Research, Society and Development, v. 14, n. 11, e247141150245, 2025
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v14i11.50245

Gestational *Diabetes mellitus*: The evolution of diagnostic criteria

Diabetes mellitus gestacional: A evolução dos critérios diagnósticos

Diabetes mellitus gestacional: La evolución de los criterios diagnósticos

Received: 11/24/2025 | Revised: 11/28/2025 | Accepted: 11/28/2025 | Published: 11/30/2025

Beatriz Martins Holtz[1]
ORCID: https://orcid.org/0009-0002-7434-4263
São Paulo State University, Brazil
E-mail: beatriz.holtz@unesp.br
Verônyca Gonçalves Paula[1]
ORCID: https://orcid.org/0000-0002-1590-9781
São Paulo State University, Brazil
E-mail: veronyca.paula@unesp.br
Maria Eduarda Picolo Gomes[1]
ORCID: https://orcid.org/0000-0003-0864-8576
São Paulo State University, Brazil
E-mail: maria.e.gomes@unesp.br
Gustavo Tadeu Volpato[2]
ORCID: https://orcid.org/0000-0002-4753-3264
Federal University of Mato Grosso, Brazil
E-mail: gtvolpato@gmail.com
Débora Cristina Damasceno[3]
ORCID: https://orcid.org/0000-0002-7003-9643
São Paulo State University, Brazil
E-mail: debora.damasceno@unesp.br

Abstract
Diabetes mellitus (DM) is a disease that generates chronic hyperglycemia and can result in secondary complications. Diagnostic criteria for diabetes are methods for detecting the illness and its clinical management. However, unlike the criteria established for non-pregnant diabetic women, there is no single consensus in the current scenario for the diagnosis of Gestational Diabetes mellitus (GDM) by regulatory agencies. Therefore, a review of articles was carried out with the aim of listing the evolution of diagnostic criteria for GDM, focusing on the influence of large clinical trials on current standards and exploring areas where gaps and divergences between guidelines still exist. This is a bibliographic update on the diagnostic criteria for gestational Diabetes mellitus in women and its evolution in recent decades. To cover the main definitions and approaches, studies published in the PubMed, Embase, Scopus and Scielo databases in Portuguese, Spanish and English were included. The clinical studies selected for descriptive analysis demonstrate that the IADPSG diagnosis, currently recommended by the ADA, is the most effective in the early identification of gestational Diabetes mellitus (GDM) and works as a predictor of maternal-fetal risks.
Keywords: Translational Research; Pregnancy; Blood Glucose; Diabetes; Diagnosis.

Resumo
O *Diabetes mellitus* (DM) é uma doença que gera hiperglicemia crônica e pode resultar em complicações secundárias. Os critérios diagnósticos para diabetes são métodos para detecção da doença e seu manejo clínico. No entanto, diferentemente dos critérios estabelecidos para mulheres diabéticas não grávidas, não há consenso atual entre os órgãos reguladores para o diagnóstico de diabetes mellitus gestacional (DMG). Portanto, foi realizada uma revisão bibliográfica com o objetivo de apresentar a evolução dos critérios diagnósticos para DMG, com foco na influência de grandes ensaios clínicos sobre os padrões atuais e explorando áreas onde ainda existem lacunas e divergências entre as diretrizes. Trata-se de uma atualização bibliográfica sobre os critérios diagnósticos para diabetes mellitus gestacional em mulheres e sua evolução nas últimas décadas. Para abranger as principais definições e abordagens, foram incluídos estudos publicados nas bases de dados PubMed, Embase, Scopus e SciELO em português, espanhol e inglês. Os estudos clínicos selecionados para análise descritiva demonstram que o diagnóstico da IADPSG, atualmente

[1] The authors ***Beatriz Martins Holtz*** and ***Verônyca Gonçalves Paula*** credited as joint first authors. Tocogynecology Postgraduate Course. São Paulo State University (Unesp), Brazil.
[2] Laboratory of System Physiology and Reproductive Toxicology. Federal University of Mato Grosso (UFMT), Brazil.
[3] São Paulo State University (Unesp), Brazil.

recomendado pela ADA, é o mais eficaz na identificação precoce do diabetes mellitus gestacional (DMG) e funciona como preditor de riscos materno-fetais.
Palavras-chave: Pesquisa Translacional; Gravidez; Glicemia; Diabetes; Diagnóstico.

Resumen
La *Diabetes mellitus* (DM) es una enfermedad que causa hiperglucemia crónica y puede resultar en complicaciones secundarias. Los criterios diagnósticos para la diabetes son métodos para detectar la enfermedad y su manejo clínico. Sin embargo, a diferencia de los criterios establecidos para mujeres diabéticas no embarazadas, actualmente no existe un consenso entre los organismos reguladores para el diagnóstico de la diabetes mellitus gestacional (DMG). Por lo tanto, se realizó una revisión de la literatura para presentar la evolución de los criterios diagnósticos para la DMG, centrándose en la influencia de grandes ensayos clínicos en los estándares actuales y explorando áreas donde aún existen brechas y divergencias entre las guías. Esta es una actualización bibliográfica sobre los criterios diagnósticos para la diabetes mellitus gestacional en mujeres y su evolución en las últimas décadas. Para cubrir las principales definiciones y enfoques, se incluyeron estudios publicados en las bases de datos PubMed, Embase, Scopus y SciELO en portugués, español e inglés. Los estudios clínicos seleccionados para el análisis descriptivo demuestran que el diagnóstico IADPSG, actualmente recomendado por la ADA, es el más efectivo en la identificación temprana de la diabetes mellitus gestacional (DMG) y funciona como predictor de riesgos materno-fetales.
Palabras clave: Investigación Traslacional; Embarazo; Glucemia; Diabetes; Diagnóstico.

1. Introduction

Diabetes mellitus (DM) is a complex and multifactorial disease that causes implications related to dysfunction in glycemic regulation, generating a state of chronic hyperglycemia that results in secondary and progressive complications (American Diabetes Association - ADA, 2024). The pathophysiology of diabetes involves genetic and environmental factors that contribute to chronic hyperglycemia leading to micro and macrovascular metabolic dysfunctions. Hyperglycemia in DM occurs due to different mechanisms of failure in the secretion/action of insulin by pancreatic beta (β) cells, responsible for synthesizing and secreting insulin and, thus, modulates plasma glucose (Khan et al., 2019; Sociedade Brasileira de Diabetes - Brazilian Diabetes Society - SBD, 2023). Resistance, deficiency or absence of insulin secretion is decisive in the classification of DM. In type 1 diabetes (DM1), the increase in plasma glucose is due to the immunological self-destruction of pancreatic β cells. In type 2 diabetes (DM2), there is a progressive defect in the synthesis and/or secretion of insulin, generating a resistance to this hormone, leading to an inadequate response of the body to the amount of insulin synthesized (Khan et al., 2019). In long term, diabetes causes complications in different organs and tissues, including the kidneys, heart, eyes and blood vessels. These complications negatively impact individuals' health and significantly burden public finances due to their high morbidity and mortality rates. (Glechner et al., 2018; Khan et al., 2019; Marciano et al., 2019).

Regarding the diagnostic criteria for diabetes, standardization is essential for the early detection of the disease and its clinical management, as well as for the prevention of complications through individualized interventions and treatments. The development of investigation protocols by regulatory agencies specialized in diabetes follows scientific evidence and different screening methods (ADA, 2014). The ADA's recent recommendations for the diagnosis of diabetes are based on the measurement of glycated hemoglobin (HbA1c), fasting plasma glucose (FPG), 2-hour blood glucose value during the 75g oral glucose tolerance test (OGTT) or random glucose, with the first three tests being appropriate for diagnostic screening. It is noteworthy that the same tests can be used to screen individuals with prediabetes (ADA, 2024).

The Brazilian Diabetes Society (SBD) recommends that screening for *Diabetes mellitus* in non-pregnant and asymptomatic women be performed by fasting plasma glucose greater than or equal to 126 mg/dL, 2-hour glucose levels after a 75g glucose overload greater than or equal to 200 mg/dL, or glycated hemoglobin (HbA1c or A1c) greater than or equal to 6.5%. For this, at least two of these parameters must be altered (SBD, 2023). The diagnosis can also be made based on random blood glucose levels that, when equal to or greater than 200 mg/dL and associated with symptoms of hyperglycemia, indicate the presence of DM. These recommendations follow the guidelines of the Brazilian Diabetes Society (SBD, 2021).

The ADA emphasizes that there is greater specificity in diagnosing diabetes by measuring HbA1C, because its values are less altered by daily changes, including stressful situations, and fasting is not necessary for collection. In addition, HbA1c reflects the glucose bound to hemoglobin over the last 120 days, so it is less susceptible to changes by generating a "weighted average". However, there is a higher cost to perform the test and it may be inaccessible in some regions of the world and is not ideal for individuals with syndromes that affect red blood cells (Eckhardt et al., 2012; ADA, 2024).

Considering the latest technological advances, new research correlates the pathophysiology of diabetes with the existence of specific biomarkers, oxidative stress and epigenetics (Dhawan and Natarajan, 2019). Molecular compounds, which are observed before the first symptoms appear through clinical analyses of biological materials, could also be considered as genetic biomarkers. In addition, they play an essential role in the detection and management of diabetes, especially in DM1 and DM2 (Silva et al., 2009; Obando et al., 2022). Currently, the analysis of biomarkers has become a strategy for the prevention of comorbidities, since they are identified before the onset of the clinical disease (FDA-NIH, 2016; Califf, 2018; Obando et al., 2022). As research progresses, biomarkers for *Diabetes mellitus* (DM) may serve as complementary tools to traditional diagnostic criteria (Balkrishna et al., 2024).

DM2, present before pregnancy, is related to adverse outcomes such as maternal morbidity, fetal macrosomia, fetal loss, and neonatal death (Szmuilowicz et al., 2019). If not managed correctly during prenatal care, it can lead to worsening of glycemic control and chronic microvascular complications, since pregnancy itself generates a diabetogenic state (ABI-ABIB et al., 2014). The diagnosis of GDM, in turn, is based on criteria similar to those defined by different regulatory agencies that regulate the main care guidelines and address the most recent recommendations in the area. Diagnostic criteria are determined from the measurement of fasting plasma glucose levels, OGTT, and/or HbA1c screening, observing specific collection and evaluation protocols (ADA, 2024). These parameters were determined after several reviews, clinical trials and observational studies that highlighted the need for greater diagnostic accuracy to improve clinical practice and research (O'Sullivan and Mahan, 1964; Carpenter and Coustan, 1982; HAPO, 2008; IADPSG, 2010). GDM is characterized by glucose intolerance with diagnosis from the second trimester of pregnancy (ADA, 2024). According to the International Diabetes Federation (IDF), one in six births are affected by hyperglycemia during pregnancy (IDF, 2021).

There is controversy among regulatory agencies regarding the screening and management of diabetes in pregnant women. There is no single consensus in the current scenario for the diagnosis of GDM (IADPSG, 2010; WHO – World Health Organization, 2023; ADA, 2024). Given the various criteria for diagnosing diabetes in pregnancy by regulatory agencies, it is necessary to review the diagnostic criteria for GDM, highlighting their crucial points in diagnostic accuracy and early detection of the disease. To this end, a review of articles was carried out that aimed to list the evolution of the diagnostic criteria for GDM, focusing on the influence of large clinical trials on current standards and exploring areas where there are still gaps and divergences between the guidelines.

2. Methodology

A systematic bibliographic research was carried out (Snyder, 2019), of a quantitative nature in relation to the quantity 8 (Eight) articles and, qualitative in relation to the analysis carried out on these articles (Pereira et al., 2018). This is a bibliographical update on the diagnostic criteria for gestational *Diabetes mellitus* in women and its evolution in recent decades. To cover the main definitions and approaches, studies published in PubMed, Embase, Scopus and Scielo databases in Portuguese, Spanish and English were included.

The combination of Health Sciences Descriptors (DeCS) was performed using Boolean operators, such as AND and OR to refine the search and ensure the retrieval of relevant studies: ("Gestational *Diabetes mellitus*" AND "Diagnostic

Criteria") AND (Clinical Trials OR Guidelines). Subsequently, the inclusion criteria were defined as follows: 1. Clinical trials and systematic reviews published between 1964 and 2024 were included, covering studies from the earliest research on GDM to the present day. This enables the analysis of various diagnostic methodologies in relation to gestational outcomes; 2. Articles available in English, Portuguese and Spanish to ensure greater breadth. The study filtering period was based on pioneering studies (from the 1960s), which address GDM diagnostic values and methods. For the exclusion criteria, the following were excluded: 1. Case studies or isolated reports, which did not address the diagnostic criteria in diabetes or did not correspond to the title; 2. Duplicate publications; 3. Studies that did not clearly mention the relationship between diagnostic criteria and gestational outcomes and did not focus on GDM.

The selected articles were exported to Mendeley reference management software. The Mendeley deduplication tool was used to identify and remove duplicate articles, comparing records based on metadata such as title, authors, year of publication and DOI (Digital Object Identifier). The “Check for duplicates” function guaranteed the exclusion of duplicate articles without losing relevant information. Next, the studies were compared directly with the research objectives, focusing on the diagnostic criteria established by regulatory agencies and the discussion about the best diagnostic method. This step allowed the removal of articles that did not clearly and consistently address the diagnostic criteria for GDM or that addressed other issues not relevant to the analysis. After filtering, the selected articles were read in full and a qualitative analysis was carried out with extraction of information such as: Title, Author, Year, Type of Study, Diagnostic criteria and Recommendations for clinical practice.

3. Results

In the overall screening of studies using DeCS, a total of 958 articles were identified, establishing the search period over the last six decades. After applying the first filter including the inclusion criteria - clinical trials and systematic reviews - 195 studies were listed and 763 were removed. Of the total of 195 articles imported from different databases, 21 duplicates were identified. After removing duplicates, the titles and abstracts of the remaining 174 articles were read, applying previously defined inclusion and exclusion criteria, such as compatibility between the title of the paper and the objective of the research. Articles whose title and abstract did not correspond to the research objective were removed, leaving 20 studies, which were read in full. Of the studies analyzed in the last filtering stage, 60% were excluded because they did not clearly mention the influence of diagnostic criteria on the management of GDM. The works selected after screening related articles regarding the descriptive analysis of the studies are presented in Table 1. In the end, eight articles were listed (Figure 1).

Table 1. Summary of the main studies selected.

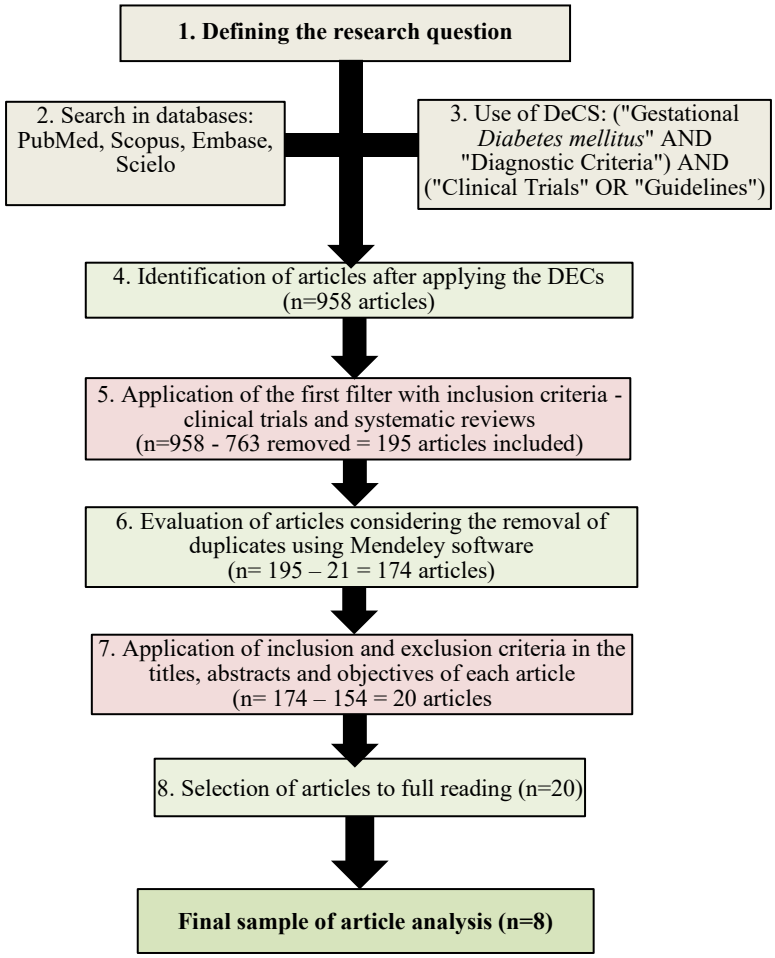
Author (year) - Journal	Title	Type of Study	Diagnostic criteria addressed	Recommendations for clinical practice
Carpenter e Coustan (1982) - American Journal of Obstetrics and Gynecology	*Criteria for Screening Tests for Gestational Diabetes*	Clinical trial	Adaptation of the O’Sullivan criteria for pregnant women.	Perform the Oral Glucose Tolerance Test (OGTT) in pregnant women with blood glucose levels ≤ 130mg/dL
Coustan et al. (2010) - American Journal of Obstetrics and Gynecology	*The Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study: paving the way for new diagnostic criteria for gestational Diabetes mellitus*	Observational multicenter study that provided data for guidelines	Standardization of the use of the 75g TOTG (one-step strategy recommended by the ADA)	International consensus for the diagnosis of GDM using just one altered OGTT value of 75g (ADA): Fasting: 92 mg/dL 1 hour: 180 mg/dL 2 h: 153 mg/dL

Houshmand et al. (2013) - Acta Obstetricia et Gynecologica Scandinavica	*Evolution of diagnostic criteria for gestational diabetes mellitus*	Review	O'Sullivan and Mahan, Carpenter-Coustan, NDDG (National Diabetes Data Group), ADA, WHO, Australian Diabetes in Pregnancy Society (ADIPS), European Association for the Study of Diabetes (EASD), IADPSG, WHO.	Recommend the IADPSG guidelines, as it is the only diagnostic methodology that classifies hyperglycemia in pregnancy and associates it with the risk of adverse perinatal events. 75g OGTT (IADPSG): Fasting: 92 mg/dL 1 hour: 180 mg/dL 2 h: 153 mg/dL
Agarwal (2015) - Journal of Diabetes and its Complications	*Gestational diabetes: differences between the current international diagnostic criteria and implications of switching to IADPSG*	Clinical Trial	ADA (2003), ADIPS, (1998), Canadian Diabetes Association (2013), Canadian Diabetes Association Clinical Practice Guidelines Expert Committee (CDA-CPG, 2003), EASD (1996), IADPSG (2010), New Zealand Society for the Study of Diabetes (NZSSD, 2004), WHO, 1999.	Establishing the IADPSG criteria as the gold standard for diagnosing GDM, as a single globally accepted guideline would resolve the disparity between regulatory agencies.
Harper et al. (2016) - Obstetrics and Gynecology	*Carpenter-Coustan Compared With National Diabetes Data Group Criteria for Diagnosing Gestational Diabetes*	Clinical Trial	Carpenter-Coustan e NDDG	Women diagnosed with GDM by the less stringent Carpenter-Coustan criteria and women diagnosed by the more stringent NDDG criteria benefit equally from treatment. For GDM, two or more values must be altered in a 3-hour OGTT with 100g of glucose: Carpenter-Coustan: Fasting: 95 mg/dL 1 hour: 180 mg/dL 2 h: 155 mg/dL 3h: 140 mg/dL NDDG: Fasting: 105 mg/dL 1 h: 190 mg/dL 2 h: 165 mg/dL 3h: 145 mg/dL
Moon e Jang (2022) - Diabetes and Metabolism Journal	*Gestational Diabetes Mellitus: Diagnostic Approaches and Maternal-Offspring Complications*	Systematic Review	IADPSG, NDDG, KDA (Korean Diabetes Association), Carpenter-Coustan.	The one-step strategy allowed two to three times more women to be diagnosed with GDM compared to the two-step strategy, however, the study highlights that the choice of diagnostic approach must also take into account cost-effectiveness and clinical feasibility. 75g OGTT (IADPSG): Fasting: 92 mg/dL 1 hour: 180 mg/dL 2 h: 153 mg/dL Or 2-step strategy with 50g TSG: If blood glucose ≥130, 135 or 140 mg/dL, proceed with the 100g OGTT: Fasting: 95 mg/dL 1 hour: 180 mg/dL 2 h: 155 mg/dL 3 h: 140 mg/dL

Wenrui Ye et al. (2023) - BMJ	*Gestational diabetes mellitus and adverse pregnancy outcomes: systematic review and meta-analysis*	Systematic Review	IADPSG, DIPSI (Diabetes Pregnancy Study Group of India) e ADIPS	The diversity of diagnostic criteria used before 2010 was a limiting factor in determining pre-existing hyperglycemia, demonstrating that the standardization of a criterion in clinical practice improves diagnosis and analysis in future studies. 75g OGTT (IADPSG): Fasting: 92 mg/dL 1 hour: 180 mg/dL 2 h: 153 mg/dL
Mocellin *et al.* (2024) - Cadernos de Saúde Pública	Prevalence of gestational diabetes in Brazil: systematic review and meta-analysis	Systematic Review	IADPSG e ADA	Since 2017, Brazilian guidelines have been based on the IADPSG consensus. This is the most up-to-date diagnostic criterion and has achieved the highest prevalence in detecting GDM. 75g OGTT (IADPSG): Fasting: 92 mg/dL 1 hour: 180 mg/dL 2 h: 153 mg/dL

Source: Research data (2025).

Figure 1. Flowchart of the selection process and choice of articles for analysis.



Source: Research data (2025).

4. Discussion

The review of articles sought to map the evolution of the criteria over time, with emphasis on the influence of large clinical trials such as the Hyperglycemia and Adverse Pregnancy Outcome - HAPO study (2008) in the formulation of current standards. The HAPO study was a large-scale study that assessed the risk of adverse maternal-fetal and neonatal outcomes, which increases as maternal blood glucose levels rise between 24-28 weeks of gestation. This study was a landmark for the determination of new diagnostic criteria for gestational *Diabetes mellitus* (GDM) because it evaluated more than 25,000 pregnant women in an international and multicenter manner, generating a high clinical impact (Scholtens et al., 2019). The research associated glycemic ranges with gestational outcomes, establishing that maternal hyperglycemia, even when considered mild and below the diagnostic thresholds previously used, is related to an increase in maternal-placental adverse events (HAPO, 2008; Coustan et al., 2010).

The main finding of the study was the consensus established by the IADPSG and has been widely accepted and considered the most effective for early screening of GDM (Houshmand et al., 2013; Agarwal, 2015; Moon and Jang, 2022; Mocellin et al., 2024). Researchers agree that the IADPSG criteria, adopted by the ADA, has greater sensitivity in identifying pregnant women with hyperglycemia and is strongly associated with the prevention of adverse perinatal outcomes, such as macrosomia, preeclampsia, and neonatal complications (Farrar et al., 2017). According to Harper et al. (2016), the IADPSG method was able to detect a higher prevalence of GDM compared to the NDDG and Carpenter-Coustan criteria. Housmand et al. (2013) and Agarwal (2015) concluded that the IADPSG criteria are considered the gold standard for diagnosing GDM and discussed the importance of postpartum follow-up, since women with GDM have a higher risk of developing T2DM in the future. Mocellin et al. (2024) presented the Brazilian guidelines for the diagnosis of GDM and the 2017 consensus on the use of the IADPSG diagnostic criteria by national regulatory agencies. However, according to Moon and Jang (2022), there are still regional divergences and differences in the implementation of the guidelines, especially in countries with scarce resources and infrastructure.

It was expected that, following the recommendations made by the HAPO study, discussions about the diagnostic criteria for GDM would be resolved. However, what actually happened was a prolonged debate about the advantages and disadvantages of the criteria already established (Tsutida et al., 2022). The lack of global uniformity raises concerns about the suitability of tests in specific populations, suggesting that future studies should evaluate diagnostic efficacy in different cultural and socioeconomic contexts (Ye et al., 2023).

Pioneering studies on gestational Diabetes mellitus

Over the past few decades, the diagnostic criteria for gestational *Diabetes mellitus* have been revised and adjusted several times, based mainly on evidence provided by clinical trials and observational studies that highlighted the need for greater diagnostic accuracy. In 1949, the study “Pregnancy Complicating Diabetes” was published by Priscilla White, one of the pioneers in the study of diabetes during pregnancy. The research was published in the American Journal of Medicine and covered 15 years of research on fetal mortality in diabetic pregnancies. These findings were based on the P. White Classification, which is used to categorize GDM according to the risk and duration of the disease. White was instrumental in developing guidelines for the diagnosis and treatment of gestational diabetes. His work helped establish diagnostic criteria that are still used today and his influence had clinical repercussions on the importance of rigorous monitoring of GDM in endocrinology and obstetrics through the creation of protocols that optimize perinatal outcomes (White, 1949; Hare and White, 1980; Castagnetti, 2017).

In 1964, O'Sullivan and Mahan proposed a diagnosis based on glycemic ranges using the Oral Glucose Tolerance Test (OGTT) as a method to detect diabetes in pregnant women. This criterion was later adapted by Carpenter and Coustan (1982), who adjusted the cutoff values and established the relationship between maternal glucose levels, risk of developing DM2 and obstetric complications. For these researchers, the diagnosis of GDM would be confirmed if two or more glycemic values were altered after a 100g glucose overload in the OGTT. The cutoff values for detecting diabetes during pregnancy were classified as: fasting ≥ 95 mg/dL; 1h: ≥ 180 mg/dL; 2h: ≥ 155 mg/dL; 3h: ≥ 140 mg/dL. (Carpenter and Coustan, 1982).

The National Diabetes Data Group (NDDG, 1979) established cutoff values for diagnosing GDM based on the 100g OGTT performed in adults in general. The main objective of the study was to standardize the diagnostic approach. According to the NDDG, the diagnosis of gestational *Diabetes mellitus* was established when two or more of these glucose values exceeded during the test: fasting ≥ 105 mg/dL; 1h: ≥ 190 mg/dL; 2h: ≥ 165 mg/dL; 3h: ≥ 145 mg/dL. Although it was one of the pioneering studies, the criteria were not based exclusively on pregnant women, which raised questions about the accuracy of the technique. Thus, it was considered an inconclusive criterion because it did not take into account the metabolic peculiarities of pregnancy (Berggren, 2011; Harper et al., 2016).

In 1998, the Lancet published the United Kingdom Prospective Diabetes Study (UKPDS, 1998), which was fundamental to understanding the comorbidities associated with diabetes and their risk factors. Although it focused on the general population, the results presented were essential to demonstrate strict glycemic control to prevent comorbidities associated with the disease. This finding has direct implications for the early diagnosis and treatment of diabetes in pregnancy, since both conditions share similar pathophysiological mechanisms. Furthermore, previous diabetes is a significant risk factor for maternal and fetal morbidity and mortality (Feig et al., 2016).

Consensus among regulatory agencies for the diagnosis of gestational diabetes

The HAPO study was a large-scale study that assessed the risk of adverse maternal-fetal and neonatal outcomes and is a study that consolidated glycemic levels for GDM (HAPO, 2008; Coustan et al., 2010). This study was reviewed and discussed by the International Association of Diabetes in Pregnancy Study Groups (IADPSG) at the 2010 International Conference on Diagnosis and Classification of Gestational Diabetes. At this meeting, a session among the delegations was held in which approximately fifty representatives from IADPSG organizations such as the American College of Obstetricians and Gynecologists (ACOG), WHO, ADA, European Association for the Study of Diabetes (EASD), International Diabetes Federation (IDF), and the Centers for Disease Control and Prevention (CDC) took the first steps toward reaching consensus on international recommendations. Considering that the first diagnostic criteria for GDM were established in the 1960s and were derived from criteria used for the general population, researchers highlighted the need to assess the increased risk of adverse events associated with maternal hyperglycemia and develop new diagnostic criteria for GDM, since even slight elevations in blood glucose levels can increase the risk of perinatal complications (Coustan et al., 2010).

The IADPSG consensus panel indicated that the results of the HAPO study on maternal hyperglycemia were consistent with the worst pregnancy outcomes. The data were then used to establish new diagnostic thresholds for GDM. The 75-g OGTT, demonstrated in the one-step strategy (Table 2), was based on the results of the HAPO study, while the two-step approach with a nonfasting glucose screening test is based on the criteria of O'Sullivan and Mahan (1964), as interpreted by Carpenter and Coustan (1982). The overall strategy recommended by the IADPSG is to perform a fasting glucose measurement or a random glucose test at the first prenatal visit and, if negative, to proceed with a 75-g OGTT between 24 and 28 weeks of gestation.

Table 2. Diagnostic criteria for Gestational *Diabetes mellitus* (ADA, 2024).

One-step strategy
Perform a 75 g OGTT, with plasma glucose measurement when the woman is fasting and every 1 and 2 hours, between 24 and 28 weeks of gestation in women without a previous diagnosis of diabetes. For that: ✓ Perform the OGTT in the morning, after an overnight fast of at least 8 hours. ✓ When any of the following plasma glucose values are reached or 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) Diabetes is diagnosed.
Two-step strategy
Step 1: ✓ Perform a GOT of 50 g (without fasting), with plasma glucose measurement in 1 hour, between 24 and 28 weeks of gestation in pregnant women without a previous diagnosis of diabetes. ✓ If the plasma glucose level measured 1h after loading is ≥130, 135 or 140 mg/dL (7.2, 7.5 or 7.8 mmol/L, respectively)*, proceed to a 100 g OGTT.
Step 2: ✓ Perform the 100g OGTT with fasting. ✓ When at least two† of the following four plasma glucose levels (measured fasting and at 1, 2 and 3 hours during OGTT) are met or exceeded (Carpenter-Coustan criteria): • Fasting: 95 mg/dL (5.3 mmol/L) • 1 h: 180 mg/dL (10,0 mmol/L) • 2 h: 155 mg/dL (8,6 mmol/L) • 3 h: 140 mg/dL (7,8 mmol/L) Diabetes is diagnosed.

Source: Diagnosis and Classification of Diabetes: Standards of Care in Diabetes (ADA, 2024 – with modifications).
*Caption: GDM: Gestational Diabetes mellitus; GOT: glycemic overload test; OGTT: oral glucose tolerance test. *The American College of Obstetricians and Gynecologists (ACOG) recommend any of the commonly used thresholds of 130, 135, or 140 mg/dL for the 1-hour 50 g GCT. † According to ACOG, a high value may be sufficient for diagnosis.*

During pregnancy, the most recommended methods for determining blood glucose levels are OGTT and fasting blood glucose levels, since, especially between the second and third weeks of pregnancy, there is an increase in erythrocyte turnover, which makes the glycated hemoglobin (HbA1c) test less reliable in reading the clinical picture (Edelson et al., 2020). The most common prevalence of gestational hyperglycemia is in GDM, which is characterized by changes in blood glucose parameters that begin during pregnancy but do not meet the diagnostic criteria for DM before pregnancy (SBD, 2021; WHO, 2014). Before the latest IADPSG recommendations, the diagnosis of diabetes for the first time during pregnancy was made regardless of the assessment of the degree of hyperglycemia (Zhang et al., 2010). This definition, however, does not reflect cases of pre-existing hyperglycemia in the pre-conception period (overt diabetes), because the glycemic ranges currently found in pregnancy can indicate when hyperglycemia was installed: before or during pregnancy (SBD, 2021).

Diabetes should ideally be diagnosed before pregnancy due to the increased risk of congenital malformations, premature birth, and perinatal mortality (Poltavski et al., 2016; Wahabita et al., 2020; ADA, 2024). When there is a fasting blood glucose result greater than or equal to 126 mg/dL in the first prenatal consultation usually performed in the first trimester, it can be concluded that the pregnant woman had previous DM2 (Table 3). A result greater than or equal to 92 mg/dL and less than 126 mg/dL indicates the onset of gestational *Diabetes mellitus*. In contrast, a fasting blood glucose result less than 92 mg/dL indicates that there is no hyperglycemia and that a new screening should be performed between 24 and 28 weeks using a 75g OGTT (IADPSG, 2010; WHO, 2014; ADA, 2024).

Table 3. Strategies for detecting hyperglycemic disorders in pregnancy (IADPSG, 2010).

FIRST PRENATAL CONSULTATION
Measure FPG, HbA1C, or random plasma glucose in all or only high-risk women † ✓ **If the results indicate diabetes:** Treatment and follow-up as for pre-existing diabetes. ✓ **If the results are not diagnostic of clear diabetes:** fasting plasma glucose is ≥5.1 mmol/L (92 mg/dL) but <7.0 mmol/L (126 mg/dL), diagnose as GDM. If fasting plasma glucose is <5.1 mmol/L (92 mg/dL), test for GDM at 24 to 28 weeks of gestation with a 75 g OGTT‡
24–28 WEEKS OF GESTATION: GDM DIAGNOSIS
2 hours of 75 g OGTT: performed after overnight fasting in all women who were not previously diagnosed with overt diabetes or GDM during the test at the beginning of this pregnancy ✓ **Overt diabetes:** fasting plasma glucose (FPG) ≥7.0 mmol/L (126 mg/dL) ✓ **Gestational *Diabetes mellitus*:** one or more values are equal to or exceed the indicated limits: FPG greater than or equal to 92 mg/dL, after 1 hour greater than or equal to 180 mg/dl, after 2 hours greater than or equal to 153 mg/dL. ✓ **Normal:** all values in the OGTT are lower than the indicated limits.

Source: IADPSG, 2020 – with modifications.
*Caption: FPG: fasting plasma glucose; GDM: Gestational diabetes mellitus *To be applied to women without known diabetes before pregnancy. Postpartum glucose testing should be performed on all women diagnosed with overt diabetes during pregnancy or GDM. †The decision to perform blood glucose testing in all pregnant women or only in women with characteristics that indicate a high risk of diabetes should be made based on the background frequency of abnormal glucose metabolism in the population and local circumstances. ‡The panel concluded that not enough studies have been done to know whether there is a benefit of widespread testing to diagnose and treat GDM before the usual window of 24-28 weeks of gestation.*

Divergences between diagnostic criteria

The main difference between the guidelines is related to the cutoff values for OGTT, the choice between the one- or two-step strategy, and the technological support available for choosing the diagnostic method (Table 4). The two-step strategy using a 100g OGTT may be less sensitive and lead to underdiagnosis of GDM, as it requires the woman to undergo an initial screening with a 50g glucose overload, followed by a 100g OGTT only in case of changes in the first step (Buchanan and Xiang, 2005). In contrast, the one-step strategy adopted by the WHO and IADPSG indicates the use of 75g of glucose directly, which favors the identification of more cases of hyperglycemia. However, it may be limited in countries where access to healthcare is more difficult, as is the case in Brazil (Farrar, 2017). The lower sensitivity of the two-step strategy is related to the low screening of pregnant women who may have slightly elevated blood glucose levels after the 50g test and still be at risk of maternal-fetal complications (Buchanan and Xiang, 2005).

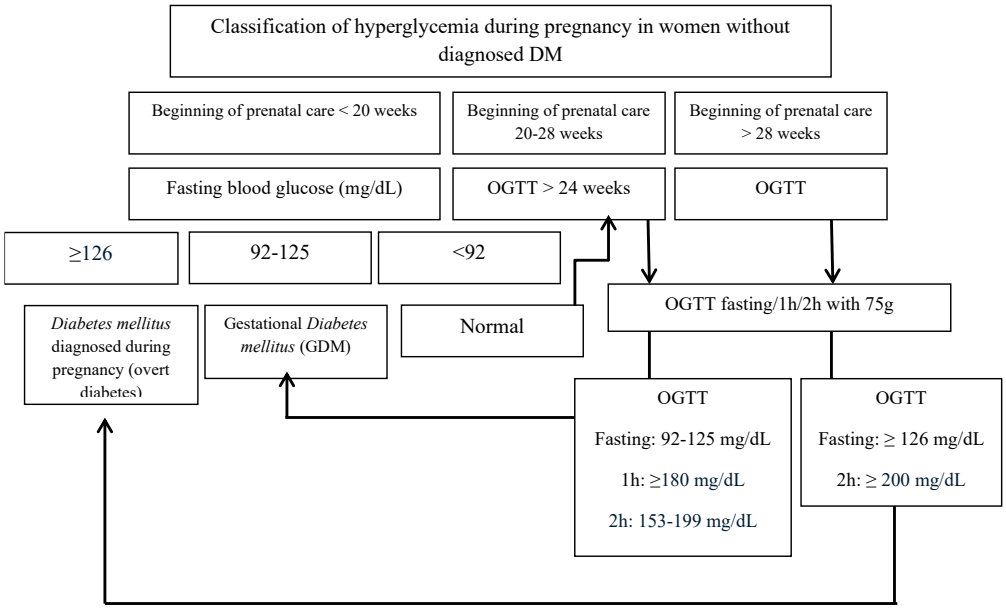
Table 4. Diagnostic criteria for Gestational *Diabetes mellitus*.

Recommendation (year)	Strategy	Glucose limits
ADA (2024)	One step or two steps	IADPSG Criteria Carpenter-Coustan Criteria
IADPSG (2010)	OGTT 75g (one step)	Fasting ≥ 92mg/dL 1h ≥ 180mg/dL 2h ≥ 153mg/dL
OMS (2013)	OGTT 75g (one stage)	Fasting ≥ 92-125 mg/dL 1h ≥ 180mg/dL 2h ≥ 153-199mg/dL **Diabetes:** Fasting : ≥ 126mg/dL 2h: ≥ 200mg/dL
ACOG (2018)	50g glycemic overload test, followed by 100g OGTT (preferably two-step or one-step strategy)	OGT: > 130,135 or 140mg/dL OGTT Carpenter-Coustan criterion Fasting ≥ 95mg/dL 1h ≥ 180mg/dL 2h ≥ 155mg/dL 3h ≥ 140 mg/dL Or IADPSG criteria

Source: Zera and Seely, 2021 (adapted).
Caption: ACOG: American College of Obstetricians and Gynecologists; ADA: American Diabetes Association; GOT: glucose overload test; IADPSG: International Association of Diabetes in Pregnancy Study Groups; OGTT: Oral glucose tolerance test; WHO: World Health Organization.

In Brazil, GDM screening was standardized in 2017 through a consensus between the Brazilian Diabetes Society (SBD) and the Brazilian Federation of Gynecology and Obstetrics Associations (FEBRASGO), the Organização Panamericana de Saúde - Pan American Health Organization (OPAS) and the Ministério da Saúde - Ministry of Health (MS). In this forum, representatives reached a consensus on the main recommendations and prepared the document "Screening and Diagnosis of Gestational Diabetes Mellitus in Brazil". The organizations took into account the peculiarities and availability of health resources in the country and concluded that the screening flowchart should also be adapted for regions where there is less financial and technical viability (OPAS, MS and FEBRASGO, 2017) (Figure 2).

Figure 2. Flowchart of the diagnosis of gestational Diabetes mellitus (GDM) in locations with financial viability and full technical availability.



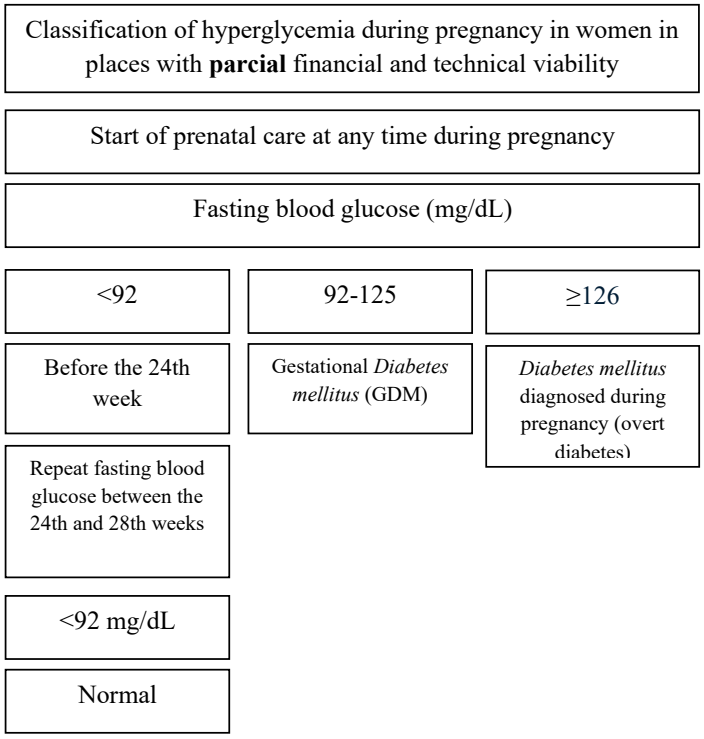
Source: OPAS; MS; FEBRASGO; SBD; Screening and diagnosis of gestational diabetes mellitus in Brazil. Vol. 1, Brazilian Diabetes Society.

The Ministério da Saúde GDM screening protocol, available in the SBD guidelines and in the Caderno de Atenção Básica - Basic Care Booklet No. 32 – Low-Risk Prenatal Care, recommends performing the OGTT between 24 and 28 weeks based on the one-step strategy of the ADA and IADPSG. The difference in the diagnostic criteria for gestational Diabetes mellitus in Brazil compared to other European and American associations is based on the existence of an alternative protocol for cases in which prenatal care begins at any time during pregnancy, in places where there is less financial and technical viability and there is no possibility of performing the OGTT. In the diagnostic criteria created by consensus between the SBD, FEBRASGO, OPAS and MS, fasting blood glucose is assessed and the glycemic ranges shown in Figure 2 indicate whether hyperglycemia was diagnosed for the first time during pregnancy or whether it was already present as previously unidentified Diabetes mellitus (overt diabetes).

The results of this study demonstrate that limited access to OGTT may impair the clinical management of GDM, considering that metabolic changes in the second trimester of pregnancy generate a state of insulin resistance that will be identified after glucose overload, making OGTT more sensitive than fasting blood glucose in the diagnosis of GDM (Sacks et al. 2012). The existence of alternative protocols at the national level is justified by the low technical and resource feasibility in certain municipalities. However, this measure disagrees with the universal nature of the Sistema Único de Saúde - Unified Health System (SUS), as OGTT coverage is not accessible to all women, despite being a recommendation of the SBD (Zajdenverg et al., 2023).

According to Duran et al. (2014), healthcare costs decrease as gestational outcomes improve, since there is a considerable reduction in the rate of cesarean sections and admissions to the neonatal intensive care unit. The authors showed that the savings from preventing these complications outweigh the costs of purchasing strips and supplies for the OGTT. However, in Brazil, pregnant women with better financial conditions have access to the diagnosis recommended by the main regulatory agencies in diabetes, women in remote regions monitor their blood glucose during prenatal care only through fasting blood glucose – as shown in Figure 3. The lack of standardization in the diagnostic criteria for GDM in Brazil represents a public health problem because many women go undiagnosed. According to Reichenbach et al. (2021), the costs of treating GDM are higher than those of prevention. Therefore, screening for GDM using the globally recognized protocol could provide pregnant women with the opportunity to achieve better maternal-fetal outcomes through targeted dietary and/or pharmacological interventions.

Figure 3. Flowchart of the diagnosis of gestational Diabetes mellitus in locations with parcial financial and technical viability.



Source: OPAS; MS; FEBRASGO; SBD; Screening and diagnosis of gestational diabetes mellitus in Brazil. Vol. 1, Brazilian Diabetes Society.

5. Conclusion

The diagnostic criteria established by various regulatory agencies are based on studies with large sample sizes and strong evidence for screening. However, they exhibit discrepancies in the glycemic ranges used for screening gestational Diabetes mellitus. Before the standardization proposed by the HAPO study, researchers adopted their own epidemiological data, which had lower accuracy in detecting GDM, as diagnostic criteria. The studies selected for descriptive analysis demonstrate that the IADPSG diagnostic criteria, currently recommended by the ADA, is the most effective in the early identification of gestational Diabetes mellitus (GDM) and works as a predictor of maternal-fetal risks. However, many pregnant women still undergo screening based on outdated criteria, which can delay diagnosis and increase the risk of complications. It is necessary to establish new investment policies in GDM screening by making OGTT viable throughout the country, given that the adoption of a single, standardized criterion by public management is essential to guarantee early and uniform diagnosis, ensuring better maternal-fetal outcomes, reducing inequalities in prenatal care and costs associated with obstetric complications.

References

American Diabetes Association Professional Practice Committee. (2024). Diagnosis and classification of diabetes: Standards of care in diabetes. Diabetes Care, 47(Suppl. 1), S20–S42. https://doi.org/10.2337/dc24-S002

American Diabetes Association. (2023). Standards of medical care in diabetes. Diabetes Care, 46(Suppl. 1), S1–S4. https://doi.org/10.2337/dc23-Sint

Agarwal, M. M. (2015). Gestational diabetes: Differences between the current international diagnostic criteria and implications of switching to IADPSG. Diabetes Care, 38, 9–12. https://doi.org/10.2337/dc14-1224

Abi-Abib, R., et al. (2014). Diabetes na gestação. Revista HUPE, 13, 40–47.

Balkrishna, A., Singh, S., Mishra, S., et al. (2024). Impact of biosensors and biomarkers in diabetes care: A review. Biomedical Materials & Devices. https://doi.org/10.1007/s44174-024-00230-z

Khan, R., et al. (2019). From pre-diabetes to diabetes: Diagnosis, treatments and translational research. Medicina, 55, 546. https://doi.org/10.3390/medicina55090546

Berggren, E. K., Boggess, K. A., Stuebe, A. M., & Jonsson Funk, M. (2011). National Diabetes Data Group vs. Carpenter–Coustan criteria to diagnose gestational diabetes. American Journal of Obstetrics and Gynecology, 205, 253. https://doi.org/10.1016/j.ajog.2011.06.025

Buchanan, T. A., & Xiang, A. H. (2005). Gestational diabetes mellitus. Journal of Clinical Investigation, 115, 525–534.

Castagnetti, B. (2017). “Pregnancy Complicating Diabetes” (1949), by Priscilla White. Embryo Project Encyclopedia. https://doi.org/10.25335/10776/13002

Califf, R. M. (2018). Biomarker definitions and their applications. Experimental Biology and Medicine, 243, 213–221. https://doi.org/10.1177/1535370217750088

CDC – Centers for Disease Control and Prevention. (2024). National Diabetes Statistics Report: Diabetes basics.

Committee on Practice Bulletins—Obstetrics. (2018). ACOG practice bulletin No. 190: Gestational diabetes mellitus. Obstetrics & Gynecology, 131, e49–e64. https://doi.org/10.1097/AOG.0000000000002501

O’Sullivan, J. B., & Mahan, C. M. (1964). Criteria for the oral glucose tolerance test in pregnancy. Diabetes, 13, 278–285.

Carpenter, M. W., & Coustan, D. R. (1982). Criteria for screening tests for gestational diabetes. American Journal of Obstetrics and Gynecology, 144, 768–773. https://doi.org/10.1016/0002-9378(82)90349-0

Coustan, D. R., et al. (2010). The Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study: Paving the way for new diagnostic criteria for gestational diabetes mellitus. American Journal of Obstetrics and Gynecology, 202, 654. https://doi.org/10.1016/j.ajog.2010.04.006

Dhawan, S., & Natarajan, R. (2019). Epigenetics and type 2 diabetes risk. Current Diabetes Reports, 19, 47. https://doi.org/10.1007/s11892-019-1168-8

Duran, A., et al. (2014). Introduction of IADPSG criteria for the screening and diagnosis of gestational diabetes mellitus results in improved pregnancy outcomes at a lower cost in a large cohort of pregnant women: The St. Carlos Gestational Diabetes Study. Diabetes Care, 37, 2442–2450. https://doi.org/10.2337/dc14-0179

Eckhardt, B. J., Holzman, R. S., Kwan, C. K., Bagdadi, J., & Aberg, J. (2012). Hemoglobina A1c glicada como triagem para diabetes mellitus em indivíduos infectados pelo HIV. Cuidados com Pacientes com AIDS, 26, 197–201. https://doi.org/10.1089/apc.2011.0379

Edelson, K. P., James, K. E., Leong, A., Arenas, J., Cayford, M., Callahan, M. J., et al. (2020). Longitudinal changes in the relationship between hemoglobin A1c and glucose tolerance across pregnancy and postpartum. The Journal of Clinical Endocrinology & Metabolism, 105, 1999–2007. https://doi.org/10.1210/clinem/dgaa053

Feig, D. S., Murphy, K., Asztalos, E., et al. (2016). Metformin in women with type 2 diabetes in pregnancy (MiTy): A multi-center randomized controlled trial. BMC Pregnancy and Childbirth, 16, 173.

Farrar, D., et al. (2017). Diagnostic criteria for gestational diabetes: A systematic review of the literature. BMJ, 359, 4875. https://doi.org/10.1136/bmj-2022-071920

FDA–NIH Biomarker Working Group. (2016). Biomarkers, endpoints, and other tools (BEST) resource.

Glechner, A., Keuchel, L., Affengruber, L., Titscher, V., Sommer, I., Matyas, N., et al. (2018). Effects of lifestyle changes on adults with prediabetes: A systematic review and meta-analysis. Primary Care Diabetes, 12, 393–408. https://doi.org/10.1016/j.pcd.2018.07.003

HAPO Study Cooperative Research Group. (2008). Hyperglycemia and adverse pregnancy outcomes. New England Journal of Medicine, 358, 1991–2002. https://doi.org/10.1056/NEJMoa0707943

Houshmand, G. (2019). Evolution of diagnostic criteria for gestational diabetes mellitus. Journal of Clinical Endocrinology & Metabolism, 104, 720–726. https://doi.org/10.1111/aogs.12152

(Obs.: O DOI informado pertence a outro periódico — Acta Obstetricia et Gynecologica Scandinavica. Posso corrigir se desejar.)

Harper, L. M., et al. (2016). Carpenter–Coustan compared with National Diabetes Data Group criteria for diagnosing gestational diabetes. Obstetrics & Gynecology, 127, 873–879. https://doi.org/10.1097/AOG.0000000000001383

IADPSG Consensus Panel. (2010). International Association of Diabetes and Pregnancy Study Groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy. Diabetes Care, 33, 676–682. https://doi.org/10.2337/dc09-1848

Hare, J., & White, P. (1980). Gestational diabetes and the White classification. Diabetes Care, 3, 394. https://doi.org/10.2337/diacare.3.2.394

Marciano, L., Camerini, A. L., & Schulz, P. J. (2019). The role of health literacy in diabetes knowledge, self-care, and glycemic control: A meta-analysis. Journal of General Internal Medicine, 34, 1007–1017. https://doi.org/10.1007/s11606-019-04864-x

Ministério da Saúde & IBGE. (2019). Percepção do estado de saúde, estilos de vida, doenças crônicas e saúde bucal – Pesquisa Nacional de Saúde, 2019. Ministério da Saúde.

Malerbi, F., Andrade, R., Morales, P., Travassos, S., Rodacki, M., & Bertoluci, M. (2023). Manejo da retinopatia diabética. Diretriz Oficial da Sociedade Brasileira de Diabetes.

Malerbi, F. K., Andrade, R. E., Morales, P. H., Stuchi, J. A., Lencione, D., de Paulo, J. V., et al. (2021). Diabetic retinopathy screening using artificial intelligence and handheld smartphone-based retinal camera. Journal of Diabetes Science and Technology, 15, 1–9. https://doi.org/10.1177/1932296820985567

Moon, J., & Jang, H. (2022). Gestational diabetes mellitus: Diagnostic approaches and maternal–offspring complications. Journal of Maternal-Fetal & Neonatal Medicine, 35, 1951–1957. https://doi.org/10.1080/14767058.2021.1970193

Mocellin, M. C., et al. (2024). Prevalência de diabetes gestacional no Brasil: Revisão sistemática e metanálise. Revista Brasileira de Ginecologia e Obstetrícia, 46, 45–53. https://doi.org/10.1055/s-0043-1760190

Organização Pan-Americana da Saúde, Ministério da Saúde, Federação Brasileira das Associações de Ginecologia e Obstetrícia & Sociedade Brasileira de Diabetes. (2017). Rastreamento e diagnóstico de diabetes mellitus gestacional no Brasil (pp. 1–36). Sociedade Brasileira de Diabetes.

O'Sullivan, J. B., & Mahan, C. M. (1964). Criteria for the oral glucose tolerance test in pregnancy. Diabetes, 13, 278–285.

Pereira, A. S. et al. (2018). Metodologia da pesquisa científica. [free ebook]. Santa Maria: Editora da UFSM.

Pititto, A., et al. (2023). Dados epidemiológicos do diabetes mellitus no Brasil. Sociedade Brasileira de Diabetes.

Poltavski, E., Kim, D. J., & Bang, H. (2016). Comparação das pontuações de triagem para diabetes e pré-diabetes. Diabetes Research and Clinical Practice, 118, 146–153. https://doi.org/10.1016/j.diabres.2016.06.022

Sacks, D. A., et al. (2012). Frequency of gestational diabetes mellitus at collaborating centers based on IADPSG consensus panel-recommended criteria: The Hyperglycemia and Adverse Pregnancy Outcome (HAPO) Study. Diabetes Care, 35, 526–528. https://doi.org/10.2337/dc11-2040

Silva, M. E. R., Mory, D., & Davini, E. (2008). Marcadores genéticos e autoimunes do diabetes melito tipo 1: Da teoria para a prática. Arquivos Brasileiros de Endocrinologia & Metabologia, 52, 166–180. https://doi.org/10.1590/S0004-27302008000200003

Scholtens, D. M., et al. (2019). Hyperglycemia and Adverse Pregnancy Outcome Follow-up Study (HAPO FUS): Maternal glycemia and childhood glucose metabolism. Diabetes Care, 42, 381–392. https://doi.org/10.2337/dc18-1599

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. Journal of Business Research, 104, 333–339.

Szmuilowicz, E. D., et al. (2019). Gestational diabetes mellitus. Endocrinology & Metabolism Clinics, 48, 479–493. https://doi.org/10.1016/j.ecl.2019.01.001

UKPDS Study Group. (1998). UK Prospective Diabetes Study (UKPDS). The Lancet, 352, 878–887. https://doi.org/10.1016/S0140-6736(98)02255-6

Wahabita, H. A., Fayed, A., Esmail, S., et al. (2020). Revisão sistemática e meta-análise da eficácia dos cuidados pré-gravidez para mulheres com diabetes para melhorar os resultados maternos e perinatais. PLoS ONE, 15. https://doi.org/10.1371/journal.pone.0237571

World Health Organization. (2013). Diagnostic criteria and classification of hyperglycemia first detected in pregnancy. Diabetes Research and Clinical Practice, 103, 341–363. https://doi.org/10.1016/j.diabres.2013.06.002

World Health Organization. (2014). Diagnostic criteria and classification of hyperglycemia first detected in pregnancy: A World Health Organization guideline. Diabetes Research and Clinical Practice, 103, 341–363. https://doi.org/10.1016/j.diabres.2013.12.002

White, P. (1949). Pregnancy complicating diabetes. The American Journal of Medicine, 7, 609–616. https://doi.org/10.1016/0002-9343(49)90382-4

Ye, W., et al. (2023). Gestational diabetes mellitus and adverse pregnancy outcomes: Systematic review and meta-analysis. BMJ, 382(2), e072134. https://doi.org/10.1136/bmj-2023-072134

Zajdenverg, L., et al. (2023). Rastreamento e diagnóstico da hiperglicemia na gestação. Diretriz Oficial da Sociedade Brasileira de Diabetes.

Zhang, X., Gregg, A. I., Williamson, D. F., et al. (2010). Nível de A1C e risco futuro de diabetes: Uma revisão sistemática. Diabetes Care, 33, 1665–1673. https://doi.org/10.2337/dc09-2071

Zamora-Obando, H. R., et al. (2022). Biomarcadores moleculares de doenças humanas: Conceitos fundamentais, modelos de estudo e aplicações clínicas. Química Nova, 45, 1098–1113. https://doi.org/10.21577/0100-4042.20220065

Zera, C. A., & Seely, E. W. (2021). Controversies in gestational diabetes. Touch Medical Media. https://doi.org/10.17925/EE.2021.17.2.102