Role of Chatbots and Virtual Assistants in the Management of Type 2 Diabetes Mellitus

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Abstract:

The rising prevalence of Type 2 Diabetes Mellitus (T2DM) calls for new digital tools and chatbots and virtual assistants are emerging as important enablers of patient care. In this article, we review their core technologies, including rule-based designs and advanced AI models using natural language processing, machine learning, and dialogue systems, and their roles in T2DM support, such as education, medication compliance, blood glucose tracking with tailored insights, dietary and physical activity changes, and connections with wearable devices and electronic health records. Clinical data from meta-analyses, randomised trials and implementation studies show significant impacts, including HbA1c reductions of 0.5–1.2%, increased patient engagement, and economic benefits. But there are still challenges, including technological limitations (such as accuracy issues), privacy concerns, moral questions (such as bias and access inequality), and issues with broad adoption by diverse groups. Future directions include next-generation AI with multi-sensory capabilities, harmonised regulations, and embedding into pharmacy-led clinical workflows to enable inclusive and effective T2DM management.

Keywords: Chatbots, Virtual Assistants, Type 2 Diabetes, Digital Health, Glycemic Control, AI in Healthcare

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1. Introduction

Type 2 diabetes mellitus (T2DM) is one of the most significant global public health challenges, placing an increasing burden on healthcare systems due to its rising prevalence and the growing incidence of long-term complications [1,2]. Effective management of T2DM requires lifelong adherence to self-care practices, including regular blood glucose monitoring, appropriate dietary modifications, consistent medication use, and healthy lifestyle behaviours [3]. Despite advances in treatment, many individuals face difficulties in maintaining optimal glycaemic control, increasing their risk of serious microvascular and macrovascular complications that adversely affect health outcomes and quality of life [4]. In a typical office visit, the time constraints faced by healthcare providers often prevent them from offering the level of support necessary to enable patients to sustain these healthy behaviours outside the clinical environment. This lack of steady, continuous support has created opportunities for digital health technologies that are now developing as a critical element of our approach to modern-day chronic disease management[5]. Studies have shown that the use of smartphone apps, remote tracking tools, and online portals can shift the meter on patient outcomes to deliver quantifiable improvements in HbA1c levels and overall metabolic stability[6].And so, entering this space, the development of artificial intelligence-powered chatbots and virtual assistants is a more nuanced move towards personalised, empathetic care that feels much more responsive than the static tools of the past[7]. These digital assistants are built to emulate the kind of interaction you might have with a clinical educator, using sophisticated language processing to provide real-time, context-specific guidance to help you manage an individual patient's day-to-day challenges – from figuring out what to do about a high blood sugar reading to remembering to give a dose of insulin[8]. These tools are more than data loggers; they are active players in the patient's health journey, presenting real-time feedback that enables people to have more power over their diagnosis. Most importantly, these intelligent systems deal with the everyday, repetitive questions that usually flood primary care clinics, freeing up doctors and nurses to focus on the most complex cases, ultimately creating a more sustainable and accessible care model for everyone involved[9].

2. Chatbots and Virtual Assistants: Technological Foundations

Digital tools like chatbots and virtual assistants are built to talk to users conversationally, through text or voice. They are used for health education, to remind patients of their treatment schedules, and to provide ongoing support for self-care in the management of type 2 diabetes[10].

A chatbot is a computer program or software application designed to simulate human conversation through text or voice interactions. A virtual assistant is a more advanced intelligent system capable of understanding user requests, performing specific tasks, and engaging in continuous, context-aware interactions with users [11]. In healthcare, these conversational systems are broadly classified into two categories: rule-based systems and artificial intelligence (AI)-based systems. Rule-based chatbots [12] operate using predefined rules, decision trees, or scripted responses that are activated by specific keywords or user inputs. Their predictable behavior, ease of implementation, and reliability make them well suited for structured clinical environments where consistent and standardized responses are essential. Chatbots powered by AI use machine learning and linguistics to understand context, learn how users interact, and offer more adaptive responses for personalized diabetic assistance[13,14].

2.1. Core technologies

These systems use the natural language processing to understand spoken or written language, and to generate the appropriate responses[15]. Machine learning (ML) helps to improve the performance over the time by recognizing patterns in user interactions and also customising the responses according to individual needs. Conversational AI brings together NLP, machine learning, dialogue management, and sometimes speech recognition to create smooth, interactive conversations. In type 2 diabetes care, these technologies can be used for medication prompts, dietary advice, glucose monitoring support, and other self-management functions[16].

2.2. Development in Healthcare

Earlier healthcare chatbots were primarily used as a basic rule-based systems designed for tasks such as answering common questions, sending time reminders and helping patients with appointment-related needs[17]. With advances in technology, they started supporting more complex functions like chronic disease education, symptom checking and patient engagement. More recent tools are increasingly AI-driven[18] and created to offer more adaptive and context-aware support. In type 2 diabetes this evolution has seen chatbots evolve from basic information services to interactive companions that may improve patient understanding, adherence and self-management outcomes[19].

3. Applications in Type 2 Diabetes Management

Novel digital platforms such as chatbots and virtual assistants enhance type 2 diabetes mellitus (T2DM) care by offering continuous patient-tailored interventions alongside traditional clinical methods [20]. They are interactive and available 24/7, which makes them useful tools to address the various needs of diabetes self-care such as education, treatment adherence, glucose monitoring, behavioural advice and connectivity with health technologies.

3.1. Educational and Self-Care Support

Patient education is the cornerstone of diabetes management and it has a direct effect on self-care competence and health outcomes [21]. Health literacy was low among T2DM patients and educational resources were inconsistently available, limiting their understanding of complex care guidelines. Conversational agents can help overcome these challenges by providing dynamic, dialogue-based teaching content at the user's convenience[22].They provide basic information on the pathophysiology, methods of glucose control, nutrition guidelines, exercise programs, drug therapy, and prevention of complications. These tools support understanding and empowerment by offering tailored responses to users' questions[23]. Additionally, chatbots help support self-care by helping them with glucose testing, treatment compliance, and awareness of symptoms which provides continuous support that could help bridge the gaps between medical checkups[24].

3.2. Medication Compliance Promotion

Consistent medication use is a constant challenge in T2DM, especially with polypharmacy or insulin therapy, leading to suboptimal glucose control and higher risks [25]. Virtual assistants meet this need with schedule-specific notifications and interactive compliance checks [26].Unlike passive notifications, chatbots confirm whether doses are taken, identify missed doses, and provide contextdependent nudges to aid recovery [27]. They may include reasons to stay on the track and to identify the risks of falling off, which may be particularly useful for those who have difficulty with cognition or motivation [28]. They progress from simple prompters to full adherence facilitators.

3.3. Glucose Monitoring and Personalized Insights

Regular glucose monitoring is needed to detect deviations and adjust diabetes management [29]. Chatbots can help with this by collecting manual inputs or synchronizing data from devices and then offering personalized analysis and advice [30].If high levels are persistent, a prompt to review meals, activity, or dose may be prompted. Hypoglycemia alerts may prompt corrective action or seeking professional advice [31]. More advanced versions use algorithms or AI to amplify guidance from longitudinal patterns into increased vigilance and finer self-adjustment [32].

3.4. Lifestyle-related behaviour guidance

Management of T2DM is based on life style changes like nutrition, movement, weight management and habits, which need a constant commitment, despite the daily challenges [33]. Chatbots can offer accessible coaching through personalised tips and encouragement[34].For nutrition, they suggest balanced meals, carb tracking, and eating cues; for activity, they motivate steps, routines, and anti-sedentary habits [35]. Features such as milestone logging, affirmations and targets increase motivation and mastery, and their conversational style demystifies advice, facilitating lasting change[36].

3.5. Connect Devices and Health Data

Chatbot effectiveness improves when integrated with wearables and EHR platforms. Glucose monitors, activity bands, and watches feature sensors that offer live metrics for precise, context-aware responses [37].Having access to EHR can build on insights with lab data, drug profiles and medical history to further personalise care and bridge patient-clinician workflows [38]. This allows for faster response to anomalies and enhanced collaborative oversight, moving toward integrated evidence-based care [39].

3.6. Implications and Future Directions

Chatbots represent a paradigm shift to technology-enabled, user-centred support for chronic illness [40]. They extend the reach of the clinic, relieve the burden of self-care, and keep patients engaged by virtue of adaptive interactions, and are therefore suitable for resource poor settings.For it to work, it has to be intuitive, inclusive, privacy aware and clinically integrated. New iterations can combine dialogue with prediction, biometrics, and oversight to provide holistic help [41]. If they evolve like this, they could become the staples of diabetes therapy [41].

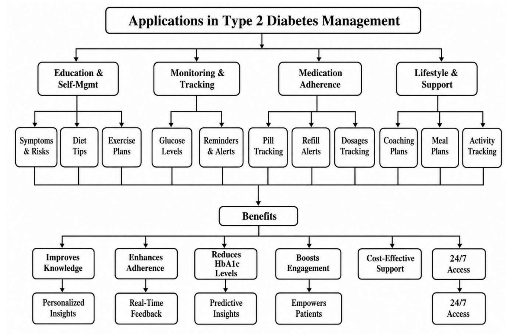

Figure 1. Flowchart of Applications of Chatbots and Virtual Assistants in Type 2 Diabetes Management [41].

4. Evidence from Clinical Studies and Real-World Use

4.1. Systematic reviews and randomized controlled trials

Recent systematic reviews suggest that digital interventions based on chatbots have potential in promoting self-management of type 2 diabetes (T2DM), especially in domains such as lifestyle modification, medication adherence and glycaemic monitoring. A synthesis of chatbot-based diabetes programs in several countries found a modest but statistically significant decrease in HbA1c, with an average improvement of about 0.3% compared to control/standard-care groups[42]. These interventions typically included structured educational content addressing diet, physical activity, and glucose monitoring, accompanied by conversational AI- or rule-based interfaces, delivered through smartphones or web-based platforms.

More generic reviews of chatbots for handling chronic diseases also report improvements in patient self-efficacy, satisfaction and important clinical markers such as blood pressure and behavioural adherence further supporting the utility of conversational agents in diabetes care. However, many of the available trials are small, short-term or open-label, highlighting the need for larger, well-designed randomised controlled trials with longer duration to confirm the durability and generalisability of these effects[43].

4.2. Key case studies and pilot programs

Several pilot implementations have demonstrated the successful integration of chatbots and virtual assistants designed for diabetes management into routine clinical and community-based settings [43]. A community-based educational chatbot program for adults with type 2 diabetes mellitus (T2DM) reported high user acceptability, with participants expressing greater confidence in self-management and finding the information provided to be valuable and easy to understand. Furthermore, analysis of user engagement revealed that individuals who participated in multiple chatbot interactions achieved greater reductions in HbA1c levels than those who used the service only once, suggesting that sustained engagement with chatbot-based interventions is positively associated with improved glycaemic control [44].Another notable example is a voice-enabled virtual assistant study among older adults with T2DM that provided participants with personalised guidance for self-care behaviours and mental health support via a smart-speaker-style device[45]. During the 12-week period, the intervention group demonstrated significant improvements in self-care adherence, quality of life and psychological well-being, and achieved a clinically relevant HbA1c reduction of approximately 0.5%. Examples like these case studies show that integrating conversational AI tools into existing diabetes care programs is feasible, especially for ageing or underserved populations that may benefit from low-burden, home-based support[46].

Table 1. Clinical studies regarding chatbot

Study / program type	**Description of the digital intervention**	**Who was involved (T2DM or at-risk group)**	**HbA1c trend or key biochemical outcome**	**Engagement and user experience**	**Additional benefits observed**
Chatbot-based meta-analysis	Aggregated trials using chatbots for diet, activity, medication, and glucose-monitoring guidance	Adults with T2DM across several countries	Average HbA1c dropped by about 0.3%	High message completion and frequent use linked to better results	Better self-confidence and satisfaction; some blood-pressure improvements
Community education chatbot pilot	Conversational chatbot (via SMS/app) giving structured self-care and diabetes education	Adults living with T2DM in a community setting	Around −1.0 % in users who engaged repeatedly vs. minimal change in low-use participants	Most users found the timing, content, and tone helpful and easy to follow	Greater perceived ability to manage daily diabetes tasks
IVAM-ED voice-assistant trial	AI-powered voice assistant on a home device offering daily guidance and mental-health support	Older adults with T2DM participating in an open-label RCT	HbA1c decreased by roughly 0.5% over 12 weeks	Over 90% used the device regularly; adherence to self-care steps improved	Better quality of life and less psychological distress
Workplace virtual-assistant program	Lifestyle coaching via a virtual assistant for employees at risk of diabetes /overweight	Young working-age adults with excess weight or prediabetes risk	Focus on preventing further weight gain and metabolic deterioration	Nearly all participants viewed the program positively; many logged in regularly	Appeared cost-effective for preventing early-stage diabetes complications

4.3. Outcomes: HbA1c reduction, engagement, and cost-effectiveness

Aggregated data from randomized trials and meta-analyses indicate that chatbot- and virtual-assistant-based programs tend to produce modest yet clinically meaningful reductions in HbA1c in T2DM, generally in the range of 0.3–0.5%[47]. These improvements are comparable to those observed with other digital-health interventions, such as telehealth-guided counseling or structured mobile-app programs, suggesting that conversational agents can serve as scalable adjuncts rather than replacements for human-led care[48].

Certain engagement metrics (e.g. message completion, session frequency, user satisfaction) are often associated with better outcomes. In several pilot deployments, the more often participants interacted with the chatbot or virtual assistant, the greater the HbA1c declines and the higher the adherence to recommended behaviours, suggesting that sustained engagement is the key for optimal impact[49]. Usability data also suggest that intuitive conversational interfaces can sustain relatively high adherence over weeks to months even for older or less technologically experienced users.Early economic evaluations suggest that virtual-assistant-based lifestyle and diabetes-prevention programs can be cost-effective, particularly when deployed in large-scale or workplace settings[50]. For instance, a virtual-assistant-driven preventive program targeting overweight employees reported favourable cost-per-case-averted ratios, combined with broad user acceptance. Given the relatively low marginal cost of serving additional users via chat-based systems versus traditional one-on-one counseling, these tools appear promising for population-level diabetes management, especially in resource-constrained health systems where access to specialist education and follow-up remains limited[51].

5. Challenges and Limitations

Although chatbots and virtual assistants show potential in supporting self-management of type 2 diabetes (T2D), several overlapping challenges restrict their safe, equitable, and sustained implementation in clinical practice. These limitations span technical reliability, data governance, clinical ethics, and patient-centered usability.[52]

5.1. Technical barriers (accuracy, data privacy, and infrastructure)

Accuracy and reliability of clinical advice

Many current diabetes-focused chatbots operate on limited or non-representative datasets, which can reduce the precision of their recommendations regarding glucose targets, medication timing, or lifestyle modifications[53]. A 2024 systematic review and meta-analysis of 25 diabetes chatbot studies noted that most reports were pilot experiments or observational studies, with only a single randomized controlled trial, indicating low-certainty evidence and limited generalizability. In practice, some conversational agents misinterpret free-text patient inputs—such as “I feel dizzy” or “I skipped my meal”—and may provide generic or incomplete guidance instead of triggering appropriate escalation for suspected hypoglycaemia or urgent care[54]. Generative AI–based assistants can further amplify these errors by generating plausible-sounding but incorrect responses when clinical context is incomplete, which is particularly risky in T2D where improper insulin or carbohydrate advice can precipitate acute complications.

Data privacy, security, and governance

The use of chatbots typically involves continuous collection and storage of sensitive health information, including self-reported blood glucose values, medications, body weight, and dietary patterns, raising serious privacy and security concerns. Cloud-hosted models and third-party data processors add further points of vulnerability, increasing the risk of unauthorized access, data breaches, or secondary use of information for commercial gain[55]. A 2023 review of AI chatbots in health care found many platforms lacked transparent consent processes, clear data-retention policies, end-to-end encryption, and well-defined liability frameworks, leaving users and clinicians unsure who owns and controls health data. For long-term T2D management where longitudinal data are key, robust data-governance structures consistent with jurisdictional regulations (e.g., HIPAA, GDPR, or national data-protection laws) are critical, yet often inconsistently implemented[56].

Interoperability and digital infrastructure

Many chatbots run as standalone mobile or web applications with minimal integration into electronic health records, pharmacy systems, or hospital registries, which limits their ability to incorporate real-time laboratory results, medication changes, or specialist notes[57]. This lack of connectivity can result in advice that is based on outdated or fragmented clinical information, reducing both safety and relevance. In resource-constrained environments, such as rural or semi-urban regions of India, unstable internet connectivity, low-end devices, and limited technical support further restrict the feasibility of deploying cloud-dependent, AI-driven tools, even when they demonstrate promise in controlled trials[58].

5.2. Clinical and ethical concerns (bias, equity, and accountability)

Algorithmic bias and underrepresentation

AI models used in diabetes chatbots are commonly trained on datasets that overrepresent urban, higher-income, and younger populations, while under-sampling older adults, ethnic minorities, and individuals with low health literacy. Emerging evaluations of large-language-model–based assistants for diabetes care have identified systematic variations in advice quality by gender, socioeconomic status, and region, even when the underlying clinical scenario is identical[59]. In T2D, where social determinants such as food environment, occupation-related physical activity, and access to medicines differ markedly across groups, biased algorithms may unintentionally reinforce existing health disparities rather than ameliorate them.

Health inequity and digital exclusion

In settings with pronounced socioeconomic and geographic diversity, uneven access to smartphones, affordable data plans, and multilingual or low-literacy interfaces can limit the reach of chatbots to relatively advantaged subpopulations. This risk of "digital exclusion" may amplify the gap between high-burden, underserved communities and those who can readily adopt digital tools, thereby exacerbating inequities in T2D outcomes. In addition, many chatbots are developed in dominant languages (e.g., English, Hindi, or other urban languages), creating barriers for users who are more comfortable with regional dialects or who require simplified, pictorial, or voice-based communication[60].

Clinical responsibility and ethical accountability

As chatbots deliver increasingly clinical-sounding guidance—such as dose-adjustment suggestions, timing of insulin, or responses to hypoglycaemia symptoms—questions arise about the boundaries of their role and the distribution of professional responsibility. When incorrect advice leads to adverse events, it remains unclear whether accountability lies with the clinician, the software developer, the hosting institution, or a combination of stakeholders. Ethical frameworks specific to AI in diabetes are still evolving, but there is growing consensus on the need for explicit risk-signaling protocols, mandatory human review for high-risk decisions, and clear disclaimers stating that chatbots are adjunctive tools rather than substitutes for clinical judgment[61].

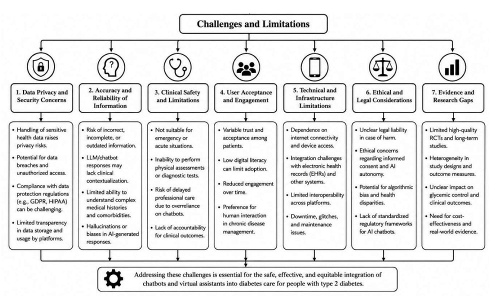

Figure 2. Challenges and Limitations for the Management of Type 2 Diabetes While Using Chatbots and Virtual Assistants

5.3. User adoption and accessibility issues

User engagement, trust, and adherence

While some studies report short-term improvements in glycemic control or self-management behaviors, long-term engagement with chatbots and virtual assistants tends to decline after the initial novelty wears off. Some common reasons could be the perception of unreliability of the responses, repetition of the content and advice that feels generalized, or not relevant to daily routines and personal preferences[62]. In one mobile-based virtual assistant trial for T2D, a substantial proportion of participants stopped using the system within the first month, underscoring the importance of highly personalized, context-aware, and adaptive dialog design.

Digital literacy and usability design

The user is assumed to have some basic digital competence to interact with the chatbot, e.g. knowledge of messaging interfaces, symptom-reporting forms and digital data entry. Older adults make up a large percentage of the T2D population and can be discouraged from continued use by small targets, multi-step menus, ambiguous instructions, or expectations of quick responses[63]. Additionally, bad design of the user experience (e.g., unclear prompts, no confirmation message or the inability to gracefully handle ambiguous input) can further erode trust and perceived usefulness especially when patients are expecting empathetic, context-sensitive responses as a human clinician or chemist would provide[64].Access to culture and socio-economical Many of the conversations are based on generic diet templates, exercise plans and medication assumptions that may not be relevant to local cultural norms, religious practices or socioeconomic realities. For example, recommendations based on Western-style diets or 9-to-5 working hours may not be relevant to rural or low-income communities with different food choices, working hours and financial priorities. Future designs should also incorporate participatory approaches to engage patients, community health workers, and primary-care providers in the development of culturally sensitive, linguistically appropriate, and context-specific virtual assistance strategies that take into account real-life living conditions in order to promote acceptability and adoption[65].

6. Future Directions and Recommendation

Advances in AI, from chatbots and virtual assistants, will transform type 2 diabetes (T2D) care. Hybrid systems combining voice commands, meal image recognition and sensor data will enable personalised insulin or GLP-1 therapy adjustments that could cut hypoglycaemia by almost a third. Global standards will be strengthened to drive certified testing, continuous monitoring of safety issues for clashes between medicines and AI (e.g., SGLT2 fluid problems) and fairness assessments against demography.

7. Conclusion

Chatbots and virtual assistants represent a promising advancement in the management of type 2 diabetes mellitus (T2DM), providing personalized support for patient education, lifestyle modification, medication adherence, and self-management—areas that are often insufficiently addressed through conventional care. Evidence from clinical studies indicates that these AI-driven tools can improve glycaemic control, with short-term reductions in HbA1c typically ranging from 0.4% to 1.0%, while also enhancing patient engagement through features such as real-time feedback, personalized recommendations, and predictive analytics. Furthermore, they have the potential to reduce the burden on healthcare systems by extending accessible and continuous support, particularly in resource-limited settings.

Despite these encouraging outcomes, several challenges must be addressed before widespread clinical implementation. Ensuring data privacy and security, minimizing algorithmic bias, maintaining transparency, and integrating AI tools with existing healthcare infrastructure while preserving appropriate human oversight remain essential considerations. Future advancements in adaptive artificial intelligence, interoperability with digital health systems, and robust regulatory frameworks are expected to further enhance the effectiveness and accessibility of these technologies. With continued validation through well-designed clinical studies and adherence to ethical and regulatory standards, chatbots and virtual assistants have the potential to become integral components of patient-centred, technology-enabled diabetes care, ultimately improving long-term clinical outcomes and quality of life for individuals living with T2DM.

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The authors confirm their contribution to the paper: study conception and design:**A1**; data collection: **A2**; Analysis and interpretation of results: **A3**; draft manuscript. All the authors reviewed the results and approved the final version of the manuscript.

Conflict of Interest

The authors declare they have no conflict of interest.

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