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Review Article

AI-Based Approaches for Early Detection and Prevention of Diabetes

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ABSTRACT

Diabetes mellitus is a chronic and multifaceted disorder representing a major global health concern. The two primary forms, Type 1 and Type 2 diabetes, differ in origin and progression yet share serious complications, including cardiovascular disease, kidney impairment, and nerve damage. In recent years, Artificial Intelligence (AI) has emerged as a transformative tool for early detection, treatment optimization, and prevention of diabetes-related risks. This review examines the role of AI in diabetes management, focusing on its integration into early diagnostic systems, personalized treatment planning, and risk prediction based on diverse and large datasets. These data sources include medical history, lifestyle patterns, and genetic profiles. AI-based models, particularly machine learning algorithms and neural networks, demonstrate improved accuracy in identifying diabetes and enabling timely intervention. AI-powered wearables and mobile applications support continuous self-monitoring and provide real-time recommendations for glycemic control. Moreover, the application of AI within traditional medical systems such as Ayurveda and Unani shows potential for enhancing diagnostic precision and individualized care. However, challenges persist, including inconsistent data quality, algorithmic limitations, and concerns regarding patient data privacy. Advancements in big data analytics and IoT technologies continue to expand the scope of AI in diabetes care. AI is reshaping diabetes management by improving clinical outcomes, reducing healthcare costs, and contributing to global efforts to mitigate the burden of the disease.

Keywords: Artificial Intelligence, Diabetes Mellitus, Digital Health, Early Detection, IOT, Machine Learning, Personalized Medicine, Predictive Modelling.

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INTRODUCTION

Type 1 diabetes happens when the body's immune system attacks its own insulin-producing cells in the pancreas. This leads to a lack of insulin and, over time, the cells just stop working right. People with it need insulin shots or pumps for the rest of their lives. Insulin got discovered over a century ago now. Since then, treatments have come a long way. They've helped tons of folks manage the disease better. Researchers keep digging into the genetics and immune stuff behind type 1 diabetes. They're also looking at ways to slow down complications and keep those beta cells going longer. All this has built up a bigger picture of how the condition works. Biomarkers show up months or even years before real problems hit. That's why experts now split type 1 diabetes into three stages. Continuous glucose monitors have totally shifted how we handle the day-to-day. New automated insulin systems go with them. They help keep blood sugar steadier, lower A1C levels, and cut down on those scary low-sugar episodes. Other treatments might join in soon, like SGLT-1 blockers or GLP-1 agonists. You know, stuff that could tweak management in fresh ways. But even with all these quick steps forward, people in poorer areas still can't get basics like insulin, syringes, or glucose strips. It's tough. This review looks at the latest in diagnosis and care, plus where things might head next in type 1 diabetes research (Subramanian *et al*., 2024).

Type 2 diabetes, or T2DM, ranks as one of the most widespread metabolic issues out there globally. The sickness and death rates from it keep climbing. That's turned it into a huge worldwide health headache. Right now, there's no full cure for T2DM. Treatments mostly aim at keeping blood sugar in check. They also focus on stopping complications or dealing with them when they come. Here's something interesting though. The bacteria in your gut, the microbiota, seem to play a big part in how metabolic

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problems like T2DM develop. In this review, we go over what the gut microbiota looks like in people with T2DM. We cover animal models of the disease too. And yeah, how it ties into complications. On top of that, we break down the ways the host body and gut bacteria connect in T2DM. Like, the host factors that mess up the gut balance, or dysbiosis. Immune reactions and inflammation get involved. Then there are the gut microbes' byproducts that drive the disease forward. All these insights point to one thing. We could tackle T2DM and its side effects by tweaking the gut microbiota. Ways to do that include meds, probiotics, prebiotics, even fecal transplants or FMT, and special diets (Zhou *et al*., 2022).

In recent years, artificial intelligence has moved ahead really fast. That has gotten a lot of attention in healthcare. People are excited about it. This looks at how AI fits into changing patient care and well-being. It shows the ways it could reshape how healthcare gets delivered. When we dig into AI uses in drugs, you see all these options. They promise better, more solid results in healthcare. The piece goes through different areas of bringing AI into healthcare. That includes things like personal accuracy, perfect drugs, finding new medicines, and automating processes. It also covers ethical stuff that comes with adding AI to healthcare. Responsible and fair use matters a lot here. With some real-world examples, it highlights wins from AI in healthcare spots. Those give useful ideas for what's next. In the end, this gives a full picture of AI's big changes in healthcare. It touches on what that means for patients and their well-being (Zhou *et al*., 2022).

UNDERSTANDING DIABETES

Risk factors, symptoms, causes, and complications. People with diabetes often see their life expectancy drop. In our time, diabetes hits hard and can be deadly. It leads to hidden problems like eye damage, kidney failure, circulation issues, heart trouble, and plenty more health headaches (Sanyaolu *et al*., 2023).

Prevention

The fourth way AI gets used in diagnosing stuff. For treating diabetes, it means planning ahead and spotting risks for the condition. This fits right into preventive medicine. It targets folks most likely to get it. You build a fake version of the disease from everyday people data at different points. Before the illness even starts. So this tech, in the end, helps fight diabetes with early medical steps. Actions taken soon to help those hit by it. You can't just predict diabetes from birth alone. Machine learning tech comes in handy there. So far, tons of diabetes cases out there. Stats get used to make models that predict when it starts. Big groups of people show clear risk factors tied to diabetes as mentioned in Figure 1. Models like logistic regression, the Cox proportional hazard one, or Weibull have proven useful, *et al*. They did a study predicting diabetes onset in non-diabetics over 5 to 10 years using data breakdowns. In this paper, the accuracy for predicting new diabetes cases stays solid within that 5 to 10 year window (Nomura *et al*., 2021).

CAUSES

The study points out that obesity and diabetes stand as big reasons for sickness and death across the United States. You know, both obesity and putting on weight tie right into a higher chance of getting diabetes for folks out there. Pancreatic beta cell function takes a hit, and it really worsens as time goes on in type 2 diabetes cases. Ageing, obesity, not getting enough energy from food, drinking alcohol, smoking, those things all act as separate risks in how type 2 diabetes develops. Overeating, smoking, ramping up alcohol, issues with the nervous and endocrine systems, higher cortisol levels, messed up sex hormone release, skimping on exercise which drops energy use, and even stuff passed down from family, kind of like aging, they all can lead to diabetes mellitus. Factors like aging, obesity, poor energy intake, smoking, and alcohol use play into it (Nomura *et al*., 2021).

Complications

High glucose levels sticking around for years bring on heavy problems, like organs not working right or failing altogether, hitting the eyes, kidneys, nerves, heart, blood vessels especially (Ellahham *et al*., 2020). Long-lasting or permanent issues from diabetes mellitus include eye problems that end in total vision loss, kidneys not doing their job properly, and nerve damage in the outer parts of the body.

ROLE OF AI IN HEALTHCARE

Introduction of AI

Artificial intelligence is really picking up steam when it comes to handling and spotting diabetes. You know, this disease is like a global nightmare. Pretty much everywhere. And this AI stuff could totally change how we diagnose and deal with it. People have put together these predictive models. They figure out risks for diabetes or the nasty complications that come with it. All based on machine learning basics. To make these algorithms work. Digital therapeutics are now a solid way to manage diabetes. Kind of like a lifestyle fix. Patients are getting more control over things themselves. So, either they or their doctors end up with better clinical decision support. AI lets you monitor symptoms and biomarkers from far away. They boost how engaged patients are in managing their diabetes. Tech advances help diabetic folks use resources way better. Smart tweaks in the tech cut down fasting and postprandial glucose levels. glycosylated haemoglobin drops with better glycemic control (Ellahham *et al*., 2020).

Types of AI technologies used in healthcare

Several parts of healthcare deal with AI solutions. You know, services get used in all sorts of ways. Like in surgery, or with nursing assistants, even medical consultations. Those are just

some areas where AI fits right in. Then there's administration stuff, workflow management, treatment planning, cybersecurity, and so on. Health monitoring, machine vision for spotting things, pre-diagnosis, automatic diagnosis. Drug management, research, clinical trials. Operations too. All these spots have ways AI gets applied. We stuck mainly to quantitative studies for our main look. Basically, we pulled results from PubMed and other medical journals, using AI to gather info on services in healthcare. Sources like Oxford University Press, the Food and Drug Administration, Nature Biomedical Engineering. Reports from PWC and the Drug Administration. Accenture too. We checked out how effective these articles and reports are, comparing them to other sources. Services without AI versus ones that do use it. In the end, our paper lays out a bunch of AI-based services for healthcare. They show real effects on care outcomes. Plus, we give suggestions to make those outcomes better. It's like putting together services that could lead to the best possible results. Preventive healthcare and clinical work matter a lot (Vaamanen *et al.*, 2021).

The benefits of using AI in medical diagnosis and prevention. AI really steps in to handle that demand. It streamlines all sorts of processes. Boosts productivity too. Thing is, it's getting woven into everyday life more and more. Tackles tough problems across industries. Medicine included. You have neural networks. Machine learning. Big data analytics. All of that is pushing into medical practice now. Could totally change modern medicine. Feels natural. Inevitable even. This kind of progress opens doors. Better diagnosis. Improved treatment. Stronger patient care. Plus, it ramps up efficiency in medical research (Kothinti *et al.*,2024).

Artificial intelligence automates billing tasks. Handles inventory management. Reduces administrative overhead. Frees up resources for actual healthcare stuff.

AI offers personalized treatment options. Helps decrease complications. Thing is, without it, there's often a lack of effective treatments. High costs hit patients needing intensive care. Better monitoring. Smarter treatment overall (Sheliemina *et al.*, 2024).

AI FOR DIBETES DETECTION

Machine learning involves computers generating new ideas and setups on their own. Basically, it's about a system called machine learning, or ML, where the key parts are data, features, and models. You pull those features from the info, then feed them into algorithms to spot fresh patterns or rules. Depending on how much you guide the output, it falls into supervised, unsupervised, or reinforcement types. Supervised learning gives the system tons of input data to predict results, like guessing low blood sugar episodes. Unsupervised skips the outside help, just letting the algorithm dig out patterns from the data alone. Take robotics, for example. Reinforcement learning lets a robot figure out the smartest moves by messing around with its environment. Over the last few decades, folks have built ML algorithms based on stats or logical thinking. Neural networks are one that's really caught on lately in medical AI stuff (Sheliemina *et al.*, 2024).

Spotting diabetes early really matters for stopping problems and improving how patients do. As AI keeps advancing, more people are looking at using its algorithms to catch diabetes sooner. By sifting through huge piles of data, like genes, daily habits, health records, and body markers, AI can flag folks at risk and push for quick fixes. That early heads-up lets doctors set up custom treatments, tweak lifestyles, and give the right support to manage the condition. AI picks up on patterns, links, and risks that regular checkups might miss entirely. So, experts can step in before big issues hit, you know, like nerve damage, kidney trouble, or heart problems. And it's not just in clinics where AI helps with this. Figure 1 shows how AI apps spot diabetic foot ulcers. Wearables and phone apps are getting big now, so people can track their blood sugar, exercise, and what they eat on their own. Link those to AI, and you get instant tips, personal advice, and warnings if something's off. Still, even with all that promise for early diabetes detection, there are hurdles to sort out (Sheliemina *et al.*, 2024).

AI Systems

Artificial intelligence chatbots are programs that handle natural language processing to sound like real talk. They use machine learning to crunch data and answer all sorts of queries. Lately, they've become super useful in areas like marketing, education, customer support, info sharing, healthcare, entertainment, and beyond (Cappellani *et al.*, 2024).

Traditional Medicine

The way artificial intelligence and electronics are getting mixed into traditional medical practices is really changing things up in healthcare. It helps with better watching over patients, tailoring treatments just for them, and getting diagnoses spot on. In Ayurvedic medicine, they use stuff like wearable tech, you know, AI-powered pulse monitors that keep tabs on vital signs and dosha balances all the time. Practitioners can tweak treatment plans right away because of the live data coming in. AI might even pick up on tiny details in Ayurvedic pulse checks, like Nadi Pariksha, that people could miss, leading to sharper diagnoses. There are case studies showing how this tech blends in successfully. One example is using AI to customise Unani medicines by looking at patient data and predicting outcomes. That boosts the good effects of treatments and cuts down the bad ones (Zhou *et al.*, 2020). When it comes to preventing diabetes with AI, these technologies step in big time. They spot people at high risk before the disease even hits, so early steps can be taken to lower how often it happens (Wright *et al.*, 2017). AI really shines at finding those high-risk folks for diabetes way ahead of time. Using machine learning and crunching big data, it digs through things like health records, genes, daily habits, and even gut bacteria to predict Type 2 diabetes or prediabetes. It catches small body changes that humans might not notice. Plus, it sorts

patients into risk groups for custom plans. Oh and, there's this whole issue with modern systems handling multiple tasks, like dealing with both types of diabetes from spotting it to developing drugs for treatment (Chavali *et al.*, 2024). AI's role in actually treating diabetes has stepped things up with smarter monitoring and tools powered by machine learning and algorithms that help understand everything better. This leads to early checks, quick responses, and treatments made just for the person. Analyzing patient info with AI improves how accurate diabetes predictions are, which means better personal options and overall health results. On top of that, AI speeds up making new drugs for diabetes, giving more ways to help. Systems based on AI for decisions and self-management tools put patients in charge of their care, letting them lead in controlling diabetes. But to make sure AI is used right in clinics, we have to tackle worries about keeping data safe and getting consent. Basically, AI could totally change how diabetes is handled and improve global health efforts (Rigla *et al.*, 2018). Using AI to catch diabetic retinopathy early is a smart, low-cost way to screen and cut down on eye problems from diabetes, even preventing blindness that could be avoided. Continuous glucose monitors, those CGMs, help drop the costs of diabetes care overall. Also, image networks spotting foot ulcers or retinal issues in diabetics mean faster referrals to specialists, which improves life quality with interventions that happen right when needed (Tahir *et al.*, 2023).

AI Technologies and Diabetes: Areas of Application

The AI tech stuff from section 1, you know, it's all been put to work in various parts of managing diabetes. Check the appendix for details. This part here just sums up a few examples. Helps get a better grip on how useful they really as mentioned in Figure 2. Patient decision support using CBR. Researchers at Imperial College in London did some key experiments on this with expert systems. They built and tested a bolus calculator based on case-based reasoning. It pulls in data from continuous glucose monitors and runs right on the patient's phone (Chavali *et al.*, 2024). Then there's this AI-powered mobile app acting as a virtual health assistant. It comes with smart features, like personalized recommendations for what to do next. Predictive analytics to spot patterns early. Natural language stuff, think chatbots or voice commands for easy talking. Computer vision that lets you scan food or even body measurements. And real-time monitoring through sensors or wearables. As mentioned in Figure 3. Virtual nurses use things like wireless straps for continuous tracking to get that health data. They can even figure out what's wrong based on symptoms. It's on them to send reports over to the right doctor or therapist. Involves checking in regularly, looking at symptoms, mapping out progress, all that. Physicians or surgeons, they might need extra time for those tasks otherwise for prevention as mentioned in Figure 4 (Draznin *et al.*, 2018). Virtual nurse assistants help medical pros saves time. Let's them focus on the big stuff, the critical patient needs. AI in healthcare IT makes this possible now. Besides straight AI algorithms, machine learning ones get used to for building these assistants (Wright *et al.*, 2017).

CHALLENGES AND LIMITATIONS CHALLENGE

Spotting new digital biomarkers from stuff like CGMs, FGMs, activity trackers, and other gadgets hooked up to data. That is going to shake up clinical practice big time. We are moving away from just aiming to control HbA_{1c} as the main goal, you know, like back in Miotto *et al.* (2016). Now it is all about tailoring HbA_{1c} checks to the individual. Combine that with readings from these devices. Things like time in range, how much glycemic exposure there is, variability in blood sugar, hypo and hyper episodes. And yeah, more stuff coming soon. In the end, this lets clinicians and health pros craft diabetes plans that fit each person just right,

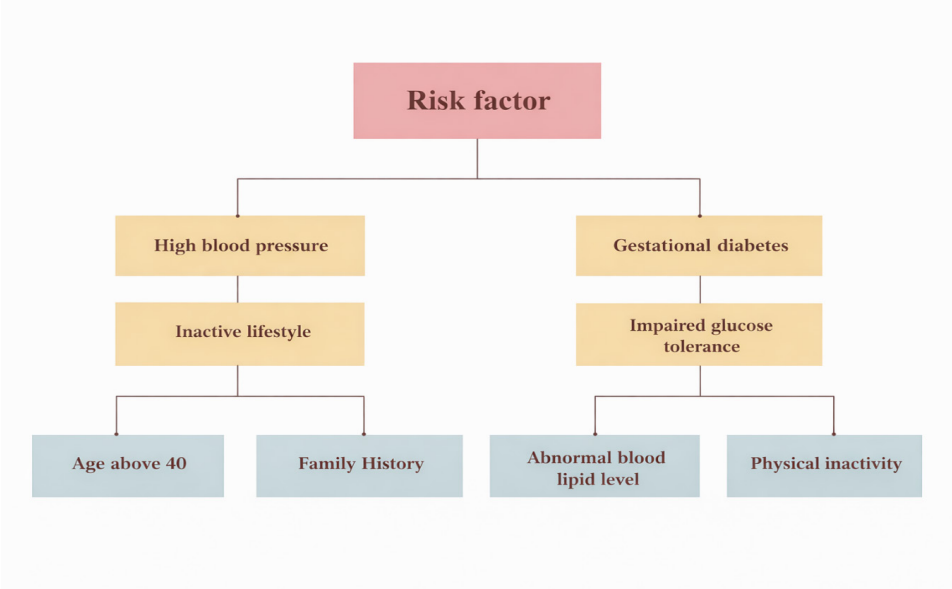

Figure 1: Risk factor.

Figure 2: Benefits of AI in Healthcare.

basically like Dagliati *et al.* (2018) talked about. Oh and, with tons of data pouring in from personal devices and e-health records, think Joubert *et al.* (2015). AI is stepping in to build sharper risk models for diabetes itself and the complications that tag along. That helps tweak treatments, care, watching over patients, all the management bits. So yeah, it pushes us closer to precision medicine for diabetes, pretty much as Guan *et al.* (2023) laid out. But hold on. For this augmented way of handling diabetes in clinics to really take off, two things have to line up. Easy to see, visualize descriptively. In the usual face-to-face doctor setups, dealing with diabetes management and prevention. It comes with a bunch of hurdles. For one, lots of diabetes cases stay hidden for years. So, preventing it and catching it early. Those are still huge challenges. The second, treating folks with diabetes means regular check-ins. Full checks on blood glucose control and any complications popping up from the disease. Third, diabetes leans so heavy on diet and exercise. It is probably the classic case of a long-term condition where the patient has to stay involved, keep at it over time. Dankwa-Mullan *et al.* (2019) nailed that. This shift to personalized, data-driven approaches in diabetes care will ultimately transform how we prevent, diagnose, and treat the condition across all settings.

LIMITATIONS

Artificial intelligence, yeah, it's stirring up a lot of debate in the medical world these days. Some experts figure AI could really step up diabetes management in big ways. Take those AI-powered gadgets, like continuous glucose monitors and insulin pumps. They help folks keep their diabetes in check and cut down on those scary high blood sugar spikes. AI might even spot which patients are headed for trouble, stuff like diabetic ketoacidosis before it hits hard. And it could nudge people to stay on top of their meds, check blood sugar regularly, plan out meals, eat better, you know, all those lifestyle tweaks that make a difference. Now, machine learning and AI, they won't fix the whole diabetes mess on their own, not by a long shot. For one thing, AI needs tons of data to learn and improve. Problem is, the data from healthcare systems is often junky, full of errors and missing bits. Those machine learning algorithms, they're only as solid as what you feed them. So yeah, bad data leads to AI spitting out wrong info (Dankwa-Mullan *et al.*, 2019).

FUTURE PROSPECTS

AI tech has gotten quicker at spotting diabetes issues, moving from basic checks to fancy stuff like detecting weird patterns in medical images. It uses object detection and segmentation to back up doctors' calls on the spot. Deep learning setups are getting tested out for handling those images, after showing real promise in computer vision and analyzing pics. With all these AI algorithms popping up, the way we use medical images for treating diabetes has jumped ahead fast. Compared to what doctors do by eye, this AI imaging approach means more patients can get tested cheaper and quicker.

Integration of AI with IoT and Big Data

Big Data

Social media, mobile apps, data analytics, and cloud storage are all integrated into big data, which is why SMAC is an

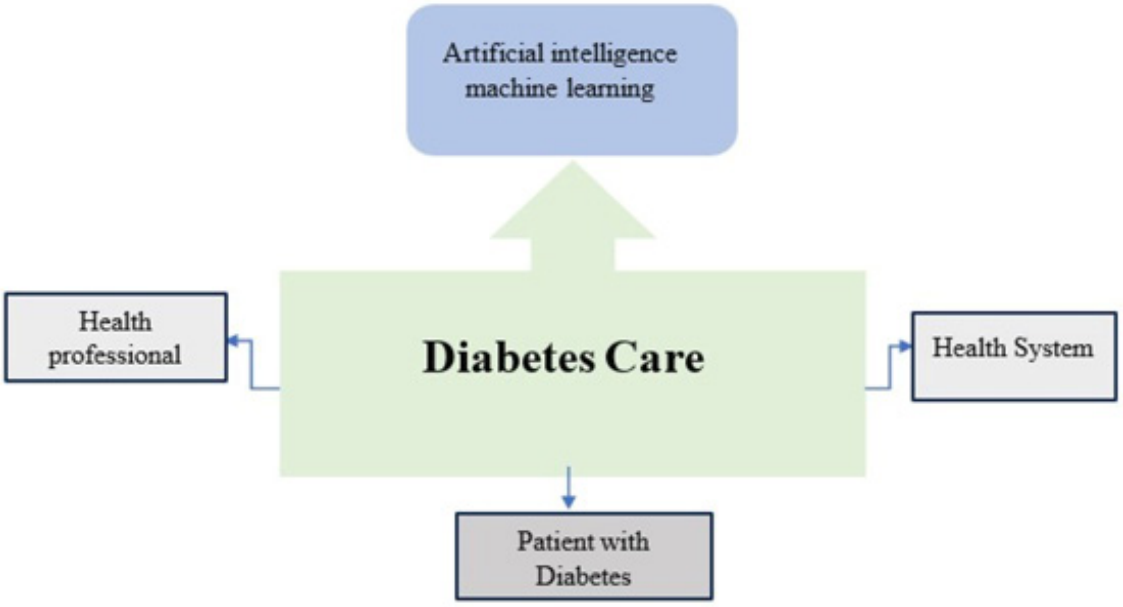

Figure 3: Diabetes Care.

acronym. Numerous fields of study, including scientific and industrial research, generate enormous volumes of information. Using traditional technology to store and analyse such quickly expanding data within the given time frame is difficult. There is a high demand for data management and analysis systems that can handle the volume of data coming from numerous commercial and scientific applications. A company can generate, modify, and handle vast volumes of data by utilising the methods, procedures, and tools associated with big data. Because big data is hard for humans to process in large quantities, a quick system is needed to manage it. Big data technologies are being used to expedite data analysis and provide users with the insights they require for forecasting and decision-making.

Data is cleaned up and updated after being stored in a warehouse for some time. For the Big Data system, raw data is gathered from a variety of sources, including reports, website monitoring, and real-time data (Ahmad *et al.*, 2024).

Because it helps ensure that patients are treated appropriately, big data analytics in healthcare is especially beneficial to both patients and clinicians. The four V's of big data volume, velocity, variety, and veracity present challenges. Diabetes patients will be especially useful data sources. Due to the sheer number of available healthcare data, you'll require effective and dependable methods for handling this information. Researchers have shown that Big Data in healthcare may be used to foresee epidemics. Corporations are analysing the challenges of handling massive amounts of data. Gaining a deeper insight into physiological processes through data collection may pave the way for significant medical progress (Sadhana *et al.*, 2014).

IoT Potential for curing and reversing diabetes with AI assisted research

AI has a promising future in diabetes treatment, but more research is required to fully grasp its potential. Further research is needed for model validation and improvement in order to ensure the precision and reliability of AI models for forecasting individual responses to therapy across a variety of patient groups. It would be very helpful to conduct long-term research assessing the real-world impacts of AI-driven interventions, especially in relation to patient outcomes and healthcare resource consumption. Additionally, examining the potential integration of AI with state-of-the-art technologies such as wearables and the Internet of Things (IoT) could enhance real-time diabetic monitoring and support. To help people effectively manage their own conditions, research should focus on developing AI tools that support adherence, lifestyle changes, and patient education. The ethical, legal, and social ramifications of Artificial Intelligence (AI) in diabetes treatment must be navigated by researchers, medical practitioners, and technology developers working together to provide a responsible and patient-centered approach to technological innovation.

The combination of Artificial Intelligence (AI) and Internet of Things (IoT) technology is healthcare delivery and providing previously unheard-of chances to improve patient care. The use of AI-driven virtual health assistants and IoT-enabled remote monitoring systems, which use machine learning algorithms and Natural Language Processing (NLP) to deliver complex, real-time health management solutions, is at the heart of this shift.

The capacity to continuously monitor patient health metrics via a network of interconnected sensors and devices is at the heart

Figure 4: Prevention of Diabetes.

of IoT-enabled remote monitoring. Vital signs, medication compliance, activity levels, and even environmental factors that impact patient health can all be collected with this technology. IoT devices enable proactive interventions, eliminate the need for in-person visits, and help patients better manage chronic conditions by sending this data to healthcare providers in real time.

CONCLUSION

Integrating Artificial Intelligence (AI) in healthcare has brought about a new era of diabetes management that has provided the field with numerous opportunities for early diagnosis, treatment personalisation, and disease prevention. AI combined with machine learning algorithms, big data analytics, and IoT technologies not only makes healthcare more precise and timely in terms of interventions but also allows for both healthcare providers and patients to control diabetes most effectively. Devices like AI-enabled wearable gadgets, chatbots, and predictive modelling solve not only glycemic control and complication problems but also arm patients with real-time feedback and self-monitoring tools. AI combined with traditional medicine, such as Ayurveda and Unani, also gives a huge boost to the holistic and individualised methods of treating people. Nevertheless, obstacles like data quality, the effectiveness of the process, and questions involving the privacy of patients have to be resolved to obtain safe and fair accessibility of the technology. Very careful attention to the high-quality of the data, the reliability of the algorithm used, and how the information is extracted and managed safely is required for a successful and responsible implementation of AI. As AI and technology in general progress, diabetes care will be transformed, the global patient outcomes will be bettered and in the same way healthcare will become more agile and smart.

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ABBREVIATIONS

AI: Artificial Intelligence; **ML:** Machine Learning; **IoT:** Internet of Things; **T1DM:** Type 1 Diabetes Mellitus; **T2DM:** Type 2 Diabetes Mellitus; **CGM:** Continuous Glucose Monitoring; **HbA_{1c}:** Hemoglobin A1c (Glycated Hemoglobin); **NLP:** Natural Language Processing; **FMT:** Fecal Microbiota Transplantation; **CBR:** Case-Based Reasoning.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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