Impact Factor: 5.731

IJETIR

ISSN (Online) 2583-0554

International Journal of Emerging Technologies and Innovative Research (IJETIR)

Volume 5, Issue 3, March 2025

Glucose Monitoring Technologies – Current Trends and Future Prospects in Diabetes Care

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Abstract*: Our paper aims to review the latest technologies used in diabetes management, focusing on their role in improving glycaemic control and overall quality of life for individuals with both type 1 and type 2 diabetes. Continuous glucose monitoring (CGM) systems provide valuable insights into daily glycaemic variations and are beneficial for both children and adults, reducing diabetic distress and lowering the risk of hypoglycaemia. Similarly, continuous subcutaneous insulin infusion (CSII) has demonstrated significant benefits in selected patients.*

There is a growing trend towards more advanced systems, such as hybrid closed-loop systems that integrate glycaemic data with automated insulin modulation, leveraging artificial intelligence-based algorithms. These technologies help mitigate challenges associated with diabetes management, including fear of hypoglycaemia, exercise-related glucose fluctuations, and long-term complications.

While these innovations have been widely applied in T1DM, there is a clinical need to extend their use to the T2DM population to address the consequences of sub-optimal disease management. This review explores currently available diabetes technologies, their evidence-based benefits for people with T2DM, and future advancements aimed at enhancing automated glycaemic control to reduce the burden on individuals living with diabetes.

Keywords: Diabetes, Glucose, Monitoring, Biosensors, Innovation

I. INTRODUCTION

1.1 Overview of Diabetes Mellitus: Pathophysiology & Incidence

Diabetes mellitus is a significant metabolic disorder marked by insufficient insulin production or the pancreas's inability to produce enough insulin, leading to elevated blood glucose levels[1] (Fig. 1.1& 1.2).The Islets of Langerhans are clusters of specialized cells in the pancreas responsible for endocrine functions, including blood glucose regulation. These clusters contain beta cells that produce insulin and alpha cells that secrete glucagon.[2]

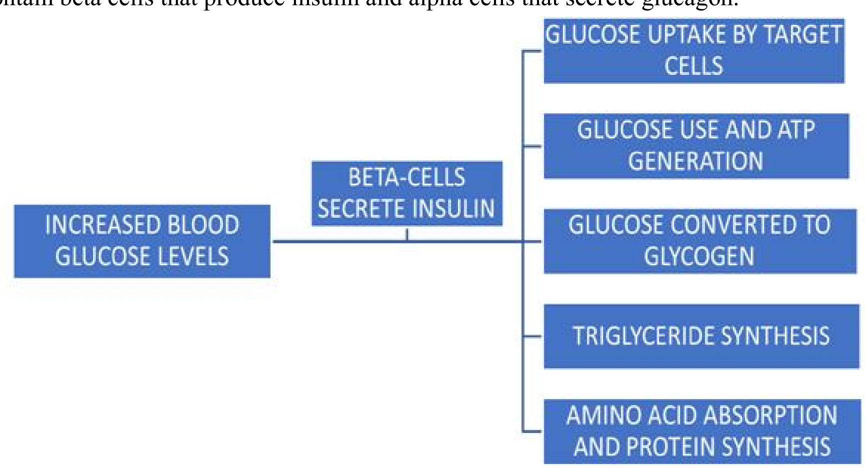

Figure 1: Physiological Response to Increased Blood Glucose Levels.

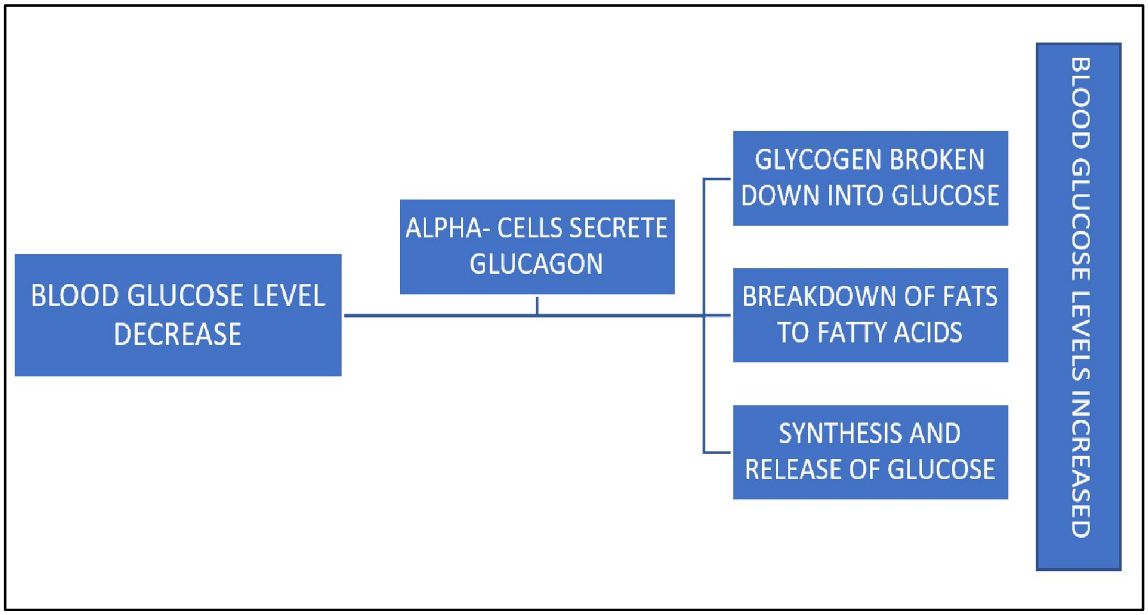

Figure 2: Physiological Response to Decreased Blood Glucose Levels.

Furthermore, Diabetic ketoacidosis (DKA) is a frequent complication of diabetes mellitus (DM), triggered by high blood sugar levels, elevated insulin counterregulatory hormones, and an imbalance in electrolytes[3]. To compensate for the inability of glucose to enter cells, the body initiates two processes: (i) lipolysis, where fatty acids are metabolized, and (ii) hepatic ketogenesis, which leads to excessive ketone production, resulting in hyperketonaemia and metabolic acidosis. Additionally, hyperglycaemia causes increased osmolality, leading to water loss from tissues and osmotic diuresis, which further depletes fluids and electrolytes. If left untreated, DKA can progress to hypotension and shock, a major cause of death in individuals with type 1 diabetes. While the overall inpatient mortality rate for DKA in the U.S. is below 1%, it can rise significantly to 20–40% among patients aged 65–75 years[4].

Advances in Glucose Monitoring: Emerging Theories & Trends

Recent advancements in medical devices for diabetes measurement have significantly enhanced monitoring accuracy and patient convenience. Notable developments include:

A. Continuous Ketone Monitoring

In 2025, continuous ketone monitoring devices are expected to emerge, enabling real-time tracking of ketone levels. This advancement is particularly beneficial for individuals at risk of diabetic ketoacidosis, providing an additional layer of safety in diabetes management[5].

B. Integrated Biosensing Wearables

The integration of continuous glucose monitors (CGMs) with other health monitoring devices is on the rise. For instance, Dexcom has partnered with ŌURA to combine glucose monitoring with data on heart rate, activity levels, sleep, and stress, offering a comprehensive health overview[6].

C. Advanced Continuous Glucose Monitors (CGMs)

The FDA has approved devices like the Eversense 365, an implantable CGM that lasts up to a year. This sensor, placed under the skin, provides real-time glucose monitoring via a mobile app, reducing the frequency of sensor replacements[7].

D. Non-Invasive Glucose Monitoring

Research is advancing in non-invasive glucose monitoring technologies. Studies have explored methods such as photoplethysmography (PPG) and breath acetone analysis, aiming to measure glucose levels without the need for blood samples[8].

E. Artificial Pancreas Systems

These systems automate blood glucose control by continuously monitoring glucose levels and delivering insulin as needed. The NHS in England has introduced such devices, reducing the need for daily insulin injections and enhancing patient outcomes[9].

1.2 Current Challenges & Gaps in Diabetes Management

Diabetes mellitus (DM) affects over 800 million people globally, with projections indicating a rise to 1.3 billion by 2050. Type 1 diabetes (T1DM) constitutes approximately 10% of these cases, predominantly emerging in children and young adults[10]. T1DM arises from the autoimmune destruction of insulin-producing beta cells, influenced by genetic factors and environmental triggers[11].

It has been reported that **Africa will see the fastest increase in diabetes** prevalence due to rapid urbanization and changing dietary habits whereas in contrast **Asia will remain the region with the highest number of cases**.**Table 1**

Region	2021 (Million)	2030 (Million)	2045 (Million)	% Increase
North America & Caribbean (NAC)	51	57	63	24%
South & Central America (SACA)	32	40	49	50%
Africa (AFR)	24	33	55	134%
Middle East & North Africa (MENA)	73	95	136	87%
Europe (EUR)	61	67	69	13%
South-East Asia (SEA)	90	113	152	68%
Western Pacific (WP)	206	238	260	27%
Total (Cumulative)	537	643	784	46%

Table 1: Regional Distribution of Diabetes Prevalence[33]

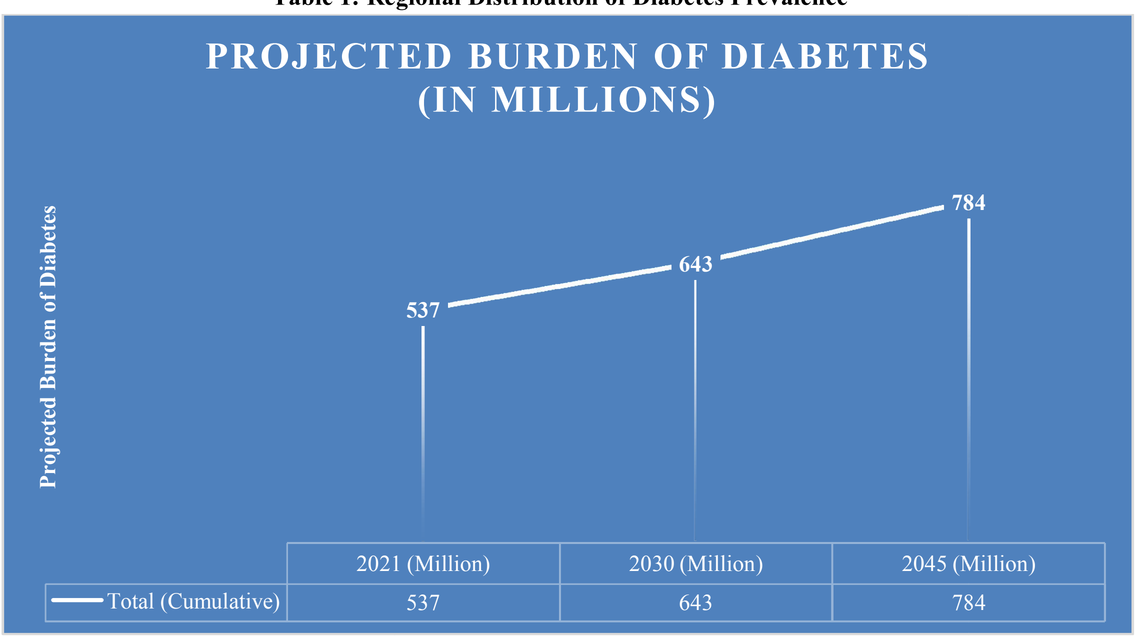

Figure 3: Trends in Burden of Diabetes by 2050

Advancements in technology have introduced devices such as continuous glucose monitors (CGMs), insulin pumps, and smartwatches, enhancing real-time glucose monitoring and insulin delivery[12]. Despite these innovations, many individuals still rely on intensive insulin therapy, which demands regular blood glucose testing. The development of non-invasive glucose biosensors remains a priority to reduce discomfort and improve management[13].

Continuous glucose monitoring systems offer insights into glycaemic fluctuations, aiding in better diabetes control and reducing hypoglycaemia. The integration of artificial intelligence in hybrid closed-loop systems shows promise in automating glycaemic regulation, potentially alleviating the daily burdens associated with T1DM management[14]. This review paper examines recent innovations in glucose monitoring and diabetes care, focusing on advancements in continuous glucose monitoring (CGM) technologies, integration of artificial intelligence for predictive analytics, and the development of non-invasive biosensors.

II. INNOVATIONS IN GLUCOSE MONITORING & DIABETES CARE

It has been reported in various patents, have greatly improved both measurement accuracy and patient ease of use.Table 2

Category	Company	Technology	Patent Method	Functionality
Non-Invasive Glucose Monitoring	**DiaMonTech AG**	D-Pocket Device	IRE-PTD (Infrared Evoked-Photothermal Detection)	Detects glucose molecules in skin's tissue fluid
	Apple Inc.	Apple Watch CGM	Silicon Photonics & Optical Absorption Spectroscopy	Non-invasive glucose monitoring via smartwatch
	Masimo Corporation	Joint CGM & Insulin Pump System	Cercacor CGM Patents	Real-time glucose tracking with advanced sensor technology
Glucose-Sensitive Insulin	**Novo Nordisk**	NNC2215 Insulin	Bioengineered glucose-sensitive insulin	Adjusts insulin activity based on glucose levels, reducing hypoglycemia risk
Patent Settlements in CGM	**DexCom& Abbott**	Patent Cross-License Agreement	Legal Settlement	Resolves patent disputes, granting worldwide, royalty-free licenses

Table 2: Summary of the Key Patent-Related Developments in Diabetic Management.

2.1 Implantable Glucose Monitors

The Eversense implantable continuous glucose monitor (CGM), developed by Senseonics Inc. (Germantown, MD, USA), has been available since 2016. This system includes a small cylindrical sensor that is implanted in the upper arm by a trained professional. It works in conjunction with a wearable transmitter placed over the sensor and a smartphone application, providing continuous glucose data for up to 180 days[15].

Clinical evaluations involving patients with type 2 diabetes (T2D) assessed the safety and accuracy of the Eversense CGM. These studies confirmed that the system consistently delivered accurate glucose readings throughout its lifespan while demonstrating a favourable safety profile compared to traditional transcutaneous CGMs[16-17].

Currently, the 90-day Eversense® CGM system is approved for non-adjunctive use in the United States, while the 180-day Eversense XL® system is approved for adjunctive use in Europe[18-19].

2.2 Insulin Delivery

2.2.1 Smart Insulin Pens

Insulin pens are the most commonly used method for administering insulin in individuals with type 2 diabetes mellitus (T2DM). These pens allow for subcutaneous insulin delivery via a disposable needle attached to a cartridge. While they offer convenience, traditional insulin pens require manual record-keeping of blood glucose levels, making it difficult for both patients and healthcare providers to track dosage adherence and glucose trends effectively[20].

Recent innovations have led to the development of smart insulin pens, which feature memory functions, Bluetooth connectivity, and integration with mobile applications. These advancements help users track previous doses, monitor insulin temperature, receive reminders, and even calculate remaining insulin. Such features are particularly beneficial for individuals with cognitive impairments or those struggling with the complexity of insulin management. Smart insulin pen caps and attachments further enhance usability by automatically logging insulin usage, making diabetes management more precise and less burdensome.

2.2.2 Insulin Pumps and Closed-Loop Systems

Insulin pump therapy, also known as continuous subcutaneous insulin infusion (CSII), has been available since the 1970s. This method aims to replicate the body’s natural insulin secretion by delivering rapid-acting insulin from a reservoir through a cannula implanted under the skin. The cannula is replaced every 48–72 hours, and the device allows for precise insulin adjustments throughout the day. Over time, insulin pumps have become smaller, more efficient, and easier to use, making them increasingly popular—especially among children and adolescents with type 1 diabetes (T1D)[21].

Although insulin pumps have long been a standard treatment for T1D, their use in T2DM has been more limited. Earlier guidelines from NICE, ADA, and EASD suggested that insulin pump therapy played a minimal role in T2D management. However, recent studies indicate that CSII may be a safer and more effective alternative to traditional insulin injections in certain cases. As a result, the 2021 ADA Standards of Medical Care have recognized insulin pumps as a viable treatment option for adults and youth with T2DM who require multiple daily injections (MDI) and can manage pump therapy.

A major advancement in insulin pump technology is the closed-loop system, also known as the "artificial pancreas." These systems deliver insulin in response to real-time glucose levels, reducing the need for frequent manual adjustments. The first hybrid closed-loop system (which requires users to input mealtime information) was introduced in 2017 with the Medtronic 670G pump. Since then, various hybrid and fully automated systems have been developed, aiming to improve glucose control while minimizing the burden on users[22].

Recent randomized controlled trials (RCTs) have shown that fully automated closed-loop systems significantly increase the time spent within the target glucose range while reducing the risk of hypoglycaemia. Notably, a study by Bally et al., which included 136 hospitalized patients with T2DM, found that those using a closed-loop system maintained 65.8% time in range, compared to 41.5% in the control group. Additionally, 89% of users expressed satisfaction with having their glucose levels managed by the system.

While closed-loop insulin delivery systems are now widely available for T1D, further research is needed to evaluate their long-term effectiveness and safety in individuals with T2DM. However, preliminary findings suggest that these systems may revolutionize diabetes care, particularly for patients with complex medical conditions such as kidney disease or those on artificial nutrition[23].

2.3 Flash Glucose Monitoring: A Convenient Alternative for Glucose Tracking

Introduced in 2016, flash glucose monitoring (FGM) has revolutionized diabetes management by offering a factory-calibrated, minimally invasive alternative to traditional blood glucose monitoring. The FreeStyle Libre system (Abbott Diabetes Care, CA, USA) features a small circular sensor with a thin fiber that is inserted into the upper arm, continuously recording interstitial glucose levels every minute[24]. The device stores up to 8 hours of glucose data, requiring users to scan it at least three times a day at 8-hour intervals to maintain a full 24-hour glucose record.Users can scan the sensor using a handheld reader or an NFC-enabled smartphone, generating an ambulatory glucose profile (AGP). This provides valuable insights into glucose trends, fluctuations, and patterns throughout the day and night, helping users make informed decisions about their diabetes management. Studies have shown that FGM is highly preferred by users due to its ease of use, reduced need for finger pricks, and simple sensor insertion.

As flash and continuous glucose monitoring (CGM) systems gain popularity, they offer instant glucose readings, alerts for high or low glucose levels, and remote monitoring capabilities. These features enable both healthcare professionals and users to make timely adjustments to insulin therapy and lifestyle choices.

While flash glucose monitors provide significant advantages, they require manual scanning to access glucose data. In contrast, CGMs offer real-time readings and automatic alerts without needing a manual scan, making them especially beneficial for individuals who require constant glucose monitoring. With ongoing advancements in design and accuracy, CGMs are becoming increasingly popular, particularly among people with type 1 diabetes (T1D), with growing evidence supporting their use in type 2 diabetes (T2D) as well.

2.4 Biosensors

Traditional glucometers are becoming increasingly expensive and less effective, leading to a shift towards biosensors—advanced analytical devices that enable continuous glucose monitoring rather than single-point readings. These biosensors come in various types, including electrochemical, optical, enzymatic, non-enzymatic, and noninvasive sensors, each optimized for different applications[25].

A biosensor detects biomarkers from interstitial fluid, translating the data into readable signals through molecular recognition, signal generation, and interpretation by a reader device. The detected signals can be optical, electronic, or luminescent, offering real-time monitoring for improved disease management.

Beyond glucose tracking, biosensors are now being used for food analysis (e.g., garlic and ginger testing), breath diagnostics, and soil testing. Some advanced applications include COVID-19 detection through breath analysis and nitrate sensors for agricultural monitoring via smartphone connectivity[26].

Key biosensor categories include electrochemical, piezoelectric, thermometric, optical, silica-based, nanomaterial-based, genetically encoded, and microbial biosensors. Among them, genetically encoded biosensors represent a cutting-edge approach to personalized healthcare and diagnostics.

With continuous monitoring capabilities, biosensors reduce hospital visits, optimize treatment, and enhance disease diagnosis, making them a cornerstone of modern medical technology.

2.5 Novel Treatment and Diagnosis Equipment for Diabetes Mellites

Blood glucose monitoring has evolved with the introduction of minimally invasive and noninvasive technologies. FDA-approved continuous glucose monitoring (CGM) devices, such as the Dexcom G6 and MiniMed™ 780G, have improved diabetes management, but fully noninvasive options remain limited due to technological and market challenges. Ongoing advancements, including predictive analytics and AI-driven solutions, could further personalize diabetes care, especially for individuals with type 1 diabetes (T1D)[27].

Biosensors play a crucial role in diabetes management, ranging from digital glucometers and CGMs to insulin pumps, which mimic an artificial pancreas by automatically releasing insulin. Some implantable microchips connect directly to smartwatches and smartphones, providing real-time health data and activating alerts if glucose levels become abnormal. Despite some drawbacks—such as cost, skin irritation, and frequent replacements—biosensors offer immediate, accurate glucose readings and track additional markers like HbA1C levels.

Beyond diabetes care, biosensors have expanded into environmental monitoring, assessing water and air purity, and even studying cancer molecules. Recent developments have also enabled their use in detecting viral infections, including COVID-19. As CGM and biosensor technology advance, they are expected to enhance metabolic control and improve the quality of life for people with diabetes[28].

2.6 Emerging Devices & Future Trends in Diabetes Care (Fig 4)

1. Continuous Glucose and Ketone Monitoring Systems

Abbott's Dual Monitoring System: Abbott is developing a continuous glucose-ketone monitor (CGM) that tracks both blood glucose and ketone levels. This technology aims to provide early warnings for elevated ketones, potentially preventing diabetic ketoacidosis[29].

Dexcom G7 15-Day Sensor: Dexcom has submitted an application to the FDA for a 15-day wear sensor for their G7 CGM, extending usage from the current 10.5 days. Approval is anticipated in 2025.

2. Integrated Automated Insulin Delivery (AID) Systems

Medtronic and Abbott Collaboration: Medtronic and Abbott are collaborating on an integrated CGM system. Abbott will supply Medtronic with a CGM to work exclusively with Medtronic's smart dosing devices and software across both AID and Smart MDI systems.Eversense 365 with Pump Integration: The Eversense 365 implantable CGM, approved in 2024, is seeking partnerships with pump manufacturers to integrate into AID systems, offering a unique implantable design.

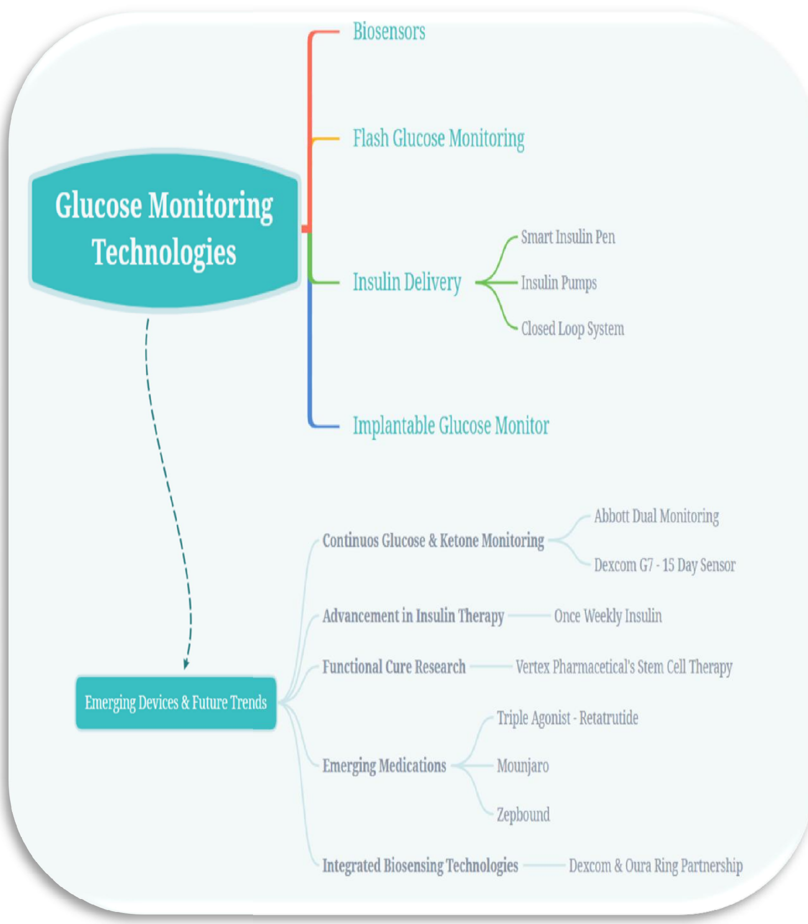

Fig 4: Graphical Layout of Emerging Devices & Future Trends in Diabetes Care

Tandem's Tubeless Mobi Insulin Pump: Tandem is introducing the Tubeless Mobi, allowing users to switch between tubed and tubeless configurations, enhancing personalization in insulin delivery.
Sequel's Twiist AID System: Approved by the FDA in 2024, the Twiist system measures insulin delivery volume and flow, rapidly detecting obstructions. It utilizes the Tidepool Loop algorithm and is compatible with various iCGMs.

3. Advancements in Insulin Therapy

Once-Weekly Insulin: Novo Nordisk and Eli Lilly are developing once-weekly insulin formulations, with potential FDA approval for type 2 diabetes treatment expected later this year.

4. Research Towards a Functional Cure for Type 1 Diabetes

Vertex Pharmaceuticals' Stem Cell Therapy: Vertex is entering pivotal trials for VX-880, an investigational islet cell infusion therapy aimed at providing a functional cure for type 1 diabetes.

5. Emerging Medications

Lilly's Triple Agonist Retatrutide: Retatrutide, a triple agonist targeting GLP-1, GIP, and glucagon receptors, is in phase 3 trials for type 2 diabetes, potentially offering improved glucose control and weight loss.
Expanded Indications for Mounjaro and Zepbound: These medications are undergoing studies for additional health benefits, including cardiovascular outcomes and treatment of conditions like congestive heart failure and kidney disease.

6. Integrated Biosensing Technologies

Dexcom and Oura Ring Partnership: This collaboration aims to integrate continuous glucose monitoring with comprehensive biometric data, providing personalized health insights[30].

III. CONCLUSION & FUTURE PERSPECTIVES

This year is poised to not only introduce transformative technologies and treatments, but also improve accessibility, ease, and outcomes for millions of people with type 1 and type 2 diabetes. Most research on diabetes technology has been conducted in developed countries, despite the fact that most individuals with type 2 diabetes (T2D) reside in low- and middle-income nations. High costs, limited health literacy, and lack of education make these devices inaccessible to many in these regions. Even in developed countries, many individuals with type 1 and type 2 diabetes personally fund technologies that are not covered by their healthcare providers[31]. A major challenge is ensuring equal access to diabetes technology across different socioeconomic groups and countries[32].
To address this, simpler technologies should be designed to accommodate individuals with cognitive or sensory impairments, older adults with T2D, and those with limited technical skills. Additionally, more clinical trials focusing on these populations are needed to improve accessibility and quality of life.Biosensors, such as digital glucometers, continuous glucose monitoring (CGM) devices, and insulin pumps, play a crucial role in diabetes management. Advanced microchips implanted under the skin can connect to smart devices, providing real-time health data and alerts for glucose fluctuations. While biosensors offer immediate and accurate monitoring, they have drawbacks like high costs, skin irritation, and the need for frequent replacements. Besides diabetes care, biosensors are used for environmental analysis, water and air quality testing, cancer research, and virus detection, including COVID-19. CGM technology is expected to enhance metabolic control and improve the quality of life for diabetics.

REFERENCES

[1]. Classification and diagnosis of diabetes: Standards of medical care in Diabetes-2018, Diabetes Care. 41 (2018) S13–S27. https://doi.org/10.2337/dc18-S002.
[2]. S.A. ElSayed, S. Mukherjee, Physiology, StatPearls Publishing, Pancreas, 2018, http://www.ncbi.nlm.nih.gov/pubmed/29083590 (accessed April 22, 2020.

[3]. D.E. Trachtenbarg, Diabetic ketoacidosis, Am. Fam. Physician. 71 (2005)1705–1714, https://doi.org/10.7326/0003-4819-152-1-201001050-01001.

[4]. G.E. Umpierrez, The Diabetes Textbook, Diabetes Textb.(2019), https://doi.org/10.1007/978-3-030-11815-0.

[5]. https://tcoyd.org/2024/12/news-2025-diabetes-devices-and-advancements/#:~:text=Abbott's%20Novel%20Continuous%20Glucose%2DKetone,use%20in%20type%201%20diabetes.

[6]. https://www.barrons.com/articles/dexcom-stock-oura-smart-ring-ff59a16e?

[7]. https://www.verywellhealth.com/eversense-365-cgm-fda-clearance-8718361?

[8]. https://diabetes.org/about-diabetes/devices-technology?

[9]. https://knowridge.com/2025/02/simple-skin-patch-with-gene-switch-could-help-treat-diabetes/?

[10]. IDF Diabetes Atlas | Tenth Edition, Int. Diabetes Fed. (2021).https://diabetesatlas.org/ (accessed February 21, 2022).

[11]. L.A. DiMeglio, C. Evans-Molina, R.A. Oram, Type 1 diabetes, Lancet. 391 (2018) 2449–2462, https://doi.org/10.1016/S0140-6736(18)31320-5.

[12]. L. Heinemann, O. Schnell, B. Gehr, N.C. Schloot, S.W. Görgens, and C.J. Görgen, J. Diabetes Sci. Technol. 16 (2022) 587.

[13]. J. Chaki, S. T. Ganesh, S. Cidham, and U.C. Theertan, J. King Saud Univ. Comput. Inf. Sci. 34 (2022) 3204.

[14]. Domingo-Lopez DA, Lattanzi G, H J Schreiber L, Wallace EJ, Wylie R, O'Sullivan J, Dolan EB, Duffy GP. Medical devices, smart drug delivery, wearables and technology for the treatment of Diabetes Mellitus. Adv Drug Deliv Rev. 2022 Jun;185:114280. doi: 10.1016/j.addr.2022.114280. Epub 2022 Apr 8. PMID: 35405298.

[15]. Deiss D, Szadkowska A, Gordon D, et al. Clinical Practice Recommendations on the Routine Use of Eversense, the First Long-Term Implantable Continuous Glucose Monitoring System. Diabetes Technol Ther. 2019; 21(5):254–264. [PubMed: 31021180]

[16]. Christiansen MP, Klaff LJ, Brazg R, et al. A Prospective Multicenter Evaluation of the Accuracy of a Novel Implanted Continuous Glucose Sensor: PRECISE II. Diabetes Technol Ther. 2018; 20(3):197–206. [PubMed: 29381090]

[17]. E. Ospelt, N. Noor, J. Sanchez, G. Nelson, N. Rioles, F.S. Malik, M. Basina, J. Indyk, F. Vendrame, and J. J. C. d. Schmitt, Clin. Diabetes. 41 (2023), 56.

[18]. Y. Jia, N. Gao, X. Yao, J. Nie, and T. Chen, 11th International Conference on Bioinformatics, and Biomedical Science (2022).

[19]. G.G.R. Sng, J.Y.M. Tung, D.Y.Z. Lim, and D.C. Bee, Diabetes Care 46 (2023) e103.

[20]. Klonoff DC, Kerr D. Smart Pens Will Improve Insulin Therapy. J Diabetes Sci Technol. 2018; 12(3):551–553. [PubMed: 29411641]

[21]. Peyrot M, Barnett AH, Meneghini LF, Schumm-Draeger PM. Insulin adherence behaviours and barriers in the multinational Global Attitudes of Patients and Physicians in Insulin Therapy study. Diabet Med. 2012 May; 29(5):682–9. [PubMed: 22313123]

[22]. Sangave NA, Aungst TD, Patel DK. Smart Connected Insulin Pens, Caps, and Attachments: A Review of the Future of Diabetes Technology. Diabetes Spectr. 2019 Nov; 32(4):378–384. [PubMed: 31798296]

[23]. Diasend. [Accessed 10th November 2020] List of devices that can be uploaded via Glooko Transmitter. 2020. Available fromhttps://support.diasend.com/hc/en-us/articles/360000994897-List-of-devices-that-can-be-uploaded-via-Glooko-Transmitter

[24]. Gildon BW. InPen Smart Insulin Pen System: Product Review and User Experience. Diabetes Spectr. 2018 Nov; 31(4):354–358. [PubMed: 30510392]

[25]. Munshi MN, Slyne C, Greenberg JM, et al. Nonadherence to Insulin Therapy Detected by Bluetooth-Enabled Pen Cap Is Associated With Poor Glycemic Control. Diabetes Care. 2019; 42(6):1129–1131. [PubMed: 30862650]

[26]. Adolfsson P, Hartvig NV, Kaas A, Møller JB, Hellman J. Increased Time in Range and Fewer Missed Bolus Injections After Introduction of a Smart Connected Insulin Pen. Diabetes Technol Ther. 2020; 22(10):709–718. [PubMed: 32003590]

[27]. Pickup JC, Reznik Y, Sutton AJ. Glycemic Control During Continuous Subcutaneous Insulin Infusion Versus Multiple Daily Insulin Injections in Type 2 Diabetes: Individual Patient Data Meta-analysis and Meta-regression of Randomized Controlled Trials. Diabetes Care. 2017; 40(5):715–722. [PubMed: 28428322]

[28]. National Institute for Health and Care Excellence (NICE). Technology appraisal guidance (TA151). Continuous subcutaneous insulin infusion for the treatment of diabetes mellitus. Available from:http://nice.org.uk/guidance/ta151

[29]. American Diabetes Asociation. 7. Diabetes Technology: Diabetes Care. 2021 Jan; 44(Suppl 1):S85–S99. [PubMed: 33298418]

[30]. Frias JP, Bode BW, Bailey TS, Kipnes MS, Brunelle R, Edelman SV. A 16-week open-label, multicenter pilot study assessing insulin pump therapy in patients with type 2 diabetes suboptimally controlled with multiple daily injections. J Diabetes Sci Technol. 2011 Jul; 5(4):887–93. [PubMed: 21880230]

[31]. Li A, Hussain S. Diabetes technologies -what the general physician needs to know. Clin Med (Lond). 2020; 20(5):469–476. [PubMed: 32934039]

[32]. Marso SP, Daniels GH, Brown-Frandsen K, et al. Liraglutide and Cardiovascular Outcomes in Type 2 Diabetes. N Engl JMed. 2016; 375(4):311–22. [PubMed: 27295427]

[33]. International Diabetes Federation.IDF Diabetes Atlas, 10th edn. Brussels,Belgium: 2021. Available at: https://www.diabetesatlas.org (Accessed 22 February, 2025)