Systematic Review

A systematic review and meta-analysis of the prevalence and determinants of gestational diabetes mellitus in Nigeria

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Abstract

Background: Gestational diabetes mellitus (GDM) is any degree of glucose intolerance with onset or first diagnosis in pregnancy. GDM has numerous potential complications and it is important to estimate its burden and risk factors. The objective of the meta-analysis was to determine the pooled prevalence of GDM in Nigeria and identify its determinants. **Methods:** The study design was a meta-analysis; therefore the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed. Electronic databases (African Journal Online, PubMed, SCOPUS, and Google Scholar) and the gray literature were systematically searched. Statistical analysis was done with MetaXL using the random effect model. Heterogeneity was determined using the I^2 statistic and the publication bias was checked with the Doi plot. **Results:** The total sample size was 46 210. The prevalence of GDM in Nigeria was 0.5 – 38% and the pooled prevalence was 11.0% (95% CI 8-13). The I^2 statistic was 99%. The Doi plot suggested some degree of bias. The most frequently reported determinants of GDM were previous macrosomic babies, maternal obesity, family history of diabetes, previous miscarriage, and advanced maternal age. **Conclusion:** The prevalence of GDM in Nigeria is high and efforts should be geared at modifying its risk factors so as to reduce its prevalence and prevent the associated complications.

Keywords: Gestational diabetes, meta-analysis, Nigeria, prevalence, risk factors

Introduction

Gestational diabetes mellitus (GDM) is defined as any degree of glucose intolerance whose onset or first diagnosis occurs during pregnancy.[1] Pregnant women with pre-gestational type 1 or type 2 diabetes and (recently) overt diabetes in pregnancy are not included in GDM.[2] The diagnosis of GDM implies an extra feto-maternal risk and a greater burden to the health system, especially in low-resource settings.[3] The extra feto-maternal risk includes a higher incidence of Cesarean sections, pre-eclampsia, macrosomia, neonatal hypoglycemia, and jaundice.[4] In the long term, such women with GDM have a higher risk of having type 2 diabetes and the babies from such pregnancies have a higher risk of developing obesity and type 2 diabetes later in life.[5,6]

The global prevalence of gestational diabetes was quoted as 1-28% and the wide range was due to differences in screening method, diagnostic criteria, ethnicity/race, and maternal age.[7] In a meta-analysis, the pooled prevalence of GDM in Africa was reported as 13.6%.[8] Kampmann *et al*.[4] posited that data on the prevalence and risk factors of GDM in developing countries (such as Nigeria) are scanty due to paucity of research funds among others. This makes it difficult for health-care planners and governments to pay adequate attention to GDM.[9] It is however remarkable that despite the huge burden of GDM, the prevalence is increasing due to the rise in its risk factors such as obesity.[4,10] In separate meta-analyses on the determinants of GDM among Asians and Africans, the most common determinants were previous history of GDM, pre-gestational maternal obesity, and previous deliveries of macrosomic babies.[8,11]

Access this article online

Quick Response Code:

Website: www.ijem.in

DOI: 10.4103/ijem.ijem_301_21

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Submitted: 09-Jul-2021 **Published**: 26-Oct-2021
Accepted: 24-Aug-2021

How to cite this article: Azeez TA, Abo-Briggs T, Adeyanju AS. A systematic review and meta-analysis of the prevalence and determinants of gestational diabetes mellitus in Nigeria. Indian J Endocr Metab 2021;25:182-90.

There is no universal consensus on the screening and diagnosis of GDM.[11] Different diagnostic criteria have been proposed by various relevant bodies and associations.[12] The various associations who have proposed different diagnostic criteria for GDM include the World Health Organization (WHO), International Association of Diabetes in Pregnancy Study Group (IADPSG), American Diabetes Association (ADA), European Association for the Study of Diabetes (EASD), Australian Diabetes in Pregnancy Society (ADIPS), American College of Obstetricians and Gynaecology (ACOG), and Japan Diabetes Society and the Canadian Diabetes Association (CDA).[11] Pregnant women who present in the first trimester with risk factors for type 2 diabetes but who were previously undiagnosed to diabetes mellitus should be screened at the first contact with the health personnel.[13] Such women are identified when the body mass index (BMI) is greater than or equal to 25.0 kg/m^2 in addition with another risk factor for type 2 diabetes such as sedentary lifestyle, family history of type 2 diabetes, high risk ethnic groups like Asian and Blacks, hypertension, or previous history of GDM.[14,15]

It is recommended that GDM should be screened for between 24 and 28 weeks of gestation.[16,17] Screening for GDM could involve the one-step or two-step approach. The one-step approach involves administering 75 g of glucose in an oral glucose tolerance test (OGTT) in the fasting state so as to determine the fasting plasma glucose, 1 hour and 2 hours' postglucose load values.[18] The IADPSG criteria involve this approach and the threshold values are shown in Table 1.[19] At least one of the glucose values must be deranged. This has been adopted by the WHO (but still recommends a range to exclude overt diabetes), the Endocrine Society, and the International Diabetes Federation.[20,21]

The two-step approach involves administration of 50 g of glucose in a nonfasting state and checking the random plasma glucose after 1 hour. This is termed the glucose challenge test (GCT).[18] The threshold of 135 mg/dl is the most commonly referenced glucose level.[18] Those who have positive GCT test are then administered the 3-hour 100-g OGTT test, which is done after 8-12 hours of overnight fast. The Carpenter and Coustan criteria are shown in Table 1.[13] The National Diabetes Data Group (NDDG) criteria are also shown in Table 1.[22] For the Carpenter and Coustan as well as the NDDG criteria, at least two glucose values must be deranged. The ADA and ACOG recommend that any of the approaches (either the one-step approach or the two-step approach) could be adopted in making a diagnosis of GDM.[23]

In the past, WHO had recommended a set of criteria, often tagged the 'WHO 1999 criteria,' for the diagnosis of GDM. In the WHO 1999 criteria, GDM was diagnosed if FPG was greater than or equal to 126 mg/dl and/or the 2-hour postglucose load was greater than or greater than 140 mg/dl, following a 75-g OGTT.[13] Subsequently, the WHO criteria were revised to what is known as the 'WHO 2013 criteria' due to the ambiguity of the 1999 criteria and the emerging evidence from the HAPO study. Using the WHO 2013 criteria, GDM would be diagnosed if the FPG is 92 – 125 mg/dl, and/or 1-hour postglucose load is greater than or equal to 180 mg/dl and/or the 2-hour postglucose load is 153 – 199 mg/dl after the administration of the 75-g OGTT test.[13]

Lifestyle changes, including medical nutrition therapy and increased physical activity, as well as self-monitoring of blood glucose are the initial approaches to the management of GDM.[24] The target glucose levels are – fasting plasma glucose <95 mg/dl, 1-hour postprandial glucose level less than 140 mg/dl, and 2-hour postprandial glucose level <120 mg/dl.[13] When these targets are not achieved, there is a need for pharmacotherapy. The first line drug in the management of GDM is insulin.[25] However, metformin and glibenclamide may also be used although they are known to cross the placenta and there is uncertainty about their long-term effects.[26]

Objectives

The objectives of the study were to determine the pooled prevalence of GDM in Nigeria and to identify the associated risk factors.

Methods

The study is a meta-analysis and the articles used were obtained from a careful search of African Journal Online, PubMed, SCOPUS, and Google Scholar. The preprint database 'medRxiv' as well as the gray literature were also searched. The study was done in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The inclusion criteria were studies on GDM done in Nigeria, which also reported the prevalence of GDM and its associated determinants. In addition, the studies must have been done between 2000 and 2020. Studies on GDM done outside Nigeria or not including the frequency of GDM and/or its determinants were excluded from the meta-analysis. Studies done outside the stipulated period were also excluded. The search terms included "gestational diabetes," "diabetes in pregnancy," "risk factors," "determinants," "glucose intolerance in pregnancy," "prevalence," "macrosomia," and

Table 1: Diagnostic criteria for GDM

Criteria	Screening	FPG	1 h PGL	2 h PGL	3 h PGL
IADPSG	None	≥92 mg/dl	≥180 mg/dl	≥153 mg/dl	-
Carpenter and Coustan	≥130 mg/dl or ≥135 mg/dl or ≥140 mg/dl	≥95 mg/dl	≥180 mg/dl	≥155 mg/dl	≥140 mg/dl
NDDG	Same as Carpenter and Coustan	≥105 mg/dl	≥190 mg/dl	≥165 mg/dl	≥145 mg/dl

"Nigeria." The Boolean operators 'AND,' 'OR,' as well as 'NOT' were used appropriately to enhance the results of the database search.

The authors independently scrutinized the abstracts as well as the main texts of the studies. The decision to include the relevant studies was based on the eligibility criteria and independent endorsement by the majority of the authors. The Excel spreadsheet was employed for the initial data extraction, collation, and scrutiny. The outcome variables of interest were the prevalence of GDM, the identified risk factor, the sample size, the geographic region, and the type of study. The quality of the studies were independently assessed by the authors using the NIH study quality assessment tools for cohort, cross-sectional, and case-control studies. Ratings that were 50% and above were considered fair/good and were selected for the meta-analysis. This was arrived at by asking research-based questions appropriate for the respective study type.[11] Risk of bias was assessed using the Cochrane risk of bias tool, which was done independently by the authors.

The meta-analysis was done by using Meta XL version 5.3 (EpiGear International Ltd.), a meta-analysis add-in software for Microsoft Excel. The DerSimonian Laird random effect model was utilized in the meta-analysis. I^2 statistic and the Cochran's Q test were the indicators of heterogeneity of the studies. Publication bias was assessed with the LFK index and Doi plot. Subgroup analysis was also done using the DerSimonian Laird random effect model. This was used to determine the prevalence of GDM in the various geopolitical regions and the prevalence rate using different diagnostic criteria. The PRISMA flow diagram is shown in Figure 1 below.

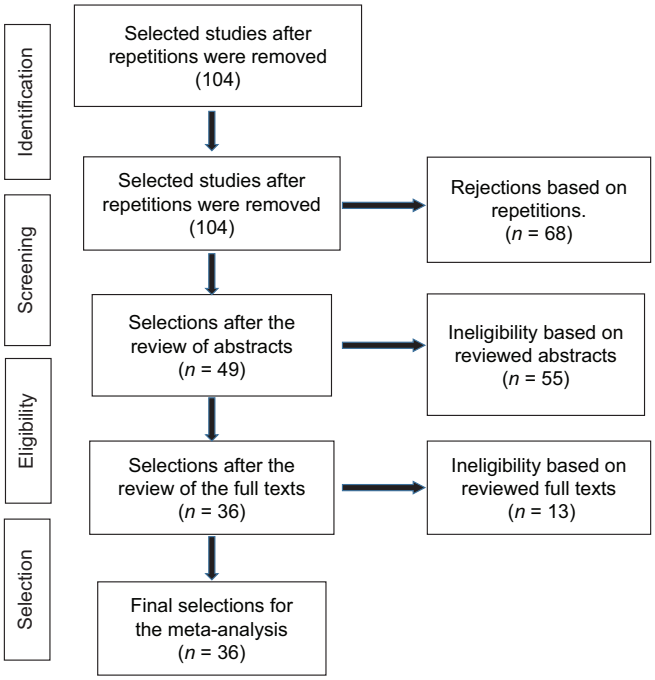

Figure 1: The PRISMA Flow diagram for selection of studies for the meta-analysis

Results

The number of studies that met the eligibility criteria and were selected for the meta-analysis was 36. The studies are shown in Table 2 below. All the studies were of fair or good quality based on the criterion stated above. The total sample size was 46 210. The prevalence of GDM in Nigeria was 0.5 – 38%. The pooled prevalence of GDM in Nigeria was 11.0% (95% CI 8-13). Figure 2 shows the types of studies found eligible for the meta-analysis. They were mostly prospective studies, although a significant portion of the studies was retrospective in nature.

The forest plot of the meta-analysis is shown in Figure 3 below. Heterogeneity was tested with the I^2 statistic and the Cochran's Q, which were 99% and 2548 ($P < 0.001$), respectively. This suggests that the selected studies were heterogeneous. The LFK index was 6.85 and the Doi plot is shown in Figure 4 below. The asymmetry suggests that there must have been some degree of publication bias.

In terms of diagnostic criteria for GDM, the WHO 2013 criteria were the most commonly used diagnostic criteria accounting for about 42% of the diagnostic criteria employed in the eligible studies. About 29% of the studies utilized the IADPSG criteria for the diagnosis of GDM in their studies. The Carpenter and Coustan criteria were the least favored criteria reported among studies on GDM in Nigeria representing a paltry proportion of 4%.

Table 3 shows the results of the subgroup analysis of the meta-analysis. The prevalence of GDM varies slightly from one geo-political zone to the other. Prevalence of GDM is the highest (16%) in the North central zone (the Federal Capital Territory, Abuja is included) and the lowest (7%) in the South-south. Similarly, the prevalence of GDM depended on the diagnostic criteria used. The prevalence ranges from 5.0% (using the WHO 1999 criteria) to 20.0% (using the IADPSG criteria).

Figure 5 shows the determinants of GDM reported in various studies across Nigeria. The most commonly reported determinants of GDM in Nigeria were previous macrosomic babies, maternal obesity, family history of diabetes mellitus, advanced maternal age, and previous miscarriage(s).

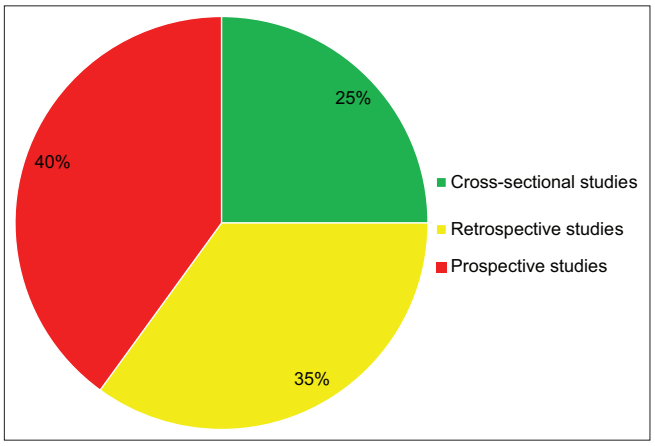

Figure 2: Types of studies selected for the meta-analysis

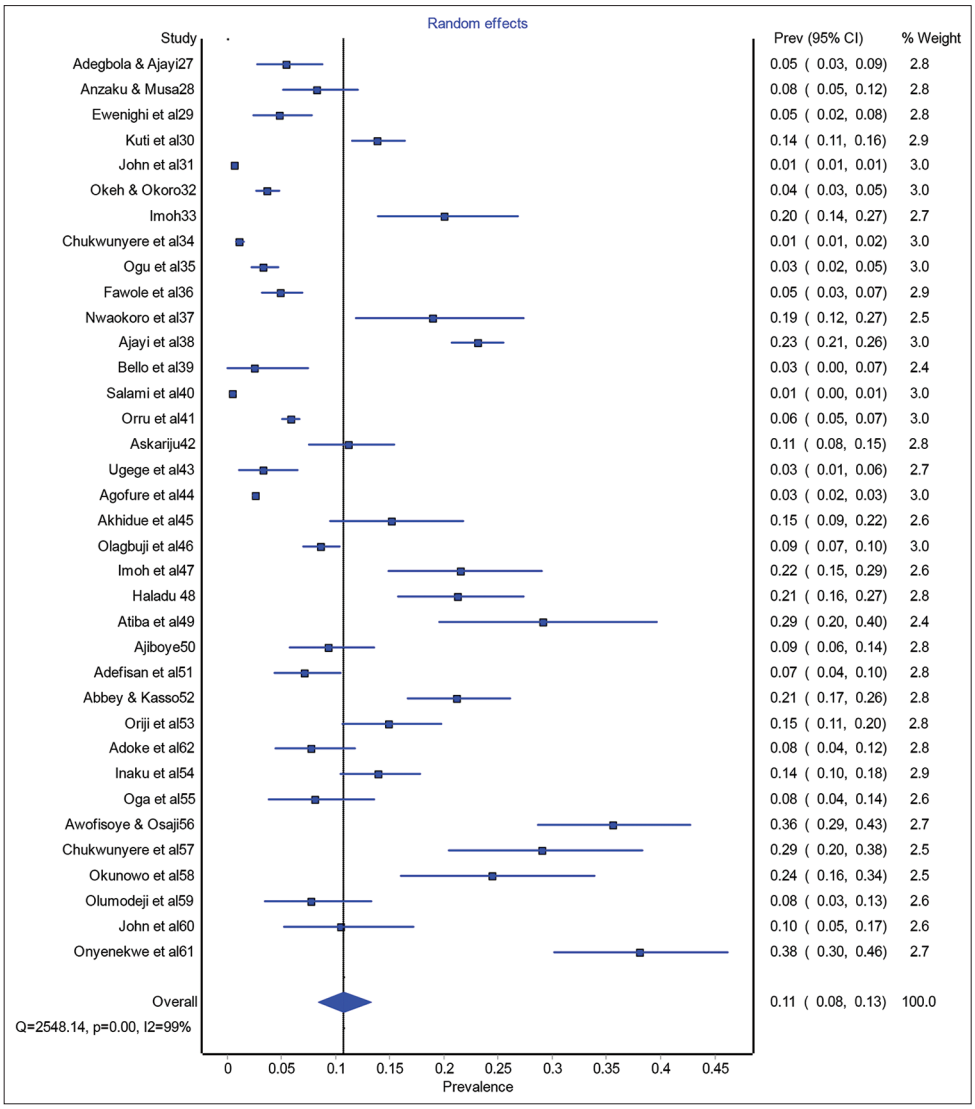

Figure 3: Forest plot of the selected studies

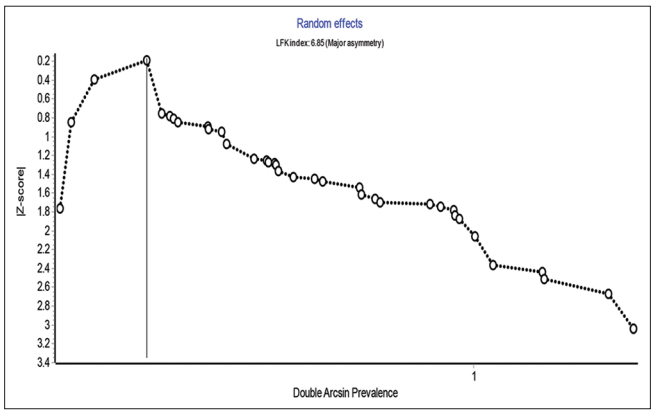

Figure 4: Doi plot for publication bias

Discussion

The prevalence of GDM in Nigeria, from this meta-analysis, is 0.5 – 38%. The range is quite wide partly because of the differences in the characteristics of the participants and the diagnostic criteria used in the selected studies. Jiwani *et al*.[63] have also quoted the global prevalence of GDM as 1-28% and the wide variation was also attributed to the disparities in the characteristics of the women, screening approach, and diagnostic criteria. The maternal characteristics that tend to vary from one study to the other include age, pregestational body mass index, parity, and previous obstetric histories.

The pooled prevalence of GDM in Nigeria as found in this meta-analysis is 11.0%. This is similar to the pooled prevalence of GDM (13.6%) in Africa as reported from a meta-analysis.[8] In addition, it is similar to the pooled prevalence of GDM in Asia (10.6%) as reported in a meta-analysis by Nguyen *et al*.[7] However, the prevalence of GDM in Nigeria found in this meta-analysis (11.0%) is higher than the pooled prevalence of GDM in Europe (5.4%) and the USA (7.6%).[64,65] The present meta-analysis does not explain the difference in the GDM prevalence between Nigeria and the developed Europe and America. However, it has been documented that these discrepancies may be partly explained by socioeconomic

Table 2: The characteristics of the studies selected for the analysis

Studies	Year	Geopolitical zone	Study design	Prevalence (%)	Sample size
Adegbola and Ajayi[27]	2008	South-West	C	5.4	222
Anzaku and Musa[28]	2009	North-Central	C	8.1	253
Ewenighi *et al*.[29]	2010	South-East	C	4.8	250
Kuti *et al*.[30]	2011	South-West	R	13.9	765
John *et al*.[31]	2012	South-South	P	0.7	101
Okeh and Okoro[32]	2012	South-East	P	3.7	1301
Imoh[33]	2013	North-Central	C	20.0	150
Chukwunyere *et al*.[34]	2013	South-West	C	1.13	3624
Ogu *et al*.[35]	2014	South-South	R	3.3	837
Fawole *et al*.[36]	2014	South-West	C	4.9	530
Nwaokoro *et al*.[37]	2014	South-South	C	19.0	100
Ajayi *et al*.[38]	2014	South-West	R	23.2	1204
Bello *et al*.[39]	2015	South-West	P	2.5	79
Salami *et al*.[40]	2015	North-Central	R	0.5	4755
Orru *et al*.[41]	2015	South-South	R	5.85	3589
Askariju[42]	2015	North-East	C	11.2	250
Ugege *et al*.[43]	2015	South-South	C	3.3	182
Agofure *et al*.[44]	2015	South-South	R	2.59	23996
Akhidue *et al*.[45]	2015	South-South	P	15.2	132
Olagbuji *et al*.[46]	2015	South-West	P	8.6	1059
Imoh *et al*.[47]	2016	North-Central	P	21.5	130
Haladu[48]	2017	North-West	C	21.2	193
Atiba *et al*.[49]	2017	South-West	C	29.1	79
Ajiboye[50]	2017	North-Central	C	9.0	215
Adefisan *et al*.[51]	2017	South-West	P	7.4	281
Abbey & Kasso[52]	2017	South-South	R	21.2	288
Oriji *et al*.[53]	2017	South-South	P	14.9	235
Adoke *et al*.[54]	2018	North-West	P	7.7	207
Inaku *et al*.[55]	2018	South-South	P	13.9	345
Oga *et al*.[56]	2018	North-Central	C	8.1	124
Awofisoye & Osaji[57]	2019	North-Central	C	35.6	180
Chukwunyere *et al*.[58]	2019	South-West	C	29.0	100
Okunowo *et al*.[59]	2019	South-West	P	24.0	90
Olumodeji *et al*.[60]	2019	South-West	P	7.7	117
John *et al*.[61]	2019	South-South	R	10.5	105
Onyenekwe *et al*.[62]	2019	South-East	C	38.0	142
Pooled				11.0	46210

C - Cross-sectional study, P - Prospective study, R - Retrospective study

factors, ethnic/racial influences, and lifestyle differences.[7] Furthermore, differences in screening and diagnostic criteria as well as possible childhood exposure of Nigerian girls to undernutrition, which has been hypothesized to influence the development of GDM later in adulthood, may also explain some aspect of the differences in GDM prevalence between the developing Nigeria and the developed Europe and the USA.[66,67]

This study showed that the prevalence of GDM clearly depends on the diagnostic criteria used. The IADPSG criteria detect a higher prevalence when compared with the WHO 2013 criteria. Also, the WHO 2013 criteria are able to predict a higher prevalence when compared with the Carpenter and Coustan criteria. Previous authors have also made similar observations.[7,8,68,69] There are no universal criteria for the diagnosis of GDM. However, previous studies have reported that the IADPSG criteria has a better sensitivity than the other criteria and can detect more women with GSM.[70,71] Similarly, the one-step criteria (IADPSG and WHO 2013 criteria) have been documented to diagnose more women with GDM when compared with Carpenter and Coustan criteria that depend on the two-step approach.[18]

Over a period of about two decades, only 36 studies met the eligibility criteria for the meta-analysis. This suggests that the studies on the prevalence of GDM and its determinants are quite few in Nigeria. This is rather surprising because studies done outside sub-Saharan Africa have reported that the Black race/ethnicity seems to confer a higher risk of GDM on women and it would be expected that a large number of studies would be carried out to explore this observation further.[72]

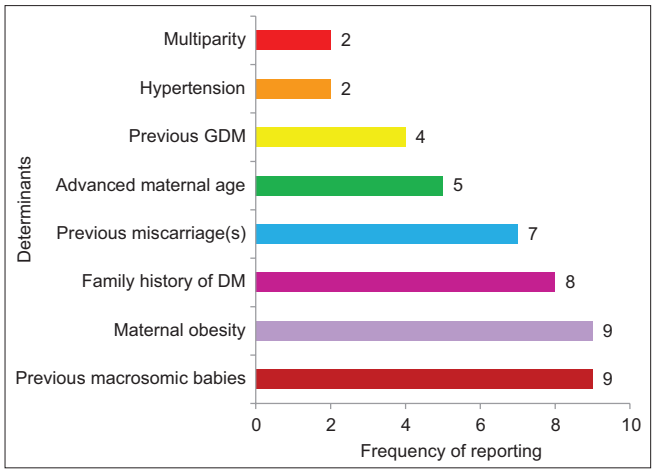

Figure 5: Determinants of GDM in Nigeria

Table 3: Prevalence of GDM in the geopolitical zones and according to the diagnostic criteria

Subgroup analysis	Prevalence (%)	95% CI	I^2 statistic
Prevalence across the geo-political zones			
South-west	11.0	5.0-19.0	99%
South-south	7.0	5.0-11.0	99%
South-east	12.0	10.0-23.0	97%
North-west	13.0	5.0-23.0	99%
North-central & Abuja	16.0	8.0-25.0	99%
North-east	11.0	7.0-16.0	99%
Prevalence of GDM using different criteria			
Carpenter & Coustan[13]	5.4	2.8-8.8	99%
WHO (1999)	5.0	3.0-8.0	97%
WHO (2013)	9.0	4.0-15.0	99%
IADPSG criteria[19]	20.0	12.0-29.0	95%

Moreover, it has been documented that the risk of developing type 2 diabetes following the diagnosis of GDM is relatively higher among black women. So, the expectation would be that researches on GDM should be widespread in Nigeria as it has the highest population of black women in the world.[73,74] However, the scarcity of researches in an important topic as GDM in Nigeria may be partly explained by inadequacy of research funds, logistics, and expertise and these have been alluded to by Baro *et al*.[75]

Similarly, in this meta-analysis, a significant portion of the selected studies were found to be retrospective studies (40%). Retrospective studies are known to be associated with multiple flaws such as low quality of evidence, lack of adequate representation of the studied population, and bias.[76] In comparison with systematic review and meta-analyses reported from other parts of the world, retrospective studies do not usually constitute the largest portion of the selected studies.[8,77,78] Again, this may be connected with funds, logistics, and expertise as retrospective studies are relatively cheaper to conduct and the logistics are somewhat easier when compared with prospective studies or trials.[76]

Furthermore, there was significant heterogeneity among the selected studies for the heterogeneity (I^2 statistic was 99%). This could be due to the differences in socio-demographics of the participants and the study designs. More importantly, there is a wide variation in the diagnostic criteria employed by the various authors of the selected studies. The WHO 2013 and the IADPSG criteria were the most commonly applied criteria (42% and 29%, respectively) whereas the Carpenter and Coustan criteria were the least favored (about 4%) among the Nigerian studies. The wide variatiation is not unexpected because there are no universal criteria recommended for the diagnosis of GDM.[12] Studies on the prevalence of GDM in sub-Saharan Africa tend to apply the one-step approach (WHO or the IADPSG criteria) rather than the two-step approach (required for the Carpenter and Coustan criteria).[8] Celen *et al*.[79] have posited that the one-step approach is more cost-effective, simpler, and more sensitive and this may explain why the studies tend to prefer the one-step approach for the diagnosis of GDM.

The determinants of GDM in this meta-analysis are previous macrosomic babies, maternal obesity, family history of diabetes, and previous miscarriage. Other determinants include advanced maternal age (above 35 years), previous diagnosis of GDM, hypertension, and multiparity. Studies done in various parts of the world have also documented similar determinants of GDM.[8,80,81] Insulin resistance in the mother leads to excess blood glucose, which crosses the placenta to the baby thereby stimulating the fetal pancreas to produce excess insulin.[82] Insulin is an anabolic hormone that encourages accumulation of subcutaneous fat leading to macrosomia of the baby with attendant potential complications such as shoulder dystocia and increased rate of Cesarean delivery. Muche *et al*.[8] have also posited that previous GDM has four times increased risk of GDM in subsequent pregnancies. Maternal obesity and advancing maternal age predispose to insulin resistance, which is also necessary for the development of GDM.[83]

Conclusions

The prevalence of GDM in Nigeria is 11.0%. The most common determinants of GDM in Nigeria are previous macrosomic babies, maternal obesity, family history of diabetes, and previous miscarriage. The prevalence rate would help policymakers to plan on how to allocate appropriate resources to address the problems of GDM. It would also help Diabetologists and Obstetricians to appreciate the enormosity of the burden of GDM and to plan for future research works in GDM.

Strengths of the study

To the best of the authors' knowledge, this is the first systematic review and meta-analysis of the prevalence and determinants of GDM in Nigeria. The number of selected studies for the

meta-analysis is relatively large when compared to similar meta-analyses on GDM in African nations.

Limitations

The heterogeneity of the studies is quite substantial due to the differences in participants' characteristics and diagnostic criteria.

Abbreviations

ACOG - American College of Obstetricians and Gynaecology
ADA - American Diabetes Association
ADIPS - Australian Diabetes in Pregnancy Society
BMI - Body mass index
CDA - Canadian Diabetes Association
CI – Confidence Interval
EASD - European Association for the Study of Diabetes
FPG - Fasting plasma glucose
GCT - Glucose challenge test
GDM – Gestational diabetes mellitus
IADPSG - International Association of Diabetes in Pregnancy Study Group
NDDG - National Diabetes Data Group
OGTT - Oral glucose tolerance test
PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analyses
WHO - World Health Organization

Ethical approval and consent to participate

Not applicable.

Financial support and sponsorship

Self-funded.

Conflicts of interest

There are no conflicts of interest.

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