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Screening and diagnosis of gestational diabetes in India: a systematic review and meta-analysis

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Abstract

Aims—Although diabetes is rapidly increasing in India, there is no national consensus on best practices for screening, diagnosis, and management of gestational diabetes mellitus (GDM). The goal of this study was to systematically review the literature for studies reporting the prevalence and screening and diagnostic methods for gestational diabetes in India.

Methods—We searched MEDLINE, Embase, and POPLINE for studies on screening for GDM in India. We included English-language full reports and conference abstracts of cross-sectional studies, prospective, and retrospective cohorts that reported the screening method and prevalence of GDM. We performed descriptive analysis on all studies and meta-analysis, meta-regression, and subgroup meta-analysis on studies with medium or low risk of bias.

Results—We included 64 studies reporting 90 prevalence estimates. Prevalence estimates ranged from 0 to 41.9%. Subset meta-analyses showed that the IADPSG diagnostic criteria found significantly more GDM cases (prevalence = 19.19% [15.5, 23.6], $p < 0.05$) than the WHO 1999 criteria (10.13% [8.17, 12.50]) and DIPSI criteria (7.37% [5.2, 10.16]). Studies that compared the IADPSG and WHO 1999 criteria showed poor positive agreement (33–79%). Studies specifying time of GDM diagnosis showed that patients (11–60%) develop GDM as early as the first trimester, but many GDM cases (16–40%) are missed if screened only at first visit.

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Conclusions—In India, prevalence estimates of GDM vary substantially by diagnostic criteria. When evaluating screening and diagnostic criteria for GDM, providers should consider their patients' needs and correlate screening criteria with pregnancy outcomes.

Keywords

Gestational diabetes; Pregnancy; India; Screening

Introduction

In 2015, the International Diabetic Foundation (IDF) reported that 1 in 11 people worldwide have diabetes, with 75% of them residing in low and middle income countries [1]. India has the second highest burden of diabetes in the world, with an estimated 69.2 million cases in 2015, which is expected to increase to 123.5 million cases in 2040 [1].

Gestational diabetes mellitus (GDM) is defined by the WHO as hyperglycemia first detected during pregnancy that does not meet diagnostic criteria for diabetes mellitus [2]. Untreated, GDM can lead to a series of adverse outcomes including fetal macrosomia, fetal hypoglycemia and hyper-insulinemia, prematurity, need for C-section, and preeclampsia [3]. However, GDM can often be asymptomatic in the mother.

In India, there is no mandated national screening or diagnostic program for GDM, resulting in a variety of screening, diagnosis, and management algorithms used throughout the country (see Table 1). The questions of who, when, and how to screen and diagnose, and how to manage patients with GDM have been the subject of multiple review papers and perspective pieces [4–7]. Currently, the Diabetes in Pregnancy Study Group of India advocates for universal screening using a single nonfasting 2-h 75 g glucose challenge test, with 2 h value > 140 mg/dL being diagnostic of GDM [8]. However, this recommendation contrasts with guidelines set forth by the WHO [2]. The lack of consensus results in confusion and inconsistent screening and diagnosis. Several provider-based survey studies found that few clinicians abide by the correct cutoffs of any of the available diagnostic criteria [9, 10].

The first step in solving this problem is understanding the epidemiology of GDM. A previous study of 3674 patients across 7 cities in India estimated that the prevalence of GDM was 16.55% in India using the WHO 1999 method [11]. However, subsequent studies have shown high variability in the prevalence, from rates as low as 0% in Manipur to 42% in Lucknow, Uttar Pradesh [12, 13]. A variety of factors may contribute to this variability, including differences in the genetics and population across India, as well as differences in screening practices. We conducted a systematic review on the screening and diagnostic approaches, screened populations, and estimates of GDM prevalence across India to better explain the high variability of GDM estimates in India and provide insight into optimal practices for India.

Methods

Protocol

We followed the PRISMA checklist for reporting of systematic reviews (see Appendix S3). A protocol was developed during the planning process and was not prospectively registered.

Search strategy and inclusion

We conducted a search in MEDLINE, EMBASE, and POP-LINE for studies on gestational diabetes in India. A full search strategy is provided in Appendix S1.

We included original published articles, short communications, and conference abstracts conducted in India in human populations that included the following information:

1. Screening for gestational diabetes mellitus
2. Diagnostic criteria for gestational diabetes mellitus
3. Prevalence of gestational diabetes mellitus

We excluded articles that fell into at least one of the categories listed below:

1. Overviews, editorials, other review papers, or method protocols without results
2. Molecular or genetic studies
3. Studies that did not differentiate between GDM and type 1 and/or type 2 diabetes
4. Studies that reported risk factors, associated biomarkers, or outcomes of GDM without reference to GDM prevalence
5. Studies that took place in nonrepresentative populations, such as studies done at a diabetes referral clinic

Two authors (KL, SN) examined search results for inclusion. Disagreements were settled by a third author (JM) and discussed. When more than one article reporting results from the same population were retrieved, the most informative or most up-to-date article was chosen and the others were excluded.

Data extraction

We obtained full-text articles for all included studies and extracted data regarding region, population (rural/urban), and setting of study. We categorized study region as “North,” “South,” “East,” or “West.” We also extracted and recorded the population screened for GDM, investigators' definition of GDM, screening and diagnostic criteria for GDM, methods of blood glucose collection and analysis, the gestational age of screening, and the reported prevalence of GDM. The diagnostic method for GDM was categorized into one of the methods shown in Table 1, or else categorized as “other.” Where possible, we calculated the prevalence for each study using the raw numbers provided. When a single study reported more than one prevalence proportion based on diagnostic criteria, study setting, or gestational age, we recorded the distribution. We also extracted details about the enrollment procedure and losses to follow-up.

Bias reporting

We assessed bias using the Risk of Bias Tool for Prevalence Studies developed by Hoy et al. [14], and adapted by Macaulay et al. [15] for gestational diabetes (Appendix S5). Studies with a score of eight or more were rated as having low risk of bias; studies with a score of six or seven were rated as having medium risk of bias; and studies with a score of five or less were rated as having a high risk of bias.

Statistical analysis

We calculated descriptive statistics by region, population, and diagnostic method. For studies that compared two or more diagnostic methods, we calculated the absolute difference in prevalence, positive and negative agreement, sensitivity and specificity using the older method as the gold standard, and McNemar's Test to obtain the p value.

For our meta-analysis, we included studies at low and medium risk of bias. We also used R Studio 0.98 running R 3.1.1 with a Metafor package to conduct meta-analysis and meta-regressions. First, we pooled the prevalence proportions using a logit transformation to address the distribution asymmetry of the prevalence proportions. Studies that reported more than one prevalence proportion using different methods were included as two separate estimates. We used a mixed effects model to estimate the prevalence proportion and 95% confidence interval. We used the I^2 statistic to calculate unexplained heterogeneity.

To identify possible sources of heterogeneity between studies, we ran several univariate meta-regressions with mixed effects. We considered the following as variables in each meta-regression: population type (rural vs. urban vs. both), year of publication (continuous), diagnostic criteria, and region where the study was conducted (North, South, East, or West). We examined the I^2 statistic to determine how much heterogeneity could be explained by the variables we included. We then conducted subset analyses for the variables that were found to be significant in the meta-regression and recorded the pooled prevalence proportions, 95% confidence intervals, and I^2 statistic for these subsets.

Results

We identified 1252 studies after searching in MEDLINE, EMBASE, and POPLINE. After removing duplicates, 774 studies remained. Screening by title and setting of the study resulted in 251 remaining articles. Screening abstracts for the relevant inclusion and exclusion criteria resulted in 71 studies. Of these, 2 were excluded because they took place at specialty diabetes centers with high prevalence rates not representative of the general population, and 5 were excluded for being subsets or repeats of other studies (Fig. 1).

The final 64 studies provided a total of 90 prevalence estimates. Out of these, 19 studies (29%) had low risk of bias [16–34], 27 (42%) had medium risk of bias [11–13, 35–58], and 18 (28%) had high risk of bias [59–76]. A table showing the bias tool results for each study is given in Appendix S6. The prevalence of GDM ranged from 0 to 41.9% (see Fig. 3) [12, 13]. Studies varied widely in population type, geography, as well as diagnostic method used. Publication date of the studies ranged from 1988 to 2016. A full list of the included studies is provided in Appendix S2.

Geographic variation

Prevalence measurements varied widely between and within geographical regions. Figure 2 shows the distribution of prevalence throughout the represented states and territories in India. Areas of low prevalence included Assam (3.01%), Manipur (0–1%), Jammu and Kashmir (3.8–11%) and Maharashtra (0.5–9.5%). Areas of high prevalence include Andhra Pradesh (17.20–21.81%) and Uttar Pradesh (13.38–41.87%).

Urban versus rural populations

Twenty-five studies explicitly specified whether their study populations were primarily urban, primarily rural, or both. The prevalence of GDM in the 9 primarily rural studies ranged from 0.5 to 13.9%. The 12 primarily urban studies reported prevalence estimates of GDM ranging from 0.56 to 41.9%.

Of the four studies that reported separate GDM prevalence estimates for both urban and rural populations, the majority found the prevalence of GDM to be higher in urban populations than rural populations [18, 30, 66, 76]. All four studies found that in general, the prevalence of GDM was higher in urban populations than semi-urban populations, and lowest in rural populations (see Appendix S7). Two studies found that being from an urban area was significantly associated with higher rates of GDM [38, 43].

Screening methods and diagnostic criteria

Studies used a wide variety of screening tests and criteria for the diagnosis of GDM (see Table 1). Among all studies reviewed, the most commonly used criteria were WHO99 (32 prevalence estimates), IADPSG (17 prevalence estimates), C&C (16 estimates), DIPSI (12 estimates), and NDDG (5 estimates). Eight prevalence estimates used capillary blood glucose (CBG) or glucometer measurements rather than venous plasma glucose (VPG).

All prevalence estimates were categorized by diagnostic criteria. Detailed differences between the screening tests are provided in Appendix S2. O'Sullivan's, NDDG, and C&C criteria reported lower prevalence estimates than DIPSI and WHO99, which in turn reported lower prevalence estimates than IADPSG criteria (see Fig. 3).

Twenty-six prevalence estimates used a 2-step method: a screening test (usually a 50 g glucose challenge test (GCT)), followed by an oral glucose tolerance test (OGTT) [11, 12, 26, 28, 29, 34, 35, 43, 46, 48, 51, 53, 60, 62–64, 68, 69, 74–76]. GCT cutoffs ranged from 130 to 150 mg/dL, and prevalence estimates using 2-step methods ranged from 0.0 to 23.3%, with a median of 6.0%. Sixty-three prevalence estimates used a 1-step diagnostic method without an initial screening GCT and ranged from 0.5 to 41.9%, with a median of 11.0%.

Seven studies using the IADPSG criteria reported the percent of GDM cases diagnosed by the fasting plasma glucose criterion alone (fasting glucose > 92 g/dL), which ranged from 24.8 to 94%, with a median of 70% (see Appendix S8) [13, 25, 26, 31, 38, 49, 54].

Studies comparing different screening methods

Four studies compared the WHO99 and DIPSI criteria in the same population (Table 2, Appendix S9) [37, 44, 52, 71]. Two found complete agreement between WHO99 and DIPSI, while two showed higher prevalence using WHO99 rather than DIPSI [37, 52, 44, 71]

Ten studies compared the WHO99 and IADPSG criteria in the same population (Table 2, Appendix S9). [13, 18, 31, 38, 44, 49, 50, 54, 71, 77] All ten studies reported a higher prevalence using the IADPSG criteria than the WHO99 criteria, with the difference between the two criteria ranging from 0.16 to 25.90% [13, 49].

Gestational age of screening

Across studies, there was high variability in gestational age at which GDM screening and diagnosis occurred (Appendix S2). The majority ($n = 47$) reported screening at least once after 24-week gestation. However, two studies screened at any time, two studies screened only at first visit, and eight studies did not specify the gestational age of screening.

Eleven studies reported the distribution of GDM diagnosed by gestational age [18, 26, 30, 32, 37, 39, 41, 47, 52, 56, 61]. Six studies reported the percentage of total GDM cases diagnosed in the first trimester, which ranged from 11 to 60% (Appendix S11) [18, 26, 39, 41, 47, 56]. Six studies reported the percentage of total GDM cases diagnosed before 24 weeks of gestation, which ranged from 27.5 to 54.55% [26, 30, 32, 37, 52, 61].

Fourteen studies screened for GDM more than once during pregnancy. Of these, five studies recorded the distribution of GDM cases by first and subsequent visits, showing that 16–40% of GDM cases were diagnosed at subsequent visits (Appendix S11). One study began implementing an additional screen at 34 weeks in the third year of their study [47]. After implementing this, the rate of GDM detection increased by 22%.

Risk factor-based screening

Forty-three studies examined risk factors associated with GDM diagnosis. The most commonly observed risk factors were higher BMI (twenty-six studies [13, 20, 22, 23, 29, 30, 34, 37–39, 41–43, 45, 49, 51, 52, 55, 60, 61, 65–67, 75, 76]), older age (twenty-five studies [12, 18, 26, 30, 33, 34, 38, 39, 41–43, 46, 48–50, 52, 55, 56, 60, 66, 67, 72, 73, 75, 76]), and family history of diabetes mellitus (twenty-four studies [9, 18–21, 25, 29, 30, 33, 34, 37–39, 41, 42, 45, 46, 52, 55, 61, 66, 67, 72, 76]). Other observed risk factors include history of spontaneous abortions or stillbirths (nine studies [21, 33, 34, 39, 42, 53, 65, 66, 76]), history of macrosomia (7 studies [39, 42, 43, 45, 66, 72, 75]), multiparity (7 studies [11, 13, 39, 45, 52, 72, 76]), and higher socioeconomic status (5 studies [13] Hill, 2005 #21) [43, 50, 66]).

Two studies only screened patients with at least one risk factor in their medical history [49, 73], and one study only screened patients with at least two risk factors (Appendix S12) [46]. The prevalence rates ranged from 6% using the C&C method to 19.43% using the WHO99 method [46, 49, 73].

Three studies stratified their patient population into high-risk and low-risk populations (S6 Table) [24, 69, 78]. The prevalence of GDM in the high-risk groups ranged from 3.7 to 10.4%, whereas the prevalence in the low-risk groups ranged from 2.6 to 7.7%.

Meta-analysis results

We performed meta-analysis and meta-regression using the 46 studies (66 prevalence estimates) deemed to be at low or medium risk of bias. The overall meta-analysis showed a pooled prevalence value of 8.88% [7.06, 11.1], with a high rate of heterogeneity ($I^2 = 99.51\%$). We also performed five separate univariate meta-regressions on these 66 prevalence estimates studies on study characteristics of diagnostic method used, area of the country (North, East, West, or South), year (before and after 2010), and population (urban, rural, or both for the 23 estimates that specified), as provided in Appendix S2. All of these study characteristics were found to be significant ($p < 0.05$, see Fig. 4).

Within the regression on diagnostic method, the C&C, NDDG, and O'Sullivan's methods all showed significantly lower prevalence, whereas the IADPSG method showed significantly higher prevalence ($p < 0.05$) as compared to the reference level of the WHO99 method. The DIPSI and WHO99 method were not significantly different. Within the regression on population, a primarily rural population had significantly lower prevalence ($p < 0.05$) compared to the reference level of both urban and rural populations. Within the regression on region of the country, East and West both had significantly lower GDM prevalence ($p < 0.01$) compared to the reference level of South, whereas North was not statistically significant.

We then performed subset meta-analyses for those five variables that we found significant to determine the pooled prevalence values within each subset. The subset meta-analysis models with prevalence estimates are shown in Fig. 4. A higher pooled prevalence of was noted for studies using the IADPSG criteria (19.19% [15.45, 23.58]) as compared to the WHO99 criteria (10.13% [8.17, 12.50]) and DIPSI criteria (7.37% [5.2, 10.16]), and lower pooled prevalence estimates were noted for studies using C&C (5.78% [3.51, 9.38]), NDDG (0.62% [0.09, 4.22]) and O'Sullivan (0.74% [0.43, 1.28]).

Discussion

To our knowledge, this is the first systematic review that quantitatively examining the prevalence of gestational diabetes across India—and factors that influence the prevalence. We identified 64 studies reporting 90 prevalence estimates for gestational diabetes across India. Prevalence estimates ranged from 0 to 41.9% [12, 13]. We found a pooled prevalence estimate of 8.88% [7.06, 11.1] using the studies at low or medium risk of bias, but the heterogeneity of the studies was high at 99.51%, which suggests that the study populations are diverse, and this estimate cannot be generalized across populations in India. Year of publication was a significant contributor to heterogeneity, suggesting that GDM rates may be rising and/or there has been increased awareness of and testing for GDM. Geography, urban/rural populations, and diagnostic criteria were also significant contributors to heterogeneity.

One main finding was that prevalence estimates of GDM vary widely with diagnostic criteria. The most commonly used criteria was the WHO99, followed by IADPSG, C&C, and DIPSI criteria, although variations within these methods also existed in the form of 2-step versus 1-step diagnostic methods, use of capillary versus venous blood glucose, and time of screening. Both our meta-regression and descriptive analyses found that IADPSG criteria result in higher prevalence estimates for GDM than the WHO99 and DIPSI criteria, which in turn have higher prevalence estimates than the C&C, NDDG, and O'Sullivan's criteria. This suggests that existing diagnostic criteria have poor agreement with each other. While this is understandable given that these criteria were enacted for different reasons and validated in different populations, the WHO now makes it clear that the purpose of diagnosing GDM is to prevent adverse maternal and fetal outcomes of pregnancy [2]. Prior research on pregnancy, fetal, and maternal outcomes comparing different criteria have been equivocal [79, 80]. Research in these populations on the association between each diagnostic criteria and outcomes in pregnancy (e.g., macrosomia, neonatal hypoglycemia, need for Caesarian section, etc.) as well as long-term maternal outcomes (e.g., risk for subsequent T2DM) is critically needed to determine which criteria to use.

The higher prevalence using IADPSG may be due to the low fasting blood glucose threshold of 92 mg/dL (Appendix S8). Poor agreement between the IADPSG and WHO99 criteria suggest that at least one of these criteria is misdiagnosing patients with GDM. Previous studies have demonstrated that IADPSG criteria are associated with improved outcomes in pregnancy and a reduction in overall costs [81, 82]. However, there are no conclusive studies on the correlation between IADPSG criteria and pregnancy outcomes in South Asian populations. One previous study showed that fasting glucose may be higher at baseline in South Asians than Caucasian Europeans, and additional studies done in ethnic minorities have also demonstrated discrepancies between IADPSG criteria and older GDM diagnostic criteria [81, 83–85]. Thus, it is important to conduct more studies on the association of pregnancy outcomes with the IADPSG criteria for GDM on Indian populations.

At government hospitals in India, which frequently accommodate large numbers of patients with long travel times who often do not return for follow-up, there is a need for a simple, nonfasting screening test. In recent years, the DIPSI criteria has gained popularity as a one-step screen-and-diagnose test for GDM in India [8, 86]. The fact that the DIPSI criteria was not significantly different from the WHO99 criteria in our regression model may support the use of the DIPSI as a simple alternative for the WHO99 criteria. However, one study comparing DIPSI to WHO99 showed that compared to WHO99, DIPSI has sensitivity of 27.7% and a specificity of 97.7% with a C-statistic of 0.728 [0.673–0.784] [44]. This is a notable outcome: part of the reasoning behind the DIPSI test presupposes that it should be more sensitive than WHO99 [4]. Before adopting DIPSI criteria, clinicians should validate the sensitivity of DIPSI in their own patient populations.

On the question of when to screen for GDM, our descriptive analysis showed that a substantial percentage of patients (11.4–60% of GDM cases) develop GDM in the first trimester, but that a similarly large percentage of patients (16–40% of GDM cases) are missed at the first visit (Appendix S11). Thus, a comprehensive screening program would include screening once early in the first trimester with subsequent screening in the second

and third trimesters. Screening in the first trimester would be beneficial to begin treatment in early-onset cases as soon as possible, as well as detect cases of pre-gestational diabetes. Repeat screening in the second and third trimesters can identify patients who develop GDM later, when there is still time to intervene before delivery. However, this may not be a logistically feasible or cost-effective strategy for all patients, and screening may need to be risk-stratified.

In terms of risk stratification, we found that age, higher BMI, and family history of diabetes mellitus were the risk factors most commonly associated with a diagnosis of GDM. Other common risk factors included prior history of spontaneous abortions or stillbirths, prior history of macrosomia, multiparity, and higher socioeconomic status. However, studies which implemented screening only for patients with medical history risk factors did not consistently show higher rates of GDM in populations with risk factors. Population-specific research is needed on risk factors associated with GDM in order to determine who to screen.

The diversity of GDM prevalence based on geography and population type may explain some of the difficulty in establishing a national program for GDM. India is both genetically and culturally diverse [87, 88] and has recently experienced rapid and unbalanced changes in income and lifestyle correlated with an increasing burden of noncommunicable disease [89–91]. This may account for higher prevalence rates of GDM in urban populations and is consistent with epidemiological patterns of diabetes mellitus in India [16]. This wide range of prevalence estimates across populations argues against a standardized national screening program. Currently, many guidelines suggest universal screening for those of South and Southeast Asian descent, but most of these guidelines were established by examining the prevalence among South and Southeast Asians in high-income nations [92–94]. Our review shows that in some regions in India, the prevalence is as low as 0.5%, in which case universal screening would not be cost-effective, especially for high-burden, low-resource healthcare settings. Thus, regional screening and diagnosis strategies based on evidence from the local population may be more appropriate. Nevertheless, since the rate of GDM also appears to be increasing over time, it is important for clinicians to adopt appropriate screening programs as well as reevaluate their population's evolving risk over time.

Our review has several limitations. Although we comprehensively searched three large databases, we may have missed unpublished studies and studies published in other languages. We also did not conduct any analysis to determine publication bias. However, since the reporting of prevalence proportions should not be subject to publication bias one way or the other, our sample is still likely representative. Secondly, although we attempted to exclude articles that did not distinguish between pre-GDM and GDM, it is likely that many authors included cases of pre-GDM in their studies. Further, some studies did not provide detailed information about their population type, their GDM screening methods, or the distribution between multiple different screening methods that were used. We did not make any attempt to contact the authors, which limited the available information for analysis. Finally, it is difficult to attribute causality in our univariate meta-regression: any of the variables we examined may be confounded by the other variables.

In summary, the prevalence of GDM appears to be rising, though estimates vary widely throughout India. This suggests that screening and diagnosis should be tailored to patient populations. The prevalence of GDM varies widely with screening and diagnostic criteria, which highlights the pressing need for more research. While understanding the prevalence of GDM and its modulating factors is an important first step in bringing awareness to GDM, best practices for the screening and management of GDM should ultimately be supported by research on outcomes in local populations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Fig. 1.
PRISMA flowchart of study selection

Fig. 2. Median prevalence estimates by state/territory. Number of studies for each state/territory shown in bold. Figure made using mapchart.net

Fig. 3.

Distribution of prevalence estimates by screening criteria used. *Other: One study used the WHO99 criteria for type 2 diabetes (fasting > 140 mg/dL or 75 g OGTT 2 h value > 200 mg/dL). One study used 75 g 2 h value > 144 mg/dL. One study used a combination of C&C and IADPSG criteria

Fig. 4.
Results from meta-regression and subset meta-analyses

Table 1
Selected GDM diagnostic criteria commonly used in India

Method	Year	Test	Criteria	Notes
American Diabetes Association 100 g test (ADA100) [95]	2003	Nonfasting 50 g GCT screen + fasting 3 h 100 g OGTT; skip GCT for high-risk populations (e.g., Native American)	Either C&C or NDDG criteria	
American Diabetes Association 75 g test (ADA75) [95]	2003	Nonfasting 50 g GCT screen + fasting 2 h 75 g OGTT; skip GCT for high-risk populations (e.g., Native American)	At least one of the following: Fasting > 95 mg/dL 1 h > 180 mg/dL 2 h > 155 mg/dL	ADA replaced these criteria with IADPSG criteria in 2015
Carpenter and Coustan's (C&C) [96]	1982	Nonfasting 50 g GCT screen + fasting 3 h 100 g OGTT	If GCT > 140 mg/dL, proceed to OGTT At least 2 of the following for OGTT: Fasting > 95 mg/dL 1 h > 180 mg/dL 2 h > 155 mg/dL 3 h > 140 mg/dL	Modified from criteria first proposed by O'Sullivan and Mahan in 1964 to account for assay changes
Diabetes in Pregnancy Study group in India (DIPSI) [86]	2009	Nonfasting 2 h 75 g OGTT	2 h > 140 mg/dL	Prior to 2009, the DIPSI group endorsed the WHO 1999 method. The study done by Anjalakshi et al. showing complete agreement between a fasting test and a nonfasting test spurred the adoption of the nonfasting DIPSI test
International Association of Diabetes and Pregnancy Study Groups (IADPSG) [97]	2010	Fasting 2 h 75 g OGTT	At least one of the following: Fasting > 92 mg/dL 1 h > 180 mg/dL 2 h > 153 mg/dL	Adopted based on outcomes results from the HAPO study in 2008 which included 28,562 women from 15 centers in 9 countries, but did not include India. In 2013, the WHO adopted IADPSG criteria. In 2015, the ADA also adopted IADPSG criteria. However, the NIH did not adopt IADPSG criteria, citing insufficient evidence
National Diabetes Data Group (NDDG) [98]	1979	Nonfasting 50 g GCT screen + fasting 3 h 100 g OGTT	If GCT > 140 mg/dL, proceed to OGTT At least 2 of the following for OGTT: Fasting > 105 mg/dL 1 h > 190 mg/dL 2 h > 165 mg/dL 3 h > 145 mg/dL	Modified from criteria first proposed by O'Sullivan and Mahan in 1964 based on usage of plasma rather than whole blood
O'Sullivan's (O'Sul) [99]	1964	Nonfasting 50 g GCT screen + Fasting 3 h 100 g OGTT	If GCT > 140 mg/dL, proceed to OGTT At least 2 of the following for OGTT: Fasting > 90 mg/dL 1 h > 165 mg/dL 2 h > 145 mg/dL 3 h > 125 mg/dL	Based on detection of glucose in whole blood
WHO 1999 (WHQ99) [100]	1999	Fasting 2 h 75 g OGTT	Fasting > 126 mg/dL OR 2 h > 150 mg/dL	Based on the WHO'S definition of glucose intolerance in nonpregnant women

Table 2

Studies comparing more than one diagnostic method

Study	Region	Prev 1 (%)	Prev 2 (%)	Prev 1–prev 2 (%)	Positive agreement (%)	Negative agreement (%)	Mcnemar's <i>p</i> value (%)
IADPSG vs WHO99		IADPSG Prev	WHO99 Prev				
Bhavadarini et al. [18]	Tamil Nadu	15.67	10.48	5.19	52.16	92.80	< 0.001
Gopalakrishnan et al. [13]	Lucknow, Uttar Pradesh	41.87	17.50	24.37			
Mohan et al. [44]	Tamil Nadu	10.28	8.05	2.23	55.03	95.46	0.017
Nayak et al. [25]	Pondicherry	27.30	6.58	20.72	38.83	87.52	< 0.001
Nilakhe et al. [71]	Surat, Gujarat	33.10	15.68	17.42			
Sagili et al. [49]	Pondicherry	12.59	12.43	0.16	79.22	97.03	0.901
Seshiah et al. [31]	Tamil Nadu	14.63	13.40	1.23			
Surapaneni et al. [54]	Hyderabad	21.81	17.20	4.61	50.75	88.07	< 0.001
Arora et al. [38]		34.88	8.98	25.90	32.78	81.10	< 0.001
Sahariah et al. [50]	Mumbai	10.02	9.92	0.10			
WHO99 versus DIPSI		WHO99 Prev	DIPSI Prev				
Anjalakshi et al. [37]	Tamil Nadu	10.88	10.88	0.00	100.00	100.00	
Mohan et al. [44]	Tamil Nadu	8.05	4.27	3.78	36.22	95.81	< 0.001
Nilakhe et al. [71]	Gujarat	15.68	14.63	1.05			
Sharma et al. [52]	Jammu	11.00	11.00	0.00	100.00	100.00	
C&C Versus NDDG		C&C Prev	NDDG Prev				
Divakar et al. [64]	Bangalore, Karnataka	9.90	6.00	3.90			
Somani et al. [53]	Pune, Maharashtra	6.36	3.46	2.90	70.42	98.47	
Vanlalhrui et al. [12]	Manipur	1.00	0.00	1.00			
C&C versus WHO99		C&C Prev	WHO99 Prev				
Zargar et al. [76]	Kashmir	3.80	4.40	− 0.60			
Somani et al. [53]	Pune	6.36	4.84	1.52			
C&C versus IADPSG		C&C Prev	IADPSG Prev				
Satodiya et al. [51]	Chandigarh	11.81	19.23	− 7.42			