Received: 21 June 2022 | Revised: 11 August 2022 | Accepted: 17 August 2022 | Published online: 26 September 2022

DOI: 10.1002/ijgo.14453

CLINICAL ARTICLE

Obstetrics

The NDDG criteria versus the IADPSG or the ADA criteria for diagnosing early-onset gestational diabetes mellitus or abnormal glucose tolerance

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Abstract

Objective: To analyze the effects of substituting the National Diabetes Data Group (NDDG) criteria with the International Association of Diabetes and Pregnancy Study Groups (IADPSG) or American Diabetes Association (ADA) criteria for the diagnosis of early-onset gestational diabetes mellitus (Early-GDM) or first trimester abnormal glucose tolerance (1 t-AGT).

Methods: A retrospective cohort study was conducted of 3200 women: 400 with Early-GDM, 800 with GDM, and 2000 with Non-GDM, according to the NDDG criteria. Rates of women with missed and new Early-GDM according to the IADPSG or ADA criteria were calculated. Multivariate logistic regression analysis was used to compare perinatal outcomes between groups.

Results: Using the IADPSG criteria, 61.6% of women with Early-GDM according to the NDDG were undiagnosed (Missed-Early-GDM group), and 25.9% of women with GDM and 15.7% of women with Non-GDM were diagnosed with Early-GDM (New-Early-GDM groups). Perinatal outcomes were worse in Missed-Early-GDM than in Non-GDM and better in New-Early-GDM groups than in the Early-GDM group. According to the ADA recommendations, only 11.8% of women with Early-GDM according to the NDDG criteria were diagnosed.

Conclusion: Replacing the NDDG recommendations for the diagnosis of Early-GDM with the IADPSG or ADA criteria would mean depriving a large number of women with AGT and higher risk of adverse perinatal outcomes from early treatment and treating others with lower risk.

KEYWORDS

abnormal glucose tolerance, American Diabetes Association (ADA), diagnosis, early, first prenatal visit, gestational diabetes, gestational diabetes, International Association of Diabetes and Pregnancy Study Groups (IADPSG), National Diabetes Data Group (NDDG)

1 | INTRODUCTION

Gestational diabetes mellitus (GDM) is one of the most common medical complications occurring during pregnancy. Its increasing frequency and potentially adverse effects on pregnancy and the future health of both mother and child make it especially concerning.[1] Since O'Sullivan et al.[2] first described GDM almost 60 years ago, large-scale studies have continued to focus on diagnosis during weeks 24–28 of pregnancy. Controversy remains, however, as to which diagnosis to apply, especially before weeks 24–28 of pregnancy.

Recommendations by the National Diabetes Data Group (NDDG),[3] published in 1979 for the diagnosis of GDM before 24–28 weeks of pregnancy (early-onset GDM), include performing a 50-g, 1-hour glucose challenge test (O'Sullivan test) in pregnant women with risk factors at the first prenatal visit. In the case of a positive result, a 100-g, 3-hour oral glucose tolerance test (OGTT) would be performed. Two diagnostic criteria may be used for the 100-g OGTT: the NDDG criteria[3] or the Carpenter-Coustan criteria.[4]

In 2010, the International Association of Diabetes and Pregnancy Study Groups (IADPSG)[5] developed new diagnostic criteria based on the results of the prospective Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study. The IADPSG proposed using a fasting plasma glucose (FPG) range of 92–126 mg/dl during the first 24 weeks of gestation to define early-onset GDM. This threshold is identical to that used after 24 weeks of pregnancy. For the diagnosis of overt diabetes, FPG values of 126 mg/dl and above, glycosylated hemoglobin 6.5% and above, or random plasma glucose 200 mg/dl and above plus a confirmation test could be used.

In 2011, the American Diabetes Association (ADA),[6] the Endocrine Society,[7] and WHO,[8] in 2013, opted to refer to the IADPSG criteria for the diagnosis of GDM. Only 5 years later, in 2016, the ADA[10] accepted both the NDDG and the IADPSG criteria. However, the ADA does not recognize the concept of GDM before week 24 of pregnancy and it recommends testing women with risk factors for undiagnosed diabetes, overt diabetes, at the first prenatal visit, following the standard diagnostic criteria used for the general population.[11]

The American College of Obstetricians and Gynecologists (AGOG)[12] recommends the use of the NDDG criteria to diagnose GDM, although it accepts the use of the IADPSG criteria, and notes that "the best screening test for early-onset GDM (Early-GDM) or type 2 Diabetes in the first prenatal visit is not clear."

The Spanish Diabetes and Pregnancy Study Group (SDPSG), based on the results of its own prospective study,[13] has always maintained the recommendations of the NDDG.[14]

This succession of changes and diversity of criteria has led to increasing international confusion regarding the optimal strategies for the diagnosis of glucose intolerance, which reaches its maximum exponent during the initial weeks of pregnancy.

The aim of the present study was to analyze the effects of substituting the NDDG criteria with the IADPSG or ADA recommendations to diagnose Early-GDM or abnormal glucose tolerance (AGT) in the first trimester of pregnancy.

2 | MATERIAL AND METHODS

The present multicenter, retrospective cohort study was carried out in five university hospitals of the Spanish public health network. Medical records were reviewed to identify the first 400 pregnant women (80 in each hospital) with GDM diagnosed before 12 weeks of pregnancy (Early-GDM), who gave birth between January 1, 2018, and December 31, 2019, in each of the five hospitals (Early-GDM group). For each eligible woman, the next two consecutive women with GDM diagnosed at 24–28 weeks of pregnancy (GDM group) and the next five pregnant women with normal glucose tolerance (Non-GDM group) were included. Thus, the study was carried out in a total of 3200 pregnant women, 400 with GDM diagnosed in the first trimester (Early-GDM group), 800 with GDM (GDM group), and 2000 women who showed normal glucose tolerance during pregnancy (Non-GDM group).

Pregnant women with Early-GDM, GDM, and non-GDM were diagnosed according to the NDDG criteria,[3] using the two-step diagnostic test at the first prenatal visit (before 12 weeks) in pregnant women with risk factors for GDM, and universally, at 24–28 weeks. Pregnant women with glucose values of 140 mg/dl and above on the O'Sullivan test underwent the 3-hour 100-g oral glucose tolerance test (OGTT). Women with two or more values above 105 mg/dl, 190 mg/dl, 165 mg/dl, and 145 mg/dl after 0 m, 60, 120, and 180 min were considered to have Early-GDM or Late-GDM, depending on the time of diagnosis.

The control and treatment protocol for the management of GDM was in all cases the one recommended by the Spanish Group of Diabetes and Pregnancy (GEDE).[14]

The inclusion criteria were as follows: singleton pregnancy; delivery after 24 weeks of pregnancy; birth weight above 500 g; FPG value at first trimester (1 t-FPG); FPG value at 24–28 weeks of pregnancy (2 t-FPG); and a recorded O'Sullivan test and OGTT values, when indicated. All patients with pregestational or overt diabetes (1 t-FPG ≥126 mg/dl) and/or incomplete or implausible data in certain fields were excluded.

The two subgroups below were considered.

2.1 | Using the IADPSG criteria for the diagnosis of Early-GDM (fasting plasma glucose 1 t-FPG ≥92 mg/dl) versus the NDDG criteria

Women were categorized as follows: pregnant women with Early-GDM and 1 t-FPG below 92 mg/dl: Missed-Early-GDM group (M_1); Pregnant women with GDM and 1 t-FPG 92 mg/dl and above: New-Early-GDM group (New_1); and Pregnant women with Non-GDM and 1 t-FPG 92 mg/dl and above: New-Early-GDM group (New_2) (Figure 1).

Maternal characteristics and perinatal outcomes were compared between the following groups: Missed Early-GDM versus Non-GDM; and New-Early GDM (New_1 and New_2) versus Early-GDM.

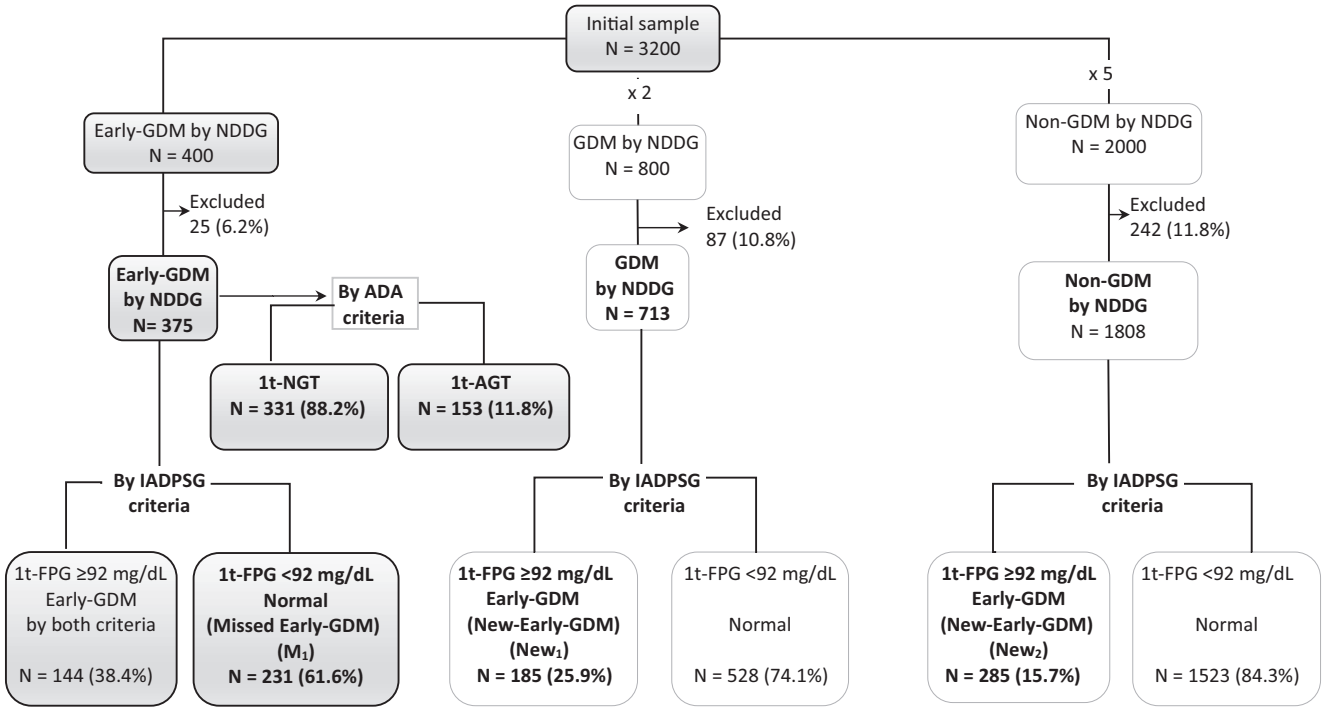

FIGURE 1 Initial and final sample and groups and subgroups analyzed. Pregnant women with early-onset GDM (Early-GDM group), GDM diagnosed at 24–28 weeks of pregnancy (GDM group), and with normal glucose tolerance during pregnancy (Non-GDM group), according to the NDDG[3] criteria. Pregnant women with missed and new early-onset GDM according to the IADPSG[5] criteria (1 t-FPG ≥92 mg/dl) (Missed- and New Early-GDM groups). Pregnant women with normal and abnormal glucose tolerance in the first trimester according to the ADA[6,11] criteria and early-onset GDM according to the NDDG.[3] 1 t-FPG, first trimester fasting plasma glucose; ADA, American Diabetes Association; AGT, abnormal glucose tolerance; GDM, gestational diabetes mellitus; IADPSG, International Association for Diabetes and Pregnancy Study Groups; NDDG, National Diabetes Data Group; NGT, normal glucose tolerance.

2.2 | Using the 2-hour 75-g OGTT 200 mg/dl or above for the diagnosis of abnormal glucose tolerance in the first trimester (1 t-AGT) according to the ADA criteria

According to the results obtained by Soonthornpun et al.,[15] a blood glucose value in a 2-hour 100-g OGTT 214.07 mg/dl or higher is equivalent to a blood glucose value of 200 mg/dl in a 2-hour 75-g OGTT. Thus 1 t-AGT was defined by a 2-hour 100-g OGTT 214.07 mg/dl or higher, according to the ADA criteria.[11,15]

The following subgroups were considered: pregnant women with early-onset GDM according to the NDDG and abnormal glucose tolerance according to the ADA; and pregnant women with early-onset GDM and abnormal glucose tolerance according to the ADA criteria (Missed Early-GDM group, M_2) (Figure 1).

Maternal characteristics and perinatal outcomes were compared between the Missed-GDM (M_2) group and Non-GDM.

2.3 | Outcomes

The following maternal characteristics were assessed: age; body mass index (BMI, calculated as weight in kilograms divided by the square of height in meters); gestational weight gain; chronic hypertension and pre-eclampsia, defined based on the criteria of the International Society for the Study of Hypertension in Pregnancy (ISSHP)[16]; 1 t-FPG and 2 t-FPG; and the need for insulin treatment (yes/no). Perinatal outcomes included pre-eclampsia, prematurity (pregnancy duration <37 weeks), mode of delivery (vaginal or cesarean delivery), birth weight, APGAR score at the 1st and 5th minutes, pH level of umbilical artery, and admission to the neonatal intensive care unit (NICU). Birth weight was converted into a percentile using customized curves from the Spanish Singleton Pregnancy Guidelines.[17] Infants were classified as large for gestational age (LGA) or small for gestational age (SGA) if their birth weight was above or below the 90th or 10th percentile cut-offs, respectively. In addition, two composite variables were considered to analyze adverse perinatal outcomes: composite perinatal outcome 1, where at least one of the following perinatal outcomes occurred: pre-eclampsia, cesarean delivery, APGAR score below 5 at the 1st and 5th minutes, admission to the NICU, or perinatal mortality; and composite perinatal outcome 2, where, in addition to a cesarean delivery, another of the following perinatal outcomes occurred: pre-eclampsia, APGAR score below 7 at the 1st and 5th minutes, admission to the NICU, or perinatal mortality.

2.4 | Ethics statement

The present study complied with the guidelines for human studies and was conducted ethically in accordance with the World Medical Association Declaration of Helsinki. It was accepted by the Ethical

Committee of the Canary Islands University Hospital Complex with the code CHUC-2021-72, on July 30, 2021, as well as by the ethical committees of the other four participating hospitals. The confidentiality of personal data was guaranteed, and given the characteristics of the study, informed consent was not required.

2.5 | Statistical methods

The normality of the data was examined using histograms and the Kolmogorov–Smirnov test. Numerical data are expressed as the mean and standard deviation for parametric variables while qualitative variables are expressed as frequencies and percentages. The differences between the groups were studied using the Student *t* test. Proportions were compared by means of the χ^2 test and the Fisher exact test when any of the expected values were below 5. Multivariate logistic regression analysis was used to compare adverse perinatal outcomes between groups adjusted for maternal characteristics. An alpha of 0.05 was used as the cut-off for significance. For statistical analysis, SPSS version 25.0 (IBM, Armonk, NY, USA) was used.

3 | RESULTS

The initial sample of 3200 patients consisted of 400 women with Early-GDM, 800 women with GDM, and 2000 women with Non-GDM. From this initial sample, 25 (6.2%), 87 (10.8%), and 105 (8.75%) women, respectively, were excluded due to incomplete or implausible data in certain fields. The final sample consisted of 2983 pregnant women: 375 with Early-GDM, 713 with Late-GDM, and 1895 with non-GDM, according to the NDDG criteria. Figure 1 presents both these groups and subgroups using the IADPSG and ADA criteria for early-onset GDM and abnormal glucose tolerance in the first trimester, respectively.

Maternal characteristics and perinatal outcomes of pregnant women with early-onset GDM and GDM, as well as with Non-GDM, are shown in Tables 1 and 2.

The 1 t-FPG, O'Sullivan test, and first trimester 3-hour 100-g OGTT values in the first trimester or at 24–28 weeks for the Early-GDM or GDM groups, respectively, are shown in Table 3. Insulin requirements were higher in the Early-GDM group than in the GDM group (50.5% vs 39.9%).

TABLE 1 Maternal characteristics and perinatal outcomes in pregnant women with early-onset Gestational Diabetes Mellitus (Early-GDM group) and normal glucose tolerance (Non-GDM group) according to the National Diabetes Data Group (NDDG)[3], and in women with early-onset GDM undiagnosed according to the International Association for Diabetes and Pregnancy Study group (IADPSG)[5] criteria [first trimester fasting plasma glucose (1 t-FPG) ≥ 92 mg/dl)], (Missed-Early-GDM by IADPSG, M_1 group)

	Early-GDM			Non-GDM	*P*-value
	1 t-FPG ≥92 mg/dl	1 t-FPG < 92 mg/dl	Total		
	Early-GDM by NDDG and IADPSG	Missed-Early-GDM by IADPSG (M_1)		Total	Missed Early-GDM by IADPSG M_1 vs. Non-GDM
	N = 144 (38.4%)	*N* = 231 (61.6%)	*N* = 375	*N* = 1808	
Maternal age (years)*	35.3 ± 4.5	35.2 ± 4.7	35.2 ± 4.6	30.1 ± 6.0	<0.001
BMI (kg/m^2)*	31.0 ± 6.7	28.5 ± 6.4	29.4 ± 6.6	25.7 ± 5.0	<0.001
Parity >1	92 (64%)	120 (52%)	212 (57%)	793 (44%)	0.021
Chronic Hypertension	15 (10%)	20 (9%)	35 (9%)	22 (1%)	<0.001
Perinatal outcomes					
Preeclampsia	9 (6%)	18 (8%)	27 (7%)	27 (2%)	0.038
Prematurity	19 (13%)	22 (10%)	41 (11%)	110 (6%)	0.030
Cesarean section	45 (31%)	69 (30%)	114 (31%)	234 (13%)	<0.001
LGA	28 (19%)	34 (15%)	62 (17%)	208 (12%)	0.294
SGA	13 (9%)	25 (11%)	38 (10%)	211 (12%)	0.999
APGAR test <7 at 1^{1}st m	12 (9%)	29 (13%)	41 (11%)	137 (8%)	0.088
APGAR test <7 at 5th	3 (2%)	1 (0.4%)	4 (1%)	31 (2%)	0.138
Umbilical artery pH <7	3 (3%)	2 (1%)	5 (2%)	28 (2%)	0.494
NICU admission	13 (9%)	35 (15%)	48 (13%)	141 (8%)	0.001
Composite outcome 1	60 (42%)	100 (43%)	160 (43%)	487 (27%)	0.002
Composite outcome 2	12 (8%)	28 (12%)	40 (11%)	53 (3%)	<0.001

Note: Results are shown as frequency (%); and *, means ± SD. BMI. Body mass index; LGA, large for gestational age; SGA, small for gestational age; NICU, neonatal intensive care unit; Composite outcome 1 (at least one): Preeclampsia, cesarean section, APGAR <7 at 1st and 5th minute, NICU admission or perinatal mortality; Composite outcome 2: Cesarean delivery plus (at least one); Preeclampsia, A <7 at 1st and 5th minute, NICU admission or perinatal mortality.

TABLE 2 Fasting plasma glucose values in the first trimester (1 t-FPG), O'Sullivan test and 100-g oral glucose tolerance test (OGTT) values in the group of women with early-onset gestational diabetes mellitus (Early-GDM group) and gestational diabetes mellitus according to the National diabetes Data group (NDDG)[3]; and in the subgroups with 1 t-FPG < or ≥ 92 mg/dl (Missed and New-Early GDM groups according to the International association for Diabetes and Pregnancy Study Group (IADPSG)[5] (M_1 and New_1, respectively)

	Early-GDM			GDM		
	1 t-FPG ≥92 mg/dl	1 t-FPG < 92 mg/dl	Total	1 t-FPG ≥92 mg/dl	1 t-FPG < 92 mg/dl	
	Early-GDM by NDDG and IADPSG	Missed-Early-GDM by IADPSG (M_1)		New-Early-GDM by IADPSG (New_1)		Total
	N = 144 (38.4%)	*N* = 231 (61.6%)	*N* = 375	*N* = 185 (25.9%)	*N* = 528 (74.1%)	*N* = 713
1 t-FPG	102.5 ± 8.37	82.7 ± 6.60	90.5 ± 12.18	91.2 ± 9.08	81.8 ± 9.15	84.3 ± 10.02
O'Sullivan test	188.6 ± 28.24	174.4 ± 21.57	179.8 ± 25.26	179.9 ± 22.38	170.1 ± 21.50	172.6 ± 22.13
OGTT (mg/dl)**						
Basal	100.0 ± 10.84	83.8 ± 9.06	90.0 ± 12.57	92.1 ± 10.72	83.6 ± 10.51	85.8 ± 11.20
60 min	206.2 ± 26.23	196.0 ± 28.87	200.0 ± 28.29	198.1 ± 24.31	190.7 ± 24.37	192.6 ± 24.55
120 min	187.2 ± 22.68	186.2 ± 22.75	186.6 ± 24.73	182.8 ± 18.82	183.5 ± 19.44	183.3 ± 19.27
180 min	149.0 ± 33.31	152.2 ± 30.43	151.0 ± 31.56	144.0 ± 32.80	152.0 ± 26.39	149.9 ± 28.38
Insulin requirement	82 (56.9%)	107 (46.5%)	189 (50.5%)	68 (42.8%)	196 (39.0%)	264 (39.9%)

Note: Results are shown as frequency (%) and *, means ± SD. 1 t-FPG, fasting plasma glucose in the first trimester of pregnancy. ** OGTT, oral glucose tolerance test at diagnosis.

TABLE 3 Maternal characteristics and perinatal outcomes in pregnant women with Gestational Diabetes (GDM group) and with early-onset Gestational Diabetes Mellitus (Early-GDM group), according to the National Diabetes Data Group (NDDG)[3]; and in women with GDM and early-onset GDM according to the International Association for Diabetes and Pregnancy Study Group (IADPSG) [5] criteria, first trimester fasting plasma glucose (1 t-FPG) ≥ 92 mg/dl, (New-Early-GDM group, New_1)

	GDM			Early-GDM	
	1 t-FPG ≥92 mg/dl	1 t-FPG < 92 mg/dl			
	New-Early-GDM by IADPSG (New_1)		Total	Total	New-Early GDM (New_1) vs. Early-GDM
	N = 185 (25.9%)	*N* = 528 (74.1%)	*N* = 713	*N* = 375	
Maternal age (years)*	34.0 ± 4.8	34.1 ± 5.1	34.1 ± 5.0	35.2 ± 4.6	0.004
BMI (kg/m^2)*	28.7 ± 6.8	26.1 ± 5.6	26.8 ± 6.0	29.4 ± 6.6	0.208
Parity >1	101 (55%)	237 (45%)	338 (47%)	212 (57%)	0.718
Chronic Hypertension	17 (9%)	27 (5%)	44 (6%)	35 (9%)	0.860
Perinatal outcomes					
Preeclampsia	16 (8%)	25 (5%)	41 (6%)	27 (7%)	0.253
Prematurity	23 (12%)	38 (7%)	61 (9%)	41 (11%)	0.418
Cesarean section	34 (18%)	135 (26%)	169 (24%)	114 (31%)	0.006
LGA	32 (17%)	75 (14%)	107 (15%)	62 (17%)	0.758
SGA	19 (10%)	57 (11%)	76 (11%)	38 (10%)	0.926
APGAR test <7 at 1st m	16 (9%)	36 (7%)	52 (8%)	41 (11%)	0.482
APGAR test <7 at 5th m	2 (1%)	8 (2%)	10 (1%)	4 (1%)	0.774
Umbilical artery pH ≤7	3 (2%)	5 (1%)	8 (2%)	5 (2%)	0.969
NICU admission	13 (7%)	46 (10%))	59 (9%)	48 (13%)	0.041
Composite outcome 1	53 (29%)	194 (37%)	247 (35%)	160 (43%)	0.004
Composite outcome 2	14 (8%)	30 (6%)	44 (6%)	40 (11%)	0.354

Note: Results are shown as frequency (%); and *, means ± SD. BMI, body mass index. LGA, large for gestational age; SGA, small for gestational age; NICU, neonatal intensive care unit; Composite outcome 1 (at least one): Preeclampsia, cesarean section, APGAR <7 at 1st and 5th minute, NICU admission or perinatal mortality; Composite outcome 2: Cesarean delivery plus (at least one); Preeclampsia, APGAR <7 at 1st and 5th minute, NICU admission or perinatal mortality.

3.1 | Using the IADPSG criteria for the diagnosis of Early-GDM (fasting plasma glucose 1 t-FPG ≥92 mg/dl) versus the NDDG criteria

- Pregnant women with Early-GDM and 1 t-FPG below 92 mg/dl: Missed-Early-GDM group: the rate of pregnant women with early-onset GDM and 1tFPG below 92 mg/dl (Missed-GDM group, M_1) was 61.6%. Maternal age, BMI, pregnancy weight gain, parity, and rate of chronic hypertension were significantly higher in the Missed-Early-GDM group than in the Non-GDM group. After controlling for maternal characteristics, the rates of pre-eclampsia, prematurity, cesarean delivery, LGA newborn, admission to the NICU, and composite adverse outcomes were also significantly higher in the Missed-Early GDM group (Table 1).
- Pregnant women with GDM and 1 t-FPG at 92 mg/dl or below: New-Early-GDM group: the rate of women with GDM and 1 t-FPG at 92 mg/dl or less was 25.9% (New-Early-GDM group, New_1). Maternal age and BMI were significantly lower in this group than in the Early-GDM group. The rate of cesarean delivery, admission to the NICU, and composite adverse outcomes were also lower in the New Early-GDM group versus the Early-GDM group, after controlling for maternal characteristics (Table 2).
- Pregnant women with Non-GDM and 1 t-FPG of 92 mg/dl or below: New-Early-GDM group: the rate of pregnant women with Non-GDM and 1 t-FPG of 92 mg/dl or less was 15.7% (New-Early-GDM group, New_2). In this group, maternal age, BMI, and the rate of chronic hypertension were significantly lower than in the Early-GDM group according to the NDDG criteria. After controlling for maternal characteristics, perinatal outcomes were significantly worse in the Early-GDM group than in the New-Early GDM group. The rate of prematurity and cesarean delivery were 5% and 13%, respectively, in the New-Early-GDM group versus 11% and 31% in the Early-GDM ($P < 0.027$ and $P < 0.001$, respectively) (Table 4).

3.2 | Using the ADA criteria for the diagnosis of the 1 t-AGT versus the NDDG criteria for the diagnosis of early-onset GDM

The rate of women with early-onset GDM according to the NDDG and normal glucose tolerance in the first trimester according to the ADA criteria (Missed Early-GDM, group, M_2) was 88.2%. Maternal

TABLE 4 Maternal characteristics and perinatal outcomes in pregnant women with normal glucose tolerance during pregnancy according to the NDDG[3] criteria (Non-GDM group) and Early-onset GDM according to the IADPSG[5] criteria, first trimester fasting plasma glucose (1 t-FPG) ≥ 92 mg/dL, (New-Early GDM group, New_2)

	Non-GDM			Early GDM	*P* value
	1 t-FPG ≥92 mg/dl	1 t-FPG < 92 mg/dl			
	New-Early-GDM by IADPSG (N_1)	Non-Early GDM by both criteria	Total	Total	New-Early-GDM (New_2) vs. Early-GDM
	n = 285 (15.7%)	*n* = 1523 (84.3%)	*n* = 1808	*N* = 375	
Maternal age (years)*	30.7 ± 5.9	29.9 ± 6.0	30.1 ± 6.0	35.2 ± 4.6	<0.001
BMI (kg/m^2)*	27.3 ± 5.6	25.5 ± 4.8	25.7 ± 5.0	29.4 ± 6.6	<0.001
Parity >1	146 (51%)	647 (43%)	793 (44%)	212 (57%)	0.181
Chronic Hypertension	6 (2%)	16 (1%)	22 (1%)	35 (9%)	<0.001
Perinatal outcomes					
Preeclampsia	6 (2%)	21 (1%)	27 (2%)	27 (7%)	0.265
Prematurity	13 (5%)	97 (6%)	110 (6%)	41 (11%)	0.027
Cesarean section	37 (13%)	197 (13%)	234 (13%)	114 (31%)	0.001
LGA	38 (13%)	170 (11%)	208 (12%)	62 (17%)	0.869
SGA	34 (12%)	177 (12%)	211 (12%)	38 (10%)	0.730
APGA test <7 at 1st m	32 (11%)	105 (7%)	137 (8%)	41 (11%)	0.466
A test <7 at tth m	2 (1%)	29 (2%)	31 (2%)	4 (1%)	0.544
Umbilical artery pH <7	4 (1%)	24 (2%)	28 (2%)	5 (2%)	0.821
NICU admission	24 (8%)	117 (8%)	141 (8%)	48 (13%)	0.109
Composite outcome 1	86 (30%)	401 (26%)	487 (27%)	160 (43%)	0.168
Composite outcome 2	12 (4%)	41 (3%)	53 (3%)	40 (11%)	0.041

Note: Results are shown as frequency (%); and *, means ± SD. BMI. Body mass index; LGA, large for gestational age; SGA, small for gestational age; NICU, neonatal intensive care unit; Composite outcome 1 (at least one): Preeclampsia, cesarean section, APGAR <7 at 1st and 5th minute, NICU admission or perinatal mortality; Composite outcome 2: Cesarean delivery plus (at least one); Preeclampsia, APGAR <7 at 1st and 5th minute, NICU admission or perinatal mortality.

age, BMI, parity, and the rate of chronic hypertension were higher than in the Missed-Early-GDM group than in the Non-GDM group according to the NDDG group. After controlling for maternal characteristics, the rate of pre-eclampsia, prematurity, cesarean delivery, admission to the NICU, and composite adverse perinatal outcomes 1 and 2 were also more frequent in the Missed-Early-GDM group than in the Non-GDM group (Table 5).

4 | DISCUSSION

In the present study, 61.6% of women with early-onset GDM according to the NDDG[3] had a 1 t-FPG less than 92 mg/dL and would therefore go undiagnosed and be missed according to the IADPSG criteria.[5] The rate of pre-eclampsia and composite adverse outcomes multiplied by four and the rate of admission to the NICU was near double in women with missed early-onset GDM versus women with normal glucose tolerance.

On the other hand, 25.9% of women with GDM diagnosed at 24–28 weeks of pregnancy showed 1 t-FPG of ≥92 mg/dl or above and they would have been diagnosed with early-onset GDM using the IADPSG criteria.[5] This percentage is very high, so it is important to highlight that although these pregnant women did not receive early treatment, perinatal outcomes were significantly better than those of women with early-onset GDM according to the NDDG recommendations.[3]

Finally, 15.7% of pregnant women with normal glucose tolerance according to the NDDG criteria had a 1 t-FPG of 92 mg/dl or above and were diagnosed with early-onset GDM according to the IADPSG. After controlling for maternal characteristics, no differences were found in perinatal outcomes between this New-Early-GDM group and the Non-GDM group. Therefore, the treatment of these new cases would not be justified.

The present results are similar to those of Hillier et al.[18] They concluded in a recent clinical trial conducted on women with GDM diagnosed at 24–28 weeks of pregnancy that, despite more diagnoses of GDM according to the IADPSG, as compared to the two-step approach recommended by the NDDG, no significant between-group differences were found in the risks of perinatal and maternal complications. Zhu et al.[19] and Corado et al.[20] observed that a 1 t-FPG value of 92 mg/dL or higher, may be considered a highly predictive risk factor for late GDM, but is not a diagnosis in itself. It is believed that there are no previous studies conducted in women with early-onset GDM.

The ADA[6,11] recommends testing women with risk factors for type 2 diabetes at the first prenatal visit, following the standard diagnostic criteria used for the general population. Women with

TABLE 5 Maternal characteristics and perinatal outcomes in pregnant woman with early-onset Gestational Diabetes Mellitus (Early-GDM group) and normal glucose tolerance in pregnancy (Non-GDM group) according to the NDDG[3]; and in the tub groups of women with early-onset GDM and normal or abnormal glucose tolerance in the first trimester (1 t-Abnormal-GT and 1 t-Normal-GT), according to the American Diabetes Association (ADA)[6,10] criteria

	Early-GDM		Non-GDM	*P*-value
	1 t-Abnormal-GT by ADA	1 t-Normal-GT by ADA	Total	
	N = 44 (11.8%)	*N* = 331 (88.2%)	*N* = 1808	1 t-Normal GT by ADA vs. Non-GDM
Maternal age (years)*	36.7 ± 4.5	35.0 ± 4.6	30.1 ± 6.0	<0.001
BMI (kg/m^2)*	29.8 ± 6.7	29.4 ± 6.7	25.7 ± 5.0	<0.001
Parity >1	24 (55%)	188 (57%)	793 (44%)	<0.001
Chronic Hypertension	4 (10%)	30 (9%)	22 (1%)	<0.001
Perinatal outcomes				
Preeclampsia	3 (7%)	14 (4%)	27 (2%)	0.091
Prematurity	9 (20%)	32 (10%)	110 (6%)	0.010
Cesarean section	13 (30%)	101 (31%)	234 (13%)	<0.001
LGA	13 (30%)	49 (15%)	208 (12%)	0.232
SGA	2 (5%)	36 (11%)	211 (12%)	0.906
APGAR test at 1 m (≤ 7)	1 (2%)	40 (12%)	137 (8%)	0.145
APGAR test at 5 m (≤ 7)	–	4 (1%)	31 (2%)	0.317
pH ≤7	–	5 (2%)	28 (2%)	0.926
NICU admission	6 (14%)	42 (13%)	141 (8%)	0.020
Composite outcome 1	18 (41%)	142 (43%)	487 (27%)	0.002
Composite outcome 2	4 (9%)	36 (11%)	53 (3%)	<0.001

Note: Results are shown as frequency (%); and *, means ± SD. BMI, body mass index; LGA, large for gestational age; SGA, small for gestational age; NICU, neonatal intensive care unit; Composite outcome 1 (at least one): Preeclampsia, cesarean section, APGAR <7 at 1st and 5th minute, NICU admission or perinatal mortality; Composite outcome 2: Cesarean delivery plus (at least one); Preeclampsia, APGA <7 at 1st and 5th minute, NICU admission or perinatal mortality.

AGT identified before week 24 of pregnancy will be diagnosed with overt diabetes. In the present study, considering the 2-hour 75-g OGTT of 200 mg/dl or above for the diagnosis of AGT in the first trimester, according to the ADA criteria, 88.2% of women with Early-GDM according to the NDDG would not have been diagnosed and they would not have received early treatment. There is no evidence that the ADA criteria for the diagnosis of impaired glucose tolerance before 24 weeks of pregnancy are the most adequate.

The numerous hormonal and biochemical changes caused by pregnancy begin at the time of fertilization and the vulnerability of the embryo and fetus to biochemical changes in their environment is very high from the first weeks of pregnancy.[21,22] However, so far, the benefits of treating pregnant women with GDM have been demonstrated in women with GDM diagnosed after 24–28 weeks of pregnancy.[23,24] Efforts to diagnose and treat GDM should focus on the first trimester rather than on the second, when more than two-thirds of the pregnancy has elapsed and treatment possibilities are limited to a few weeks. By 24–28 weeks of pregnancy, maternal glucose intolerance may have already caused permanent structural and metabolic changes, thereby predisposing the children and their offspring to mental, cardiovascular, and metabolic and endocrine diseases throughout their life.[25,26] At 24–28 weeks of pregnancy, only less severe cases of glucose intolerance should be rescued.

The present study has some limitations: its retrospective design and pregnant women with early-onset GDM received early treatment. The study also has strengths: it addresses understudied aspects of a diagnosis of early-onset GDM and only includes pregnant women with known 1 t-FPG, O'Sullivan test score, and all OGTT glucose values.

Until prospective, randomized studies are available to demonstrate the best procedure to diagnose glucose intolerance in the first weeks of pregnancy, the substitution of the NDDG recommendations for the diagnosis of Early-GDM with the IADPSG or ADA criteria, could potentially deprive more than 61% or 88.2% of women, respectively, with early-onset GDM and high risk of adverse perinatal outcomes of early treatment.

AUTHOR CONTRIBUTIONS

NLGG, EGD, and AM have participated in the conception and design of the work and in the statistical analysis, the final drafting of the manuscript, and the tables. BV, PP, LPC, NV and FB participated in the conception and design of the article and the critical review. The final version has been approved for all authors to be published and they agree with the given sequence of authors.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES

1. Farrar D, Simmonds M, Bryant M, et al. Hyperglycaemia and risk of adverse perinatal outcomes: systematic review and meta-analysis. *BMJ*. 2016;354:i4694. doi:10.1136/bmj.i4694
2. O'Sullivan JB, Mahan CM. Criteria for the oral glucose tolerance test in pregnancy. *Diabetes*. 1964;13:278-285.
3. National Diabetes Data Group. Classification and diagnosis of diabetes mellitus and other categories of glucose intolerance. *Diabetes*. 1979;28:1039-1057. doi:10.2337/diab.28.12.1039
4. Carpenter MW, Coustan DR. Criteria for screening tests for gestational diabetes. *Am J Obstet Gynecol*. 1982;144:768-773. doi:10.1016/0002-9378(82)90349-0
5. International Association of Diabetes and Pregnancy Study Groups Consensus Panel Metzger BE, Gabbe SG, Persson B, Buchanan TA, Catalano PA, Damm P, et al. International association of diabetes and pregnancy study groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy. *Diabetes Care*. 2010;33:676–82. doi: 10.2337/dc09-1848
6. American Diabetes Association. Standards of medical care in diabetes: 2011. *Diabetes Care*. 2011;34:S11-S61. doi:10.2337/dc11-S011
7. Blumer I, Hadar E, Hadden DR, et al. Diabetes and pregnancy: an endocrine society clinical practice guideline. *J Clin Endocrinol Metab*. 2013;98:4227-4249. doi:10.1210/jc.2013-2465
8. World Health Organization. Diagnostic criteria and classification of hyperglycemia first detected in pregnancy. http://apps.who.int/iris/bitstream/10665/85975/1/WHO_NMH_MND_13.2_eng.pdf. [Accessed 12 February, 2020].
9. American Diabetes Association. Classification and Diagnosis of Diabetes. *Diabetes Care*. 2016;39(Suppl. 1):S13-S22. doi:10.2337/dc16-S005
10. American Diabetes Association. 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes—2020. *Diabetes Care*. 2021;44(Suppl 1):S15-S33. doi:10.2337/dc21-S002
11. American College of Obstetricians and Gynecologists. ACOG. Gestational diabetes mellitus. ACOG Practice Bulletin No. 190. *Obstet Gynecol*. 2018;131:e49-e64. doi:10.1097/AOG.0000000000002501
12. Ricart W, López J, Mozas J, et al. Potential impact of American Diabetes Association (2000) criteria for diagnosis of gestational diabetes mellitus in Spain. *Diabetologia*. 2005;48:1135-1141. doi:10.1007/s00125-005-1756-9
13. Grupo Español de Diabetes y Embarazo (GEDE). Care of pregnancies complicated by diabetes. Clinical practice guidelines: 2014 update. *Avan Diabetol*. 2015;31:45-59. doi:10.1016/j.avdiab.2014.12.001
14. Soonthornpun S, Soonthornpun K, Aksonteing J, Thamprasit A. A comparison between a 75-g and 100-g oral glucose tolerance test in pregnant women. *Int J Gynaecol Obstet*. 2003;81:169-173. doi:10.1016/s0020-7292(03)00031-6
15. Brown MA, Magee LA, Kenny LC, et al. The hypertensive disorders of pregnancy: ISSHP classification, diagnosis and management recommendations for international practice. *Pregnancy Hypertens*. 2018;13:291-310.
16. González González NL, Gonzalez Dávila E, González Martín A, García Hernández JA. Maternal thinness and obsesity and customized fetal weight charts. *Fetal Diagn Ther*. 2021;48:551-559. doi:10.1159/000515251
17. Hillier TA, Pedula KL, Ogasawara KK, et al. Gestational diabetes-on broadening the diagnosis. *N Engl J Med*. 2021;384:965-966. doi:10.1056/NEJMoa2026028

18. Corrado F, D'Anna R, Cannata ML, Interdonato ML, Pintaudi B, Di Benedetto A. Correspondence between first-trimester fasting glycaemia, and oral glucose tolerance test in gestational diabetes diagnosis. *Diabetes Metab*. 2012;38:458-461. doi:10.1016/j.diabet.2012.03.006
19. Zhu W-W, Yang H-X, Wei Y-M, et al. Evaluation of the value of fasting plasma glucose in the first prenatal visit to diagnose gestational diabetes mellitus in China. *Diabetes Care*. 2013;36:586-590. doi:10.2337/dc12-1157
20. Angueira AR, Ludvik AE, Reddy TE, Wicksteed B, Lowe WL Jr, LaydenBT. New insights into gestational glucose metabolism: lessons learned from 21st century approaches. *Diabetes*. 2015;64:327-334. doi:10.2337/db14-0877
21. Monteiro LJ, Norman JE, Rice GE, Illanes SE. Fetal programming and gestational diabetes mellitus. *Placenta*. 2016;48:S54-S60. doi:10.1016/j.placenta.2015
22. Crowther C, Hiller JE, Moss JR, et al. Effect of treatment of gestational diabetes mellitus on pregnancy outcomes. *N Engl J Med*. 2005;352:2477-2486. doi:10.1056/NEJMoa042973
23. Landon MB, Spong CY, Thom E, et al. A multicenter, randomized trial of treatment for mild gestational diabetes. *N Engl J Med*. 2009;361:1339-1348. doi:10.1056/NEJMoa0902430
24. Kwon EJ, Kim Y. What is fetal programming?: a lifetime health is under the control of in utero health. *Obstet Gynecol Sci*. 2017;60:506-519. doi:10.5468/ogs.2017.60.6.506
25. Delanerolle G, Phiri P, Zeng Y, et al. A systematic review and meta-analysis of gestational diabetes mellitus and mental health. *Clin Med*. 2021;38:101016. doi:10.1016/j.eclinm.2021.101016

How to cite this article: González-González NL, González-Dávila E, Megía A, et al. The NDDG criteria versus the IADPSG or the ADA criteria for diagnosing early-onset gestational diabetes mellitus or abnormal glucose tolerance. *Int J Gynecol Obstet*. 2023;160:906-914. doi: 10.1002/ijgo.14453