INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

Review Paper

Advancement in the Management of the Diabetes: A Comprehensive Review

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ARTICLE INFO

Published: 06 Feb 2026
Keywords:
GLP-1 receptor agonists and SGLT2 inhibitors; Artificial Intelligence; regenerative medicine; ADA Standards of Care.
DOI:
10.5281/zenodo.18507335

ABSTRACT

Diabetes care has evolved beyond glucose monitoring to a patient-centered, cardiovascular and renal complications-focused approach. GLP-1 receptor agonists and SGLT2 inhibitors are now the standard of therapy for individuals with pre-existing cardiovascular disease, heart failure, or chronic kidney disease due to medicinal innovation. Dual-action treatments like tirzepatide have transformed hyperglycemia and obesity management. In parallel with drug advances, technological integration has reached a new peak. Continuous Glucose Monitoring (CGM) is now universally recommended for a wider demographic, including non-insulin-dependent Type 2 patients, and more precise Automated Insulin Delivery (AID) systems are now supported for diverse patient profiles. Technological integration attained "democratization" in 2025. CGM is currently recommended for most diabetics, including Type 2 non-insulin users. Through AI-driven algorithms and smartphone connectivity, improved Automated Insulin Delivery (AID) systems—or "artificial pancreas" technologies—can now treat Type 1 diabetes (T1D) more precisely and hands-off. In high-risk people, disease-modifying treatments like teplizumab may delay T1D development by years. Clinical advancements in regenerative medicine are imminent. Encapsulation and stem cell-derived islet transplants attempt to restore endogenous insulin production, possibly making some patients insulin-independent. Despite these advances, technology costs and global health inequities remain obstacles. To provide fair access to next-generation care, future management will use digital health platforms, telemedicine, and cost-effective domestic technologies. In the digital age, AI can accurately anticipate hypoglycemia and diabetic ketoacidosis. Fully integrated telemedicine solutions provide real-time data exchange and virtual coaching for underprivileged groups. Research on stem cell therapy and β-cell replacement in regenerative medicine gives promise for long-term remission in Type 1 Diabetes by restoring insulin production. Beyond clinical intervention, the 2025 ADA Standards of

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Care elevate holistic treatment, bringing sleep health—ideally 6–9 hours each night—on level with food and exercise. These advances, however, are hindered by expensive technology costs. Thus, legislative change, greater insurance coverage, and the discovery of cost-effective indigenous medicines are needed to democratize diabetes care and make life-saving advances available to all socioeconomic groups.

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic condition that causes hyperglycemia due to insulin secretion or action abnormalities. The International Diabetes Federation (IDF) predicts that 589 million adults—1 in 9—have the illness in 2025. Type 2 Diabetes (T2DM), which accounts for over 90% of cases, is connected to obesity, sedentary lifestyles, and an aging global population. Nearly 4 in 10 persons are ignorant of their illness, putting them at risk for life-threatening microvascular and macrovascular consequences such renal failure, blindness, and cardiovascular disease (3, 4). In 2025, diabetes treatment has shifted from "glucocentric" to "organ-protective". Traditional methods concentrated on decreasing blood glucose and HbA1c, while new clinical standards protect against cardiorenal consequences. Regardless of baseline glucose, ADA 2025 recommendations recommend early use of SGLT2 inhibitors and GLP-1 receptor agonists to protect the heart and kidneys (5, 6). Advanced technologies like Continuous Glucose Monitoring (CGM) and Automated Insulin Delivery (AID) systems support this holistic framework, as does a stronger focus on "Positive Health Behaviors" like standardized sleep health (6–9 hours per night) and resistance training (7, 8). Selection and use of a glucose-lowering treatment rely on severity of hyperglycemia, hepatic and renal functions, risks of hypoglycemia, body mass index, capacity to self-monitor blood glucose, and prescription cost. Type 1 diabetes treatments include GLP analogues like Exenatide and Liraglutide [8, 9], insulin injections for β cell defects, DPP-4 inhibition with Sitagliptin [10, 11], and INGAP peptide therapy for islet cell regeneration [12].

2. Classification of Diabetes

Diabetes is classified into two types: Type 1 diabetes (Insulin dependent diabetes) and Type 2 diabetes (Non-Insulin dependent diabetes) [13].

2.1 Insulin Dependent Diabetes Mellitus (IDDM)

Type 1 diabetes, which arises when the immune system targets and kills pancreatic cells, affects 5-10% of the population and has several names. Also known as juvenile onset diabetes. Most instances involve younger individuals, although anybody may get it. Maintaining blood glucose levels requires regular insulin injections. While infants and children have fast degradation of β cells, adults experience progressive degeneration. Minor fasting hyperglycemia may lead to severe hyperglycemia or ketoacidosis in response to stress or illness, although adolescents and young adults are more likely to develop it [22]. These individuals are more likely to develop celiac, autoimmune hepatitis, myasthenia gravis, Hashimoto's thyroiditis, Addison's, pernicious anemia, and Grave's illnesses [22]. Hereditary diabetes disproportionately affects African and Asian populations [23].

2.2 Idiopathic Diabetes

Few people with type 1 diabetes have no known cause; these people tend to be of Asian or African descent. The risk of ketoacidosis is high, and they have insulinopenia that never goes away. Ketoacidosis occurs in episodes, and the severity of insulin shortage varies from episode to episode. Insulin replacement therapy is essential for

patients with idiopathic diabetes, a disorder that has a hereditary component [22].

2.3 Noninsulin Dependent Diabetes Mellitus (NIDDM)

This form of diabetes, which comprises 90–95% of all cases, is also known as adult onset diabetes. There has been a type 2 diabetes epidemic due to major metabolic disorders such as obesity, insulin resistance, and dyslipidaemia [24]. In this form of diabetes, oral hypoglycemic medications and dietary changes are the mainstays of treatment. The development of illness is facilitated by insulin resistance and decreased insulin production. With a twofold excess mortality and a two- to fourfold greater risk of coronary heart disease and stroke, type 2 diabetes mellitus—the most common form of the disease—is the fourth biggest cause of death in industrialized nations.

2.4 Gestational Diabetes

Pregnancy is associated with different levels of glucose intolerance, which may result in hyperglycemia of different intensities [26]. Impaired glucose intolerance is a major form of gestational diabetes mellitus (GDM) that is first identified during pregnancy [27]. It raises the risk of type 2 diabetes in mothers and affects 14% of pregnant women, or 135,000 women in the US each year [28]. The reported risk may vary in size due to variations in type 2 diabetes and GDM tests, ethnicity, and selection criteria [29]. Gestational diabetes may cause the fetus to have macrosomia, the infant to have low blood sugar, and respiratory distress syndrome. Newborns are more likely to have birth problems such shoulder dystocia, traumatic brain damage, and cesarean sections.According to new recommendations, maintaining appropriate glycemic control may help reduce these effects for both mother and child.The majority of women with gestational diabetes benefit from diet and exercise, but some may need insulin or oral diabetic medication.

2.5 Catamenial Hyperglycaemia

Diabetic ketoacidosis (DKA) may be caused by a number of conditions, including as infections, inadequate insulin or poor insulin adherence, acute pancreatitis, stroke, medicines, anomalies in the body's metabolism, or therapeutic negligence [30]. Women who have uncontrolled hyperglycemia with diabetic ketoacidosis before to their menstrual cycle are said to have catamenial diabetic ketoacidosis, also known as catamenial hyperglycemia. Uncontrolled hyperglycemia resulted in insulin requirements that were up to four times greater. The situation deteriorates despite ongoing insulin infusion, leading to hyperglycemia, vomiting, severe acidosis, and ketonuria. It seemed strange that every test, including those for thyroid function, renal function, ECG, chest radiographs, blood and urine cultures, and inflammatory markers, came back normal.The reason of catamenial hyperglycemia is currently unknown [31]. Hormonal changes throughout the menstrual cycle and differences in diet and activity intake are potential contributing factors [32]. In addition to increasing the amount of insulin injections, diabetic ketoacidosis and other diabetic crises should be treated with a nutritious diet and frequent exercise [32].An infusion dose would be the appropriate medication approach to treat diabetic ketoacidosis and avoid diabetic crises [32].

3. Advancement in the Management of the Diabetes

3.1 Use of the Nanotechnology in Diabetes

Innovative techniques for insulin delivery and glucose testing have resulted from the use of nanotechnology in diabetes treatment. Researchers have shown that closed-loop insulin delivery

systems and glucose monitors may aid in the treatment of both type 1 and type 2 diabetes.A microcapsule containing holes that has shown potential for medication delivery is known as a nanomedical device. These holes are tiny enough to allow larger immune system chemicals like immunoglobulins and virus particles to pass through, but they are large enough for smaller molecules like oxygen, glucose, and insulin. Diabetes patients may get subcutaneous implants of microcapsules containing replacement islets of Langerhans cells, mostly derived from pigs. The body's delicate glucose management feedback loop may be momentarily restored without the need for strong immunosuppressants, which might increase the patient's risk of infection. [35] Table 2 lists the major problems associated with diabetes as well as how nanomedicine might help cure it.By focusing on certain tissues, organs, and tumors, the nanoparticle-targeted drug delivery technique improves the bioavailability of pharmaceuticals and ensures that the maximum quantity of medicine reaches the intended location. The difficulty of increasing the size of nanoparticles is one of the most challenging aspects in technology. Since there are now no established techniques for creating three-dimensional nanostructures, the process is more difficult than creating two-dimensional layer-shaped nanosurfaces.The possibility that being near nanoparticles might be harmful to your health is another concern. Concerns concerning the potential negative consequences of produced nanomaterials, such as carbon buckyballs and nanotubes, when inhaled, consumed, or absorbed via the skin are growing [35].Insulin is an essential need for those with severe type 1 and type 2 diabetes. Infections, uncomfortable administration, and poor patient compliance have all been linked to traditional insulin delivery methods. By controlling insulin distribution using pulmonary, nasal, transdermal, and closed-loop devices, recent developments in micro- and nanotechnologies have simplified the insulin administration process [36].

3.2 Stem Cell Technology

Due to the underlying causes of both type 1 and type 2 diabetes, which are defined by defects in pancreatic β cells that result in inadequate insulin production, research into prospective diabetes therapeutics has increasingly centered on stem cell technologies. Techniques are designed to increase insulin sensitivity or correct these cells' malfunction [37]. Although β cell replacement techniques provide novel resources, the lack of donors limits existing methods such as islet cell and pancreas transplants. Insulin resistance and β cell malfunction are associated with type 2 diabetes, while autoimmune loss of β cells causes type 1 diabetes [38, 39]. Because mesenchymal stem cells (MSCs) have immunosuppressive qualities and may effectively modify immune responses both in vitro and in vivo, MSC therapy has become a viable treatment for type 1 diabetes. Additionally, hematopoietic stem cells, which have the ability to develop into many blood cell types and display immunomodulatory effects, may potentially help newly diagnosed type 1 diabetics by enhancing β cell activity. Furthermore, adult fibroblasts from patients with type 1 diabetes may develop into insulin-producing cells using induced pluripotent stem (iPS) cells, which offers benefits for cellular replacement therapy and disease models [40, 41]. According to some research, MSCs produced from bone marrow may also develop into cells that produce insulin. Although human embryonic stem cells (ESCs) have attracted a lot of interest due to their pluripotent benefits, they also have drawbacks, including the production of certain cell types, immunological rejection, and unchecked growth after transplantation. Stem cell technology has great potential for treating diabetes, despite several ethical and scientific obstacles [42, 43].

3.3 Statin Therapy

Low-density lipoprotein (LDL) cholesterol is effectively reduced by statin medication, which considerably lowers the risk of coronary heart disease. The Scottish Intercollegiate Guidelines Network (SIGN) and the National Institute for Health and Clinical Excellence (NICE) both recommend lipid-lowering therapy as primary prevention for patients over 40 with type 2 diabetes (Grade A recommendation), while those over 40 with type 1 diabetes (Grade B recommendation) [44, 45]. Despite these recommendations, new research from a European diabetes conference shows that a large American cohort of more than 100,000 people with type 2 diabetes underutilize statin medication. Statins have drawbacks despite their effectiveness in reducing cardiovascular events in those with moderate cholesterol levels and no pre-existing cardiovascular disease [46, 47]. Notably, uncommon hepatic dysfunction, muscular problems (from myositis to rhabdomyolysis), and renal failure are among the possible adverse effects. Younger people and those without illness had poor statin drug compliance, according to a study with 6,422 participants. Therefore, elderly patients should be the main target of the treatment, especially those with significant risk factors for cardiovascular problems [48, 49]. Furthermore, while typically well-tolerated, statin therapy may nevertheless cause problems such myopathies and raised liver enzymes in those with type 2 diabetes [50]. It has also been observed that statin use may modestly boost blood sugar levels, possibly leading to diabetes mellitus.

3.4 Use of the Natural Products in Diabetes

The use of herbal medicines to treat diabetes, both insulin-dependent and non-insulin-dependent, has long been noted in the literature. Plants having antidiabetic qualities have historically been seen as sources of novel hypoglycemic chemicals or as possible supplements to current treatments. Ayurvedic books such as the Sushruta Samhita, which was written in the fourth and fifth centuries BC, mention diabetes and its acknowledgment goes back to the Brahmic period. Two forms of diabetes are discussed in these texts: one that results from dietary errors and the other that is inherited [51, 52]. Due to their affordability and very low side effects, herbal medicines have become quite popular. Even while plant-based therapies have been effectively used in traditional medicine around the world, many of these herbs' underlying processes are still unclear and inconsistent. Recent research has shown that plant-based bioactive chemicals have antidiabetic effects that are on par with or even stronger than those of well-known oral hypoglycemic medications like daonil, tolbutamide, and chlorpropamide. Nevertheless, many plant-based active chemicals remain poorly described [53, 54]. The ethnobotanical community is very interested in plants with antidiabetic qualities because of their important medicinal components and varying hypoglycemic activity, according to research, including those done by Grover et al. [55, 56]. It is possible to separate and use the bioactive components of different plant species as pharmacological agents or drug lead compounds, which may provide natural remedies for the difficulties associated with diabetes [57,58]. A phytomolecule's antidiabetic effectiveness is greatly influenced by its chemical structure. According to Jung et al., a number of plant species are rich in terpenoids, flavonoids, phenolics, and coumarins that have been shown to be effective in decreasing blood glucose levels. In addition to Murraya koenigii (L.) Spreng. (Rutaceae), Allium sativum Linn. (Liliaceae), Gymnema sylvestre (Retz.) Schult (Asclepiadaceae), Allium cepa (Liliaceae), Withania somnifera Dunal (Solanaceae), and Ferula foetida Linn. In

experimental diabetes models, (Umbelliferae) have shown encouraging antidiabetic qualities. The significance of G. sylvestre in the management and treatment of diabetes has been well investigated [59, 60].

CONCLUSION

After a comprehensive search across many databases, this review article outlines the significant findings and developments in our understanding and management of DR during the last few years. They covered the epidemiology, pathophysiology, systemic risk factors, screening methods, and treatment strategies of DR in great detail. The epidemiological data presented shows a concerning rise in diabetes incidence globally, with a particular emphasis on the Caribbean, Africa, the Middle East, and North America. Among other demographic disparities, the frequency of DR varies significantly by gender and diabetes. DR puts one's vision at risk in addition to being a possible predictor of overall health problems. The pathophysiology section explains the intricate mechanisms of DR, with hyperglycemia playing a major role in the breakdown of retinal microvascular tissue. Vascular damage brought on by hyperglycemia may alter blood flow, harm the blood-retina barrier, thicken the basement membrane, kill endothelial cells, and more. The metabolic processes connected to this damage are investigated in this work. The research also discusses novel biomarkers that might be helpful for DR diagnosis and prognosis. These consist of advanced glycoxidation products, C-reactive protein, and neuroglobin. The main factors that promote DR neovascularization are VEFG and pro-angiogenic cytokines. The effects of glycemic control, medication usage, diabetes duration, hypertension, obesity, and hyperlipidemia on DR are thoroughly examined. The review emphasizes how crucial it is to manage these risk factors in order to halt DR in its tracks. The authors provided insight into current DR screening standards and practices by compared opportunistic and systematic screening techniques. They also examine the many screening techniques, including telemedicine-based possibilities, emphasizing the cost-effectiveness and potential to improve access to treatment. The section on treatment techniques explores the several options for treating DR, including as surgery, laser photocoagulation, and medication. Important treatments for diabetic macular oedema include intravitreal glucocorticoids and antiVEFG medications, however laser photocoagulation remains the most successful treatment option. Pars plana vitrectomy can be a possibility if existing therapies are unable to halt the vitreous hemorrhage or if the retina separates. In conclusion, this review study provides an excellent summary of the state of knowledge on DR. It emphasizes the need of risk factor management, early screening, and novel treatment approaches. The article emphasizes the need for ongoing research and innovation to counteract the growing global effect of DR and its significant impact on public health.

CONFLICT OF INTEREST

None

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HOW TO CITE: Purushottam Kumar, Mamta Kadawal, Neha Yadav, Rupesh Kumar, Ankit Kumar, Kirti Yadav Advancement in the Management of the Diabetes: A Comprehensive Review' Int. J. of Pharm. Sci., 2026, Vol 4, Issue 2, 873-882. https://doi.org/10.5281/zenodo.18507335