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Systematic Review

Gestational diabetes mellitus in sub-Saharan Africa: systematic review and metaregression on prevalence and risk factors*

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Abstract

OBJECTIVE We systematically reviewed publications on prevalence and risk factors for gestational diabetes mellitus (GDM) in the 47 countries of sub-Saharan Africa.

METHODS We conducted a systematic search in PUBMED and reviewed articles published until June 2014 and searched the references of retrieved articles. We explored sources of heterogeneity among prevalence proportions with metaregression analysis.

RESULTS Of 1069 articles retrieved 22 studies were included. Half were from West Africa, specifically Nigeria, five from South Africa and six from East and Central Africa. There were differences in screening methods and diagnosis criteria used, even between studies carried out in the same country and same time period. Metaregression analysis indicated high heterogeneity among the studies ($I^2 = 100$, $P < 0.001$), which could not be sufficiently explained by study setting, population, diagnostic criteria or time trend, although we observed a relatively higher prevalence in studies carried out after 2000 (5.1% *vs.* 3.2%), when women at risk were selected (6.5% *vs.* 3.8%) and when more current diagnostic criteria were used (5.1% *vs.* 4.2%). Associations with risk factors were reported in six studies. Significant risk factors reported in more than one study were overweight and/or obesity, family history for type 2 diabetes, previous stillbirth, previous macrosomic child and age >30 years.

CONCLUSIONS There are few studies on prevalence and risk factors for GDM in Sub-Saharan Africa and heterogeneity is high. Prevalence was up to about 14% when high-risk women were studied. Preventive actions should be taken to reduce the short- and long-term complications related to GDM in Sub-Saharan Africa.

keywords Gestational diabetes, prevalence, risk factors, review, metaregression, sub-Saharan Africa

Introduction

Recently, the global prevalence of hyperglycaemia in pregnancy in women 20–49 years was estimated to be 16.9% and affecting 21.4 million live births, in 2013, and more than 90% of cases are estimated to occur in low- and middle-income countries [1]. The prevalence varies depending on the population and diagnostic criteria used. For example, it can be up to 100% higher when International Association of Diabetes in Pregnancy Study Group (IADPSG) criteria is used compared to 1999 World Health Organisation criteria [2, 3]. Regarding the estimated number of cases of hyperglycaemia in pregnancy, Africa ranks second after South-East Asia [1]. Gestational diabetes mellitus (GDM) is the common cause of hyperglycaemia in pregnancy, accounting for about 90% of all diabetes during pregnancy [4]. Usually, GDM resolves after the baby is born [5], nevertheless, it makes a woman prone to GDM in later pregnancies, and is associated with long-term health risks to the mother as well as the child, such as predisposition to obesity, metabolic syndrome and diabetes later in life [6–9]. It is also associated with maternal and perinatal outcomes such as pregnancy-induced hypertension, pre-eclampsia, antepar-

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tum haemorrhage, caesarean, preterm birth, birth trauma and congenital anomalies [10]. As with type 2 diabetes mellitus, the highest prevalence in GDM may be seen in urban areas, partly due to increased overweight and obesity, and changes in dietary and physical activity patterns.

Understanding the prevalence and the risk for GDM in Africa may provide evidence on how interventions should be targeted to reduce the magnitude of the problem, to improve maternal and child health and to reduce the burden of type 2 diabetes in the region.

A 2011 review on diabetes in Sub-Saharan Africa included the prevalence of gestational diabetes and reported it to range from 0% to 9% based on five studies, the latest one being published in 2007 [11]. A more recent review on the prevalence of GDM in Africa reported data from 14 studies conducted in six African countries and reported the prevalence to range from 0% in Tanzania to 13.9% in high-risk women in Nigeria [12]. The two previous reviews included few studies did not investigate the sources of heterogeneity between the studies and did not report findings on risk factors for GDM.

We therefore conducted a systematic review of literature to assess prevalence and trends of GDM and to examine associated risk factors in published articles from original research conducted in sub-Saharan Africa.

Methods

Search strategy and study selection

We conducted a systematic literature search for published papers on gestational diabetes in sub-Saharan Africa in PUBMED database published until June 2014. A comprehensive key word search strategy for related terms associated with diabetes and pregnancy and sub-Saharan Africa, sub-African region or country specific were used without language restriction (Appendix 1). To expand the search, wildcard symbol '*' was used and the search words or phrases were combined using Boolean operators. We included original published articles, short communications and letter to the editor for studies conducted in sub-Saharan Africa and in humans, reporting prevalence and or risk factors for GDM in any Sub-Saharan country regardless of screening and diagnostic criteria used, and regardless of method used for selection of participants. Studies which reported only type 1 and/or type 2 diabetes were excluded. A manual search for additional studies was carried out using references cited in the reviewed articles.

Retrieved articles were transferred to EndNote library X7 where sorting for duplicates was performed. Titles and abstracts were screened by one author (AM) and when decision could not be made through the abstract alone, full articles were acquired for the third stage of screening. Full articles were examined for inclusion by two authors (AM, EF); disagreement was settled by discussion through joint review of the article. Two articles in French, reporting results of the same study, were translated by one investigator and reviewed for inclusion by the two authors. However, they were excluded as information to establish prevalence and diagnostic criteria was lacking. A number of articles not meeting inclusion criteria and reasons for exclusion are shown in Figure 1 and details in Appendix 2. When more than one article reporting similar results were retrieved, the most informative article was included. Authors were contacted to provide extra information, such as on sampling procedure, the year the study was carried out and or study setting, when deemed necessary.

Data extraction

The main findings regarding the prevalence and the risk factors for GDM were summarised by two authors in a prepared Excel sheet under subheadings agreed upon by all authors. The subheadings were study title, name and contact details for first author, country, year when the study was conducted (i.e. year study ended), year of publication sample size, study design, setting, study population, selection of participants, mean age, mean gestational age, exclusion criteria, screening method (random, fasting or oral glucose tolerance test), diagnostic criteria used, prevalence (including 95% CI), risk factors and key conclusion(s). When a single study reported more than one prevalence proportion, based on, for example, study setting or subsample, or compared diagnostic criteria, data were extracted separately and each was considered as separate study in the metaregression analysis. We used the definition of GDM according to World Health Organisation, that is carbohydrate intolerance resulting in hyperglycaemia of variable severity with onset or first recognition during pregnancy. The definition applies irrespective of whether or not insulin is used for treatment or the condition persists after pregnancy [13]. Prevalence proportions and confidence intervals (CI) reported by each study were recorded or calculated from the given information whenever necessary using spreadsheets for analysis of Epidemiologic Data by Rothman 2005 (version of Nov 10, 2005). We followed the PRISMA checklist (Appendix 3) for reporting of systematic reviews [14]. We developed a review protocol and immediately started the review; the protocol was not registered.

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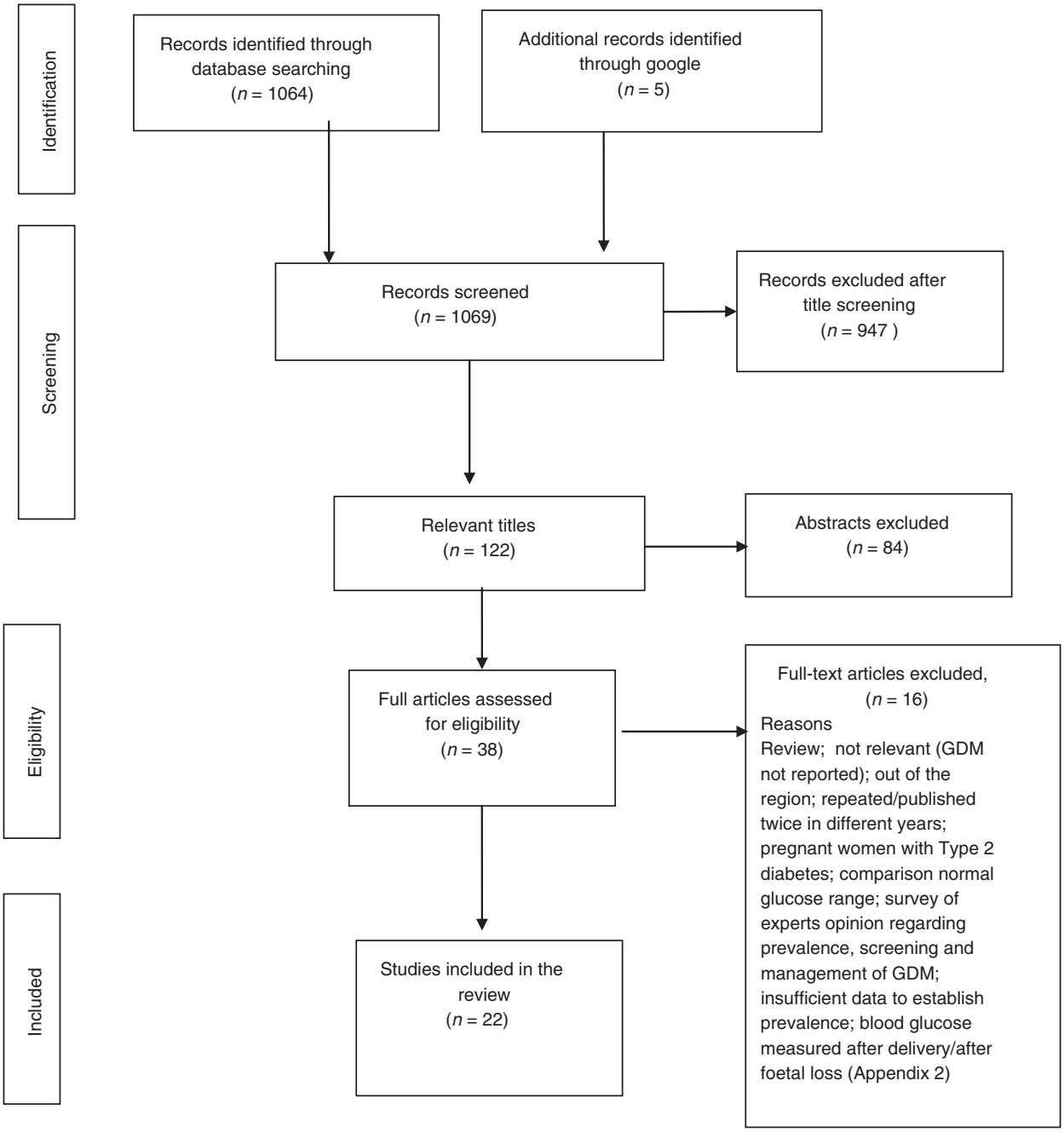

Figure 1 Flow diagram for selection of the studies and reasons for exclusion.

Risk of bias

The studies included were assessed for the risk of bias, that is quality of the study, by two reviewers independently, and any disagreement was resolved through a discussion until they reached consensus. We adopted a risk of bias tool developed by Hoy *et al.* [15] and modified it to suit to our study. The tool consists of ten items that assess sampling, attrition, measurement and reporting bias (Appendix 4a). The validity of methodology, appropriateness and reporting of results were assessed; and

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whenever the information provided was not enough to assist in making judgement for a certain item, we agreed to grade that item with a 'NO' meaning high risk of bias. Each article was graded as low, moderate or high risk of bias depending on the number of items judged 'yes'. We included all articles in the synthesis of results, but only articles judged to have low or moderate risk of bias were included in metaregression analysis (Appendix 4b).

Statistical analysis

We first performed arcsine transformation of the prevalence proportions to handle the distribution asymmetry [16]. Arcsine transformation was preferred to logit transformation because with very small prevalence proportions that approaches zero, variance for proportions tend to be magnified; hence, the variance instability would persist even after logit transformation [16]. We used the random effects model to estimate prevalence proportion and the 95% CI. Heterogeneity between studies was assessed using I^2 statistic [17]. To identify possible sources of heterogeneity among prevalence proportions, mixed effect metaregression models were used [18]. The variables considered were year the study/survey was completed (as a continuous variable); study setting (rural and mixed or urban), gestational age of the studied population during diagnosis (all trimesters or ≥24 weeks), diagnostic criteria (older and relatively recent) and population included (general or high risk). The older criteria included O'Sullivan, National Diabetes Data Group World Health Organisation 1985 and own, while the more recent ones were American Diabetes Association 2002, 2010, World Health Organisation 1999 and European Association for the Study of Diabetes. A funnel plot was generated to assess publication bias, with the symmetry of the plot assessed both visually and using Begg's test of asymmetry [19]. All statistical analyses were performed using R Studio 0.98 program utilising R statistical language version 2.15.3 using Metafor commands.

Results

A total of 1064 single articles and five articles from manual search in Google were retrieved and transferred to EndNote library. Titles and abstracts were screened and 1031 articles were excluded because they were either irrelevant, conducted outside Sub-Saharan Africa referred to other types of diabetes or reviews (Figure 1). Thirty-seven articles were accessed as full paper, and finally 22 articles of studies conducted from 1969 to 2014 were included in the review (Table 1).

With respect to risk of bias, ten studies were considered to have low risk of bias (45.5%), five (22.7%) were classified as having moderate risk of bias and seven studies (31.8%) had high risk of bias (Table 1 & Appendix 4b). The studies with high risk of bias had small sample size, unclear selection of study participants, unclear measurement protocol, low response rate and/or data collected from hospital records rather than from the subjects.

Eleven studies were conducted in West Africa, 5 in South Africa and 6 in East and Central Africa (Table 1). The majority were descriptive with a range of study designs, including 10 cross-sectional studies with sample sizes ranging from 189 to 1086 [3, 20–28]. There were seven prospective studies with sample size ranging from 58 pregnant women recruited during their first trimester to 5026 women recruited during their first antenatal clinic visit and followed until their first post-natal visit [23, 29–34]. Furthermore, we found four retrospective studies which were conducted by reviewing hospital delivery registry [35–38]. The sample size ranged from 765 in a review of a two-year period [37] to 12 030 in a 10-year review in Nigeria [38]. Only two studies carried out in the 1990s in Ethiopia and Tanzania were community based and were conducted in rural settings [27, 28], all others were clinic based.

A total of six studies reported prevalence in the rural setting, four of which were clinic based. The prevalence in rural clinics ranged from 1% in Tanzanian clinics to 8.8% in South Africa [3, 22, 24, 25]. Variations in selection of study participants in the studies conducted at the clinic setting were noted. Some studies included all consenting women, others did random selection of those meeting inclusion criteria, and others selected only those at risk while the retrospective studies reviewed all registered women (Table 1).

Study characteristics and prevalence of GDM according to region

Eleven studies from West Africa were reviewed. They were published from 1987 to 2014, and all were conducted in Nigeria. Most of these studies (n = 9) were carried out in tertiary university teaching hospitals [20, 21, 23, 29, 32, 34, 36–38]. The remaining two studies were carried out either in selected rural clinics [22] or in clinics from urban, semi-urban and rural areas [39]. One study compared prevalence using World Health Organisation and National Diabetes Data Group diagnostic criteria [32]; two studies compared women with and without risk factors [23, 40], and one study compared prevalence among women with and without macrocosmic child [36]. Prevalence of GDM in women with at least one risk factor ranged from 1.5% (1.3–1.8) in a

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Table 1 Prevalence/Incidence of GDM in SSA by main study characteristics

Author/year of publication (year study was conducted)	Country	Sample size (response rate)	Setting	Sampling frame	Selection of participants	Study design	Mean age/ range (years)	Mean gestational age/range (wks)	Screening criteria	Diagnosis criteria	Prevalence (95% CI)	Remarks (risk of bias)
Studies carried out in West Africa												
Abudu & Kuti (1987) [20] (1981/ 1982)	Nigeria	336 (87%)	Urban (Lagos) University hospital	Tertiary hospital	All	Cross-sectional	27	All trimesters	Random BG and 50 g GCT (1 h BG >7.2 mmol/l)	Fasting BG and 50 g OGTT* (O'Sullivan)	1.5% (0.5–3.3)	Moderate
Wokoma *et al.* (2001) [34] (1998/ 2000)	Nigeria	5026 (NR)	Urban (Port Harcourt) University hospital	Tertiary hospital	All eligible	Prospective cohort	31	24 (8–36)	Fasting BG and Urine dipstick test	Own criteria and O'Sullivan†	0.3% (0.2–0.5)	Moderate
Ozumba *et al.* (2004) [38] (1990/ 1999)	Nigeria	12030 (NR)	Urban (University of Nigeria) University hospital	Tertiary hospital	All recorded deliveries	Retrospective review of delivery registry (10 years)	15–54	≥28	Risk factors‡	WHO 1999	Overall: 1.7% (1.4–1.9) GDM: 1.0% (0.8–1.2)	High
Olarinoye *et al.* (2004) [32] (1997/ 1999)	Nigeria	248: 138 WHO criteria and110 NDDG criteria (84.6%)	Urban (Lagos) University hospital	Tertiary hospital	Random	Prospective cohort	31 (18–41)	≥28 (third trimester only)	NR	WHO 1985 NDDG 1979	WHO: 11.6% (7.0–17.8) NDDG: 4.6% (1.7–9.8) Overall: 8.5% (5.4–12.8)	Low
Adegbola & Ajayi (2008) [29]§ NS	Nigeria	222: 113 in at risk group (84.3%) 109 in normal group (81.3%)	Urban (Lagos) University hospital	Tertiary hospital	Random	Prospective cohort	32 (19–45)	24–32	50 g GCT (1 h BG ≥7.2Mol/l)	ADA 2002	At risk group: 6.2% (2.7–11.9) Normal group: 4.6% (1.7–9.9)	Low
Kamanu *et al.* (2009) [36]¶ (1999/2003)	Nigeria	9040 available for analysis (96.4%)	Urban (state University) University hospital	Tertiary hospital	All deliveries	Retrospective review of hospital records	Normal: 27.1 (19–45) macrosomic: 30.5 (19–45)	24–28	50 gm GCT (1 h BG ≥7.8 mmol/l	1 h after 50 g > 7.8 mmol/l or 1 h 75 g OGTT >10 mmol/l or 2 h 75 g OGTT >8.6 mmol/l	Overall: 1.5% (1.3–1.8)	High
Kuti *et al.* (2011) [37] ** (2007/ 2009)	Nigeria	765 (NR)	Urban (Ibadan) University hospital	Tertiary hospital	All	Retrospective review of hospital records	32	4–40	Risk factors	WHO 1999	13.9% (11.5–6.4)	Moderate

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Table 1 (*Continued*)

Author/year of publication (year study was conducted)	Country	Sample size (response rate)	Setting	Sampling frame	Selection of participants	Study design	Mean age/ range (years)	Mean gestational age/range (wks)	Screening criteria	Diagnosis criteria	Prevalence (95% CI)	Remarks (risk of bias)
Ugboma *et al.* (2012) [39]†† (2006/2009)	Nigeria	960 (49.8%)	Mixed (urban, semi-urban and rural)	Tertiary, secondary and primary hospital and maternity homes	Random	Case control	30	24–34	Risk factors and 50 g GCT (1 h BG ≥7.8 mmol/l)	WHO 1999	5% (3.8–6.4)	High
Ewenighi *et al.* (2013) [22] (2010/2011)	Nigeria	250 (NS)	Rural (Three centres in Ebony State)	Three antenatal clinics	All	Cross-sectional	30 (15 to 44)	All trimesters (mean 26)	NR	NDDG 1979	4.8% (2.6–8.0)	Low
Anzaku & Musa (2013) [21] (2009)	Nigeria	253 (95.5%)	Urban (Jos) University hospital	Tertiary hospital	Random	Cross-sectional	31 (19–42)	26 (24–28)	50 g GCT (1 h BG ≥7.8 mmol/l	WHO 1985	8.3% (5.2–12.4)	Low
Fawole *et al.* (2014) [23]‡‡ (2007)	Nigeria	1086: with risk: 530 (98.7%) General population: 530 (96.9%)	Urban (Ibadan) University hospital	Tertiary hospital	NR	Cross-sectional (prospective and retrospective)	30.3	22 (24–28)	Risk factors	WHO 1999	With risk: 4.9% (3.2–6.9) General population 1.6% (0.8–2.9)	Moderate

Author/year of publication	Country	Sample size	Setting	Selection of participants	Sampling frame	Study design	Mean age/ range	Mean gestational age/range	Screening criteria	Diagnosis criteria	Prevalence (95% CI)	Remark (risk of bias)
Studies carried out in South Africa												
Notelovitz (1969) [26]§§ (NS)	South Africa (Indian women)	566 without risk: 301 with risk: 265 (NR)	Durban (Indians) King Edwards Hospital	All	Tertiary hospital	Cross-sectional	NR	All trimesters	NR	(Venous blood taken at fasting and two hrs after 100 g OGTT).	Without risk: 8.3% (3.6–11.8) With risk 23.8% (18.9–29.2)	High
Jackson & Coetzee (1979) [30]¶¶ (1977/1978)	South Africa	558 (14.8%)	Urban (Cape town) Mixed ethnicity	NR	ANC at Groote Schuur Hospital Secondary/ tertiary hospital	Prospective cohort	NR	All trimesters	Risk factors	50 g GCT‡	Diabetic 3.0% (1.8–4.7)	Moderate

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Table 1 (*Continued*)

Author/year of publication	Country	Sample size	Setting	Selection of participants	Sampling frame	Study design	Mean age/ range	Mean gestational age/range	Screening criteria	Diagnosis criteria	Prevalence (95% CI)	Remark (risk of bias)
Ranchod *et al.* (1991) [41] (1987/1988)	South Africa (Indian and collared minority)	1717 (NR)	Urban (Indians and coloured minority)	All eligible	Northdale Hospital, Pietermaritzburg Secondary/ tertiary hospital	Prospective descriptive??	NR	All trimesters	75 g (1 h BG ≥7.8 mmol/l)	WHO 1985 DPSG/ EASD ***	WHO: 3.8% (2.9–4.8) DPSG: 1.6% (1.0–2.2)	Low
Mamabolo *et al.* (2007) [25] (1999/2000)	South Africa	262 (95%)	Rural (Limpopo) Bantu	Random	9 Randomly selected local ANC	Cross-sectional	26 years	>28 (28–36)	NR	WHO 1999	8.8% (5.6–12.9)	Low
Basu *et al.* (2006) [35]†††	South Africa	767 (NR)	Urban Johannesburg (mixed ethnic group)	All deliveries	CMJA Hospital, Johannesburg Secondary/ tertiary hospital	Retrospective review	Median age 27 years (13 to 31)	Median 28 (23–32)	Institutional Protocol (fasting BG >8.0 mmol/l or random > 11 mmol/l	Institutional Protocol (Pre-and post-meal BG levels for 6 times within 24 h)	1.8% (1.0–2.9)	High

Author/year of publication	Country	Sample size	Setting	Sampling frame	Selection of participants	Study design	Mean age/range (years)	Mean gestational age/range (wks)	Screening criteria	Diagnosis criteria	Prevalence (95% CI)	Remarks (risk of bias)
Studies carried out in East and Central Africa												
Swai *et al.* (1989) [28]	Tanzania	18985%	Rural community survey	Community survey (8 villages)	All in the studied communities	Cross-sectional	27.5 (>14)	All trimesters (4 to 42)	NR	WHO 1985	0.0%	Low
Lutale *et al.* (1990) [31]	Tanzania	58 (65%)	Urban ANC	NS	< 14 gestational weeks	Prospective cohort	23 (15 to 44)	≤14, 14–29 and ≥30	NR	WHO 1985	0.0%	High
Seyoum *et al.* (1996) [27]	Ethiopia	890 (95%)	Rural (community survey)	Community (18 randomly selected villages)	All	Cross-sectional	27 years (15–50)	≥24	NR	WHO 1985	3.7% (2.5–4.9)	Low
Jao *et al.* (2013) [24] (2013)	Cameroon	316 (NR)	Semi-urban clinic	Community ANC	All	Cross-sectional	15–50 (30.5)	≥24 (24–28 weeks or first visit for those who booked late)	NR	ADA 2010	6.3% (4.0–9.4)	Low
Tandu-Umba & Muela (2011) [33]	Congo	108 (NR)	Urban (University hospital)	Tertiary hospital	All	Cohort	30	28 (24–32)	NR	WHO fasting BG only	7.4 (3.5–13.6)	High
Mwanri *et al.* (2014) [3] (2011/2012)	Tanzania	609 (94.0%)	Urban (ANC)	Six ANC	All eligible	Cross-sectional	28 (20–40)	28 (20–38)	NR	WHO 1999	WHO 1999: 8.4% (6.3–10.9)	Low

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Table 1 (*Continued*)

Author/year of publication	Country	Sample size	Setting	Sampling frame	Selection of participants	Study design	Mean age/range (years)	Mean gestational age/range (wks)	Screening criteria	Diagnosis criteria	Prevalence (95% CI)	Remarks (risk of bias)
Mwanri *et al.* (2014) [3] (2011/2012)		301 (95.5%)	Rural (ANC)	Two ANC	All eligible	Cross-sectional	27 (20–43)	28 (20–38)	NR	WHO 1999	WHO 1999: 1.0% (0.2–2.9)	Low

NR, not reported; BG, blood glucose; WHO, World Health Organisation; NDDG, National Diabetes Data Group; DPSG, Diabetes in Pregnancy Study Group; ADA, American Diabetes Association; EASD, European Association for the Study of Diabetes; IADPSG, International Association of Diabetes and pregnancy Study Groups.
*50 g after 12 h fasting.
†Persistence glycosuria at least two occasions; fasting BG 5.8 mmol/l on at least two occasions; 2 h BG after 50 g OGTT >7.8 mmol/l; Diabetic pattern as recommended by O'Sullivan; History of GDM in previous pregnancies (Any three of the listed criteria).
‡Fasting >5.5 mmol/l; 1 h BG after 50 g OGTT > 10.0 mmol/l; 2 h BG after 50 g OGTT >6.7 mmol/l (any two values).
§Family history of Type 2 diabetes in first-degree relative, previous macrosomia, previous GDM; BMI ≥30 kg/m^2, history of stillbirth, unexplained perinatal death, spontaneous abortion, newborn pathophysiology conditions, previous history of congenital malformations, glycosuria in two or more occasions.
¶Previous GDM, family history of type 2 diabetes in first-degree relative, obesity, previous macrosomia, previous unexplained intrauterine death, previous baby with gross congenital malformation, polyhydramnios and large baby in the index pregnancy.
**History of foetal macrosomia or foetal anomalies, obesity, first-degree relative with diabetes mellitus, previous intrauterine foetal death, glycosuria and history of GDM in a previous pregnancy.
††Obesity, failure to gain weight in pregnancy/maintain pre-pregnancy weight, polyhydramnios confirmed by ultrasonic scan, family history of diabetes in first-degree relative, previous adverse obstetrical history, history of glucose intolerance, previous macrosomia, repeated miscarriage without a clear cause and unexplained repeated stillbirth.
‡‡Family history of type 2 diabetes in first-degree relative, previous unexplained stillbirth, recurrent pregnant losses, history of previous congenital abnormality, maternal weight ≥90 kg, heavy glycosuria, previous macrosomia, history of GDM, macrosomia in index pregnant and unexplained polyhydramnios.
§§Family history diabetes, unexplained stillbirth or neonatal deaths, glycosuria, history of macrosomic baby, history of progressive increase in birthweight of infants.
¶¶Diabetes in parent or sibling, repeated miscarriages, weight ≥80 kg, previous infant weighing ≥4000 g, previous perinatal death, fasting or repeated postprandial glycosuria, polyhydramnios, previous hyperglycaemia, previous infant with congenital anomaly and Indian ethnic origin.
***Fasting BG >5.2 mmol/l and or 2 h BG after 75 g OGTT >9 mmol/l.
†††Previous macrosomia, previous stillbirth, previous GDM and persistent glycosuria.

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retrospective review of hospital registry study carried out in 2003 [36] to 13.9% (95% CI: 11.5–16.4) women referred for oral glucose tolerance test in a metabolic clinic at a university teaching hospital using World Health Organisation criteria in 2009 [37]. The general trend shows increasing of GDM in Western Africa with time (Figure 2).

In South Africa, the earliest study was carried out in 1969 [26] and the latest in 2010 [35]. The highest prevalence was observed in 1969, a study among Indian women with one or more risk factors (23%, 95% CI 18.9–29.2) [26]. With regard to ethnicity, one study was carried out in a rural Bantu population [25] and reported prevalence of 8.8%, two in a mixed ethnic population [30, 35], one in subjects from Indian origin [26] and one among combined Indians origin and coloured minority [41]. In this subregion, a general trend could not be clearly seen from the plot (Figure 3), likely because of the variation in ethnic groups studied.

We reviewed six studies from East and Central Africa: four were conducted in East Africa (Tanzania and Ethiopia) [3, 27, 28, 31] and two in Central Africa (Cameroon and Congo) [24, 33]. The oldest study was a community survey in rural Tanzania in 1989 reporting no existence of GDM in the study population (0%) [28], and the most recent study was published in 2014 on rural and urban clinics in Tanzania reporting a prevalence of 1% (95% CI: 0.2–2.9) and 8.4% (95% CI 6.3–10.9), respectively, using World Health Organisation diagnostic criteria [3]. Almost all the studies in East and Central Africa used World Health Organisation criteria except the study in Cameroon where American Diabetes Association criteria was used and a cohort study in Congo where the authors reported using World Health Organisation criteria for diagnosis of GDM, but blood glucose was measured fasting only. Studies carried out in early nineties showed low prevalence specifically compared to the studies carried out after 2010 (Figure 4).

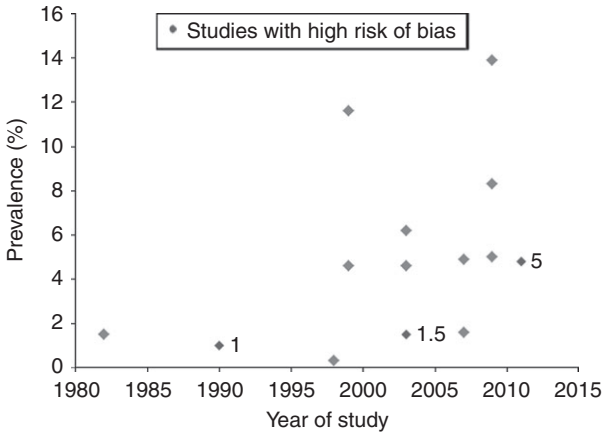

Figure 2 Trend of GDM in West Africa: Studies published from 1987 to 2014.

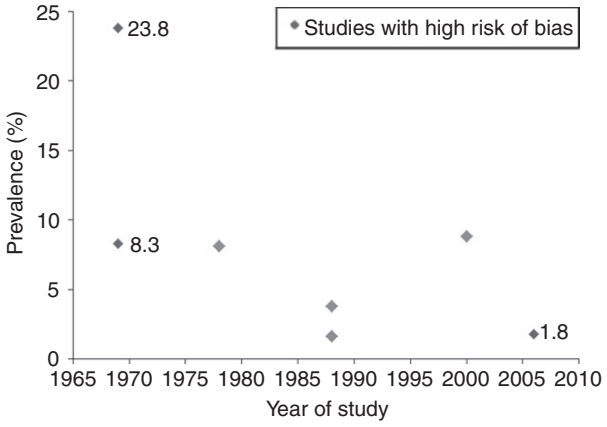

Figure 3 Trend of prevalence of GDM for the studies done in South Africa from 1969 to 2010.

Screening practices and diagnosis criteria

In most studies, screening was carried out at gestational age of ≥24 weeks. Except for the Tanzanian study which excluded teenagers, other studies assessed women attending antenatal clinic regardless of their age using either universal or selective screening based on risk factors. The commonly used diagnosis criteria were World Health Organisation 1985/1999, reported in 13 studies, two studies used American Diabetes Association criteria (either 2002 or 2010) and older ones applied National Diabetes Data Group (1979) or O'Sullivan criteria (1964), own local criteria or a combination of methods (Table 1). Thus, there were differences in screening and diagnosis criteria used even among studies carried out within the same country and same time period. Two studies compared two diagnosis criteria, World Health Organisation and National Diabetes Data Group/European Association for the Study of Diabetes, where more women were diagnosed using World Health Organisation as compared to the other two criteria: 11.6% (95% CI 7.0–17.8) *vs.* 4.6% (95% CI 1.7–9.8) in Nigeria [32] and 3.8 (95% CI 6.0–10.5) *vs.* 1.6% (95% CI 1.0–2.2) in South Africa [41]. Few studies used diagnostic methods considered to be less reliable, for example using fasting blood glucose only [33] and use of institutional protocol of pre- and post-meal blood sampling [35] without OGTT. Furthermore, a 50 g glucose challenge test was

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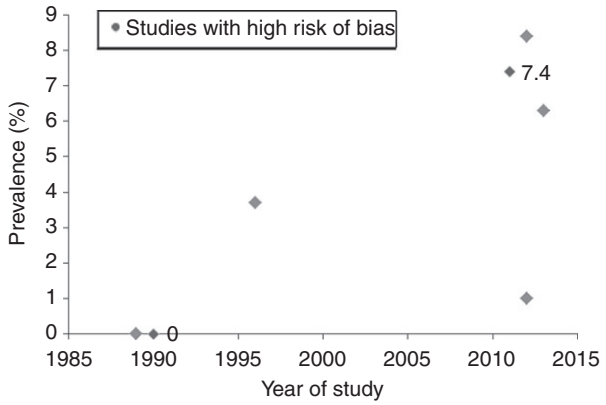

Figure 4 Trend of GDM in East and Central: studies published from 1991 to 2014.

used which is nowadays not recommended for diagnostic purpose [20, 26, 34, 36].

Sources of heterogeneity

As indicated in the methods, only studies judged as having low or moderate risk of bias were included in the metaregression. The metaregression analysis showed high heterogeneity among the reviewed studies (I^2 = 100, $P < 0.001$); hence, the results could not be reliably pooled. None of the study characteristics were significantly associated with the prevalence (Table 2), and in all models the heterogeneity remained high (I^2 = 100%, $P < 0.001$). Mutual adjustment in metaregression was not possible due to limited power. Publication bias was not observed ($P > 0.05$). Although not significant, slightly higher prevalences were noted in women with at least one risk factor (6.5%) compared to the normal population (3.8%) ($P = 0.21$) and in more present studies (5.1%) compared to those conducted before the year 2000 (3.2%) ($P = 0.37$). Likewise, there was slightly higher prevalences in studies conducted in urban (4.6%) compared to rural areas (3.5%).

Risk factors associated with GDM

Associations with potential risk factors for GDM were reported in six studies; four from Nigeria [21–23, 37], one from Cameroon [24] and one from Tanzania [3] (Table 3). Independent risk factors were previous foetal macrosomia (odds ratio (OR) 11.1, 95% CI 2.9–42.1 and OR 3.28, 95% CI 1.01–10.46) [21, 23]; previous unexplained stillbirth (OR 2.8, 95% CI 1.5–5.4); family history of type 2 diabetes (OR 2.1, 95% CI 1.1–4.2) and high mid upper arm circumference (OR 1.9, 95% CI 1.1–3.3) [3]. Women with normal haemoglobin levels had reduced risk compared with women who were anaemic (OR 0.45, 95% CI 0.22–0.93) [3]. In addition, age ≥30 years was independently associated with GDM after adjusting gestational age, HIV status and pre-pregnancy body mass index, but the OR was not stated [24]. Other factors studied as risk factors in univariate analysis were previous GDM, current glycosuria and polyhydramnios [21, 23, 37].

Table 2 Prevalence estimates according to selected study characteristics as obtained from metaregression

Variable	Prevalence (%)	95% CI Lower	95% CI Upper	*P*-value*
Study setting				
Rural	3.52	1.80	5.76	0.59
Urban	4.59	2.54	7.18	
Diagnostic criteria†				
Old criteria†	4.25	2.58	6.30	0.39
Recent criteria‡	5.11	2.27	8.95	
Population studied				
Less risk	3.76	2.26	5.60	0.21
High risk	6.52	2.01	13.24	
Year the study was completed				
< year 2000	3.17	2.15	4.37	0.37
≥year 2000	5.06	1.68	10.01	
Study subregion				
West Africa	4.90	1.44	10.10	0.40
South Africa	3.92	2.23	6.04	
East and Central Africa	3.25	1.27	6.03	

**P*-value derived from metaregression of prevalence on study characteristic.
†O'Sullivan, NDDG, WHO 1985 and own.
‡ADA 2002, 2010, WHO 1999 and EASD.

Discussion

Prevalence and trend of GDM

We systematically reviewed existing literature to assess the prevalence of GDM and its associated risk factors in Sub-Saharan Africa. We identified 22 studies conducted in six of the 47 sub-Saharan African countries; half of the studies (eleven studies) were from West Africa, specifically Nigeria. We included ten studies that were not included in the previous reviews. We observed higher prevalence proportions, although not significantly so, when selective screening for only high-risk women was carried out compared to universal screening, when studies were more recent or when more recent diagnostic criteria were used.

Regardless of diagnostic criteria and study setting, we generally observed that the prevalence of GDM in sub-

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Table 3 Risk factors associated with GDM as reported in the reviewed studies carried out in SSA published between 1969 and 2014

Risk factors	Study	OR (CI)	Comments	Other factors investigated but not significant
Mwanri *et al.* [3]	MUAC ≥ 28 cm	1.9 (1.1–3.3)	Adjusted for previous stillbirth, family history of diabetes, haemoglobin level	Age, gestational age, gravidae, physical activity level, birthweight of the previous child and previous Caesarean section
	Family history of Type 2 diabetes mellitus	2.1 (1.1–4.2)	Adjusted for previous stillbirth, MUAC and haemoglobin level	
	Previous/unexplained stillbirth	2.8 (1.5–5.4)	Adjusted for MUAC, family history of diabetes, haemoglobin level	
	Normal Haemoglobin	0.45 (0.22–0.93)	Adjusted for MUAC, family history of diabetes, previous stillbirth	
Fawole *et al.* [23]	BMI ≥ 25	2.25 (0.99–5.10)	Unadjusted	Family history of diabetes, history of congenital anomaly, heavy glycosuria, maternal weight ≥ 90 kg
		2.23 (0.96–5.20)	Adjusted for previous unexplained stillbirth, previous history of macrosomia, history of diabetes in a first-degree relation	
	Previous GDM	123.76 (58.2–263.21)	Unadjusted OR	
	Previous/unexplained stillbirth	3.13 (1.16–8.47)	Unadjusted OR	
		2.15 (0.68–6.86)	Adjusted for previous macrosomia, BMI, family history for type 2 diabetes	
	Previous foetal macrosomia	3.99 (1.49–10.68)	Unadjusted OR	
		3.25 (1.01–10.46)	Adjusted for stillbirth, BMI, family history for type 2 diabetes	
Anzaku & Musa [21]	Obesity (>90 kg)	NR	Significantly associated with higher likelihood of GDM (Univariate)*	Family history of diabetes, blood pressure, height, history of intrauterine foetal death, history of congenital malformation
	Previous foetal macrosomia	11.1 (2.93–42.12)	Adjusted for age, obesity, polyhydramnios, current glycosuria	
	Polyhydramnios	NR	Significantly associated with higher likelihood of GDM (Univariate)*	
	Current glycosuria	NR	Significantly associated with higher likelihood of GDM (Univariate)*	
	Age ≥ 31 years	NR	Significantly associated with higher likelihood of GDM (Univariate)*	
Kuti *et al.* [37]	Previous GDM	NR	Independent association using multiple regression model	Body mass index
	Family history of diabetes	NR	Independent association using multiple regression model	
	Previous foetal macrosomia	NR	Independent association using multiple regression model	
	Age ≥ 31 years	NR	Independent association using multiple regression model	
Ewenighi et al. [22]	Age categories (≥35 years)	NR	Significant using Chi-square test in three age categories	Parity, family history of diabetes, gestational age
Jao *et al.* [24]	Age >30 years	NR	Adjusted for gestational age, family history of diabetes mellitus, HIV and pre-pregnancy BMI	Family history of diabetes, gravidity, family history of hypertension, pre-pregnancy body mass index, pre-eclampsia, previous stillbirth, C-section, HIV infection

NR, not reported; MUAC, mid upper arm circumference; OR, odds ratio; BMI, body mass index.
*Significant in univariate analysis using chi-square or Fisher's exact tests.

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Saharan Africa is in a range comparable to the 2–6% as reported for European countries [42], and even higher prevalence proportions were observed after selective screening. Our graphs also indicate that the prevalence of GDM increased with time. Similar results were reported in some Asian countries [43], where the evidence of increased in trend was noted in China. The observed increase in prevalence of GDM with time is likely to be due to changes in lifestyle associated with urbanisation, including dietary changes and sedentary lifestyle, which lead to overweight and obesity. Obesity is rising in sub-Saharan Africa as well [44]; and specifically, in Africa, it has been shown that obesity is more prevalent in women than in men [45]. Another factor could be that women are becoming pregnant at more advanced age which has recently also been reported for sub-Saharan Africa [46, 47].

Different screening and diagnostic criteria were used and other studies used less common or locally known criteria. Individual studies that compared different diagnostic criteria found that there were significant differences in prevalence according to criteria used [32, 41]. As a result, it is difficult to compare the prevalence reported and to make general conclusions with regard to the prevalence of GDM in sub-Saharan Africa. Variation in methods for screening and diagnosis of GDM was also reported among other European and Asian countries [42, 43]. However, our metaregression analysis did not show statistically significant associations of diagnostic criteria with the prevalence of GDM. To make comparison easier, using standardised diagnostic criteria in the region is advocated for the future.

More studies were conducted in urban compared to rural areas, but the metaregression analysis did not show any influence of study setting on the prevalence of GDM. This may be in contrast to results from India, where higher prevalence proportions in urban compared to rural populations were reported [48, 49]. On the other hand, in Nigeria, South Africa and Ethiopia prevalence proportions in rural populations were similar to those reported for urban communities [22, 25, 27]. This may be due to differences in diagnosis criteria used or other factors, such as intrauterine exposure of the studied population to undernutrition, which is an additional risk factor for GDM [50, 51]. Another reason could be the selection of study participants, where some studies involved women attending antenatal clinic while others were community studies involving all pregnant women in that particular community. The two community studies were conducted in the nineties, and 189 and 890 women were investigated in Tanzania and Ethiopia, respectively. Generally, there are limited community studies available in this sub-region.

Risk factors

The reported risk factors in our review were advanced maternal age, overweight and obesity, previous macrosomia, previous stillbirth, family history of type 2 diabetes mellitus, history of GDM in the previous pregnancies, polyhydramnios and glycosuria [3, 21–24, 37]. This is similar to results of studies in other regions which reported advanced maternal age (>30 years), body mass index and history of GDM as risk factors for GDM [52]. However, three of our reviewed studies did not find a significant association between GDM and family history of type 2 diabetes [21, 22]. Undiagnosed diabetes is highest in sub-Saharan Africa [1]; hence, the family history for type 2 diabetes might not be known to many people, thus underestimating the frequency of a positive family history.

There is increased concern on association between infections such as HIV and tuberculosis with diabetes in sub-Saharan Africa [53, 54]. Although there is a possibility of co-existence of this infections in pregnant women, of the reviewed studies, only one study reported to have assessed the association between HIV and GDM [24]. Future studies should take this into consideration.

Three reviewed studies identified overweight or obesity as a risk for GDM, but all used different classifications. Of the two Nigerian studies, one used a body mass index cut off of ≥25 kg/m^2 [23] and the other one used weight of >90 kg [21]. A study in Tanzania used mid upper arm circumference ≥28 cm [3]. In sub-Saharan Africa, weight measurement is not regularly carried out, so it is difficult to estimate pre-pregnancy weight accurately from maternal recall. Another possible estimation would be body mass index during first visit [55], but this is hampered by late initiation of antenatal clinic visits. There is a need for further studies to establish body mass index cut offs during pregnancy and to better classify obese and overweight women during pregnancy in sub-Saharan Africa.

Several studies in our review included selective screening based on risk factors and reported that it was a common practice for example in Nigeria [34, 36, 37] and South Africa [35]. However, the criteria for identifying women at risk were different, even in studies carried out within the same country. Higher GDM prevalence in women with at least one risk factor compared to the general population implies that selective screening and or counselling of a high-risk group could be a better option in sub-Saharan Africa as there are limited resources. However, if selective screening is to be used, there is a need for establishing simple, suitable and acceptable criteria for identifying women at risk in sub-Saharan Africa.

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Limitations

This review presents up-to-date information on the prevalence and risk factors for GDM in sub-Saharan Africa. Nevertheless, it is important to mention some limitations. Although most studies excluded known diabetes patients, due to the high prevalence of undiagnosed type 2 diabetes mellitus in the African population, some women diagnosed as having GDM might have had type 2 diabetes mellitus, which was undiagnosed until they were pregnant. Very few studies indicated to have tested the women after delivery to investigate disappearance of GDM. In a rural Ethiopian study, among the 33 women diagnosed with GDM 15 (45%) had blood glucose levels in the diabetes range, 4–6 weeks post-partum, which shows that they might have had undiagnosed diabetes [27]. Hence, the true prevalence of GDM in sub-Saharan Africa was probably overestimated.

All reviewed studies were from six of a total of 47 sub-Saharan Africa countries, and half of them (50%) were from only one West African country, Nigeria. Hence, it is difficult to draw conclusion regarding the prevalence and risk factors for GDM in all of sub-Saharan Africa. We included studies on non-African ethnic groups. Gestational diabetes varies according to ethnicity and/or racial differences; some ethnic or racial groups are at higher risk than others irrespective of their body mass index [56]. However, this does not affect our conclusion.

Conclusion

There are few studies on prevalence and risk factors for GDM in sub-Saharan Africa. The heterogeneity of the reviewed studies was high and could not easily be explained by selected study characteristics. The prevalence was as high as about 14% when women with at least one risk factor were studied, which indicates that preventive actions should be taken to reduce the short- and long-term complications related to GDM in sub-Saharan Africa.

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Appendix 1
Search terms used for final search 20 June 2014

Search	Add to builder	Query	Items found	Time
#9	Add	Search ((((((((((((((diabet* OR hyperglycemi* OR glucose intolerance OR gestational diabetes OR impaired glucose tolerance OR diabetes mellitus OR postprandial glucose tolerance)) OR glucose tolerance)) AND (((pregnan*) OR gestation*) OR Gravid*))) OR gestational diabetes)) AND ((Africa* OR East Africa* OR North Africa* OR Central Africa* OR Angola* OR Benin* OR Botswan* OR Burkina Faso OR Burkinabe* OR Burundi OR Cameroon* OR Cape Verde* OR 'Central African Republic' OR Chad* OR Comor* OR Congo* OR Cote d'Ivoire OR Ivory Coast OR Ivorian OR Djibouti* OR Dominica* OR Ecuador* OR Guinea* OR Eritrea* OR Ethiopia* OR Gabon* OR Gambia* OR Ghana* OR Kenya* OR Lesotho OR Liberia* OR Madagasca* OR Malawi* OR Mali* OR Mauritania* OR Mauritius OR Mozambi* OR Namibia* OR Niger* OR Rwanda* OR Senegal* OR Seychell* OR Sierra Leone* OR Somali* OR South Africa* OR Sudan* OR Swaziland OR Swazi OR Tanzania* OR Togo* OR Tonga* OR Uganda* OR Zambia* OR Zimbabwe*)))))) AND Human) NOT animal)	1064	02:29:4

Appendix 2
Characteristics of studies that were excluded after full screening of the article

Author (Year of publication)	Title	Reason for exclusion
Macaulay *et al.* (2014) [12]	Gestational diabetes mellitus in Africa: A systematic review	Review
Jiwani *et al.* (2012) [57]	Gestational diabetes mellitus: results from a survey of country prevalence and practices	Worldwide survey, experts opinion regarding prevalence, screening and management of GDM
Hall *et al.* (2011) [11]	Diabetes in Sub-Saharan Africa 1999–2011: epidemiology and public health implications. A systematic review	Review

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Appendix 2 (*Continued*)

Author (Year of publication)	Title	Reason for exclusion
Cpyrky *et al.* (2008) [58]	Gestational diabetes mellitus - an analysis of risk factors	Out of the region (Poland)
Challis *et al.* (2002) [59]	Gestational diabetes mellitus and foetal death in Mozambique: an incident case-referent study	Checked after delivery or child loss hence does not fit in to GD definition
Van Bogaert (1998) [60]	Gestational diabetes mellitus–are African diagnostic criteria warranted?	Diagnosis criteria
Kinnear and Ojo (1966) [61]	Pregnancy and diabetes in Nigeria	Already known type 2 diabetic women
Hailu and Kabede (1994) [62]	High-risk pregnancies in urban and rural communities in central part of Ethiopia	Assessed risk factors associated with poor birth outcome, but GDM was not assessed.
Iloki *et al.* (1993) [63]	Diabetes and pregnancy in Africa: a pathology often not recognised	Most information is missing
Iloki *et al.* (1992) [64]	Diabetes and pregnancy in Africa. An often overlooked pathology	Same data and content as Iloki 1993
Fraser (1981) [65]	The effect of pregnancy on the normal range of the oral glucose tolerance in Africans	Compared blood glucose range in normal and pregnant women
Notelovitz (1974) [66]	Gestational diabetes in general practice	Not relevant, discussed the role of health practitioner
Notelovitz (1970) [67]	Diabetes screening during pregnancy	Screening criteria
Notelovitz (1970) [68]	The pregnant Bantu diabetic	Not enough information to establish prevalence
Notelevitz (1969) [69]	The pregnant Natal Indian diabetic	Description of Indian diabetic pregnant women
Notelovitz (1968) [70]	The pregnant Natal Indian diabetic-facts and fancies	Repeated results in another published paper by the same author

Appendix 3
PRISMA Checklist

Section/topic	#	Checklist item	Reported on page #
Title			
Title	1	Identify the report as a systematic review, meta-analysis or both.	1
Abstract			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; and systematic review registration number.	2
Introduction			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4–5
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes and study design (PICOS).	5
Methods			

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Appendix 3 (*Continued*)

Section/topic	#	Checklist item	Reported on page #
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g. Web address), and, if available, provide registration information including registration number.	NA
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g. years considered, language and publication status) used as criteria for eligibility, giving rationale.	5–6
Information sources	7	Describe all information sources (e.g. databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5–6
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	5–6 & Appendix 1
Study selection	9	State the process for selecting studies (i.e. screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	6–7, Figure 1 & Appendix 2
Data collection process	10	Describe method of data extraction from reports (e.g. piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6–7
Data items	11	List and define all variables for which data were sought (e.g. PICOS, funding sources) and any assumptions and simplifications made.	6–7
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was carried out at the study or outcome level), and how this information is to be used in any data synthesis.	7–8 Appendices 4a,b
Summary measures	13	State the principal summary measures (e.g. risk ratio, difference in means).	NA
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if carried out, including measures of consistency (e.g. I^2) for each meta-analysis.	8–9
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g. publication bias, selective reporting within studies).	8–9
Additional analyses	16	Describe methods of additional analyses (e.g. sensitivity or subgroup analyses, metaregression), if carried out, indicating which were pre-specified.	8–9
Results			
Study selection	17	Give numbers of studies screened, assessed for eligibility and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	9–10 & Figure 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g. study size, PICOS, follow-up period) and provide the citations.	9–12 & Table 1
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	9, Table 1 & Appendices 4a,b

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Appendix 3 (*Continued*)

Section/topic	#	Checklist item	Reported on page #
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	9–12, Tables 1&3 & Figures 1,2 & 3)
Synthesis of results	21	Present results of each meta-analysis carried out, including confidence intervals and measures of consistency.	9–12
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	NA
Additional analysis	23	Give results of additional analyses, if carried out (e.g. sensitivity or subgroup analyses, metaregression (see Item 16)).	13 & Table 2
Discussion			
Summary of evidence	24	Summarise the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g. healthcare providers, users and policymakers).	14–18
Limitations	25	Discuss limitations at study and outcome level (e.g. risk of bias) and at review level (e.g. incomplete retrieval of identified research, reporting bias).	18
Conclusions	26	Provide a general interpretation of the results in the context of other evidence and implications for future research.	19
Funding			
Funding	27	Describe sources of funding for the systematic review and other support (e.g. supply of data); role of funders for the systematic review.	20

Appendix 4a
Risk of bias assessment tool: Adapted from the Risk of Bias Tool for Prevalence Studies developed by [15] Name of the author and year of publication

Risk of Bias Item	Answer: Yes (Low Risk) or No (High risk)
External Validity	
1. Was the study target population a close representation of the national pregnant population in relation to relevant variables?	
2. Was the sampling frame a true or close representation of the target population? (risk factors used appropriate?)	
3. Was some form of random selection used to select the sample, OR, was a census undertaken?	
4. Was the likelihood of non-participation bias minimal? (i.e. ≥75% response rate)?	
Internal Validity	
5. Were data collected directly from the subjects? (as opposed to medical records)	
6. Were acceptable diagnostic criteria for GDM used?	
7. Was a reliable and accepted method of testing for blood glucose utilised?	
8. Was the same mode of data collection used for all subjects?	
9. Was GDM tested for within the advised gestational period of 24–28 weeks?	
10. Were the numerator(s) and denominator(s) for the calculation of the prevalence of GDM appropriate?	
11. Summary item on the overall risk of study bias LOW RISK OF BIAS: 8 or more 'yes' answers. Further research is very unlikely to change our confidence in the estimate. MODERATE RISK OF BIAS: 6 to 7 'yes' answers. Further research is likely to have an important impact on our confidence in the estimate and may change the estimate. HIGH RISK OF BIAS: 5 or fewer 'yes' answers. Further research is very likely to have an important impact on our confidence in the estimate and is likely to change the estimate.	

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Appendix 4b Assessment of risk of bias of the included studies

Author (year of publication)	Sample of pregnant women representative?	Sampling frame representative?	Random or census selection?	Response rate ≥75%?	Data from subjects?	Acceptable diagnostic criteria?	Reliable testing for BG?	Same method for all?	Proper gestational age GDM test?	Proper calculation prevalence	Total 'Yes'	Overall risk of bias
Abudu and Kuti (1987) [20]	No	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	6	Moderate
Wokoma *et al.* (2001) [34]	No	Yes	Yes	NR	Yes	No	No	Yes	Yes	Yes	6	Moderate
Ozumba *et al* (2004) [38]	No	No	No	Yes	No	Yes	Yes	Yes	No	Yes	5	High
Olarinoye *et al.* (2004) [32]	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	8	Low
Adegbola *et al.* (2008) [29]	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8	Low
Kamanu *et al.* (2009) [36]	No	No	No	Yes	No	Yes	No	Yes	NR	No	3	High
Kuti *et al.* (2011) [37]	No	No	Yes	NR	Yes	Yes	Yes	Yes	No	Yes	6	Moderate
Ugboma *et al.* (2012) [39]	Yes	Yes	No	No	Yes	Yes	No	No	No	Yes	5	High
Ewenighi *et al.* (2013) [22]	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	8	Low
Anzaku *et al.* (2013) [21]	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8	Low
Fawole *et al.* (2014) [23]	No	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	6	Moderate
Notelovitz (1969) [26]	No	Yes	NR	NR	Yes	Yes	Yes	Yes	No	No	5	High
Jackson and Coetzee (1979) [30]	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	6	Moderate
Ranchold *et al.* (1991) [41]	No	Yes	Yes	NR	Yes	Yes	Yes	Yes	Yes	Yes	8	Low
Mamabolo *et al.* (2007) [25]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	9	Low
Basu *et al.* (2010) [35]	No	No	Yes	NR	No	No	No	Yes	NR	Yes	3	High
Swai *et al.* (1991) [28]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	9	Low
Lutate *et al.* (1993) [31]	No	No	No	No	Yes	Yes	NR	Yes	No	Yes	3	High
Seyoum *et al.* (1999) [27]	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9	Low
Jao *et al.* (2013) [24]	No	Yes	Yes	NR	Yes	Yes	Yes	Yes	Yes	Yes	8	Low

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Appendix 4b (*Continued*)

Author (year of publication)	Sample of pregnant women representative?	Sampling frame representative?	Random or census selection?	Response rate ≥75%?	Data from subjects?	Acceptable diagnostic criteria?	Reliable testing for BG?	Same method for all?	Proper gestational age GDM test?	Proper calculation prevalence	Total 'Yes'	Overall risk of bias
Tandu-Umba *et al.* (2013) [33]	No	No	No	NR	Yes	No	No	Yes	Yes	Yes	4	High
Mwanri *et al.* (2014) [3]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	9	Low

NR, not reported.

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