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Research Article

Global Prevalence of Gestational Diabetes Mellitus: A Systematic Review and Meta-Analysis

Gyasi-Antwi P[1*], Walker L[1], Moody C[1], Okyere S[2], Salt K[3], Anang L[4], Eduful E[4], Laryea D[5], Ottie-Boakye D[6,10], Asah- Opoku K[4,6], Asibey S[7], Sarfo-Kantanka O[7], Baffour-Agyei E[8], Shaw I[9] and Adams G[1*]

[1]School of Health Sciences, Faculty of Medicine and Health Sciences, Queens Medical Centre, University of Nottingham, Nottingham, UK

[2]School of Sociology, Politics and International Studies, University of Bristol, UK

[3]Centre for Research in Race and Rights, American & Canadian Studies, Faculty of Arts, University Park, University of Nottingham, Nottingham, UK

[4]Korle Bu Teaching Hospital, Accra, Ghana

[5]Non-Communicable Diseases Control Programme, Ghana Health Service, Accra, Ghana

[6]University of Ghana School of Medicine and Dentistry - Accra, Ghana

[7]Komfo Anokye Teaching Hospital, Kumasi, Ghana

[8]Centre for Pregnancy and Childbirth Education (CEPACE), Accra, Ghana

[9]School of Sociology and Social Policy, Faculty of Social Sciences, University Park, University of Nottingham, Nottingham, UK

[10]Citadel Research Network for Development, Ghana

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***Corresponding author:**

Philemon Gyasi-Antwi and Gary Adams, School of Health Sciences, Faculty of Medicine and Health Sciences, Queens Medical Centre, University of Nottingham, Nottingham, UK, E-mail: bwzpg3@nottingham.ac.uk; E-mail: Gary.adams@nottingham.ac.uk

1. Abstract

1.1. Background: Evidence suggests that diabetes in all forms are on the rise especially gestational diabetes mellitus which increases the risk of maternal and neonatal morbidities; however global prevalence rates and geographical distribution of GDM remain uncertain. The aim of this study is to examine the global burden of gestational diabetes mellitus.

1.2. Methods: A systematic review and meta-analysis of studies reporting Randomised Clinical Trials (RCTs) in pregnant women who have GDM was conducted. Cochrane (Central), PubMed, Scopus, JBI, Medline, EMBASE and reference lists of retrieved studies were searched from inception to March 2019. Publications on prevalence of GDM irrespective of the baseline criteria used to diagnose GDM were included in the study. Studies were limited to English language, randomised control trials and women aged between 19 – 44 years inclusive.

1.3. Results: Eleven RCTs met the inclusion criteria for this review. The included studies collectively reported GDM rates of 13,450 pregnant women from 7 countries. The diagnostic criteria used in the studies were World Health Organisation (WHO) 1985 and 1999, International Association of Diabetes, Pregnancy Study Group (IADPSG), National Diabetes Data Group (NDDG), Carpenter–Coustan (C&C) and O'Sullivan's criteria. Seven RCTs screened for GDM in comparison with different diagnostic criteria in the same population while three studies used the same criteria for different groups. One study compared 100g, 3h OGTT to 75g, 2h OGTT for diagnosing GDM using Carpenter and Coustan criteria. All seven RCTs that compared different diagnostic criteria in the same population detected different prevalence rates of GDM. Three RCTs measured prevalence of GDM in the same population using WHO 1999 and IADPSG 2013 criteria. Using random effect model, data from three studies that compared IADPSG criteria to WHO 1999 showed an Odds Ratio (OR) of 0.52(0.15, 1.84), 95% Confidence Interval (CI) and high heterogeneity of 99%. In all three studies, prevalence of GDM measured by IADPSG criteria was higher than WHO 1999 criteria, although not significant (p= 0.31). Combining all the studies gave a global estimated prevalence of GDM to be 10.13% (95% CI, 7.33 - 12.94) with moderate heterogeneity of 27%. The highest prevalence of GDM with

a median estimate of 38.25% (95% CI, 32.93 - 43.57) was reported in Kuala Lumpur while Ireland had the lowest prevalence 2.075 % (95% CI, 1.36–2.79).

1.4. Conclusion: The results indicate that global burden of GDM is high, particularly in Southeast Asia. Applying different diagnostic criteria indicate that different group of women are identified; consequently, creating large differences in GDM prevalence even in the same population.

2. Keywords: Gestational Diabetes Mellitus (GDM); Pregnancy-Induced diabetes; Prevalence

3. Introduction

Gestational Diabetes Mellitus (GDM) is defined as glucose intolerance with onset or first recognition during pregnancy. Although the mechanism is unclear, inadequate insulin production and or progressive insulin resistance as in the case of GDM has been attributed to a combination of increased maternal adiposity and insulin-desensitizing effects of placental hormones [1, 2]. It has been suggested that placental growth hormones, Human Placental Lactogen (HPL) and prolactin, play a major role in the onset of GDM by increasing maternal food intake, mobilising maternal nutrients for foetal growth and increasing insulin resistance to maternal nutrients [2]. Thus, pancreatic beta cells increase their insulin secretion to compensate for the high glucose and insulin resistance caused, leading to defect in pancreatic beta cell function over time [1].

As at 2017, over 451 million people between the ages of 18 and 99 were estimated to have diabetes worldwide. Out of this, approximately 21.3 million were estimated to be women affected by some form of hyperglycaemia during pregnancy, of which 18.4 million of these cases were due to Gestational Diabetes Mellitus (GDM) [3]. This indicates that approximately 14% of pregnancies worldwide are affected by GDM yearly [3, 4]. It is instructive to note that out of 221 data sources from 131 countries selected for the International Diabetes Federation (IDF) diabetes atlas study, only 37 countries were reported to have data sources for GDM. Of these, only three were in Africa (Figure 1) [5].

For over a century, studies have shown that GDM causes grave adverse effects on pregnancy and foetal outcomes [1]. Back in 1882, a study by Matthews Duncan reported that 10 out of 19 maternal deaths which occurred at the time of labour or within a few weeks were due to diabetic coma caused by 'diabetes antedating pregnancy'. This seminal study also reported that of the 27 pregnancies which were examined, abortion occurred in 6 cases, while 8 others had stillbirth or death of babies shortly after birth. In all cases, the foetuses and babies were unusually large sized (macrosomia) and affected by diabetes in one case [6, 7]. In the early 1940s, it was recognised that women who developed diabetes years after pregnancy had also previously experienced foetal and neonatal mortality. Successive research through to the contemporary era have made similar findings of increased risk of foetal macrosomia, childhood obesity, as well as risk both women and children developing type 2 diabetes and other cardiovascular diseases [8, 9].

Until recently, the exact threshold for a diagnosis of GDM depends on the criteria used, and so far, there has been a lack of consensus amongst health professionals. It is now advised by the ADA, the World Health Organization (WHO), the International Federation of Gynaecology and Obstetrics, and the Endocrine Society, that the International Association of Diabetes and Pregnancy Study Group (IADPSG) criteria be used in the diagnosis of GDM [10]. The IADPSG criteria as summarised in Table 1, was developed based on the results of the Hyperglycaemia and Adverse Pregnancy Outcomes (HAPO) Study—a large multinational and multicentre study of 23,000 pregnant women [11].

With the increasing epidemic of obesity and sedentary lifestyle, the global burden of GDM is predicted to increase, putting women of reproductive age and their babies at risk of intergenerational transmission of type 2 diabetes [12]. The literature on prevalence of GDM and risk of exposure to pregnant women is sparse and varied, particularly in Lower- and Middle-Income Countries (LMICs) where there is lack of national policies on the diagnosis and management of the disease. The objective of the present systematic review and meta-analysis was to investigate the global burden of gestational diabetes mellitus by examining published data.

Table 1: The IADPSG criteria for screening and diagnosis of Gestational diabetes

Perform a 75-g oral glucose tolerance test (OGTT), with plasma glucose measurement fasting and at 1 and 2 h, at 24-28 of weeks gestation in women not previously diagnosed with overt diabetes.
The OGTT should be performed in the morning after an overnight fast of at least 8 h.
The diagnosis of GDM is made when any of the following plasma glucose values are exceeded • Fasting: ≥92 mg/dl (5.1 mmol/l) • 1 h: ≥180 mg/dl (10.0 mmol/l) • 2 h: ≥153 mg/dl (8.5 mmol/l)

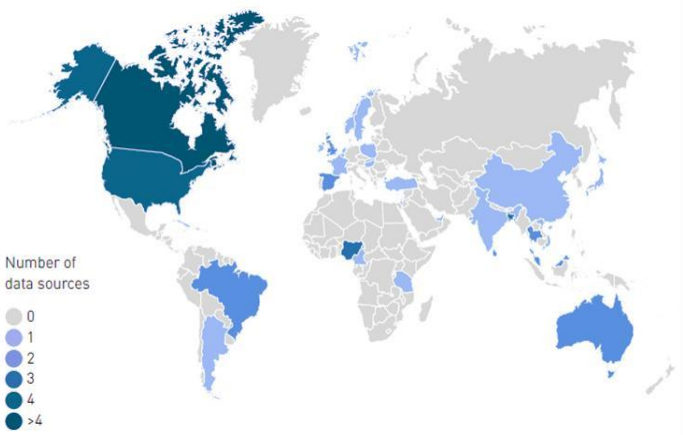

Figure 1: Countries and territories with data sources reporting the prevalence of hyperglycaemia in pregnancy. Figure was adapted from International Diabetes Federation report, 2017 [5].

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4. Methods

4.1 Search Strategy

EMBASE, MEDLINE, Cochrane CENTRAL, Scopus, PubMed, Joanna Briggs Institute (JBI), and Cumulative Index to Nursing and Allied Health Literature (CINAHL) databases were searched from inception to week 6 March 2019 using a broad search strategy to identify all potentially relevant publications for this review. Broad keywords including Medical Subject Heading (MeSH) search terms "prevalence", "epidemiology" and "frequency" were combined with terms that covered "GDM", "Gestational diabetes mellitus", "Pregnancy-Induced Diabetes" and "Gestational Diabetes". Grey literature search as well as citation chaining was done to identify other relevant studies.

4.2 Study Inclusion and Exclusion Criteria

Original publications reporting on prevalence of GDM irrespective of the baseline criteria used to diagnose GDM were included in the study. Prevalence is defined as the percentage of existing cases of a disease in a given population at a particular time [13]. Studies were limited to English language, randomised control trials and women aged between 19 – 44 years inclusive. In terms of exclusion criteria, studies that reported prevalence of GDM only in a selective group such as women with obesity and those already at risk of developing type 2 diabetes were not included.

4.3 Selection of Studies

Titles and abstracts of studies retrieved from the databases were initially screened. Full details of those that fulfilled the inclusion criteria were assessed and included in the study whereas duplicates and irrelevant studies were excluded. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [14] was used for the study selection.

4.4 Data Extraction

Two review authors assessed the titles and abstracts of all articles identified from the database searches. Full texts of selected articles were retrieved and assessed independently for study eligibility. Disagreements were resolved through discussion or through consulting a third reviewer.

4.5 Appraising the Quality of the Included Studies and Risk of Bias

The quality of the eleven selected RCTs were assessed based on the Cochrane risk-of-bias tool criteria using three domains: randomisation method, allocation concealment and blinding. The quality assessment was presented using the Review Manager 5.3 (RevMan).

4.6 Data Analysis

To measure heterogeneity or variability among studies, Chi-squared (Chi2) statistic was used. This was to assess whether differences in prevalence was due to sampling error or due to differences in sample populations. Prevalence data from all studies were pooled to get a single group summary using a random effect model. The meta-analyses results are presented using forest plots produced using RevMan and MS Excel (2016).

5. Results

A total of 17, 473 articles were identified from different databases and sources. Irrelevant studies were removed by assessing titles and abstracts. Removing duplicates and applying the inclusion criteria, 53 studies were retrieved for a more detailed assessment of full text; from which 11 were found to be suitable for this review and 42 being excluded with reasons (Figure 2).

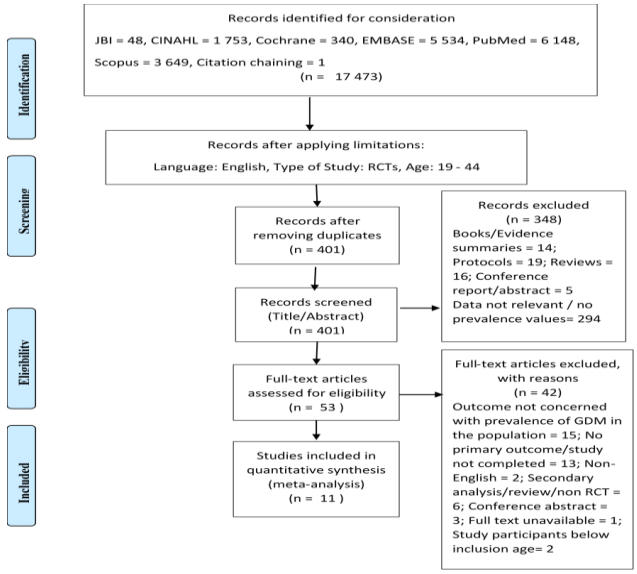

Figure 2: Flowchart of search strategy and study selection process

The included studies collectively reported GDM rates of 13,450 pregnant women from seven countries under different health settings. Multiple published prevalence studies from some countries such as India (n=2), Thailand (n=2), Norway (n=2), and Ireland (n=2) based on various study populations and diagnostic criteria were retrieved, while others such as Malaysia, Nigeria and Turkey had single prevalent studies. The studies were published from 1996 – 2018. Details of 11 studies included in this review are shown in Table2.

About 75% of the selected studies had unclear risk of bias after quality assessment using three domains: randomisation method, allocation concealment and blinding (Figure 3). 4 out of the 11 included studies reported a method of randomisation:

- Participants were randomised at their first visit to either selective screening when one or more risk factors were present or to universal screening (4).
- Randomisation was generated by an independent researcher using the NQuery statistical software programme (version 2.0) (6).

- Randomisation was generated using a computer program (Random Number Generator Version 1.0 Segobit software, Issaquah, WA) (8).
- Concealed randomisation was performed by independent researchers using a Web-based computerized procedure (11).

Information on randomisation method for seven of the included studies were not provided (1, 2, 3, 5, 7, 9 and 10).

Only one study had information on a method of allocation concealment:

- Sealed envelopes were used to assign participants after allocation sequence was generated using NQuery statistical software programme (version 2.0) (6).

No clear information on allocation concealment was reported by the remaining 10 studies (1, 2, 3, 4, 5, 7, 8, 9, 10 and 11).

Outcome assessment and analyses of glucose and insulin levels were performed blinded in (11). No clear information on blinding was reported by the remaining 10 studies (1, 2, 3, 4, 5, 6, 7, 8, 9 and 10)

The primary outcome of concern was the prevalence of gestational diabetes in the population studied. The diagnostic criteria used in the studies were World Health Organisation (WHO) 1985 and 1999, International Association of Diabetes, Pregnancy Study Group (IADPSG), National Diabetes Data Group (NDDG), Carpenter–Coustan (C&C) and O'Sullivan's criteria (Figure 4).

Seven RCTs (1, 2, 3, 5, 7, 8 and 9) screened for GDM in comparison with different diagnostic criteria in the same population while three studies (4, 6, and 11) used the same criteria for different groups. One study compared 100g, 3h OGTT to 75g, 2h OGTT for diagnosing GDM using Carpenter and Coustan criteria (10). Data from two or more studies that compared the same set of diagnostic criteria for GDM detection were combined for Meta-analyses.

Three RCTs measured prevalence of GDM in the same population using WHO 1999 and IADPSG 2013 criteria. Using a random effect model, the data from (1, 2, and 5) were pooled for meta-analyses of GDM prevalence in 6, 307 participants (Figure 5). The result indicates an Odds Ratio (OR) of 0.52(0.15, 1.84), 95% Confidence Interval (CI) and high heterogeneity of 99%. In all three studies, prevalence of GDM measured by IADPSG criteria was higher than WHO 1999 criteria, although not statistically significant (p= 0.31).

Using NDDG criteria, data from (4) indicated that universal screening of pregnant women for GDM detected significantly higher prevalence rate compared to selective risk-factor group (p <0.03). Conversely, no significant difference was detected in GDM prevalence when pregnant women were screened either at a primary care facility (local General practice) or at a secondary health facility (p = 0.75) (6). Data from (11) also showed that receiving a 12-week standard exercise during pregnancy did not significantly affect GDM prevalence compared to women who received standard antenatal care (p = 0.52).

Prevalence data from each study were averaged and the mean values combined using a random effect model for a group summary analysis following a guide for descriptive data analysis in MS Excel developed by [26]. Combining all the studies showed an estimated global GDM prevalence of 10.13 [95%CI 7.33 - 12.94] with moderate heterogeneity of 27%. Overall, the highest prevalence of GDM with a median estimate of 38.25% (32.93 - 43.57%) was reported in Kuala Lumpur, Malaysia, followed by Punjab, India, Thailand, Turkey, and Nigeria (median prevalence 21.95, 14.25, 10.25, and 8.05%, respectively), whereas Ireland had the lowest prevalence (median 2.075 %; range 1.36–2.79 %) (Figure 6).

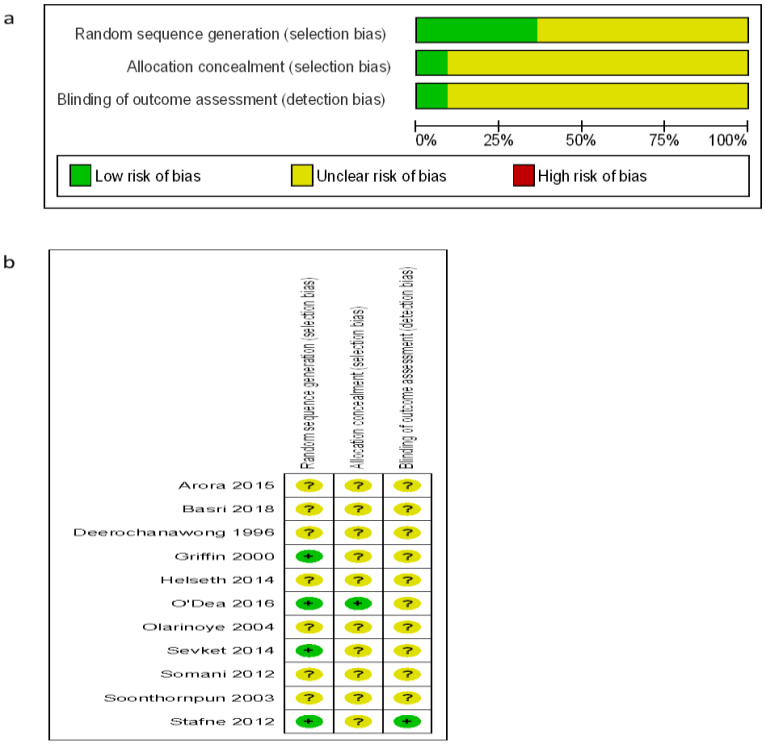

Figure 3: Summary of risk of bias: Presented as
(a) each risk of bias item for each included study and
(b) percentages across all included studies using RevMan 5.3.

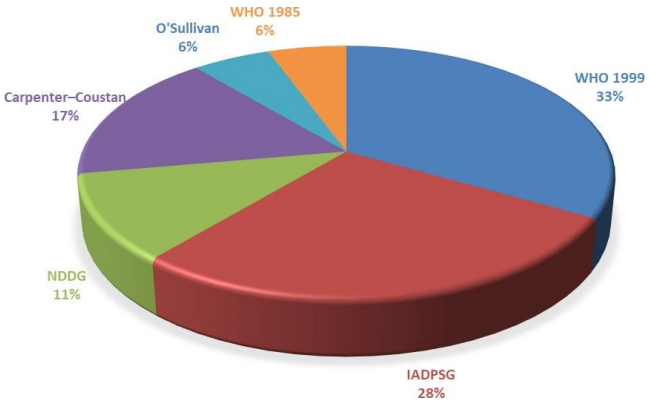

Figure 4: Different GDM diagnostic criteria used in the selected studies.

Table 2: Characteristics of studies included in this review.

	First author and year	City/Country	Study setting	Study participants/Sample size	Period of study	Diagnosis criteria	Prevalence (%)	Main outcomes
1	(Arora, Thaman et al. 2015) [15]	Punjab/India	Multistate and multi-departmental clinics	5100 participants were randomly selected and screened for GDM of which 2179 urban (77.7%) and 2921 rural (84.6%); Age ≤20to ≥30, mean age 21.5±3.3 years	2009 - 2012	WHO 1999; FPG level ≥7.0 mmol/l (126 mg/ dl) or 2-h PG levels after a 75 g OGTT ≥7.8 mmol/l (140 mg/dl)	9.00%	1. 1014 declined participation. Main reason for declining participation was fear of GDM diagnosis as it is considered a social stigma. 2. Applying both diagnostic criteria, GDM women had significantly higher FPG and 2-h PG levels (*P*<0.001), increased BMI (*P*=0.01), were older (*P*<0.001) and shorter (*P*=0.01, WHO 2013; *P*<0.001, using WHO 1999) compared to non-GDM women. 3. Percentage of women classified as having GDM was 7.2% by both criteria, 1.8% by the 1999 criteria only, and 27.7% by the 2013 criteria only. 4. For prevalence according to risk factor, urban women had significantlyincreased GDM prevalence compared to rural women using both GDM criteria (P<0.001 for WHO 2013 and P=0.001 for WHO 1999)
						WHO 2013 (IADPSG); FPG ≥5.1 mmol/L and/ or 1-h glucose ≥10.0 mmol/L and/or 2-h ≥8.5 mmol/L	34.90%	
2	(Basri, Mahdy et al. 2018) [16]	Kuala Lumpur, Malaysia	Antenatal clinic in a tertiary hospital and referral centre	520 pregnant women with one or more risk factors for GDM at gestational age between 14 and 37 weeks were randomly screened for GDM. Mean maternal age 31.5±4.38 years. Included if any of the following were present: previous history of GDM, first degree relative with diabetes mellitus, obese body mass index (BMI) > 27, age 25 years and above, current obstetric problem (essential hypertension, pregnancy induced hypertension, polyhydramnios, current use of steroids), previous macrosomic baby with birth weight ≥4.0 kg, previous unexplained still birth, foetus with congenital anomaly,	2015 - 2017	WHO 1999 (modified); FPG ≥6.1 mmol/L, 2 h ≥7.8 mmol/L	37.90%	1. GDM prevalence using IADPSG (37.90%) and WHO (38.60%) diagnostic criteria. 2. Prevalence rates obtained is 30% higher compared to the previously reported 18% and 24.9% by local studies. 3. Reasons for high prevalence: a. the study setting is a referral centre hence more likely to receive high risk women b. all women age 25 years and above were considered high risk and part of the study 4. GDM women diagnosed with WHO criteria had significantly increased incidences of gestational hypertension/pre-eclampsia (p=0.004) and neonatal hypoglycaemia (p=0.042) compared to those diagnosed with IADPSG while primary caesarean section (p=0.012) and foetal macrosomia (p=0.027) were significantly higher the IADPSG group
						IADPSG; FPG ≥5.1 mmol/L, 2 h ≥8.5 mmol/L	38.60%	
3	(Deerochanawong, Putiyanun et al. 1996) [17]	Bangkok, Thailand	Antenatal clinic of a tertiary hospital	persistent glycosuria, recurrent urinary tract infection (UTI) or vaginal discharge 709 pregnant women with a mean age of 26.9±5.6years. Subjects were randomly recruited from among women who were attending the antenatal clinic	-	National DiabetesData Group (NDDG); 100-g OGTT blood glucose ≥ 5.8, 10.6, 9.2 and 8.1 mmol/l of FPG levels at 1, 2 and 3 h, respectively	1.40%	1. Prevalence of GDM by WHO criteria in the same group of patients in this study was about 10 times higher than that using the NDDG criteria 2. The sensitivity of GDM using NDDG and WHO criteria for detecting macrosomia was 21.4 and 42.9 %, and the sensitivity for detecting large for gestational age infants was 9.8 and 41.5 %, respectively.
						WHO 1999; 2-h plasma glucose after 75-g OGTT of 7.8 mmol/l	15.70%	
4	(Griffin, Coffey et al. 2000) [18]	Dublin, Ireland	Outpatient obstetric clinic in a tertiary hospital	3 152 pregnant women randomized at their first visit to either selective screening (1853, mean age 27.4±5.6), when one or more risk factors were present or to universal screening (1299, mean age 27.3±5.7). Risk factors for the selective group include; first degree relative with diabetesmellitus; >100 kg in current pregnancy; previous baby >4.5 kg; Previous unexplainedstillbirth/ intra-uterine death; previous major malformation; previous gestational diabetes mellitus; glycosuria in 2nd fasting urine sample; macrosomia in current	-	Risk factor group had a 3-h 100-g OGTT at 32weeks (Standard hospital protocol)	1.45%	1. GDM prevalence detected in the selective group was significantly less than detected in the universal group (P< 0.03) 2. GDM women were significantly older (p<0.05) in both groups (selective group = 30.6±5.5 years; universal group = 31.0±5.6 years) than those without GDM (27.0±5.7 years) 3. Universal screening of GDM led to a higher rate of spontaneous vaginal delivery at term (77.0%), and lower rates of macrosomia (0.0%), Caesarean section (11.4%), pre-eclampsia (0.0%) and admission to neonatal intensive care unit (2.9%) compared to selective screening: lower rate of spontaneous vaginal delivery at term (56.0%), and higher rates of macrosomia (11.1%), Caesarean section (18.5%), pre-eclampsia (14.8%) and admission to neonatal intensive care unit (18.5%)
						The universal group had a 50-g GCT at 26-28 weeks and if their plasma glucose at 1 h was ≥7.8mmol/l, a formal 3-h 100-g OGTT was performed	2.7%,	
5	(Helseth, Salvesen et al. 2014)[19]	Trondheim/ Stavanger, Norway	Tertiary hospital	pregnancy; polyhydramnios in current pregnancy Study population was extracted from a previously reported randomized controlled trial (RCT) assessing the effect of regular exercise during pregnancy on the incidence of GDM. 687 women with mean age of 30.6±4.2years were selected to be screened with both WHO 1999 and simplified IADPSG criteria. 89.7% of the participants were college/ university educated	2007 - 2009	WHO 1999; FPG ≥7.0 mmol/L and/ or 2-h plasma glucose ≥7.8 mmol/L either at 18 – 22 weeks and/or 32 – 36 weeks.	6.1% (42/687)	1. GDM prevalence was 0.4% according to the WHO criteria at 18 – 22 weeks and 5.7% at 32 – 36 weeks, while GDM prevalence was 2.6% and 4.8% according to simplified IADPSG criteria at same time points. IADPSG criterion is sensitive to detect GDM early which may reduce the short or long-term burden of GDM in mother or child. 2. Maternal age was the only risk factor that was independently associated with both WHO (p=0.008) and IADPSG (p=0.002) criteria indicating each criterion identify different group of women. 3. Only 27% of GDM women fulfilled both criteria for GDM.
						Simplified IADPSG; FPG ≥5.1 mmol/L and/ or 2-h plasma glucose ≥8.5 mmol/L at the same time points.	7.4% (51/687	

6	(O'Dea, Tierney et al. 2016)[20]	Galway, Ireland	Three hospital sites	781 were recruited and randomised to have screening completed either in primary care (n= 391) or secondary care (n= 390). 215 women received their GDM screen in primary care while 475 women received their screen in secondary care. The primary care group were screened for GDM at their local general practitioner (GP) clinic while secondary care group were screened at the hospital site at which they attended for ante-natal care. An independent researcher was responsible for generating the allocation sequence using the NQuery statistical software programme (version 2.0)	2013	IADPSG	6.5%, primary care (*n* = 215) 7.2%, secondary care (*n* = 475)	1. significant difference between Primary care group (32.5±5.0) and Secondary care group (33.5±5.0) in terms of maternal age at delivery (p= 0.02) 2. No significant differences (p= 0.75) in GDM prevalence between primary care (6.5%) and secondary care (7.2%). 3. Mean days to begin specialist ante-natal diabetes care for the primary care group was longer (23.6 days) compared to 18.9 days for the secondary care group, though statistically not significant (p=0.09).
7	(Olarinoye, Ohwovoriole et al. 2004)[21]	Lagos, Nigeria	Tertiary hospital	248 pregnant women in their 3rd trimester with mean age of 30.7±4.2 years were randomly selected for 75g (n=138) or 100g OGTT (n=110).	1997-1999	WHO (1985) criteria 75g OGTT; FPG ≥105mg/dl; 2-h plasma glucose ≥165mg/dl National Diabetes Data Group (NDDG) (1979) criteria for 100g OGTT; FPG≥105mg/dl; 1-h plasma glucose ≥190mg/dl; 2-h plasma glucose ≥165mg/dl; 3-h plasma glucose ≥145mg/dl	11.60% 4.50%	1. No significant differences in age (p=0.93), parity (p=0.27), BMI (p=0.33) and presence of risk factors (p=0.75) between the two groups. 2. Prevalence rate of GDM detected by WHO 1985 (11.6%) and NDGG 1979 (4.6%) criteria were significantly different (p=0.04). 3. Out of the 248 participants, 8.5% were diagnosed of GDM by either criterion. 4. 31.3% of women diagnosed of GDM by either criterion had foetal macrosomia while 11.3% non-GDM women had foetal macrosomia (p=0.01)
8	(Sevket, Ates et al. 2014)[22]	Istanbu, Turkey	Tertiary hospital	786 Participants were randomized into two groups using a computer program (Random Number Generator Version 1.0 Segobit software, Issaquah, WA). Group I (n=386, mean age 28.0±4.9), had one-step method (2-h, 75 g OGTT) while Group 2 (N=400; mean age 28.5±5.0) underwent the two-step method, a 50 g GCT at 24–28 weeks of gestation. Those with positive results (140 mg/dl) then underwent a 100 g OGTT.	2011-2012	IADPSG; FPG ≥5.1 mmol/l, 1-h plasma glucose ≥10.0 mmol/l or a 2-h plasma glucose ≥8.5 mmol/l Carpenter–Coustan (C&C); FPG ≥ 95mg/dl; 1-h plasma glucose ≥180mg/dl; 2-h ≥155mg/dl; 3-h ≥140mg/dl	14.5% 6%	1. Maternal demographic variables; Mean maternal age (p=0.171), BMI (p=0.09), history of previous macrosomic delivery (p=0.903) and Positive family history (p=0.057) were not statistically significant between Group 1 and Group 2 2. Prevalence of GDM was significantly higher in Group 1 (14.5%) verses Group 2 (6.0%) (p<0.001) 3. Non-GDM women detected in Group 1 (IADPSG-negative group) had significantly lower incidence of pre-eclampsia, macrosomia polyhydramnios, large for gestational age and greater infant birthweight (p<0.05) than the Non-GDM women in Group 2 (GCT-negative and the C&C-negative groups). 4. IADPSG criteria is more sensitive for prenatal GDM screening and women defined as having normal glucose tolerance by IADPSG criteria had better perinatal outcomes than the other criteria.
9	(Somani, Arora et al. 2012)[23]	Maharashtra, India	Tertiary hospital	723 pregnant women with mean age of 23.45 years; were screened randomly for GDM at 24–28 weeks gestation using O'Sullivan's, Carpenter and Coustan's and WHO 1999 criteria	-	WHO 1999; FPG level ≥7.0 mmol/l (126 mg/dl) or 2-h PG levels after a 75 g OGTT ≥7.8 mmol/l (140 mg/dl) Carpenter and Coustan's (C&C); FPG ≥ 95mg/dl; after 100g OGTT, 1-h plasma glucose ≥180mg/dl; 2-h ≥155mg/dl; 3-h ≥140mg/dl O'Sullivan's; 100g OGTT; FPG ≥105mg/dl; 1-h plasma glucose ≥190mg/dl; 2-h ≥165mg/dl; 3-h ≥145mg/dl	4.80% 6.36% 3.50%	1. The least GDM prevalence was detected by O'Sullivan's criteria (3.45%) compared to WHO (4.8%) and C&C (6.36%) 2. Women with past history of abortion had significantly higher percentage of GDM (p=0.05) by O'Sullivan's criteria (40%) than WHO criteria (25.7%) 3. Women positive for GDM by O'Sullivan's criteria had the highest relative risk of abnormal delivery (RR=1.93, CI= 0.84–4.39) compared to WHO(RR=1.39, CI=0.43–4.48) and C&C (RR=1.17, CI=0.51–2.71), although the differences were not statistically significant

10	(Soonthornpun, Soonthornpun et al. 2003)[24]	Thailand	-	42 pregnant women with 50g GCT values ≥140mg/dl and between 14- and 36-weeks' gestation were randomly selected for both 75g and 100g OGTT within 1-week interval. Mean maternal age 33.6±5.4	-	Carpenter and Coustan's (C&C); FPG ≥ 95mg/dl; after 100g OGTT, 1-h plasma glucose ≥180mg/dl; 2-h ≥155mg/dl; 3-h ≥140mg/dl	21.4%, 100-g, 3-h OGTT 7.1%, 75-g, 2-h OGTT	1. The interval between 75g and 100g OGTT was 3.8±1.5 days 2. GDM prevalence using the C&C and 100g OGTT criteria (21.4%) was higher than using the same C&C criteria for 75g OGTT (7.1%), though the difference was not statistically significant (OR, 0.28; 95% CI, 0.07-1.13; P=0.06). 3. The mean plasma glucose concentrations at 1, 2, and 3 h during the 100g OGTT was significantly higher than those during 75g OGTT (P<0.05)
11	(Stafne, Salvesen et al. 2012)[25]	Trondheim/ Stavanger, Norway	Tertiary hospitals	702 pregnant women booking appointments for routine ultrasound scans at participating hospitals were recruited and randomly assigned to receiving a 12-week standard exercise program (intervention group; n=375, mean age 30.5±4.4 years) or standard antenatal care (control group; n=327, mean age 30.4±4.3 years). Concealed randomization was performed by independent researchers using a Web-based computerized procedure.	2007- 2009	WHO 1999 criteria; fasting glucose level in fasting whole blood ≥6.1 mmol/L, or plasma glucose ≥7.0 mmol/L, or 2-hour value ≥7.8 mmol/L	7%, (intervention group) 6%, (control group)	1. The groups had similar baseline characteristics, except insulin resistance, which was lower in the intervention group (10.1±5.42 IU/mL) than the control group (10.7±5.47 IU/mL) 2. No significant differences in the prevalence of gestational diabetes between groups; 25 of 375 (7%, 95% CI 4.3–9.7) intervention group women compared with 18 of 327 (6%, 95% CI 3.3– 8.6) control group women (P=0.52). 3. pregnancy outcomes were not significantly different between the two groups; Gestational age at birth (p=0.22), preeclampsia (p>0.99), caesarean delivery (p=0.58)

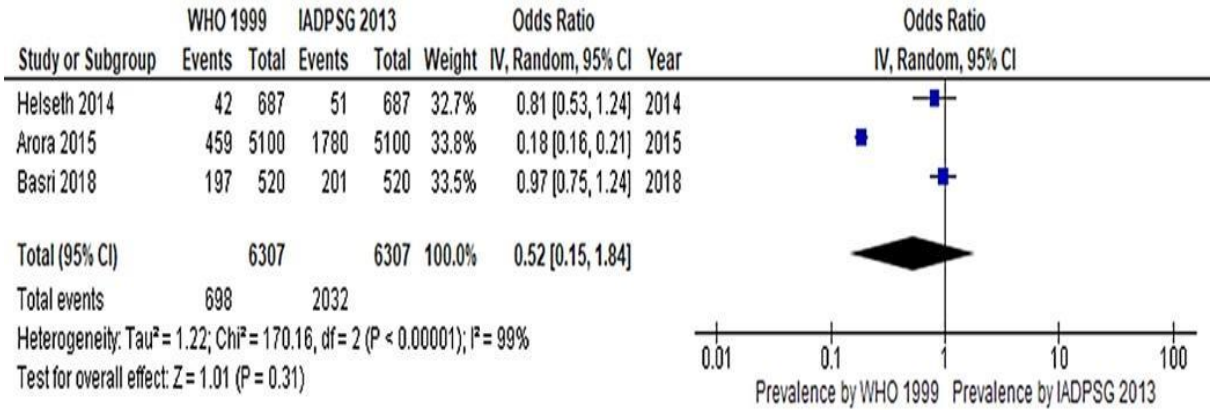

Figure 5: Forest plot showing a comparison between WHO 1999 and IADPSG 2013 diagnostic criteria

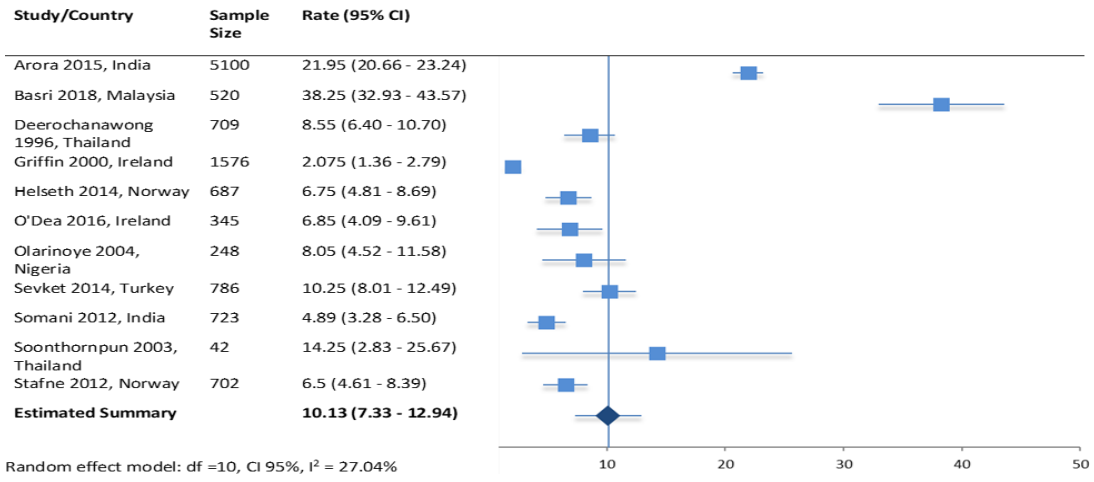

Figure 6: Forest plot showing estimated summary of GDM prevalence from selected studies

6. Discussion

Gestational diabetes mellitus is a global public health concern with adverse implications for the mother and her offspring. There are varying reported global prevalence rates of GDM partly due to differences in screening and diagnostic criteria as well as differences in race-specific risk factors [27, 28]. This review explored the global prevalence rates of GDM and its diagnosis.

Among the 11 included studies for this review, seven different criteria were employed for GDM diagnosis. Compared to selective screening, Griffin, M. E., et al. (2000) identified that universal screening of all pregnant women for GDM detected significant number of positive cases ($p< 0.03$) [18]. Universal screening led to a higher rate

of spontaneous vaginal delivery at term (77.0%), lower rates of Caesarean section (11.4%), and fewer admission to neonatal intensive care unit (2.9%) compared to selective screening: spontaneous vaginal de- livery at term (56.0%), Caesarean section (18.5%), and admission to neonatal intensive care unit (18.5%) [4]. Notwithstanding the cost effectiveness of selective screening [29], this study is in support of literature that relying on risk factors for GDM screening is less sensitive and could potentially miss about 40% of GDM cases [30-32].

The most commonly used diagnostic criterion was WHO 1999 (33%) followed by IADPSG (28%) with O'Sullivan and WHO 1985 criteria being the least (6% each). The optimum criterion for GDM diagnosis is still under debate worldwide, resulting in different approach being endorsed by different stakeholders and countries [32-35]. Within the same population, there were variations of prevalence estimates based on the diagnostic criteria used. The highest variation was recorded in Punjab, India, where the prevalence estimates ranged from 9.00% to 34.90% based on WHO 1999 and IADPSG criteria respectively (1). Likewise, in Bangkok, Thailand, GDM prevalence estimates varied from 1.40% to 15.70% based on NDDG and WHO1999 criteria respectively (3). Similar trend of wide variations in GDM prevalence detected by different diagnostic criteria were observed in Norway (5), Nigeria (7), Turkey (8), and Maharashtra, India (9), while the least variation was reported in Kuala Lumpur, where WHO 1999 and IADPSG criteria detected prevalence rates of 37.90% and 38.6% respectively (2). Variation in the incidence and prevalence rates of GDM in the same population due to different diagnostic criteria have been previously reported, with its impact on prenatal outcomes and health costs still under discussion [36, 37].

Compared with different diagnostic criteria, IADPSG consistently produced higher prevalence rates of GDM than other criteria when applied in the same population with similar maternal demographic variables (1, 2, 5 and 8). This is not surprising as IADPSG comparatively has lower threshold value of fasting glucose (5.1 mmol/L) compared to WHO1999 (7.0 mmol/L), NDDG (5.8 mmol/L), and Carpenter-Coustan (5.3 mmol/L) criteria [32]. Although IADPASG criterion has demonstrated higher sensitivity for GDM detection with associated fewer adverse outcomes for both mother and child [32, 36, 38], its potential to overestimate GDM burden in a population which will consequently inform health policy is a concern. Again, it is thought that over-diagnosis of GDM could predispose women to psychological stress, unnecessary treatments and impaired quality of life [37].

Notwithstanding the type of diagnostic criteria used, the pooled global prevalence of GDM from the included studies was 10.13 [95% CI 7.33 - 12.94]. With majority of the included studies from Southeast Asia, our reported global prevalence is comparable to another study which reported the pooled prevalence of GDM in this region as 10.1% (95% CI 6.5–15.7%) [39]. Our study supports the IDF atlas report that circa 14% of pregnancies are affected by GDM globally [3], and accordingly call for more attention and intervention.

7. Conclusion

There are several risk factors that contribute to the onset of GDM, and from our study increased maternal Body Mass Index (BMI) and age were reported to be significantly higher in women diagnosed with GDM compared to non-GDM women (1, 5). In addition to the underlying risk factors, prevalence estimates of GDM in a population may be influenced by the type of diagnostic criteria employed. Different fasting plasma glucose cut-off points used by the individual diagnostic criteria means that different group of women are identified; thus, creating large differences in GDM prevalence even in the same population. Consequently, care should be taken when interpreting prevalence estimates of GDM within a country and across a region.

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