Prevalence and risk factors for gestational diabetes mellitus according to the Diabetes in Pregnancy Study Group India in comparison to International Association of the Diabetes and Pregnancy Study Groups in El-Minya, Egypt

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Introduction
With first recognition during pregnancy, carbohydrate intolerance is defined as gestational diabetes mellitus (GDM) [1–5]. This common metabolic problem is associated with several complications to the mother and the child [6]. The fetal morbidities may include macrosomia, birth trauma, hypoglycemia, hypocalcemia, hypomagnesemia, hyperbilirubinemia, polycythemia, respiratory distress syndrome [6–8], and a higher risk for childhood metabolic syndrome, and diabetes mellitus (DM) in early adulthood [3,5,6]. Mothers may have a considerably elevated risk of preeclampsia, caesarean section, infection, and polyhydramnios [6,8], and type 2 DM later on [6,9]. Also, GDM may uncover an increased risk of developing long-term cardiovascular disease both in the mother and the child [1,4]. The risk factors for GDM include increased parity, high maternal age, prepregnancy obesity, family history of diabetes, and obstetric history of GDM, delivery of an infant with macrosomia, or with congenital malformation [3,8–10]. With a global increase, the prevalence of GDM varies from 1 to 14% [5,8] with higher rates in Australia (Indian-born 15%, Chinese 13.9%) and in the USA (Zuni Indians 14.3%) [11].

The objectives of this study were to assess the prevalence of GDM according to the Diabetes in Pregnancy Study Group India (DIPSI) criteria, and to assess its sensitivity, specificity, and predictive values in comparison to the International Association of the Diabetes and Pregnancy Study Groups (IADPSG) criteria.
Diabetes and Pregnancy Study Groups (IADPSG) criteria and also to examine the association of GDM with a number of risk factors in a sample of the Egyptian pregnant population.

**Patients and methods**

This study was carried out at Minya University Hospital, in El-Minya city (230,000 population), at Upper Egypt from June 2015 to November 2015. The sample size was calculated based on a 5% prevalence of GDM with a 2% uncertainty level [12] with an estimated number of 780 patients required for the study. After approval of the study protocol from the local institutional ethics committee, we contacted the main antenatal care centers in the city to refer the pregnant women with an estimated gestational age of between 24th and 28th weeks who met the inclusion criteria and agreed to participate in the study after signing an informed consent. The exclusion criteria for this study were pre-GDM, chronic illness, and drugs that might affect pregnancy.

All the participants in the study were subjected to full history taking, through clinical examination, and laboratory investigations. The history included demographic characteristics, educational level, smoking, occupation, parity, family history of DM and/or hypertension in the first-degree relatives, past history of GDM, macrosomia (baby was born ≥4 kg), stillbirth, or unexplained neonatal death. The clinical examination was concluded with blood pressure estimation, anthropometric measurements [weight (kg) and height (m)], and BMI estimation. The laboratory investigations included 2 h glucose level after ingestion of 75 g glucose (anhydrous glucose powder is dissolved in 250-300 ml water and consumed within 5 min) irrespective of the meal (fasting or nonfasting) according to the DIPSI criteria [13]. The capillary blood glucose level was estimated, and levels of at least 140 mg/dl were considered diabetic. Then all women screened by DIPSI were requested to come on overnight fasting on the following day and the 2 h 75 g oral glucose tolerance test (OGTT) was performed. Assessment of capillary blood glucose was done with the participant fasting, and 1, and 2 h post-glucose load. According to the International Association of the Diabetes and Pregnancy Study Groups [14], GDM was diagnosed with fasting blood sugar (FBS) of at least 92 mg/dl, 1 h postprandial of at least 180 mg/dl, or the 2-h postprandial of at least 153 mg/dl.

**Statistical analysis**

The collected data were coded, tabulated, and statistically analyzed using the statistical package for the social sciences (SPSS) software, version 23 (SPSS Inc., Chicago, Illinois, USA). Descriptive statistics were done for parametric quantitative data by mean, SD, and the range, while they were performed for categorical data based on the number and percentage. Analyses were done for parametric quantitative data between two groups using independent sample t-test, and for nonparametric quantitative data using Mann–Whitney U-test. Analyses were done for qualitative data using chi-square test, correlation between two quantitative variables was done by using Pearson’s correlation coefficient and for qualitative ordinal variable by using nonparametric Spearman’s ρ correlation coefficient. Odds ratios were calculated for different risk factors using multiple logistic regression analyses (P<0.05). The sensitivity, specificity, and the predictive values (positive and negative) of DIPSI in relation to IADPSG were calculated.

**Results**

Of the 780 consecutive pregnant women during the study period, 80 cases were excluded (68 because of chronic illness and 12 who did not come to do the 2 h 75 g OGTT), and the remaining 700 women were included. Of them, 505 (72.14%) women were from rural areas and 195 (27.86%) were from urban areas. Their mean age was 26.5±5.5 years (range: 18–42). The GDM was diagnosed in 62 (8.86%) cases based on the DIPSI criteria. Upon evaluation of the patients with the IADPSG criteria, GDM was diagnosed in 52 (7.43%) cases only (Fig. 1). The sensitivity, specificity, positive, and negative predictive value of DIPSI in comparison to the IADPSG criteria is about 100, 98.5, 83, and 100%, respectively.

Table 1 summarizes the demographic and baseline characteristics of the studied pregnant women. The
The mean age of the participants was 26.5±5.5 years (range: 18–42 years), with 380 (54.28%) of them under 25 years. The mean marital age was 20.4±2.2 years (range: 17–34 years). The mean body weight was 74.8±8.3 kg (range: 52–130 kg). The mean BMI was 26.7±2.4 (range: 21.8–47.2), with 609 (87%) patients having a BMI of at least 25%, and 91 (13%) having a BMI of less than 25%. Most of the participants (91.42%) were housewives, while only 8.57% were working. On the basis of the educational state, 575 (82.14) patients have secondary education and above versus 125 (17.86%) patients have less than a secondary education. The mean systolic blood pressure was 116.8±7.4 (range: 100–140) and the mean diastolic blood pressure was 74.1±5.4 (range: 60–90).

Table 1 Baseline characteristics of the study population

| Characteristic          | No. (%) | Mean±SD     |
|-------------------------|---------|-------------|
| Age (years)             |         |             |
| Range                   | 18–42   |             |
| Mean±SD                 | 26.5±5.5|             |
| <25 (years)             | 380 (54.28) |          |
| >25 (years)             | 320 (45.72) |          |
| Marital age (years)     |         |             |
| Range                   | 17–34   |             |
| Mean±SD                 | 20.4±2.2|             |
| Body weight (kg)        |         |             |
| Range                   | 52–130  |             |
| Mean±SD                 | 74.8±8.3|             |
| Height (cm)             |         |             |
| Range                   | 153–185 |             |
| Mean±SD                 | 167.3±4.8|            |
| BMI (kg/m²)             |         |             |
| Range                   | 21.8–47.2|            |
| Mean±SD                 | 26.7±2.4|             |
| BMI (kg/m²) <25         | 91 (13) |             |
| ≥25                     | 609 (87) |             |
| Residence               |         |             |
| Rural                   | 505 (72.14) |          |
| Urban                   | 195 (27.86) |          |
| Occupation              |         |             |
| Housewife               | 640 (91.42) |          |
| Worker                  | 60 (8.58) |             |
| Educational level       |         |             |
| <Secondary              | 125 (17.86) |          |
| Illiterate              | 32 (4.6) |             |
| Primary                 | 14 (2) |             |
| Preparatory             | 79 (11.3) |            |
| Secondary or above      | 575 (82.14) |          |
| Secondary               | 454 (64.9) |            |
| High education          | 121 (17.3) |           |
| SBP (mmHg)              |         |             |
| Range                   | 100–140 |             |
| Mean±SD                 | 116.8±7.4|            |
| DBP (mmHg)              |         |             |
| Range                   | 60–90   |             |
| Mean±SD                 | 74.1±5.4|             |

DBP, diastolic blood pressure; SBP, systolic blood pressure.

Table 2 Past obstetric history of the participants

| History                  | No. (%) | Mean±SD     |
|--------------------------|---------|-------------|
| Macrosomic baby          | 696 (99.43) | 4 (0.57)    |
| Twins                    | 690 (98.57) | 10 (1.43)   |
| Abortions or stillbirths  | 588 (84) | 112 (16)    |
| Preterm labor            | 664 (94.86) | 36 (5.14)   |
| Malformation             | 700 (100) | 0 (0)       |
| Gestational HTN          | 668 (95.43) | 32 (4.57)   |
| Previous GDM             | 689 (98.43) | 11 (1.57)   |
| PCOS                     | 698 (99.71) | 2 (0.29)    |
| Family history of DM     | 624 (89.1) | 76 (10.9)   |
| Neonatal death           | 683 (97.57) | 17 (2.43)   |
| Preeclampsia             | 700 (100) | 0 (0)       |

DM, diabetes mellitus; GD, gestational diabetes mellitus; HTN, hypertension; PCOS, polycystic ovary syndrome.
Table 3 Comparison of women with gestational diabetes versus control

| Variables         | Participants | P value |
|-------------------|--------------|---------|
|                   | Control (n=648) | GDM (n=52) |
| Age               |              |         |
| Range             | 18–42        | 20–42   | 0.001 |
| Marital age       |              |         |
| Range             | 17–34        | 18–28   | 0.001 |
| Parity            |              |         |
| <2                | 246 (38)     | 20 (38.5)|         |
| ≥2                | 402 (62)     | 32 (61.5)|         |
| Gravidity         |              |         |
| <2                | 183 (28.2)   | 6 (11.5)| 0.009  |
| ≥2                | 465 (71.8)   | 46 (88.5)|         |
| Body weight (kg)  |              |         |
| Range             | 52–124.6     | 69–130 | 0.001  |
| Height (cm)       |              |         |
| Range             | 153–185      | 159–177| 0.380  |
| BMI (kg/m²)       |              |         |
| Range             | 21.8–39.8    | 26.2–47.2| <0.001*|
| BMI (kg/m²)       |              |         |
| <25               | 84 (12.9)    | 0 (0)   | <0.001*|
| 25–29.9           | 557 (86)     | 30 (57.7)|         |
| ≥30               | 7 (1.1)      | 22 (42.3)|         |
| Residence         |              |         |
| Rural             | 480 (74.1)   | 18 (34.6)| <0.001*|
| Urban             | 168 (25.9)   | 34 (65.4)|         |
| Occupation        |              |         |
| Housewife         | 600 (92.6)   | 40 (76.9)| <0.001*|
| Worker            | 48 (7.4)     | 12 (23.1)|         |
| Educational level |              |         |
| <Secondary        | 109 (16.8)   | 16 (30.8)| <0.001*|
| Illiterate         | 30 (4.6)     | 2 (3.8) |         |
| Primary           | 10 (1.5)     | 4 (7.7) |         |
| Preparatory       | 69 (10.6)    | 10 (19.2)|         |
| ≥Secondary        | 539 (83.2)   | 36 (69.2)|         |
| High education    | 103 (15.9)   | 18 (34.6)|         |

Table 4 Past obstetric history of gestational diabetes mellitus versus control

| History                          | Non-GDM (n=648) | GDM (n=52) | P value |
|----------------------------------|-----------------|------------|---------|
| Macrosomic baby                  |                 |            |         |
| Twins                            | 0/648 (0)       | 4/52 (7.69)| <0.001*|
| Abortion or stillbirth           |                 |            |         |
| Preterm labor                    | 34/648 (5.24)   | 2/52 (3.84)| 0.660  |
| Malformation                     | 0/648 (0)       | 0/52 (0)   |         |
| Gestational hypertension         | 18/648 (2.77)   | 14/52 (26.92)| <0.001*|
| PCOS                             | 0/648 (0)       | 2/52 (3.84)| <0.001*|
| Family diabetes                  | 56/648 (8.64)   | 20/52 (38.46)| <0.001*|
| Neonatal death                   | 13/648 (2.0)    | 4/52 (7.69)| 0.010* |
| Hirsutism                        | 0/648 (0)       | 0/52 (0)   |         |
| Preeclampsia                     | 0/648 (0)       | 0/52 (0)   |         |

GDM, gestational diabetes mellitus.

Table 5 Multiple logistic regression analysis for prediction of gestational diabetes mellitus

| AOR   | 95% confidence interval | P value |
|-------|-------------------------|---------|
| Age (years) | 2.479 | 0.665 | 9.240 | 0.176 |
| Age of marriage (years) | 1.099 | 0.886 | 1.363 | 0.390 |
| BMI (kg/m²) | 1.945 | 1.529 | 2.475 | <0.001* |
| Residence (urban) | 10.116 | 3.117 | 32.828 | <0.001* |
| Job (worker) | 0.484 | 0.085 | 2.757 | 0.414 |
| Educational level (>secondary) | 0.138 | 0.041 | 0.464 | 0.001* |
| Gravidity (>2) | 1.976 | 0.401 | 9.732 | 0.403 |
| Parity (>2) | 0.945 | 0.281 | 3.176 | 0.927 |
| SBP (mmHg) | 0.999 | 0.931 | 1.072 | 0.971 |
| DBP (mmHg) | 1.090 | 0.995 | 1.194 | 0.063 |
| Gestational hypertension | 8.245 | 1.542 | 44.084 | 0.014* |
| Previous GDM | 8.208 | 0.945 | 72.427 | 0.05 |
| Family history of diabetes | 7.949 | 2.290 | 27.594 | 0.001* |
| History of neonatal death | 2.330 | 0.244 | 22.209 | 0.462 |

DBP, diastolic blood pressure; GDM, gestational diabetes mellitus; SBP, systolic blood pressure.

Table 6 presents the comparison of mean age and BMI of the participants based on their residency. The mean BMI of women with urban residency was significantly higher as compared with those with rural residency (P<0.001), but the age has nonsignificant difference. This finding explains the higher percentage of urban residency in the GDM group (Figs 2–4).

Discussion

The prevalence of DM as a major noncommunicable disease in Egypt is rapidly growing probably due to the rapid sociodemographic changes [15,16]. Egypt was identified to be the ninth leading country worldwide in terms of the number of patients with DM with a prevalence rate of 15.9% [15]. Accordingly, it is not surprising to expect an increase in GDM prevalence despite the paucity of literature in this regard [17]. Therefore, this study
was conducted to evaluate the prevalence of GDM in El-Minya city, in Upper Egypt.

Due to the near similarity of the sociocultural status between Egypt and India, we find it wise to use the DIPSJ as a simple, feasible, and single-step screening procedure. Its principle is based on that normal women could maintain an euglycemic state despite the glucose challenge; however, those women with impaired insulin secretion will respond with hyperglycemia [18]. Being a single-step test and evading the need for a second visit for diagnosis, offers a socioeconomic advantage for the Egyptian patients with low socioeconomic status. To evaluate the accuracy of DIPSJ in comparison to the most credible method of screening for DM in the world, we did 2-h OGTT according to the IADPSG criteria.

This study revealed a GDM prevalence of 8.86% based on the DIPSJ criteria versus 7.4% according to the IADPSG criteria. In comparison to the IADPSG criteria, the DIPSJ test has shown a sensitivity and specificity of 100 and 98.5%, respectively. Its positive and negative predictive values in comparison to IADPSG were about 83 and 100%, respectively. These results were comparable to those of many authors: Khalil et al. [17] in Lower Egypt, Swami

Table 6 Comparison of mean age and BMI of participants based on residency

| Variables       | Rural (n=498) | Urban (n=202) | P value |
|-----------------|---------------|---------------|---------|
| Age             |               |               |         |
| Range           | 18–42         | 18–41         | 0.373   |
| Mean±SD         | 26.6±5.6      | 26.2±4.9      |         |
| BMI (kg/m²)     |               |               |         |
| Range           | 21.9–44.8     | 21.8–47.2     | 0.008*  |
| Mean±SD         | 26.6±2.1      | 27.1±3.1      |         |

Figure 2

The state of residency in women with gestational diabetes versus control.

Figure 3

The level of education in women with gestational diabetes versus control.
et al. [19] from Nigeria, Anzaku and Musa [20] from India, and Seyoum et al. [21] from Morocco reported prevalence rates of 8, 8.3, 7.7, and 7.7%, respectively. On the contrary, Macaulay et al. [22] from Tanzania, Jafari-Shobeiri et al. [23] from Iran, and Agarwal [24] from Ethiopia reported GDM prevalence rates of 0, 3.41, and 3.7%, respectively. These stark differences may be attributed to the difference in the diagnostic criteria used or the population studied to the extent that the results reported from five African countries such as Ethiopia, Morocco, Mozambique, Nigeria, and South Africa revealed prevalence figures ranging from 1.6 to 13.9%.

Controversy still exists about the sensitivity and effectiveness of DIPSI versus the commonly used tests for GDM screening as the WHO and IADPSG. In agreement with Vijayalakshmi et al. [25], our results revealed a high sensitivity index for DIPSI test with more cases diagnosed for GDM than the IADPSG criteria. This may be explained by the diurnal variation in glucose tolerance, insulin sensitivity, and β-cell responsivity later in the day, taking into consideration that the DIPSI test can be done at any time in the day, while the IADPSG is usually done in the morning [26–29]. On the contrary, other studies [30,31] have shown that the DIPSI test showed a lower sensitivity index with fewer cases being diagnosed for GDM compared with both WHO and IADPSG criteria. Despite the controversy about DIPSI as a screening tool of GDM, we agree with Seshiah et al. [32] in favor of DIPSI being a simple, single-step screening and diagnostic procedure, economical and easy to perform. It can be considered as a useful tool for comprehensive screening for GDM in the first visit, as well as in the 24–28 gestation weeks for antenatal care, while avoiding multiple complex tests in screening.

In concordance with other studies [33–35], the current study has shown that increasing maternal age was associated with increased GDM prevalence. In our cases, GDM was more frequent among those more than 30 years, while the normal control had a mean age of 24 years. Kanadys et al. [35] reported that maternal...
age of more than 35 years increases the risk of GDM by more than three times.

Although most of the participants in this study were residing in the countryside (75%), the prevalence of the GDM was higher in those living in urban areas (65 vs. 34%). This can be explained in agreement with Macaulay et al. [22] that the transition from rural to urban lifestyle with changes in eating habits, western diet with increased consumption of fats, sugars and refined carbohydrates, increased body mass and decreased physical activity. This was evident in the current study. The mean BMI of women living in urban areas was much higher than those in rural areas (27.1±3.1 vs. 26.6±2.1, \(P=0.008\)).

In agreement with Yang et al. [36], this study has shown that the GDM group had a higher rate of parity of more than two children. On the contrary, Duman [37] reported no role for parity on the risk of GDM and Seghieri et al. [38] reported that parity is not directly related to insulin sensitivity degradation or GDM onset, unless it is associated with the effect of progressive aging and weight gain both before and during pregnancy. This difference is most likely to be explained by the differences in sample population or age.

We agree with Soheilykhah et al. [39], Rajput et al. [40], and Erem et al. [8] that the family history of DM had a significant relationship with the evolution of GDM in the studied group.

Obesity has been reported to be an important risk factor for the development of GDM [19,33,41]. In agreement with Rajput et al. [40], our study revealed that the prevalence of GDM was significantly higher in women with higher BMI and higher body weight. Bianco et al. [42] reported a three-fold higher risk of developing GDM in obese women than in nonobese women [43], 3.76 times in women with a BMI of at least 30 kg/m\(^2\) [44], and up to 60 times more likely to develop GDM in women with at least 30 kg/m\(^2\) than those with a BMI of less than 18.5 kg/m\(^2\). Even prepregnancy BMI and obesity were reported in several studies to be associated with higher prevalence of GDM and represent independent risk factors for GDM [8].

The most important factor affecting insulin sensitivity is unsaturated fatty acids. Pancreatic \(\beta\)-cells increase insulin release in case of increased insulin resistance to maintain euglycemia. These cells may be a victim of dysfunction with constant exposure to high levels of unsaturated fatty acids resulting in type 2 diabetes. Excessive adipose tissue leads to excessive release of unsaturated fatty acids. Similarly, GDM may develop through the same mechanism [45].

The educational level is considered as an indicator of the low socioeconomic position (SEP) [46]. Low SEP has been identified as a major risk factor for the development of type 2 DM [47,48] as well as GDM [49]. This risk may be explained by the relatively high rates of overweight and obesity in this group of people. In agreement with Bo et al. [50] and Bouthoorn et al. [46], we found that women with less than secondary education had an increased risk of GDM. Logistic regression analysis showed that education higher than the secondary school level is risk protective against GDM [odds ratio (OR): 0.138; 95% CI: 0.041–0.464]. On the contrary, other studies did not find any association between GDM with education in Chinese pregnant women [36], or with SEP [51,52].

In agreement with Erem et al. [8], Khalil et al. [17], and Leng et al. [53], our study revealed that gestational hypertension was significantly higher in the GDM group. This was confirmed with regression analysis. On the contrary, Zokaie et al. [34] reported a nonsignificant difference between GDM cases and the control group regarding blood pressure measurement.

In concordance with Pridjian and Benjamin [4], Erem et al. [8], and Khalil et al. [17], our findings have shown that macrosomia was significantly associated with previous history of GDM.

**Conclusion**

The DIPSI criteria may be a suitable tool for GDM screening in our area. The overall prevalence of GDM by DIPSI was 8.86% with a positive predictive value of 84% in relation to IADPSG. The risk factors for GDM development were increased BMI, urban residency, education lower than the secondary level, family history of DM, and gestational hypertension.

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Conflicts of interest
There are no conflicts of interest.

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