Evolving paradigms in diabetes diagnosis and classification

ADA standards of care 2025 and the use of artificial intelligence

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Diabetes mellitus is a chronic, metabolic disease that occurs due to the body's inability to produce enough insulin or to ineffectively utilize the insulin produced leading to hyperglycemia or elevated levels of blood glucose (or blood sugar). If not controlled, diabetes can cause damage to the heart, blood vessels, eyes, kidneys, and nerves.[1]

Per the International Diabetes Federation's Diabetes Atlas 11th edition published in 2025, diabetes is one of the fastest growing global health emergencies in the 21st century with 1 in 9 adults having diabetes. In 2024, 588.7 million people had diabetes, and it is estimated that 852.5 million would develop diabetes by 2050 with a 45% growth. In the United States, 65.6 million people have diabetes, and it is estimated that number to reach 72.4 million by 2050 with a 10% rise.[1]

The field of diabetes care is evolving through new research, technology, and treatments to improve the health and well-being of people with diabetes. Since 1989, the American Diabetes Association (ADA) has been updating the Standards of Care recommendations annually to capture the most current state in the field of diabetes.

Classification of diabetes

The America Diabetes Association (ADA) classified diabetes based on metabolic, genetic, and pathophysiology features, as below:[2]

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LEARNING OBJECTIVES

Upon completion of this article, the reader will be able to:

1. Describe the pathophysiologies in the classifications of diabetes.
2. Discuss the laboratory tests and their results in the diagnosis of the classifications of diabetes.
3. Differentiate confirmatory data of laboratory testing in the confirmation of diabetes.
4. Discuss AI strategies for the prediction and management of diabetes.

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- Type 1 diabetes (T1D) – due to autoimmune β-cell destruction, usually leading to total insulin deficiency, including latent autoimmune diabetes in adults
- Type 2 diabetes (T2D) – due to a non-autoimmune progressive loss of adequate β-cell insulin secretion, frequently causing progressive insulin resistance
- Specific types of diabetes due to other causes, e.g., monogenic diabetes caused from a mutation in a single gene; diseases of the exocrine pancreas; drug- or chemical-induced diabetes
- Gestational diabetes mellitus (GDM) – observed in the second or third trimester of pregnancy in some individuals

It is important to identify the type of diabetes — type 1 or type 2 — to render personalized therapy. Traditionally it is believed that type 1 occurs in children and type 2 in adults; however, that may not be the case always. For some individuals, it is difficult to clearly classify the diabetes type at the time of diagnosis, and misdiagnosis is common. About 40% of type 1 diabetes cases are misdiagnosed as type 2 and many maturity-onset diabetes of the young (MODY) caused by monogenic syndrome may be misdiagnosed as type 1 diabetes.[3]

AABBCC is a clinical tool that may be used to determine if a newly diagnosed diabetic has type 1 diabetes based on the following criteria:

A) Age (e.g., for individuals <35 years old, consider type 1 diabetes)

A) Autoimmunity (e.g., personal or family history of autoimmune disease or polyglandular autoimmune syndromes)

B) Body habitus (e.g., BMI <25 kg/m2)

B) Background (e.g., family history of type 1 diabetes)

C) Control (preferred term is "goal," i.e., the inability to achieve glycemic goals on noninsulin therapies)

C) Comorbidities (e.g., treatment with immune checkpoint inhibitors for cancer can cause acute autoimmune type 1 diabetes)

The American Diabetes Association encourages use of C-peptide and islet autoantibody testing in ambiguous adult-onset cases. The flowchart in **Figure 1** helps to distinguish type 1 and type 2 diabetes using age, BMI, autoantibodies, and insulin dependency.

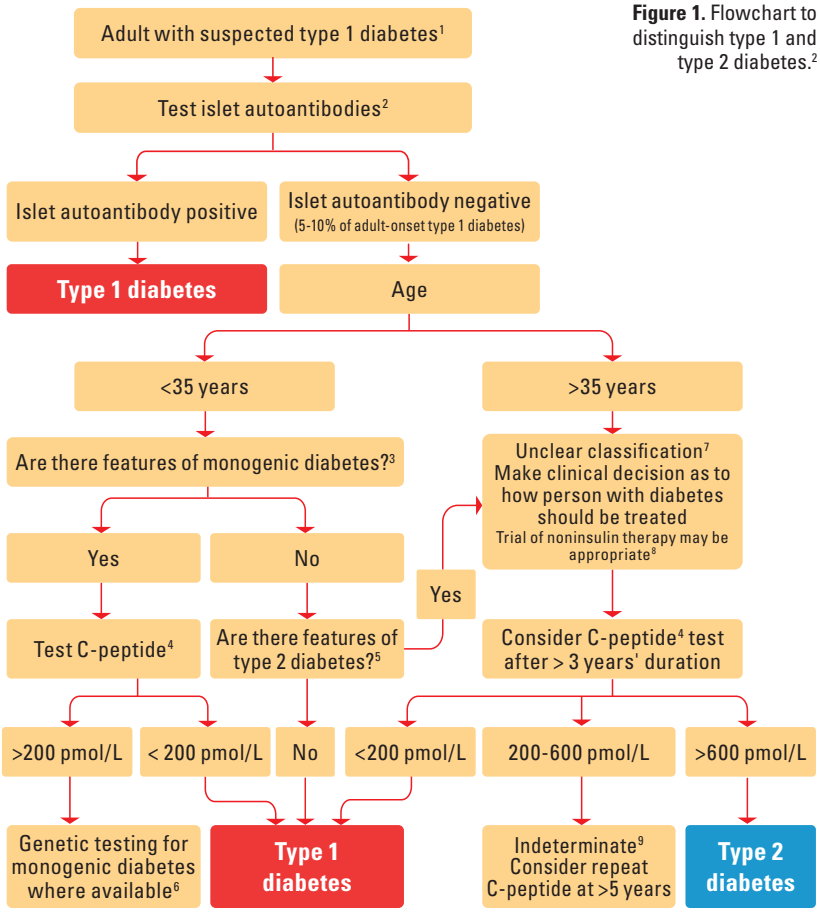

Figure 1. Flowchart to distinguish type 1 and type 2 diabetes.[2]

Tests for screening and diagnosis (see Table 1)

- Fasting plasma glucose (FPG)
- 2-h plasma glucose (2-h PG) during a 75-g oral glucose tolerance test (OGTT)
- A1C

> With diabetes impacting so many individuals across America, it is hard to see greater availability of screening tools as anything but a net positive.

The A1C test should be performed using a method that is certified by the National Glycohemoglobin Standardization Program (NGSP) (ngsp.org) and standardized or traceable to the Diabetes Control and Complications Trial (DCCT) reference assay. Point-of-care A1C assays may be NGSP certified and cleared by the U.S. Food and Drug Administration (FDA) for use in both Clinical Laboratory Improvement Amendments (CLIA)–regulated and CLIA-waived settings.[2]

Confirming the diagnosis

Unless there is an absolute match between the clinical diagnosis (e.g., individual with hyperglycemia or hyperglycemic crisis and random plasma glucose >200 mg/dL (>11.1 mmol/L), additional confirmatory tests are necessary. Diabetes can be confirmed with two abnormal screening test results measured either at the same time or at two different points of time and may be performed using two different types of tests, e.g., A1C and FPG.[2]

Criteria for diabetes in non-pregnant individuals includes one of the following:

- A1C ≥6.5% (>48 mmol/mol)
- Fasting plasma glucose (FPG) ≥126 mg/dL (≥7.0 mmol/L)
- 2-hour plasma glucose (2-h PG) ≥200 mg/dL (≥11.1 mmol/L) during OGTT
- Random plasma glucose ≥200 mg/dL in symptomatic patients

Criteria for pre-diabetes in non-pregnant individuals includes one of the following:

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Criteria	Glucose test	A1C test
Cost	Inexpensive and readily available in all labs	More expensive and may not be available in all labs
Time frame of hyperglycemia measure	Acute	Chronic – spanning past 2–3 months
Pre analytic stability	Poor	Good
Sample type	Plasma, serum, whole blood (Measurements vary based on sample type)	Whole blood
Assay standardization	Not standardized	Well standardized
Requirement of fasting	Fasting required	Fasting not required
Within variability	High	Low
Factors affecting result	Food intake, stress, recent illness, activity	Not affected by food intake, stress, recent illness, activity
Other factors affecting results	Diurnal variation, medications, alcohol, smoking, bilirubin	Altered erythrocyte turnover (e.g., anemia, iron status, splenectomy, blood loss transfusion, hemolysis, glucose-6-phosphate dehydrogenase deficiency, erythropoietin), HIV, cirrhosis, renal failure, dialysis, pregnancy
Interferences	Depends on specific assay: sample handling/processing time, hemolysis, severe hypertriglyceridemia, severe hyperbilirubinemia	Depends on specific assay: hemoglobin variants, severe hypertriglyceridemia, severe hyperbilirubinemia

Table 1. Comparison between glucose test and A1C test.[4]

	Stage 1	Stage 2	Stage 3
Characteristics	• Autoimmunity • Normal blood glucose • Pre-symptomatic	• Autoimmunity • Abnormal blood glucose • Pre-symptomatic	• Autoimmunity • Very high blood glucose • Symptomatic
Diagnostic criteria	• Multiple islet autoantibodies • No impaired glucose tolerance (IGT) or impaired fasting glucose (IFG), normal A1C	• Multiple islet autoantibodies (usually) • Abnormal blood glucose	• Autoantibodies may become absent • Diabetes by standard criteria

Table 2. Stages of type 1 diabetes.[5]

- A1C 5.7–6.4% (39–47 mmol/mol)
- Fasting plasma glucose (FPG) 100 mg/dL (5.6 mmol/L) to 125 mg/dL (6.9 mmol/L)
- 2-hour plasma glucose (2-h PG) ≥200 mg/dL (≥11.1 mmol/L) during 2-h PG during 75-g OGTT 140 mg/dL (7.8 mmol/L) to 199 mg/dL (11.0 mmol/L) impaired glucose tolerance (IGT)

Type 1 diabetes

5–10% of diabetics have type 1 diabetes.[2] For individuals with a family history of type 1 diabetes or other genetic risks, screening for presymptomatic type 1 diabetes (T1D) may be done by using standardized islet autoantibody test for detection of autoantibodies to insulin, glutamic acid decarboxylase (GAD), islet antigen 2 (IA-2), or zinc transporter 8 (ZnT8). Multiple confirmed islet autoantibodies are a risk factor for clinical diabetes. An individual may be in different stages of type 1 diabetes as depicted in **Table 2.**

Prediabetes and type 2 diabetes

90–95% of diabetics have type 2 diabetes.[2] Criteria to screen for pre-diabetes or type 2 diabetes is as follows:

1. Adults who are overweight or obese (BMI 25 kg/m^2 or 23 kg/m^2 in individuals of Asian ancestry) and have one or more of the following risk factors:
   - First-degree relative with diabetes
   - High-risk race, ethnicity, and ancestry (i.e., African American, Latino, Native American, Asian American)
   - History of cardiovascular disease
   - Hypertension (130/80 mmHg or on therapy for hypertension)
   - HDL cholesterol level <35 mg/dL (<0.9 mmol/L) and/or triglyceride level >250 mg/dL (>2.8 mmol/L)
   - Individuals with polycystic ovary syndrome
   - Physical inactivity
   - Other clinical conditions associated with insulin resistance (e.g., severe obesity, acanthosis nigricans, metabolic dysfunction–associated steatotic liver disease)
2. Individuals with pre-diabetes should be tested annually.
3. Individuals who had GDM should be tested every 1–3 years.
4. For all others, testing should begin after age 35.

Gene	Clinical characteristics
KCNJ11	Permanent or transient: intrauterine growth restriction (IUGR); possible developmental delay and seizures; responsive to sulfonylureas
INS	Permanent: IUGR; insulin requiring
ABCCB	Permanent or transient: IUGR; rarely developmental delay; responsive to sulfonylureas
6q24 (PLAGL1, HYMA1)	Transient: IUGR; macroglossia; umbilical hernia; mechanisms include uniparental disomy of chromosome (UPD6), paternal duplication, or maternal methylation defect; may be treatable with medications other than insulin
GATA6	Permanent: pancreatic hypoplasia; cardiac malformations; pancreatic exocrine insufficiency; insulin requiring
EIF2AK3	Permanent: Wolcott-Rallison syndrome: epiphyseal dysplasia; pancreatic exocrine insufficiency; insulin requiring
EIF2B1	Permanent: can be associated with fluctuating liver function[7]
FOXP3	Permanent: immunodysregulation, polyendocrinopathy, enteropathy X-linked (IPEX) syndrome: autoimmune diabetes, autoimmune thyroid disease, exfoliative dermatitis; insulin requiring

Table 3. Genes that cause neonatal diabetes.

5. If results are normal, testing should be repeated at an interval of 3 years.
6. Individuals in other high-risk groups — people with HIV, exposure to high-risk medicines, history of pancreatitis — should be monitored closely
   - Individuals having acute pancreatitis should be screened for 3 -6 months after an episode and annually thereafter
   - Individuals with cystic fibrosis should be tested annually from the age of 10 - Post transplantation after the individual is stable

Monogenic diabetes syndrome

<5% of individuals harbor monogenic defects of β-cell dysfunction in neonates causing neonatal diabetes and maturity-onset diabetes of the young (MODY).

- Neonates diagnosed with diabetes in the first 6 months of life should have genetic testing for neonatal diabetes and
- Children and young adults with diabetes who do not have typical characteristics of T1D or T2D and family history of diabetes in successive generations should have genetic testing for MODY.

Genes causing monogenic diabetes syndrome are described in **Tables 3 and 4.**[6]

Gestational diabetes mellitus

Gestational diabetes mellitus (GDM) is a metabolic disorder characterized by increased blood sugar levels during the second and third trimester of the pregnancy in some women.

Gene	Clinical characteristics
HNF1A	Progressive insulin secretory defect with presentation in adolescence or early adulthood; lowered renal threshold for glucosuria; large rise in 2-h PG level on OGTT (>90 mg/dL [>5 mmol/L]); low hs-CRP; sensitive to sulfonylureas
HNF4A	Progressive insulin secretory defect with presentation in adolescence or early adulthood; may have large birth weight (macrosomia) and transient neonatal hypoglycemia; sensitive to sulfonylureas
HNF1B	Developmental renal disease (typically cystic); genitourinary abnormalities; atrophy of the pancreas; hyperuricemia (high level of uric acid in blood); gout
GCK	Higher glucose threshold (set point) for glucose-stimulated insulin secretion, causing stable, nonprogressive elevated fasting blood glucose; typically does not require treatment; microvascular complications are rare; small rise in 2-h PG level on OGTT (<54 mg/Dl (<3 mmol/L])

Table 4. Genes that cause maturity-onset diabetes of the young.

It is associated with pancreatic β-cell dysfunction or delayed response to glucose levels and substantial insulin resistance due to release of placental hormones (human placental lactogen, estrogen, and progesterone).[8] GDM poses risks for the mother, fetus, and neonate.[2]

Screening and diagnosis for GDM can be performed using either of the following two approaches:

One step strategy

Performing a 75-g OGTT, with plasma glucose measurement when an individual is fasting and at 1 hour and 2 hours, at 24–28 weeks of gestation in individuals not previously diagnosed with diabetes.

The OGTT should be performed in the morning after an overnight fast of at least 8 hours.

The following results indicate GDM

- 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)

Two step strategy

Step 1: Performing a 50-g glucose tolerance test (non-fasting), with plasma glucose measurement at 1 hour, at 24–28 weeks of gestation in individuals not previously diagnosed with diabetes.

If the plasma glucose level measured 1 hour after the load is >130, 135, or 140 mg/dL (>7.2, 7.5, or 7.8 mmol/L, respectively), proceed to step 2 with 100-g OGTT.

Step 2: The 100-g OGTT should be performed when the individual is fasting. The individual is diagnosed with GDM if at least two of the following four plasma glucose levels (measured fasting and at 1, 2, and 3 hours during OGTT) are:[9]

- 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)

Use of artificial intelligence in diabetes care

Artificial intelligence (AI) has been transforming every field including the medical field. A new article published in the journal *Healthcare and Rehabilitation* mentions how AI is transforming diabetes care.[10] By analyzing data from blood sugar levels, medical history, and even retinal scans, AI tools can predict diabetes subtypes, identify high-risk patients, and tailor solutions to individual needs — with improved accuracy, reducing healthcare costs and addressing critical gaps in diagnosis, treatment, and daily management.

AI-enhanced continuous glucose monitoring systems not only merely report glucose trends but also anticipate hypoglycemic events hours in advance, offering patients critical time to intervene.[10] Intelligent insulin delivery systems are now available to predict glucose monitoring and personalized treatment plans.[10]

Conclusion

Though diabetes is on the rise, artificial intelligence and remote monitoring systems have the capability to proactively monitor patients, provide personalized care, and save lives. However, care needs to be taken to ensure the data are safe and secure. Hence, healthcare professionals, IT professionals, and regulatory authorities must work together to ensure that patients benefit from newer technologies and at the same time remain safe and secure.

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REFERENCES

1. Diabetes Atlas 11th Edition 2025. IDF. Published 2025. Accessed May 28, 2025. https://diabetesatlas.org/media/uploads/sites/3/2025/04/IDF_Atlas_11th_Edition_2025.pdf.
2. American Diabetes Association Professional Practice Committee. 2. Diagnosis and classification of diabetes: Standards of care in diabetes-2025. *Diabetes Care*. 2025;48(Supplement_1):S27-S49. doi:10.2337/dc25-S002.
3. Holt RIG, DeVries JH, Hess-Fischl A, et al. The management of type 1 diabetes in adults. A consensus report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). *Diabetologia*. 2021;64(12):2609-2652. doi:10.1007/s00125-021-05568-3.
4. Selvin E. Hemoglobin A1c-using epidemiology to guide medical practice: Kelly west award lecture 2020. *Diabetes Care*. 2021;44(10):2197-2204. doi:10.2337/dci21-0035.
5. Skyler JS, Bakris GL, Bonifacio E, et al. Differentiation of diabetes by pathophysiology, Natural History, and Prognosis. *Diabetes*. 2017;66(2):241-255. doi:10.2337/db16-0806.
6. Carmody D, Støy J, Greeley SAW, Bell GI, Philipson LH. A clinical guide to monogenic diabetes. In: *Genetic Diagnosis of Endocrine Disorders*. Elsevier; 2016:21-30.
7. De Franco E, Flanagan SE, Houghton JAL, et al. The effect of early, comprehensive genomic testing on clinical care in neonatal diabetes: an international cohort study. *Lancet*. 2015;386(9997):957-963. doi:10.1016/S0140-6736(15)60098-8.
8. Mittal R, Prasad K, Lemos JRN, Arevalo G, Hirani K. Unveiling gestational diabetes: An overview of pathophysiology and management. *Int J Mol Sci*. 2025;26(5):2320. doi:10.3390/ijms26052320.
9. Carpenter MW, Coustan DR. Criteria for screening tests for gestational diabetes. *Am J Obstet Gynecol*. 1982;144(7):768-773. doi:10.1016/0002-9378(82)90349-0.
10. Ma S, Zhang M, Sun W, et al. Artificial intelligence and medical-engineering integration in diabetes management: Advances, opportunities, and challenges. *Healthcare and Rehabilitation*. 2025;1(1):100006. doi:10.1016/j.hcr.2024.100006.

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1. Wiwanitkit, V. Types and frequency of preanalytical mistakes in the first Thai ISO 9002:1994 certified clinical laboratory, a 6-month monitoring. BMC Clin Pathol 1, 5 (2001).

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