elevated levels of unmetabolised folic acid can downmodulate natural killer cell immune responses and results into infiltration of β-cell in GDM [23]. This finding indicate that there is need for large-scale epidemiological studies cohort studies to look at the of long-term effects of IFAS on GDM. This will lead to formulation optimal evidence-based nutrition interventions during pregnancy that will result in good pregnancy-related outcomes.

Another finding from the current study is that the proportion of women with history of neonatal intensive care unit admission was higher (53.3%) among women with pregnancies complicated with GDM relative to 5.7% among women without diabetes. Further analysis revealed that having a history of NICU admission is a predictor of GDM. NICU admissions have been previously associated with maternal pregnancy BMI and CS [24, 25] that are also predictors of GDM. In addition, parity increases the likelihood of having both GDM and risk of NICU [25], suggesting that there is interaction between these factors. This study may have been limited by recall bias of the participants, since women were asked to recall events of their last pregnancy, which may have been months or years back.

Conclusion

Prevalence of GDM is associated with increased maternal age, marital status, education level, employment status, BM1, history of hypertension, history of hypertensive relative, history of a diabetic relative, history of glycosuria, parity, history of miscarriage, history of CS, history of macrosomic delivery and history of neonatal intensive care unit admission. The predictors of GDM include having a diabetic relative, history of CS delivery and history of NICU in addition to being on IFAS. Our findings indicate that GDM screening should be incorporated in the standard ANC services for early detection and timely treatment in order to achieve optimal pregnancy outcomes and prevent complications linked to GDM. There is need for prioritizing high risk women for screening based on their history of CS, being on IFAS, history of macrosomic delivery and history of neonatal intensive care unit admission. Further longitudinal multicenter studies should be carried out to explore long term effects of IFAS (in terms of duration and dosage) on GDM in order to provide an evidence-based antenatal based nutritional interventions. There is

also need for implementation of life modification programs such as involvement in physical activity and healthier diet to prevent the development of GDM and obstetric complication.

Abbreviations

ANC
antenatal care
BMI
Body Mass Index
CS
Cesarean section
GDM
Gestational diabetes mellitus
NICU
Neonatal intensive care unit

Declarations

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Availability of data and materials

All the data generated and used for statistical analysis during this study are included in this article (Supplementary file 1)

Authors' contributions

Authors' contributions AAO, GA and ASA conceptualized the study and supervised the data collection process. AA0 and ASA led the analysis of the data presented in this paper. AAO prepared the draft manuscript, with substantial inputs from AAO, GA and ASA. All authors have reviewed and approved this final draft of the manuscript

Ethical approval and consent to participate

This study was conducted in accordance with Declaration of Helsinki. Ethical approval was sought from Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH) Ethics Review Committee (Approval

Number: IERC/JOOTRH/220/2020). Informed consent was sought from all the study participants using an approved consent form. Privacy and confidentiality of the study participants and all raw data was strictly observed.

Consent for publication

Not applicable for this study

Competing interests

The authors declare that they have no competing interest

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Supplementary Files

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