Journal of Medical Science, Biology, and Chemistry (JMSBC)

ISSN: 3079-2576 (Online)

Volume 2 Issue 1, (2025)

https://doi.org/10.69739/jmsbc.v2i1.501

https://journals.stecab.com/jmsbc

Published by
Stecab Publishing

Review Article

The Automated Insulin Delivery System in Nigeria: Advances, Challenges, And Future Prospects in Closed-Loop Insulin Delivery Systems

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About Article

Article History

Submission: March 19, 2025
Acceptance : April 26, 2025
Publication : May 03, 2025

Keywords

Automated Insulin Delivery System, Continuous Glucose Monitoring (CGM), Diabetes Management, Health Technology Access, Nigeria Healthcare

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ABSTRACT

Despite the advancements that have been made in other countries regarding care and management, Diabetes Mellitus remains a serious concern to the public in Nigeria; its prevalence keeps increasing, and modern care methods remain inaccessible. The invention of the automated insulin delivery system is an approach that seems hopeful for enhancing glycemic control. However, adopting it in Nigeria is disadvantaged by high cost, inadequate health care facilities, and even the patients. This review mainly focuses on the important perceptions regarding the management of diabetes in Nigeria's health care, such as the handiness and approachability of Continuous Glucose Monitors (CGMs) and insulin pumps. Economic limitations, technological backwardness, and gaps in regulation are all major factors contributing to the problem in the adoption automated insulin delivery system. We strongly recommend local manufacturing of low-cost diabetic equipment, governmental changes to improve access and incorporate the automated insulin delivery system into the healthcare programs, and collaboration between public and private health sectors to improve access and make these modern care methods affordable for diabetes patients. Future directions should be focused on manufacturing low-cost, AI-driven diabetes equipment for managing diabetes and should be tailored to the needs of Nigeria's health care. Policymakers should focus primarily on providing insurance that covers these technology-driven treatment plans, efforts should be made to provide adequate training to healthcare professionals, and sensitization programs to inform patients. By doing these, Nigeria can advance to incorporating an automated insulin delivery system into diabetes care, positively impacting patient outcomes and quality of life.

Citation Style:
Lawal, O. P., Taiye, A. F., Okafor, C. E., Elechi, K. W., Orobator, E. T., Kolapo, T. J., Olaniyi, A. O., Mandal, M., & Olaniyi, H. I. (2025). The Automated Insulin Delivery System in Nigeria: Advances, Challenges, And Future Prospects in Closed-Loop Insulin Delivery Systems. *Journal of Medical Science, Biology, and Chemistry, 2*(1), 64-74. https://doi.org/10.69739/jmsbc.v2i1.501

1. INTRODUCTION

1.1. Overview of Diabetes Prevalence in Nigeria

One of the major problems facing modern medicine is Diabetes mellitus (DM), with both type 1, type 2, and type 2 giving rise to an increased mortality rate (Ajayi *et al.*, 2023). The burden of diabetes mellitus in Nigeria has been growing over the years owing to civilization, lifestyle changes, and genetic predisposition. Diabetes is sometimes even referred to as the big man's sickness (Oguoma *et al.*, 2015). Uloko *et al.* conducted a systematic review and meta-analysis that reported the prevalence of diabetes among adults aged 20–79 years in Nigeria to have increased from 2.0% in 1990 to 5.7% in 2015, subsequently affecting an estimated 4.7 million individuals. (Uloko *et al.*, 2018) However, recent studies conducted by the Endocrine and Metabolism Society of Nigeria reported a higher prevalence of about 10% among adults living in urban areas, equal to about 10 million individuals in the whole nation. This high rate could be attributed to sedentary lifestyles, diet, etc. (Onyedika-Ugoeze Nkechi & Nwanosike Ijeoma, 2024)

Caring for people with diabetes in a low-resource environment like Nigeria comes with its challenges, which include inadequate healthcare infrastructure, high cost of insulin therapy, limited access to glucose monitoring devices, and even a shortage of endocrinologists, among others (Ogurtsova *et al.*, 2022)

2. LITERATURE REVIEW

2.1. The Role of Automated Insulin Delivery Systems in Improving Diabetes Care in Resource-Limited Settings

An automated insulin delivery system is a novel closed-loop system that automatically regulates blood glucose levels (Figure 1). This device can overhaul diabetes care by modernizing glycemic control and reducing diabetes-related complications. (Haidar *et al.*, 2020) However, adopting this sophisticated method of diabetes care is halted in Nigeria due to a lot of socioeconomic and healthcare constraints (Al-Naseem *et al.*, 2023).

There are a lot of benefits in adopting an automated insulin delivery system in diabetes care in Nigeria which include: Improved Glycemic Control; since most diabetes patient in Nigeria struggle to keep up with maintaining their blood glucose levels due to erratic insulin availability and improper monitoring equipment, and many studies have reported that automated insulin delivery system can reduce HbA1c levels by 0.5%-1.5%, reducing the risk of complications like diabetic retinopathy and nephropathy (Thabit & Hovorka, 2015) Another benefit to adopting an automated insulin delivery system in diabetes care for Nigerians is that it will increase the rate at which patients adhere to treatment. Since the automated insulin delivery system automatically delivers insulin, it eliminates the need for incessant pricking of fingers for glucose testing and insulin shots. Furthermore, more automated insulin delivery systems will help address the issue of workforce shortage in Nigeria since Nigeria has less than 100 endocrinologists for more than 200 million people, making access to diabetes specialists very difficult (Ogbera *et al.*, 2014) This AI-regulated insulin delivery in the automated insulin delivery system will reduce the rate at which patients depend on specialists to manage their conditions. So, with advances in subsidized diabetes technologies, policy support, and localized innovations, the automated insulin delivery system could play a life-changing role in enhancing diabetes care and reducing complications subsequently positively improving patient outcomes (IDF, 2021). While it may seem that adopting advanced digital solutions like Artificial Insulin Delivery (AID) systems would increase the demand for specialists such as endocrinologists and diabetes educators, these systems can alleviate the burden on the existing healthcare workforce. AID systems are designed to automate routine and time-intensive tasks like continuous glucose monitoring and insulin dosing, thereby reducing the need for constant specialist supervision. In settings with limited endocrinologists, these systems allow for more remote management of patients, supported by periodic reviews rather than continuous oversight. Moreover, with the integration of mobile health platforms and telemedicine, trained general practitioners and nurses can manage patients effectively, especially with proper upskilling. This task-shifting model is effective in other low- and middle-income countries, suggesting that the use of AID systems, paired with targeted training programs, could extend the reach of diabetes care without requiring a proportional increase in specialist numbers.

2.2. Adoption of continuous glucose meters and insulin pumps in nigeria

The introduction of advanced diabetes technology devices like CGMs and insulin pumps (Figure 1) as an attempt to mirror the human pancreas has transformed diabetic care in many parts of the world, as statistics have proven their advantage over the conventional BGM systems, offering enhanced glycemic control and improved quality of life (Neha Ghosh & Saurahb Vemar, 2024). The use of CGMs and insulin pumps in third-world countries started as far back as the late 20th century. It was not until 2018 that CGMs and insulin pumps were first observed in Nigeria. This may be attributed to a decreased level of awareness, attitude, and perception of this technology in T2DM (Emmanuel *et al.*, 2021). Traditionally, T2DM patients who have adjusted to multiple daily insulin injections (MDI) schedules, routine clinic visits, and finger-pricking glucose monitoring can be predicted to have hesitations when considering the adoption of CGMs and insulin pumps (Kiconco *et al.*, 2024; Nkpozi *et al.*, 2022)

The adoption of CGMs like FreeStyle has recently gained some advantages over the more expensive Dexcom. FreeStyle CGMs require some scanning and do not transmit data in real-time, and this informs their affordability and availability in pharmacies located in big cities like Lagos and Abuja. However, the need for routine replacement of FreeStyle sensors comes with a high cost. This has limited the widespread use of this CGM across the country and restricted its availability to urban cities, while rural settlements have minimal or no access. A study evaluated the reduction in glycated hemoglobin levels for gestational women in India using FreeStyle Libre for their ambulatory glucose monitoring and found a significant reduction.(Sosale & Sosale, 2016) Insulin pumps have stalled in their availability due to their prohibitive costs, fragility, and heavy requirements for importation. After importation duty and taxes have been accrued, the out-of-pocket cost of these pumps is above the budget of an average Nigerian patient, making access to them even more difficult than the CGMs. Despite these hindrances, some private hospitals and diabetes clinics have managed to make these technological devices available in limited supply to those patients who can afford them. Other patients have relied on personal importation of these devices, while others acquire them through medical tourism to countries in Europe and America, where these devices are readily available (Chukwu *et al.*, 2022). While this is a window for healthcare device delivery start-ups, the need for policy-driven interventions is glaring, and there is much work to be done in encouraging the adoption and accessibility to these devices.

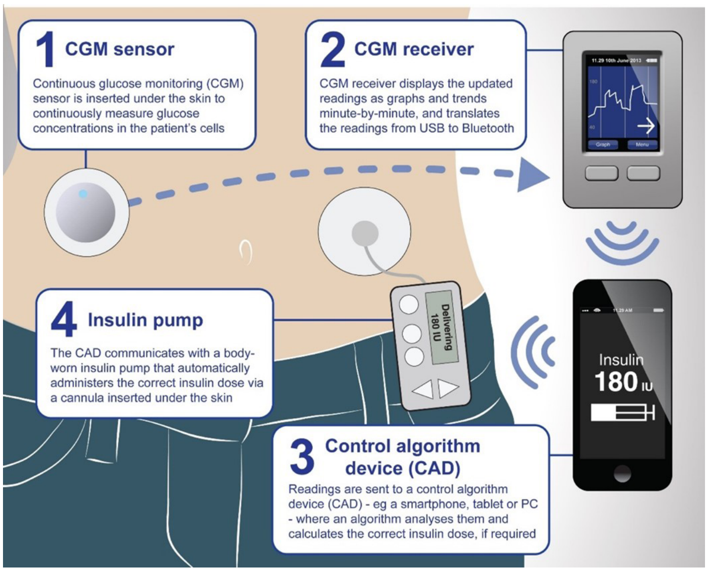


Figure 1. The artificial pancreas system at a glance (Mesko, 2016)

2.3. Challenges in adoption of automated insulin delivery system and its implication

The widespread adoption of automated insulin delivery system technologies is faced with numerous challenges in Nigeria (Mukamurera, 2024; Ubalaeze *et al.*, 2024). These range from technological and infrastructural deficits and financial constraints to regulatory issues and cultural barriers, as shown in Figure 2.

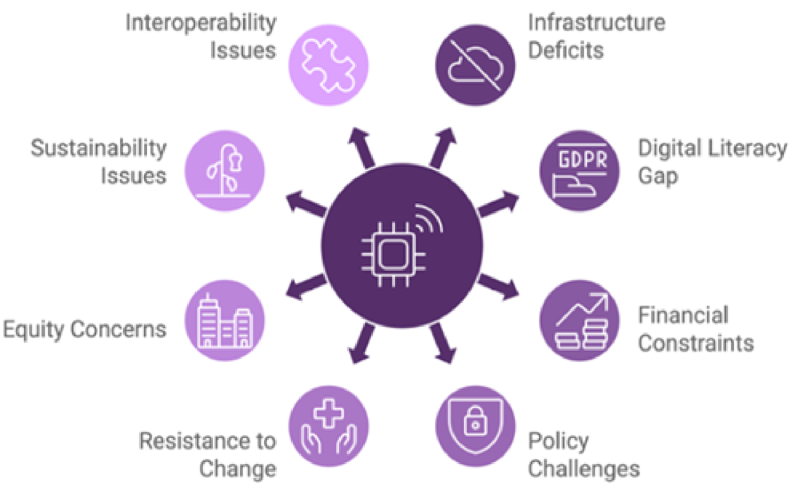


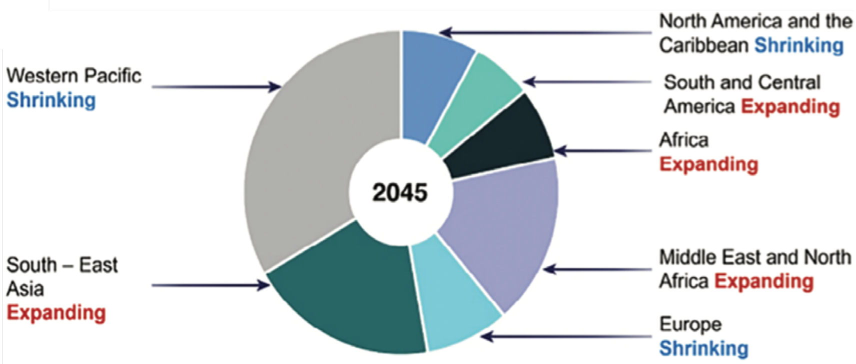
Figure 2. Challenges of AP Systems in Nigeria (Ubalaeze *et al.*, 2024)

2.4. Limited Access to Advanced Diabetes Technology

The lack of adequate ICT infrastructure development, including a low rate of internet penetration as well as limited access to high-performance computers, makes it difficult for healthcare systems to adopt and implement automated insulin delivery systems (Oladipo *et al.*, 2024). For example, the "Abiye" (Safe Motherhood) project in Ondo State, which increased facility-based deliveries by 29.1%, witnessed significant struggles with inconsistent cellular coverage, particularly in rural areas. Ubalaeze *et al.* (2024) automated insulin delivery systems are integrated with alarms that notify the user of high or low glucose levels, which helps to increase the time spent in normal glycemia. With these systems' advent and remote monitoring availability, blood glucose level data and trends may now be shared via cell phones. This feature requires stable Wi-Fi or cell phone signals to upload data to the cloud, allowing clinicians to view glucose patterns and adjust insulin therapy accordingly (Kapil *et al.*, 2020). In regions with unstable connectivity, this critical functionality is compromised, limiting the effectiveness of automated insulin delivery systems.

2.5. Cost Barriers

DM is one of the most demanding life-long illnesses, demanding close monitoring and control. The financial demands of DM for an average Nigerian may be minimal at the onset of management, however, it has been shown to rise over the years (Figure 2), often taking a toll on the patient's finances and requiring assistance from family, relatives, and governmental and non-governmental organizations. Apart from poor monitoring and control practices by the patient, the cost of diabetes care has severely impeded improvement in many patients' glycemic control (Okoronkwo *et al.*, 2015).



	Africa	Europe	Middle-East And North Africa	North America & Caribbean	South and Central America	South-East Asia	Western Pacific
2021(%)	4.5	11.4	13.6	9.5	6.0	16.7	38.3
2045(%)	7.2	8.8	17.3	8.0	6.2	19.3	33.2

Figure 3. Trend of DM Management Cost in the World (Yu *et al.*, 2024).

The World Bank report stated that at the end of 2024, 40.7% of Nigerians were estimated to live below the international poverty line. This is a setback from the 30.9% reported in 2017. (World Bank Reports, 2023) Another report revealed that there is a significant relationship between poverty and glycemic control in Nigeria (Ibrahim *et al.*, 2021). Given the current economic realities, the cost of CGMs, their sensors, and insulin pumps is prohibitive for many Nigerian diabetic patients. As opposed to the norm in high-income countries where the government caters to the healthcare costs, and insurance covers such technology, patients in Nigeria are left to bear the full financial cost by making 'out-of-pocket' payments. Direct costs of medications and monitoring devices before the artificial pancreas system are OHAs, insulin, and glucometers. Studies have indicated that insulin accounts for an average of about 51% of this direct cost monthly (Mercer *et al.*, 2019). At the end of 2024, the price of insulin had skyrocketed from 4,000 to 19,000 Nigerian naira. Insulin pumps, which should replace insulin, come at a one-time minimal cost of 4,500 USD with consumables - infusion sets and cartridges - accounting for about 33.3% of this price for 3-day usage. The continuous procurement of test strips has deterred some diabetic patients from achieving effective diabetes management (CHAI, 2021). Apart from the direct costs, indirect and intangible costs such as reduced productivity, frequent hospital visits, occasional hospitalizations, emergency medical interventions, and psychosocial disturbances that may come with advanced technology diabetes management have elaborated the cost of care. Many Nigerian patients may consider this almost insurmountable, with only a few sustaining their glycemic levels with these devices.

2.6. Lack of Local Suppliers

Aside from OHAs, the availability of diabetes care supplies in Nigeria relies predominantly on importation. Local manufacturing companies have not developed to the level of mass-producing diabetes monitoring devices. An in-vitro diagnostic manufacturing company based in Lagos, named Colexa Biosensor Limited, became the first to launch their set of locally produced glucometers only in 2023 (GBN, 2023). As exciting as this may sound, the reliance on importation will still be high. CGMs and insulin pumps are not commonly stocked in pharmacies or medical equipment stores across the country and may only be found in a handful of them in large urban cities like Lagos and Abuja, and across other states of the country where the presence of large pharmaceutical outlets is felt. Most pharmaceutical outlets require the importation of these devices to stock their premises. The risk of shortages of these advanced diabetes technology devices can result from several factors, including worldwide pandemics, geopolitical tensions, and international trade restrictions. These interruptions may lead to irregular monitoring device availability, which would be detrimental to patient care (Patel *et al.*, 2024).

2.7. Human Factor

The integration of an automated insulin delivery system into diabetes care in Nigeria encounters significant human factor challenges. Despite the rapid extension of technology into most people's everyday lives, uncertainty and frustration with emerging technologies may still lead to dissatisfaction (Moshood *et al.*, 2022). Million of Nigerians rely on traditional medicine for primary healthcare, as the belief that every illness has a cure leads many to turn to traditional healers when biomedical medicine classifies diabetes as a chronic, non-communicable disease (Modibbo *et al.*, 2024). Studies show that patient education plays a crucial role in enhancing both willingness and technical proficiency of Advanced Practice techniques in diabetic care (Mukamurera, 2024). The advancement of disease awareness helps patients realize the dangers that lead to early detection while changing their lifestyles to avoid disease progression (Olatunde, 2025).

However, users have raised various concerns, the most prevalent of which appears to be trust in Closed-Loop (CL) devices (Quintal *et al.*, 2019). Additional challenges include technical trouble, excessive intrusiveness of an alert function, the equipment's cumbersome size, inadequate device connectivity, and discomfort in incorporating CL systems into daily activities like as exercise and bathing (Kapil *et al.*, 2020).

2.8. Regulatory and Infrastructural Concerns

Nigeria suffers from insufficient specific policies, together with regulatory guidelines, which prevent the implementation of Artificial Pancreas systems in its healthcare infrastructure. The absence of e-health guidelines in numerous sub-Saharan African countries obstructs public hospital digital health implementation. While Nigeria has developed overarching digital health strategies, such as the National eHealth Policy, which addresses the application of ICT in healthcare delivery, there is a notable lack of targeted policies for the adoption and implementation of advanced AI-driven medical devices like automated insulin delivery system (Oladipo *et al.*, 2024) The Nigerian health authorities need to create extensive policies which directly target AI-based medical devices such as AP systems while implementing them. Governments must create defined authorization procedures and implementation requirements with proven systems to safeguard patient data. (Olatunde, 2025) Working together with NGOs along with global health organizations, and private sector stakeholders requires high priority for effective progress. Global health organizations WHO and the IDF, along with the World Bank, have developed necessary support systems for diabetes care in low-income countries. These organizations provide three types of assistance, including financial backing and technical and programmatic resources that were previously inaccessible (Olatunde, 2025). The challenges outlined above can be better understood and addressed through a structured approach, as summarized in Table 1 below.

Table 1: Current Barriers to the Adoption of Artificial Insulin Delivery (AID) Systems in Nigeria and Suggested Solutions

Current Barriers to the AID System Adoption in Nigeria	Suggested Solutions
1. Limited access to advanced technology and internet infrastructure	Improve ICT infrastructure, especially in rural areas; subsidize data access; promote offline-compatible AID systems.
2. High cost of CGMs, insulin pumps, and AP systems	Encourage local manufacturing; implement government subsidies or insurance coverage; promote low-cost alternatives.
3. Lack of local suppliers and dependence on imports	Support local biomedical startups; reduce import duties on diabetes technologies; establish distribution partnerships.
4. Cultural resistance and reliance on traditional medicine	Launch nationwide education and sensitization campaigns; involve community leaders in promoting modern diabetes care.
5. Distrust of and discomfort with new technologies	Provide hands-on training and user-friendly interfaces; improve device ergonomics and privacy of use.
6. Inadequate regulatory framework for AI-driven medical devices	Develop and implement specific policies for AID systems; establish clear regulatory guidelines and patient data protection laws.
7. Lack of trained healthcare professionals and inconsistent training	Integrate digital health and AI modules into medical curricula; offer continuous professional development programs.

2.8. Future Directions

Automated insulin delivery systems present a vital innovation that automates blood glucose control by minimizing the everyday complications people with diabetes face. AP system technological advancements during the upcoming years will concentrate on key elements that emerge from developing technologies.

2.8.1. Advancements in Closed-Loop Systems

User interaction remains essential for most automated insulin delivery systems because they operate as hybrid closed-loop systems, which demand both meal prompt inputs from users as well as carbohydrate measurements. Counting carbohydrates accurately presents multiple challenges because this practice requires a significant amount of time and poses risks of human error. The simple labeling system tempts individuals to choose packaged food instead of beneficial whole foods since the labels make processed food more convenient (Kadiyala *et al.*, 2024). Future iterations of artificial pancreas systems are looking towards the goal of creating fully automated closed-loop technology that operates without needing user interaction (Lal *et al.*, 2019).

2.8.2. Expanding Accessibility and Affordability

Despite technological advancements, automated insulin delivery systems remain inaccessible to many individuals with diabetes due to high costs and limited availability. Okubanjo *et al.* (2024) developed a low-cost IoT-based e-health monitoring system for diabetic patients, integrating sensors with a NodeMCU microcontroller and the Blynk IoT platform for real-time tracking of blood glucose, heart rate, SpO_2, and body temperature. Tested on 250 patients, the system showed high accuracy, with blood glucose readings deviating by a maximum of 1.97% from commercial CGMs, heart rate by 1.09%, oxygen saturation level (SpO_2) by 1.08%, and temperature within a 5% tolerance. With a cost of just NGN 12,377 ($16.09), it offers an affordable alternative to existing models (Okubanjo *et al.*, 2024). Kesavadev *et al.* (2021) examined the role of digital health in diabetes management in India, highlighting the integration of technologies like continuous glucose monitoring (CGM), insulin pumps, telemedicine, electronic medical records (EMR), and mobile health (m-Health). The diabetic population in India stands at 77 million patients, and digital healthcare systems exhibit reliable results for managing blood sugar control alongside treatment compliance and distant patient tracking. The research paper shows CGM technology reduces HbA1c levels by 0.5%−1.6 % in Type 2 diabetes cases, along with mobile health solutions achieving diet plan and exercise improvement ranges between 8%−15 % betterment. The Chunampet Rural Diabetes Prevention Project, under telemedicine, operates to deliver vital diabetes care services to isolated regions. (Kesavadev *et al.*, 2021) For Nigeria, similar telemedicine models and mobile-based interventions could enhance diabetes care, particularly in underserved areas, leveraging the country's increasing mobile penetration to improve patient outcomes.

The global market of commercial automated insulin delivery systems is expected to reach about USD 10 billion by 2028. (Dermawan & Kenichi Purbayanto, 2022), as shown in Fig. 5. Therefore, there is a need for novel technological advancements to foster startup growth within medical technology segments across sub-Saharan Africa. The widespread availability of this technology across sub-Saharan Africa will allow manufacturers to reach economies of scale, which will reduce total costs. Better market penetration from reduced device costs enables improved management of Type 1 Diabetes throughout sub-Saharan Africa (Mohammed *et al.*, 2022).

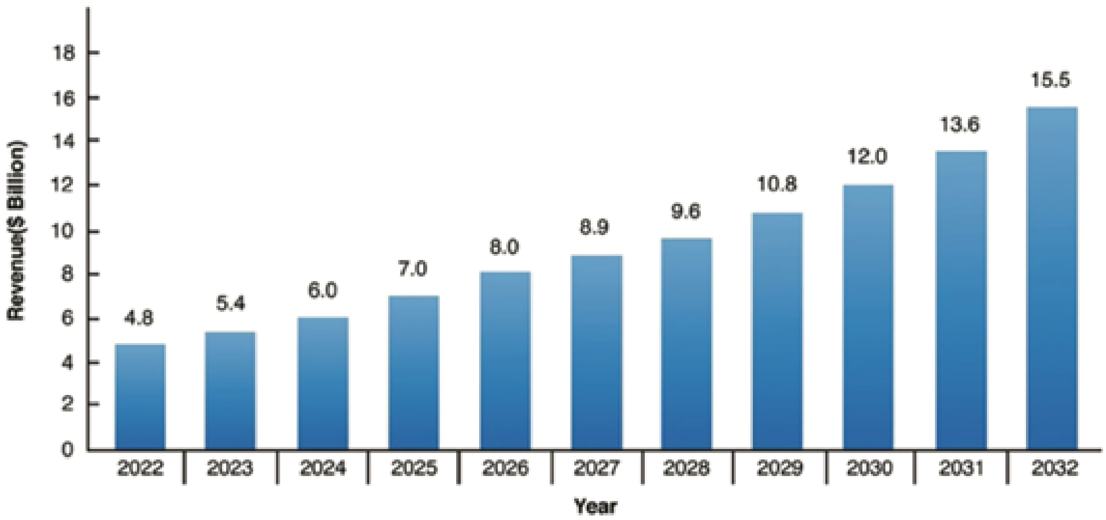


Figure 5. Revenue Trend of the Global AP Market (Yu *et al.*, 2024)

2.8.3. Standardizing Medical Education and Training

Incorporating digital health and AI-related modules into medical curricula is essential for preparing healthcare professionals to effectively utilize automated insulin delivery systems. Healthcare professionals play a key role in granting access to diabetes technology, and its widespread adoption relies on its openness and availability to support users, especially those from underserved communities (Kadiyala *et al.*, 2024). Standardizing education across institutions can ensure consistent training and better patient outcomes. For example, European medical physics societies have approved curricula that include AI training, serving as a model for other regions. It is recommended that all academic institutions offering medical training in Africa incorporate AI materials into their curriculum for aspiring medical professionals. Although some medical schools in Nigeria have begun to introduce digital health modules to their curriculum. Mohamed *et al.* (2024) the lack of a standardized national curriculum results in inconsistencies in training across institutions. The addition of digital health modules into the standardized medical curriculum would close the growing teaching shortage across Africa while making education more personalized and enduring and helping people develop digital skills needed for modern workplaces (Manson *et al.*, 2023).

3. METHODOLOGY

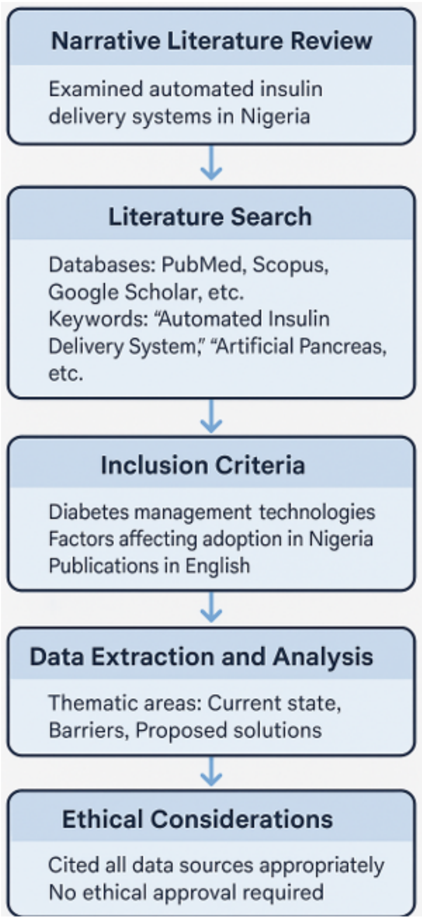


Figure 6. Flow chart of methodological approach to the study

This study employed a narrative literature review approach to explore the advancements, challenges, and future prospects of automated insulin delivery systems within the Nigerian healthcare context. The design was chosen to provide a panoramic, explanatory synthesis of different literature sources from socio-economic analyses, technological assessments, to patient-centered studies and health policy communications.

3.1. Literature Search Strategy

The search was initiated by the identification of relevant literature from major academic databases including PubMed, Google Scholar, ScienceDirect, and Europe PMC. Supplementary searches included grey literature from the World Health Organization (WHO), International Diabetes Federation (IDF), and Nigerian health policy documents. A manual screening of reference lists (snowballing technique) was conducted to capture additional pertinent studies not identified in the database search.

Keywords and search terms were used to generate specific search results and they included combinations of:

"Automated insulin delivery", "Artificial pancreas system", "Continuous glucose monitoring Nigeria", "insulin pump access Africa", "diabetes technology challenges", and "healthcare innovation Nigeria". Boolean operators (AND, OR) were applied to enhance the search sensitivity.

3.2. Inclusion and Exclusion Criteria

Articles were included if they (a) were published between 2014 and 2024 (b) were written in English (c) addressed diabetes management technologies (CGMs, insulin pumps, closed-loop systems) (d) discussed healthcare barriers, adoption issues, or socioeconomic factors in Nigeria or comparable low- and middle-income settings.

Studies were excluded if they focused solely on population groups in areas geographically remote from Nigeria, if they had traditional diabetic care content without any focus/mention about advanced diabetic technology or if they lacked relevance to the Nigerian or sub-Saharan African context.

3.3. Data Extraction and Synthesis

Identified studies were reviewed qualitatively. Data extraction focused on thematic elements such as: technological advancements in insulin delivery, barriers to technology adoption, policy, infrastructural, and human factor influences, proposed strategies for future integration of automated systems. Rather than a quantitative meta-analysis, a thematic synthesis was employed to collate insights across diverse study types. Findings are organized narratively to capture trends, challenges, and opportunities, and are supported by figures and tables where appropriate.

This narrative methodology allows for an integrative and critical understanding of complex multidisciplinary issues influencing diabetes technology adoption in Nigeria.

4. RESULTS AND DISCUSSION

4.1. Results

This section presents the findings of the reviewed literature on automated insulin delivery (AID) systems in Nigeria, synthesized into thematic areas to reflect the most pressing challenges and innovations in diabetes care as encountered in low-resource settings. Drawing on evidence from peer-reviewed studies, policy reports, and empirical reviews cited in this study, the results are discussed below under six main thematic headings.

4.1.1. Glycemic Control Outcomes with AID Systems

Automated insulin delivery systems, incorporating continuous glucose monitoring (CGM) and insulin pump technologies, have demonstrated remarkable efficacy in improving glycemic control. Studies in high-income settings report reductions in HbA1c levels ranging from 0.5% to 1.5% (Thabit & Hovorka, 2015; Haidar *et al.*, 2020). These systems reduce glycemic variability, decrease the incidence of hypoglycemia, and prevent long-term complications such as nephropathy and retinopathy. In Nigeria, while local studies remain limited, extrapolated evidence underscores the potential benefits if such systems are adopted at scale, particularly in populations struggling with glycemic instability due to erratic insulin availability and limited specialist access.

4.1.2. Adoption Rates and Accessibility in Nigeria

Despite their proven benefits, AID technologies remain underutilized in Nigeria. The first observable usage of CGMs and insulin pumps occurred post-2018 and remains largely restricted to affluent urban populations (Emmanuel *et al.*, 2021). CGMs like FreeStyle Libre have found moderate uptake due to relatively lower costs compared to Dexcom, although routine sensor replacement still poses a financial burden. Insulin pump adoption is even lower due to import dependency and prohibitive costs, with access mostly limited to private hospitals, personal imports, or overseas procurement (Nkpozi *et al.*, 2022; Chukwu *et al.*, 2022).

4.1.3. Economic Impact and Affordability

Cost remains one of the most formidable barriers to AID adoption in Nigeria. AID systems are not covered by national insurance schemes, and patients must bear out-of-pocket expenses. Insulin prices rose from NGN 4,000 to NGN 19,000 in 2024, while insulin pumps average $4,500 USD, excluding the cost of consumables which require replacement every three days (CHAI, 2021). These costs are unsustainable for the majority of patients, especially in a country where over 40% of the population lives below the poverty line (World Bank, 2023). Additional costs include hospital visits, lost work productivity, and psychosocial burdens of managing diabetes without technology (Ibrahim *et al.*, 2021).

4.1.4. Technology and Infrastructure Readiness

The infrastructural capacity to support AID systems is currently limited in Nigeria. Many regions lack the internet connectivity necessary for real-time glucose monitoring and remote clinical supervision. Projects like the 'Abiye' maternal health initiative highlight the infrastructural struggles even within government-supported programs (Ubalaeze *et al.*, 2024). Moreover, device availability is hindered by the near-total reliance on imports, although the establishment of Colexa Biosensor Ltd in Lagos marks a milestone in local glucometer production (GBN, 2023).

4.1.5. Patient Behavior, Education, and Acceptance

Cultural attitudes and awareness levels significantly impact technology acceptance. A large segment of the Nigerian population relies on traditional medicine, which complicates the acceptance of advanced medical devices like AID systems (Modibbo *et al.*, 2024). Common complaints among users include alarm fatigue, bulkiness, and integration challenges during activities such as sports and bathing (Kapil *et al.*, 2020). Education and targeted awareness campaigns have proven effective in other LMICs and could be critical in Nigeria for improving trust and reducing technological resistance (Mukamurera, 2024).

4.1.6. Policy and Regulatory Environment

There is an absence of specific regulatory policies in Nigeria concerning AI-powered and digital diabetic technologies. While the national eHealth policy offers a broad digital framework, it lacks specific provisions for automated insulin delivery systems. Coordinated collaboration between government bodies, global organizations (like WHO and IDF), and private sector stakeholders is needed to develop safety guidelines, training programs, and implementation frameworks for AID systems (Olatunde, 2025; Oladipo *et al.*, 2024).

Table 1. Thematic Synthesis of Findings on AID Systems in Nigeria

Thematic Area	Summary of Findings	Challenges Identified	Relevant References
Glycemic Control Outcomes	AID systems improve HbA1c by 0.5%–1.5% and reduce diabetes complications like retinopathy and nephropathy. Outcomes in high-income countries show consistent glycemic stability with CGM and insulin pump integration.	Limited local data in Nigeria; technology not yet widespread.	Thabit & Hovorka, 2015; Haidar *et al.*, 2020; Kadiyala *et al.*, 2024
Adoption and Accessibility	First adoption of CGMs and pumps in Nigeria observed post-2018. Uptake is low and confined to private settings in urban areas. FreeStyle CGMs moderately used; Dexcom and insulin pumps remain rare.	Poor distribution, high costs, urban-rural disparity.	Emmanuel *et al.*, 2021; Nkpozi *et al.*, 2022; Chukwu *et al.*, 2022
Economic and Cost Burden	Insulin cost rose from NGN 4,000 to NGN 19,000 (2024). Insulin pumps cost approx. $4,500 excluding consumables. Over 40% of Nigerians below poverty line struggle with affordability.	Out-of-pocket payments, no public insurance support.	CHAI, 2021; Ibrahim *et al.*, 2021; World Bank, 2023
Technological and Infrastructure Readiness	ICT infrastructure is underdeveloped. Real-time glucose upload and monitoring often fail in rural areas. First local glucometer factory (Colexa) launched only in 2023.	Inconsistent network access, reliance on imports.	Oladipo *et al.*, 2024; GBN, 2023; Ubalaeze *et al.*, 2024
Patient Behavior and Trust	Cultural preference for traditional medicine persists. Patients cite alarm fatigue, bulkiness, and poor lifestyle integration of AID devices. Limited user education.	Technological distrust, low awareness, social resistance.	Modibbo *et al.*, 2024; Mukamurera, 2024; Kapil *et al.*, 2020
Policy and Regulation	Nigeria lacks policies specific to AI-driven diabetes technologies. Broad eHealth plans exist, but there are no guidelines for AID integration. Need for cross-sector policy frameworks.	Policy vacuum, lack of structured implementation channels.	Olatunde, 2025; Oladipo *et al.*, 2024; WHO, IDF Reports

4.2. Discussion

The findings of this review underscore a profound technological and policy gap in the adoption of Automated Insulin Delivery (AID) systems in Nigeria. While the clinical benefits of AID technologies such as insulin pumps and CGMs are well-documented in high-income settings—with clear reductions in HbA1c levels, lower incidence of complications, and improved quality of life—translating these benefits into the Nigerian context remains challenging. AID systems are virtually nonexistent in public healthcare, and even private use is sparse, limited to affluent populations in urban centers.

The overwhelming cost burden—particularly in the face of rising insulin prices, unregulated import duties, and lack of local production—has made these systems inaccessible to over 95% of diabetic patients in Nigeria. The absence of universal healthcare coverage or targeted subsidy programs for diabetes care only compounds this disparity. Technologically, Nigeria suffers from inadequate ICT infrastructure necessary for remote monitoring, compounded by a dearth of trained endocrinologists and diabetes educators.

Cultural attitudes and public mistrust toward foreign or advanced technologies further complicate implementation. Many Nigerians continue to rely on traditional healing practices, which are often incompatible with continuous glucose monitoring and closed-loop systems. Meanwhile, national policies have yet to address the integration of AI and digital medical devices into chronic disease management frameworks, leaving AID systems in regulatory limbo.

However, these findings also illuminate promising avenues for intervention. Local startups like Colexa Biosensor have begun laying the groundwork for domestic production of glucometers. Studies such as that by Okubanjo *et al.* (2024) demonstrate the feasibility of low-cost, locally engineered IoT-based glucose monitors, indicating a path toward scalable innovation. Task-shifting approaches—where general practitioners and nurses manage diabetes with tech support—could also bridge the gap created by specialist shortages. Telemedicine, mobile health, and AI-driven patient monitoring are tools that, if scaled appropriately and regulated with clear guidelines, could democratize access to AID systems in Nigeria and similar LMICs.

5. CONCLUSION

This review provides compelling evidence that Automated Insulin Delivery systems can dramatically improve diabetes outcomes in Nigeria, but systemic barriers must first be addressed. Among these are the prohibitive costs of devices, infrastructural deficits, low technology literacy, cultural resistance, and the lack of clear regulatory frameworks. To actualize the benefits of AID systems in Nigeria, coordinated action is required across multiple sectors—government, private industry, academia, and international agencies.

Future efforts should focus on three pillars: (1) reducing the cost of diabetic technologies through local production and strategic partnerships; (2) strengthening health system readiness by training a digitally competent workforce; and (3) developing clear policies that regulate and encourage safe use of AI-powered medical technologies. Such interventions, if implemented strategically, could create an enabling environment for inclusive, equitable, and future-ready diabetes care in Nigeria.

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