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REVIEW PAPER

MODERN TECHNOLOGIES IN MONITORING AND TREATING TYPE 2 DIABETES IN THE ELDERLY

Elżbieta Stec-Sawina[1(E,F,G)], **Agnieszka Sawina**[2(E,F,G)], **Sara Rakotoarison**[2(E,F,G)], **Jakub Fiegler-Rudol**[2(E)], **Karolina Lau**[2(E,F,G)], **Janusz Kasperczyk**[2(E,F,G)]

[1]Department of Health Education, Chair of Nursing Development, Faculty of Health Sciences, Medical University of Lublin, Poland

[2]Chair and Department of Environmental Medicine and Epidemiology, Faculty of Medical Sciences in Zabrze, Medical University of Silesia, Katowice, Poland

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Address for correspondence: Agnieszka Sawina, Chair and Department of Environmental Medicine and Epidemiology, Faculty of Medical Sciences in Zabrze, Medical University of Silesia, Poniatowskiego 15, 40-055 Katowice, Poland, e-mail: sawina.agnieszka13@gmail.com, phone: +48 883 732 260

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ORCID: Elżbieta Stec-Sawina https://orcid.org/0009-0004-1878-359X, Agnieszka Sawina https://orcid.org/0009-0008-0111-054X, Sara Rakotoarison https://orcid.org/0009-0002-5354-9550, Jakub Fiegler-Rudol https://orcid.org/0009-0009-3173-9389, Karolina Lau https://orcid.org/0000-0002-8654-0301, Janusz Kasperczyk https://orcid.org/0000-0002-6945-1200

Summary

Modern technologies are increasingly being used in medicine. The following review focuses on their application in the treatment of type 2 diabetes, with a special focus on the elderly. The cornerstone of therapy is regular glucose measurement, which until now has relied mainly on self-monitoring. In contrast, continuous glycemic monitoring systems are increasingly being used. App-linked devices significantly improve a patient's quality of life, but advanced technology can be difficult for older patients. Another aspect of diabetes treatment is diet. Maintaining a diet can also be facilitated by apps and artificial intelligence (AI). The advantages of technologies such as voice-based AI and mHealth include ease of accessibility, effective therapy control, and reduced healthcare costs. This is especially important in older patients with multimorbidity and a difficult disease course. However, it is crucial to educate older patients and their caregivers to implement these solutions into daily therapy. Support from doctors, families, and interface customization will make them easier to use. AI-based systems will soon be a mainstay of diabetes therapy.

Keywords: artificial intelligence, telemedicine, diabetes mellitus, elderly, treatment

Introduction

The average human lifespan has doubled over the last two hundred years. The number of elderly people in society is growing, and so is the incidence of various chronic diseases, including diabetes [1]. Diabetes mellitus (DM) is a metabolic disease caused by genetic and environmental factors [2]. According to data from the National Institute of Diabetes and Digestive and Kidney Diseases in the USA, currently, about 24 million people suffer from DM. Such a vast number of patients with DM is associated with colossal expenses – every year over 245 billion USD [3].

Diabetes in the elderly is a widespread phenomenon, and the increase in this has led to a better understanding of the care of people with DM and the basis of their treatment. In 40 years, the global population of people over 65 will double. The increase in the number of elderly people and the increase in the incidence of DM in people of geriatric age are associated with impaired cognitive and physical functions [4].

Type 2 diabetes mellitus (T2DM) carries a risk of premature death, which is about 15%, and the average life expectancy is shorter by about 20 years. Unfortunately, the predictions are not optimistic; according to the latest estimates, by 2050, the number of people with diabetes worldwide may reach 1.31 billion [5]. This problem is a massive challenge for public health, and in particular for the elderly population, who are most often affected by T2DM. The development of future health care should include advances in healthcare services and technology, or computer science, as well as information technology [4,5]. The growing availability of medical data enables the development of advanced technological solutions in health care [3]. Patients with T2DM often face challenges in maintaining self-discipline, adhering to medication regimens, and adopting necessary lifestyle changes [3,4]. Recent advances in artificial intelligence (AI) and digital health technologies have significantly improved the management of diabetes in elderly populations. These modern innovations not only enhance the effectiveness of care but also contribute to a reduction in T2DM-related healthcare costs [6].

Digital health technologies can help reduce the burden of diabetes and support people struggling with DM [6]. Such technology will introduce better DM prevention strategies in risk groups, especially among the elderly. Digital health technologies also have the invaluable advantage of providing real-time information and can promote patient self-management, which contributes to saving both doctors and patients time and money [4-6]. Several technological tools designed to support diabetes management in the elderly have been available on the market for many years. Mechanical aids like age-appropriate insulin pens and age-appropriate blood glucose meters are used worldwide. There are also some electronic aids, such as pillboxes which remind the patients when to take the medication, digital aids, PC programs, or apps [7]. AI is an ideal way to facilitate the entire process related to DM from screening, prediction and diagnosis, to treatment or management of comorbidities. Such an approach to DM aims to enable the introduction of earlier, more targeted therapies, predict complications, and reduce the percentage of morbidity and mortality. The use of AI aims to improve the quality of life of patients, especially the elderly [3]. AI should be used to collect, assemble, and analyze many types of genetic, genomic, physiological, biomarker, environmental, and behavioral data and thus help in better analysis of DM [3]. The effective use of data enhances diabetes management and contributes to improved quality of life for patients with diabetes [2,4,7]. In this article, the authors focus on showing how important AI is becoming in treatment of diabetes, especially among the geriatric population. However, this group may find limitations in therapy because of new technologies. Smart devices often evoke resistance among the geriatric population, primarily due to a lack of familiarity and formal education in their use. Gradually introducing elderly patients to the digital world remains a significant challenge for both healthcare professionals and family caregivers.

Aim of the work

This review aims to explore the role of modern technologies in the monitoring and treatment of T2DM in elderly patients, with a focus on their potential to become standard practice in future clinical care.

Methods

A computer search of PubMed and Google Scholar was conducted and traced back to references included from 2020 to March 2025 to identify suitable literature. Article selection was conducted in March and April 2025. Database search filters were applied based on year of publication, text availability, and article type. Inclusion criteria were limited to studies published in English, focused on adult and elderly populations, and being freely accessible. Studies involving pediatric patients, those behind paywalls, and case reports were excluded. The literature search was conducted using combinations of the following MeSH terms: 'diabetes mellitus', 'type 2 diabetes mellitus', 'elderly', 'artificial intelligence', 'continuous glucose monitoring', 'diet', 'gut microbiota', 'treatment', and 'disease'. Additional relevant publications were identified by screening the reference lists of the initially retrieved articles. The selection primarily included review articles, randomized clinical trials, protocols, and clinical guidelines. Reference lists were manually reviewed, resulting in a total of 47 sources included in the review. The selection process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to ensure transparency and methodological rigor, as shown in Figure 1.

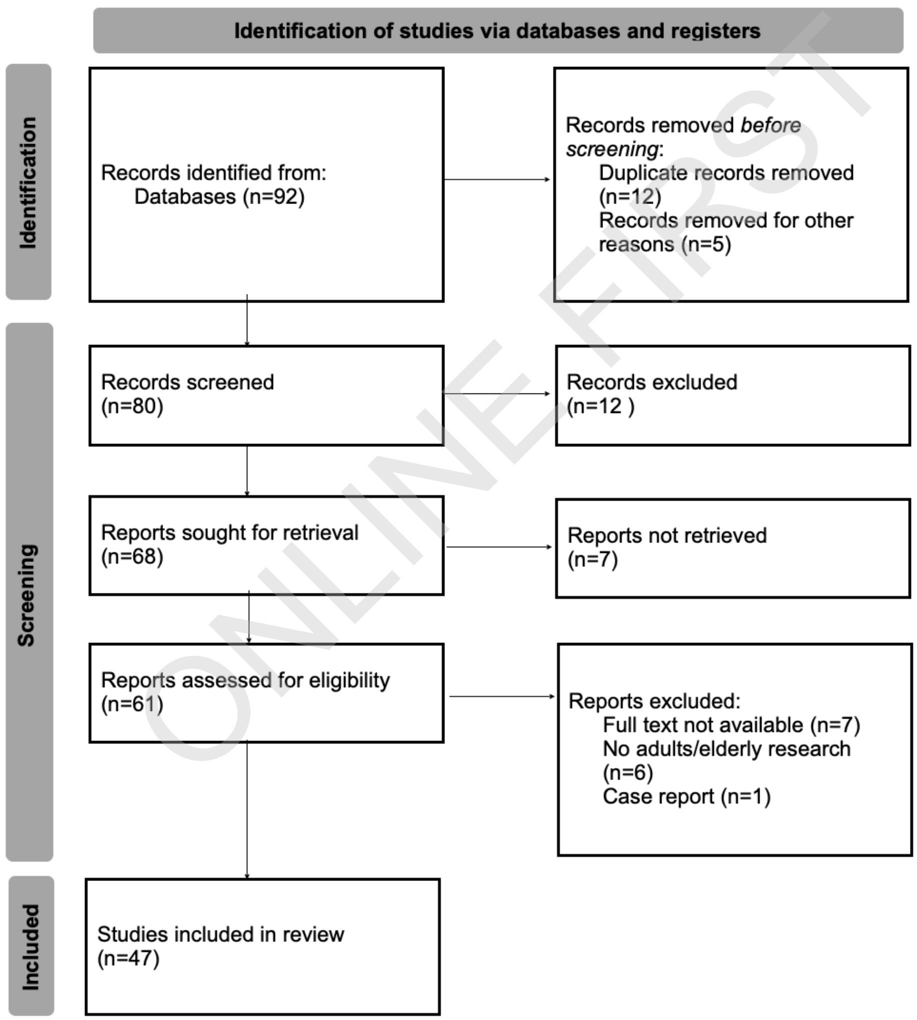

Figure 1. Diagram of search results using PRISMA

Notes: n – number of records used.

Literature review results

Blood glucose monitoring technologies

Traditional methods vs. modern systems

Glucose testing allows for the effective treatment of diabetes. The traditional self-monitoring blood glucose (SMBG) method involves drawing capillary blood and analyzing it in a glucometer. Regular monitoring helps prevent hypoglycemia, especially before physical activity or in potentially dangerous situations, such as driving a car. In addition, patients need to check blood glucose before meals, one and two hours after, and before bedtime. Such procedures, especially in the elderly, require good patient education about the disease [8]. For this reason, a Continuous Glucose Monitoring (CGM) system is increasingly being chosen. The system consists of a sensor placed on or under the skin that measures glucose levels in the interstitial fluid every few minutes and sends the data to an app. In Poland, the use of this technology for glycated hemoglobin (HbA1c) control is recommended for people over 25 years of age with type 1 diabetes with intensive insulin therapy. Studies confirm the effectiveness of CGM in terms of glycemic control and HbA1c levels. The use of this system, compared to SMBG, was significantly less frequently associated with severe hypoglycemia and macrovascular complications [9,10]. A recent umbrella review demonstrated that continuous glucose monitoring is more effective than SMBG in the management of T2DM. CGM use was associated with a greater reduction in gHbA1c, an increase in Time-In-Range (TIR), and a decrease in Time-Above-Range (TAR), indicating improved overall glycemic control [11]. Additionally, CGM contributed to enhanced quality of life by reducing anxiety related to hypoglycemic episodes [12].

There are two systems for reading blood glucose. In real-time CGM (rtCGM), the app or reader shows the result obtained in the last reading (usually every few minutes). Data is also transmitted all the time, but to check the present blood glucose, you have to pass the device over the sensor [13]. The companies on the market vary mainly in price, and their mean absolute relative difference (MARD) is usually at 8-9% [14-16].

Benefits and limitations of CGM use in seniors

Hypoglycemia is one of the most dangerous side effects of insulin and the drugs that cause its levels to rise. CGM applications effectively prevent these conditions by alerting the patient and predicting the glycemia-trend line. Another advantage is greater ease of use. They do not require as many punctures as SMBGs, and the sensor is replaced every 7 to 14 days. However, some devices require regular calibration [17]. The next plus is that these systems improve the effectiveness of therapy, and the medical team and the patient's caregivers have a continuous overview of glycemia. This is especially helpful for older people with dementia or other neurological diseases, improving the quality of life for patients and their families [13]. Indications are that the life expectancy of patients using CGMs is likely to be prolonged; moreover, this innovation may reduce healthcare costs [17]. In Poland, this system is partially reimbursed. However, despite the support from the state, it is a significant expense for the pensioner. Additionally, dermatological conditions common in older age—including fragile skin, allergies, and chronic irritation—can interfere with the accuracy and stability of CGM systems. Another limitation for older patients is the advanced technology, which not every one of them can understand. In this case, the support of the family is crucial for this device to be fully effective [13].

New developments in the technology market

Recent advancements have sparked growing interest in non-invasive methods of glucose monitoring, including the analysis of sweat, saliva, and tears. Innovative sensors are being developed in the form of hydrogel patches that can detect glucose levels from areas of high sweat gland density. These systems are painless and do not require skin pricking or induced sweating. Notably, glucose concentrations in sweat have been shown to correlate with blood glucose levels [18]. Some sensors are capable of generating reliable readings from as little as 1 μL of sweat. Furthermore, certain patches have been engineered to release metformin transdermally in response to detected glucose levels, allowing for responsive treatment during hypo- or hyperglycemic states [19,20]. Glucose detection in these systems is typically based on glucose oxidase, which produces an electrical signal proportional to glucose concentration. Similar technology is being applied to saliva-based glucose monitoring using disposable enzymatic films coated with glucose oxidase. However, these devices do not continuously transmit data to external applications, limiting their real-time utility [21]. Another promising avenue involves glucose monitoring via tear fluid, using smart contact lenses. These lenses analyze basal (constitutive) tear secretion, although emotional or reflex tearing may interfere with result accuracy [22]. Despite their promise, each of these alternative methods faces significant limitations. The biochemical composition of sweat, saliva, and tears can be influenced by diet, hydration status, and lifestyle factors. Additionally, glucose levels in these fluids tend to lag behind changes in blood glucose, which may reduce the reliability of real-time monitoring. Consequently, further validation and clinical studies are required before these technologies can be integrated into routine T2DM care.

Personalizing dietary treatment

Importance of diet in the management of T2DM in the elderly

The European Society of Clinical Nutrition and Metabolism recommends an energy intake of about 30 kcal/kg body weight/day for the elderly to prevent frailty and mortality [23]. However, reduced energy intake in elderly patients with DM may lead to a decrease in their BMI. Malnutrition in elderly people with diabetes is a serious problem, the risk of malnutrition or the prevalence of malnutrition in such patients is greater than 50% [24]. Brain function is also impaired, and cognitive functions deteriorate or are lost. It is worth emphasizing that unintentional weight loss in elderly patients with diabetes is a diagnostic criterion for frailty. However, intentional weight loss associated with lifestyle changes can play an important role in improving physical fitness [4,24,25]. When choosing the most appropriate diet for a senior suffering from DM, their overall health, capabilities, and willingness to make changes should be taken into account [26].

Older adults with diabetes should monitor several risk factors to help prevent cognitive decline, frailty, and increased mortality. Negative prognostic indicators include a body mass index (BMI) ≥ 30 kg/m², BMI < 18.5 kg/m², weight gain exceeding 10%, unintentional weight loss, the presence of metabolic syndrome in individuals under 75 years of age, sarcopenic obesity, and malnutrition [4,27]. The World Health Organization guidelines recommend a Mediterranean-like or healthy diet, which is balanced, includes sufficient amounts of fruits, vegetables, legumes, nuts, and whole grains, as well as reduced amounts of sugar, fat, and salt [28]. Adherence to a Mediterranean diet in patients aged ≥65 years is associated with low all-cause mortality [4,28]. A healthy dietary pattern is a diet that includes a high intake of portions of fruits, vegetables, and whole grains and a low intake of meat, refined grains, sugar, and snacks [28]. A Mediterranean diet or a broadly defined healthy diet should be recommended to older patients with DM to reduce the risk of frailty and cognitive impairment. Such a diet can reduce the risk of frailty by up to 60% in people aged ≥65 years [29].

Use of modern tools in diet therapy

Diet is challenging for patients struggling with diabetes. Increasingly, working on proper eating habits is being facilitated by mobile apps. Users enter products, weights, and meal times, and the app counts the calories, the amount of carbohydrates, proteins, fats, micro- and macronutrients, etc. Such apps help maintain self-control and make patients aware of the real value of their meals. Moreover, in a study lasting six months on about 150 people (mean age 53) using these apps, with integrated medical records and continuous blood glucose measurements, a decrease in HbA1c was achieved, especially in patients under 65 years of age. Patients receiving standard care had similar results, but the best-performing group was the one that received personalized guidance from doctors. Patients were satisfied with the app, although a decrease in treatment effectiveness over time was noted [30]. However, for widely available systems to be entirely convenient for diabetics, they must include a protein-fat converter, carbohydrate-exchange content, and bolus calculator [31].

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AI has the potential to significantly enhance the personalization of dietary advice for patients with diabetes. In one study, AI-based chatbots were evaluated for their ability to provide nutrition guidance, and the majority of dietitians involved responded positively to their usefulness. However, nearly 90% of patient interactions were found to require improvement, indicating that current systems are not yet fully optimized [32]. Despite these limitations, AI is expected to become an effective tool for managing the diet and lifestyle of diabetic patients in the future. Its strengths lie in the ability to generate individualized meal plans, continuously synchronize dietary recommendations with real-time blood glucose data, and suggest healthier food alternatives [33]. Nevertheless, the successful adoption of such systems, particularly among older adults, depends on patient awareness and digital literacy. It is essential to educate elderly individuals on both the importance of dietary management in diabetes and the practical use of digital health applications. Trust in the technology is crucial, as is the understanding that these tools are meant to complement, not replace, traditional medical care and human oversight [31-33].

Unique challenges in the elderly

In elderly people with diabetes, a screening of cognitive performance should be performed once a year using a validated method. Activating the body and encouraging physical activity should be encouraged within the existing physical abilities of an elderly person with diabetes and dementia. People with T2DM have an increased risk of developing dementia in old age compared to people without diabetes. The onset of dementia negatively affects frailty, worsens metabolic control, and is associated with an increased risk of hypoglycemia [4]. Using technology, especially with T2DM, is often a challenge for older people [7].

Cognitive impairment and dementia are associated with DM, resulting in impaired attention, verbal memory, information processing, and executive functions [4]. Alzheimer's disease in patients with diabetes will develop in as many as 50% of patients [4,7]. Older people with T2DM often also suffer from many other chronic diseases and face various impairments in cognitive, functional, and motor skills [26]. Such patients often struggle with neurocognitive problems, which limit their ability to self-control their blood glucose levels and respond to hyperglycemia and hypoglycemia [34]. In addition, socioeconomic changes have led to an increase in obesity manifested as sarcopenic obesity in older people with T2DM [4,35]. It is very important to develop a care strategy for older patients with T2DM that includes most of the complex and heterogeneous features of this age group. Such a strategy should be based on the distinctive habits typically associated with the lifestyle, socioeconomic factors, and support systems of people struggling with T2DM [26].

In an aging society, ensuring accessible technological solutions for older adults is increasingly demanding, particularly within the healthcare sector. However, elderly individuals often face significant challenges in understanding and adapting to these technologies. Common barriers include physical limitations (e.g. impaired vision, hearing loss, joint stiffness, and reduced dexterity), socioeconomic constraints, and cognitive decline [36]. Devices with complex interfaces, excessive icons, or data overload can be especially difficult for this population to navigate. Moreover, literature highlights broader disparities in access to modern health technologies. Older adults from ethnic and racial minority groups, those with lower levels of education, and individuals with limited financial resources are disproportionately affected [37]. In addition, limited Internet access in some populations may exclude certain elderly patients from benefiting from these technologies altogether. These inequities pose a major challenge to equitable healthcare delivery.

One of the most pressing issues remains expanding access to digital health solutions for marginalized and socially stigmatized populations [38].

However, appropriate preparation for seniors and help in understanding technology can greatly help them increase their acceptance and trust in such solutions and increase their independence. A good form of education and persuading older people to use technology could be the gradual introduction of solutions and presentation of special training programs that can show the advantages of using these issues in a friendly way [39].

Eliminating technological barriers requires an interdisciplinary approach, adapting devices to seniors' needs, supporting caregivers, and showing that such technologies are safe and can help in everyday functioning [40]. Such an approach could be promoted by Universities of the Third Age by creating new educational programs aimed specifically at older people, who are often unwell.

Physicians, nurses, and dietitians can facilitate the implementation of modern technologies and personalization of diet therapy in clinical practice among seniors who suffer from T2DM. It is the doctor, mostly a geriatrician, who plays a key role in the entire path of diabetes diagnostics. Continuous monitoring of the patient's health, medical interventions when necessary, and adapting pharmacological therapies to the individual needs of patients are steps that cannot be omitted in the process of treating T2DM. Dietitians play a key role in designing individualized meal plans aimed at optimizing blood glucose control. Nurses, on the other hand, are central to patient education regarding the use of technological tools, such as glucose monitoring applications and insulin titration devices. They provide daily support in diabetes self-management and help patients understand the value of technology-based interventions tailored to their specific needs. Digital tools facilitate real-time monitoring of insulin dosing, dietary adherence, and treatment effectiveness, enabling timely adjustments to therapy. Regular monitoring of patient progress is essential for personalizing treatment strategies. However, effective implementation of these technologies requires that healthcare professionals are adequately trained in their use. This need extends beyond physicians and nurses to include caregivers, family members, and staff in long-term care facilities. One of the key systemic barriers is the limited time allocated for patient visits—often just 20 minutes, which constrains opportunities for comprehensive education. Additionally, the administrative burden of medical documentation further limits healthcare providers' capacity to deliver personalized instruction [37]. To ensure the successful integration of digital innovations in diabetes care, it is therefore essential to support both patients and their caregivers through targeted training, ongoing guidance, and user-friendly systems. Doctors can recommend several free apps that may help elderly individuals with T2DM to manage their condition. Popular options include apps which offer features for tracking blood glucose levels, insulin doses, food intake, and physical activity.

Review of the latest research on technologies in the treatment of T2DM

Diabetes treatment is associated with lifelong treatment, thus AI virtual assistants are an ideal solution to help control the patient's health [6]. Several companies, such as Onduo, Virta, Wellpepper, and Accolade, are involved in the creation and development of virtual patient coaching. These modern technologies use AI functions to recognize food, act as a glucose sensor, and monitor physical activity and then send patients recommendations tailored to their individual needs. DayTwo is a system that, based on the patient's intestinal microbiome, can send precise proposals for nutritional recommendations after its thorough analysis. This system selects meals from a huge database of over 100,000 food products, the aim of which is to maintain the appropriate glycemia range [41]. Advisor Pro, created by DreaMed Diabetes, is a system that monitors the patient's glucose level continuously and then sends this data to the cloud, which allows for remote determination and proposal of appropriate insulin doses [42]. BlueStar is a T2DM management app that is a good way to monitor and get information constantly, thus reducing live consultations [43]. Currently, there are several CGM devices on the market, which include devices with sensors (minimally invasive or non-invasive), transmitters transmitting sensor readings, and receivers receiving data from the sensor; such devices have software that constantly analyzes the patient's data. Data from the sensor is transmitted and analyzed on the smartphone in combination with personal health records. Thanks to this, the appropriate insulin dose can be quickly selected [6].

AI can predict the risk of diabetes early enough and also classify it; thanks to machine learning (ML), a predictive model was created that identifies the symptoms of DM even before its occurrence. Unfortunately, the current methods of treating diabetes are not yet able to stop the course of the disease and prevent its development, nor are they able to stop the chronic complications of diabetes [6]. The continuous development of technology, along with the improvement of classification systems, can be tools for recognizing and identifying people at risk and predicting complications [6].

In the era of ubiquitous Internet and easy access to it, Mobile Health (mHealth) is an excellent way to promote and popularize behaviors related to self-control in people with T2DM. AI-based methods are becoming increasingly used in the treatment of diabetes, as well as in predicting blood glucose levels or monitoring drug doses. Such applications can be with the patient all the time and thus provide answers to questions about the disease in real-time. Patients can be calmer because they can check their blood glucose levels, medications taken, or eating patterns at any time, which means the period of waiting for an answer from the doctor does not cause them additional stress. Moreover, mHealth eliminates the problem related to the distance between the patient and the doctor, removes time constraints, and reduces healthcare costs. mHealth supports its users with T2DM in the process of changing their lifestyle and striving to improve HbA1c [44].

Mobile applications and remote monitoring devices provide many options that can help T2DM patients manage their insulin titration independently. Using voice-based conversational AI (VBAI) to improve usability, convenience, and accessibility, older patients can take care of their health and maintain proper blood glucose levels on their own. VBAI for self-titrating insulin is a solution that, thanks to its effectiveness and safety of use, can bring many benefits, especially among seniors. However, it is important to ensure that patients follow the dosing instructions. You do not even need a smartphone to use VBAI; it is installed on a smart speaker, thus it can support users in the comfort of their homes. VBAI is constantly based on many algorithms and emergency protocols related to hypoglycemia and hyperglycemia. It is worth noting that digital health tools are effective and safe and can be used to titrate medications, and voice interfaces in this technology help older patients whose level of digital competence is low [43,45].

AI-READI is a data generation project that focuses on T2DM. It aims to show how AI and ML are related to salutogenic (the path from T2DM to health). The dataset that was generated by AI-READI is multimodal as T2DM is a multifactorial and multisystemic disease. A multidisciplinary team of researchers, known as the AI-READI team, has developed a protocol to collect data across multiple health domains related to T2DM, examining both its impact on various health outcomes and how those domains, in turn, influence diabetes progression. People with T2DM are at risk of many adverse health consequences, including stroke, vision impairment, peripheral neuropathy, kidney disease, heart disease, and cognitive decline. Elderly people often struggle with many aspects, including limited access to health care, lower adherence to treatment, difficulties in seeking preventive care, as well as issues even during therapy. AI-READI places great emphasis on defining standards and guidelines related to the collection, preparation, and sharing of various types of data. This data can be a great basis for future AI and ML activities that will focus on developing other data sets and determining new correlations occurring and related to T2DM [46].

Further research is needed to assess the effectiveness of voice-interface applications in older adults with multimorbidity, particularly regarding their impact on reducing hospitalizations and improving quality of life.

Conclusions

Modern digital technologies including mHealth systems and AI offer significant potential to enhance self-management and therapeutic outcomes in older adults with T2DM. Central to the effective use of these tools is comprehensive patient education. While innovations such as virtual assistants and voice-based interfaces can substantially improve convenience, their successful adoption depends on careful adaptation to the physical and cognitive needs of elderly users.

However, implementing AI in geriatric diabetes care presents several challenges. Older adults, often unfamiliar with emerging technologies, may become overly reliant on AI-generated recommendations, potentially substituting them for clinical consultation or personal judgment. This overdependence can foster a false sense of security and reduce critical engagement with one's own care. Such applications should be used from the moment of diagnosis or at an early stage of the disease so that patients will more easily accept them. Physical and neurological comorbidities—

such as Alzheimer's disease, dementia, Parkinson's disease, peripheral neuropathy, tremors, or rheumatic disorders—can further impede the safe use of digital devices. An excess of functions, icons, and data can overwhelm users, especially those with vision or hearing impairments. In such cases, poorly designed interfaces may discourage use or lead to misuse. Therefore, interfaces must be carefully tailored to accommodate age-related functional limitations and ensure ease of use [4,7,26,47].

Despite these challenges, AI holds considerable promise in improving quality of life for elderly individuals with diabetes. In addition, it can also ease the burden on the health service by reducing the number of patient visits. However, its implementation must be preceded by a thorough evaluation of ethical risks, user safety, and the need for personalized design. Future research should prioritize long-term clinical validation of these technologies, their impact on patient outcomes, and their integration into healthcare systems.

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Artificial intelligence (AI) was not used in the creation of the manuscript.

References:

1. Vermeulen R, Schymanski EL, Barabási AL, Miller GW. The exposome and health: where chemistry meets biology. Science. 2020; 367(6476): 392-396. https://doi.org/10.1126/science.aay3164
2. Lu HH, Zhou Y, Chen C, Liu X, Wang Y, Zhang L, et al. Meta-analysis of the effect of exercise intervention on cognitive function in elderly patients with type 2 diabetes mellitus. BMC Geriatr. 2024; 24: 770. https://doi.org/10.1186/s12877-024-05352-z
3. Huang J, Yeung AM, Armstrong DG, Sharma S, Huang Y, Zhou Y, et al. Artificial intelligence for predicting and diagnosing complications of diabetes. J Diabetes Sci Technol. 2022; 17(1): 224-238. https://doi.org/10.1177/1932296822112458
4. Tamura Y, Omura T, Toyoshima K, Araki A. nutrition management in older adults with diabetes: a review on the importance of shifting prevention strategies from metabolic syndrome to frailty. Nutrients. 2020; 12: 3367. https://dx.doi.org/10.3390/nu12113367
5. The Lancet. Diabetes: a defining disease of the 21st century. Lancet. 2023; 401(10394): 2087. https://doi.org/10.1016/s0140-6736(23)01296-5
6. Guan Z, Li H, Liu R, Cai C, Liu Y, Li J, et al. Artificial intelligence in diabetes management: advancements, opportunities, and challenges. Cell Reports Medicine. 2023; 4(10): 101213. https://doi.org/10.1016/j.xcrm.2023.101213
7. Zeyfang A, Wernecke J, Bahrmann A. German Diabetes Association: clinical practice guidelines diabetes mellitus at an elderly age. Exp Clin Endocrinol Diabetes. 2023; 131(01/02): 24-32. https://doi.org/10.1055/a-1946-3728

8. Araszkiewicz A, Bandurska-Stankiewicz E, Borys S, Budzyński A, Cyganek K, Cypryk K, et al. 2022 Guidelines on the management of patients with diabetes. A position of Diabetes Poland. Curr Top Diabetes. 2022; 2(1): 1-130. https://doi.org/10.5114/ctd/146259
9. Jancev M, Vissers TACM, Visseren FLJ, van Bon AC, Serné EH, DeVries JH, et al. Continuous glucose monitoring in adults with type 2 diabetes: a systematic review and meta-analysis. Diabetologia. 2024; 67(5): 798-810. https://doi.org/10.1007/s00125-024-06107-6
10. Lu J, Ying Z, Wang P, Fu M, Han C, Zhang M, et al. Effects of continuous glucose monitoring on glycaemic control in type 2 diabetes: a systematic review and network meta-analysis of randomized controlled trials. Diabetes Obes Metab. 2024; 26(1): 362-372. https://doi.org/10.1111/dom.15328
11. Tan YY, Suan E, Koh GCH, Suhairi SB, Tyagi S. Effectiveness of continuous glucose monitoring in patient management of type 2 diabetes mellitus: an umbrella review of systematic reviews from 2011 to 2024. Archives of Public Health. 2024; 82: 231. https://dx.doi.org/10.1186/s13690-024-01459-2
12. Kłak A, Mańczak M, Owoc J, Olszewski R. Impact of continuous glucose monitoring on improving emotional well-being among adults with type 1 diabetes mellitus: a systematic review and meta-analysis. Pol Arch Intern Med. 2021; 131(9): 808-818. https://doi.org/10.20452/pamw.16047
13. Sacks DB, Arnold M, Bakris GL, Bruns DE, Horvath AR, Lernmark Å, et al. Guidelines and recommendations for laboratory analysis in the diagnosis and management of diabetes mellitus. Diabetes Care. 2023; 46(10): e151-e199. https://doi.org/10.2337/dci23-0036

14. Kao K, Brandner L, Virdi N. Comparison of glucose metrics between users of CGM readers and CGM-connected apps. J Diabetes Sci Technol. 2022; 16(1): 259-260. https://doi.org/10.1177/19322968211044141
15. Garg SK, Kipnes M, Castorino K, Bailey TS, Akturk HK, Welsh JB, et al. Accuracy and safety of Dexcom G7 continuous glucose monitoring in adults with diabetes. Diabetes Technol Ther. 2022; 24(6): 373-380. https://doi.org/10.1089/dia.2022.0011
16. Ng JKC, Ling J, Luk AOY, Lau ESH, Ma RCW, Li PKT, et al. Evaluation of a fourth-generation subcutaneous real-time continuous glucose monitor (CGM) in individuals with diabetes on peritoneal dialysis. Diabetes Care. 2023; 46(6): 1191-1195. https://doi.org/10.2337/dc22-2348
17. Zheng M, Patel A, Khoja A, Luo Y, Lin W, He Q, et al. Barriers and facilitators of diabetes management by continuous glucose monitoring systems among adults with type 2 diabetes: a protocol of qualitative systematic review. BMJ Open. 2021; 11(10): e046050. https://doi.org/10.1136/bmjopen-2020-046050
18. Lin PH, Sheu SC, Chen CW, Huang SC, Li BR. Wearable hydrogel patch with noninvasive, electrochemical glucose sensor for natural sweat detection. Talanta. 2022; 241: 123187. https://doi.org/10.1016/j.talanta.2021.123187
19. Karim Z, Khan MJ, Hussain A, Ahmed F, Khan ZH. Multilayer patch functionalized microfibrillated cellulosic paper sensor for sweat glucose monitoring. Sci Rep. 2024; 14(1): 23434. https://doi.org/10.1038/s41598-024-74899-z
20. Xu W, Lu L, He Y, Cheng L, Liu A. Long-term detection of glycemic glucose/hypoglycemia by microfluidic sweat monitoring patch. Biosensors (Basel). 2024; 14(6): 294. https://doi.org/10.3390/bios14060294

21. Litvinova O, Eitenberger M, Bilir A, Yeung AWK, Parvanov ED, MohanaSundaram A, et al. Patent analysis of digital sensors for continuous glucose monitoring. Front Public Health. 2023; 11: 1205903. https://doi.org/10.3389/fpubh.2023.1205903
22. Park W, Seo H, Kim J, Hong YM, Song H, Joo BJ, et al. In-depth correlation analysis between tear glucose and blood glucose using a wireless smart contact lens. Nat Commun. 2024; 15(1): 2828. https://doi.org/10.1038/s41467-024-47123-9
23. Volkert D, Beck AM, Cederholm T, Cruz-Jentoft A, Hooper L, Kiesswetter E, et al. ESPEN practical guideline: clinical nutrition and hydration in geriatrics. Clin Nutr. 2022; 41(4): 958-989. https://doi.org/10.1016/j.clnu.2022.01.024
24. Junaid OA, Ojo OA, Adejumo OA, Junaid FM, Ajiboye KJ, Ojo OE, et al. Malnutrition in elderly patients with type 2 diabetes mellitus in a Nigerian tertiary hospital: a cross-sectional study. Dialogues Health. 2022; 1: 100030. https://doi.org/10.1016/j.dialog.2022.100030
25. Veronese N, Facchini S, Stubbs B, Luchini C, Solmi M, Manzato E, et al. Weight loss is associated with improvements in cognitive function among overweight and obese people: a systematic review and meta-analysis. J Nutr Health Aging. 2016; 20(8): 829-836. https://doi.org/10.1016/j.neubiorev.2016.11.017
26. Yun JS, Kim K, Ahn YB, Han K, Ko SH. Holistic and personalized strategies for managing elderly type 2 diabetes patients. Diabetes Metab J. 2024; 48(4): 531-545. https://doi.org/10.4093/dmj.2024.0310
27. Bonikowska I, Szwamel K, Uchmanowicz I. Adherence to medication in older adults with type 2 diabetes living in Lubuskie Voivodeship in Poland: association with frailty syndrome. J Clin Med. 2022; 11(6): 1707. https://doi.org/10.3390/jcm11061707

28. World Health Organization. Healthy diet [Internet]. Geneva: WHO [access 2023 Apr 20]. Available from: https://www.who.int/health-topics/healthy-diet#tab=tab_1

29. Yan Y, Li Z, Lian Y, Liu P, Zhang B, Chen J, et al. Global research dynamics in the Mediterranean diet and diabetes mellitus: a bibliometric study from 2014 to 2024. Front Nutr. 2024; 11: 1480856. https://doi.org/10.3389/fnut.2024.1480856

30. Lee EY, Cha SA, Yun JS, Lim SY, Lee JH, Ahn YB, et al. Efficacy of personalized diabetes self-care using an electronic medical record-integrated mobile app in patients with type 2 diabetes: 6-month randomized controlled trial. J Med Internet Res. 2022; 24(7): e37430. https://doi.org/10.2196/37430

31. Więckowska-Rusek K, Danel J, Deja G. The usefulness of the nutrition apps in self-control of diabetes mellitus – the review of literature and own experience. Pediatr Endocrinol Diabetes Metab. 2022; 28(1): 75-80. https://doi.org/10.5114/pedm.2022.113631

32. Sun H, Zhang K, Lan W, Gu Q, Jiang G, Yang X, et al. An AI dietitian for type 2 diabetes mellitus management based on large language and image recognition models: preclinical concept validation study. J Med Internet Res. 2023; 25: e51300. https://doi.org/10.2196/51300

33. Khalifa M, Albadawy M. Artificial intelligence for diabetes: enhancing prevention, diagnosis, and effective management. Comput Biol Med. 2024; 100141. https://doi.org/10.1016/j.cmpbup.2024.100141

34. Sebastian MJ, Khan SKA, Pappachan JM, Jeeyavudeen MS. Diabetes and cognitive function: an evidence-based current perspective. World J Diabetes. 2023; 14(2): 92-109. https://doi.org/10.4239/wjd.v14.i2.92

35. Donati Zeppa S, Gervasi M, Bartolacci A, Ferrini F, Patti A, Sestili P, et al. Targeting the gut microbiota for prevention and management of type 2 diabetes. Nutrients. 2024; 16(22): 3951. https://doi.org/10.3390/nu16223951

36. Zaid NNM, Ahmad NA, Abd Rauf MF, Zainal A, Abdul Razak FH, Tengku Shahdan TST, et al. Elderly and their barriers to accepting and learning to use technology: a scoping review. Masyarakat Kebudayaan dan Politik. 2023; 36(1): 1-17. https://doi.org/10.20473/mkp.V36I12023.1-17

37. Huang ES, Sinclair A, Conlin PR, Cukierman-Yaffe T, Hirsch IB, Huisingh-Scheetz M, et al. The growing role of technology in the care of older adults with diabetes. Diabetes Care. 2023; 46(8): 1455-63. https://dx.doi.org/10.2337/dci23-0021

38. Mallik R, Kar P, Mulder H, Krook A. The future is here: an overview of technology in diabetes. Diabetologia. 2024; 67(10): 2019-26. https://dx.doi.org/10.1007/s00125-024-06235-z

39. Bertolazzi A, Quaglia V, Bongelli R. Barriers and facilitators to health technology adoption by older adults with chronic diseases: an integrative systematic review. BMC Public Health. 2024; 24: 506. https://doi.org/10.1186/s12889-024-18036-5

40. Lee S, Ory MG, Dahlke DV, Smith ML. Technology use among older adults and their caregivers: cross-sectional survey study. JMIR Aging. 2024; 7: 50759. https://doi.org/10.2196/50759

41. Subramanian M, Wojtusciszyn A, Favre L, Boughorbel S, Shan J, Letaief KB, et al. Precision medicine in the era of artificial intelligence: implications in chronic disease management. J Transl Med. 2020; 18: 472. https://doi.org/10.1186/s12967-020-02658-5

42. Nomura A, Noguchi M, Kometani M, Furukawa K, Yoneda T. Artificial intelligence in current diabetes management and prediction. Curr Diab Rep. 2021; 21(12). https://doi.org/10.1007/s11892-021-01423-2

43. Jia W, Fisher EB. Application and prospect of artificial intelligence in diabetes care. Med Rev. 2023; 3(1): 102-104. https://doi.org/10.1515/mr-2022-0039

44. Wu Y, Min H, Li M, Shi Y, Ma A, Han Y, et al. Effect of Artificial Intelligence-Based Health Education Accurately Linking System (AI-HEALS) for type 2 diabetes self-management: protocol for a mixed-methods study. BMC Public Health. 2023; 23: 1325. https://doi.org/10.1186/s12889-023-16066-z

45. Nayak A, Vakili S, Nayak K, Nikolov M, Chiu M, Sosseinheimer P, et al. Use of voice-based conversational artificial intelligence for basal insulin prescription management among patients with type 2 diabetes: a randomized clinical trial. JAMA Netw Open. 2023; 6(12): e2340232. https://doi.org/10.1001/jamanetworkopen.2023.40232

46. Owsley C, Matthies DS, McGwin G, Edberg JC, Baxter SL, Zangwill LM, et al. Cross-sectional design and protocol for Artificial Intelligence Ready and Equitable Atlas for Diabetes Insights (AI-READI). BMJ Open. 2024; 14(1): e097449. https://doi.org/10.1136/bmjopen-2024-097449

47. Hashi R, Thamer R, Hassan A, Canna K, Ahmed M, Hassan MT, et al. A Contemporary multifaceted insight into the association between diabetes mellitus and diverticular disease: an update about geriatric syndrome. Geriatrics. 2025; 10(1): 30. https://dx.doi.org/10.3390/geriatrics10010030