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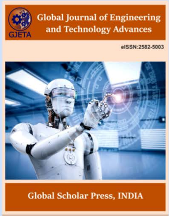

(Review Article)

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Modern technologies in dieting and diabetic management

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Abstract

The purpose of this review paper is to investigate the function of new technology in dieting and diabetic care. The paper specifically discusses wearable devices, artificial intelligence, telemedicine, virtual and augmented reality, smart insulin pens and pumps, Internet of Things (IoT) devices, social media, mobile apps, and sensors, as well as their benefits and limitations in diabetes management. Wearable glucose monitoring gadgets, smart insulin pens and pumps, and IoT devices for monitoring and managing food intake and blood sugar levels have all demonstrated encouraging results in diabetes care. Artificial intelligence and machine learning have the ability to help diabetic patients with individualized nutrition suggestions. Telemedicine and remote monitoring have aided in diabetes education and self-management skill training. These technologies, however, have drawbacks such as high costs, limited accessibility, and worries about data privacy and security. Overall, this research emphasizes the significance of modern technology in diabetes care and delves into its potential benefits and drawbacks.

Keywords: Modern technologies; Dieting; Diabetic management; Artificial intelligence; Blood sugar level

1. Introduction

Diabetes mellitus is a metabolic disorder primarily characterized by high blood glucose levels (GLs). Major health issues are more prevalent in DM patients. As the patient's quality of life declines, the likelihood that they may need special medical care rises (1).

The World Health Organization (WHO) estimates that 422 million people worldwide have diabetes (2), which eventually results in catastrophic damage to the kidneys, eyes, blood vessels, heart, and other organs. There are about 150–200 million of them treated with insulin (3).

According to data from the International Diabetes Federation, there were 4.2 million expected fatalities worldwide in 2019 and 463 million people with DM. These results indicate a worrying trend for the foreseeable future; by 2045, there will likely have been an increase of 33.9%, meaning 700 million people will have diabetes. (33).

The International Diabetes Federation reports that more individuals have died from DM than from other illnesses that are occasionally considered to be more dangerous or that are given greater attention by health organizations or governments (34).

Due to this, it is essential to prevent diabetic complications, which is why primary healthcare screening programs have been established. There were found to be various managements, each with its own foundation and body of scientific facts. One of the most important phases in the treatment of diabetes is the switch from oral to insulin therapy (35).

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Diet management is a critical component of diabetes therapy. Each patient should get nutrition therapy that is specifically tailored to their unique health objectives, cultural preferences, health literacy, access to healthy options, readiness, willingness, and ability to change (36). In recent years, there has been an increase in interest in employing technology to help people with diabetes better manage their condition. Technology's application in the management of diabetes is developing quickly and has the potential to aid those who have the disease in achieving the best possible glycaemic control. The continuous glucose monitor, insulin pump, and blood glucose meter are only a few of the innovations that have been invented and improved. In addition to equipment, contemporary technology has been applied to help patient education, support, and intervention to address the behavioural and emotional problems of diabetes management (37), including the Internet and mobile phone applications.

2. Modern technologies used in diabetes management

The practice of measuring the level of glucose in the blood is known as glucose monitoring. There are various glucose monitoring techniques, both invasive and non-invasive. Blood is drawn through a finger prick and placed on a disposable test strip, which is then inserted into a blood glucose monitoring device, as part of invasive procedures. To provide continuous glucose monitoring without the need for intrusive treatments, non-invasive techniques are being developed (6). The more sophisticated CGM technique measures interstitial fluid glucose levels with a tiny sensor implanted beneath the skin. The receiver receives the data from the sensor and shows it in real time along with the glucose levels (18). Continuous glucose monitoring (CGM) has emerged as a choice in recent years for optimum insulin administration and other activities (38). Patients can now monitor their blood sugar levels more regularly and conveniently than they could before with fingerstick tests. People with T1DM can benefit most from CGM since it can prevent hazardous blood sugar highs and lows. Additionally, it can aid them in making better nutritional and insulin dosage decisions (4). CGM sensors provide real-time data on blood glucose dynamics and trends. CGM systems have been shown to reduce glucose variability, reduce the incidence and duration of hypoglycaemia, and improve the safety and effectiveness of diabetic care (5). CGM devices have made major technological advances in the last 20 years. The precision of CGM systems has risen, with certain devices achieving accuracies comparable to or even within the range of self-monitoring blood glucose (SMBG) sensors. In terms of functionality and patient comfort, CGM devices have advanced (23).

A more practical and comfortable alternative to the present intrusive methods of blood sugar testing for diabetes management may be available in the form of continuous sweat sensor-based glucose monitoring (6). Potentiometry, chronoamperometry, anodic streaming, square wave voltammetry, cyclic voltammetry, differential pulse voltammetry, and electrochemical impedance spectroscopy are a few of the detection techniques that can be employed for sweat sensor-based glucose monitoring in the study. The choice of approach will rely on the particular application and system requirements. Each method has its own advantages and disadvantages (6). They provide diabetic individuals with a tool for monitoring their blood glucose levels that is both non-invasive and easy. These sensors can assist patients and healthcare providers make informed decisions regarding diabetes treatment by giving data simultaneously. This might potentially lead to improved glycaemic control and better health outcomes for patients (7). In a randomized clinical trial of 161 adults with type 1 diabetes, continuous glucose monitoring (CGM) was associated with improved glycaemic control compared with conventional treatment. The mean difference in HbA1c, a measure of long-term blood sugar control, was 0.43% (4.7 mmol/mol) in favour of CGM. These findings suggest that CGM may be a promising new treatment option for improving glycaemic control in adults with type 1 diabetes (39).

Modern technologies, such as mobile and wearable devices, can be used to support the self-management of chronic conditions like T2DM. These technologies may accurately gather information about the food and physical activity of individuals, which can be utilized by AI-based software. Even the medical records can be incorporated in the study to predict the future outcome of a diet before having the meal (8). For instance, a mobile app can remind individuals to take medication, exercise or track food intake. Another way is to follow personal informatics, a field that investigates the use of personal data for reflection and increased self-knowledge, which may lead to improved health outcomes. GlucoGoalie, for instance, combines machine learning and expert systems to translate personal health data into personalized nutrition goal suggestions for individuals with T2DM (9). The monitoring of indicators related to diabetes using wearable and mobile technology has early promise. Patients with diabetes, medical professionals, and researchers can all profit from its progress (40).

Another type of healthcare delivery is telemedicine which involves using modern technologies, such as information and communication technology, to remotely provide medical care to patients (10). This allows medical personnel to observe the health of patients and adjust their therapies as needed. Telemedicine can also be used to educate and support patients, such as by providing them with diabetes management information, replying to their questions, and providing emotional support. This is especially important for people who live in distant areas or have difficulty accessing medical services (10). Telemedicine can also assist patients and medical professionals communicate through phone calls or video conferences. As a result, patients can seek medical assistance and guidance without having to visit a hospital (11). Patients who use home telemonitoring use gadgets to check their health state, such as blood glucose levels, and transfer the data to healthcare providers for assessment. Telephone support entails healthcare providers calling patients to offer advice and education about diabetes control. When compared to standard treatment, home telemonitoring improved glycaemic control, although telephone support had mixed results (12). Numerous studies show that patients prefer insulin pens over vials or syringes (41) and that convenience of patients is increased by the portability of insulin pens (42).

Smart insulin pens (SIPs) are being used to drive digital transformation and create a linked diabetic care ecosystem. These pens have wireless communication, digital dose capture, and individualized dosing decision help. The integration of glucose data with SIPs has been shown to be a viable approach for conducting retrospective assessments of insulin dosage information. Such an approach has demonstrated effectiveness in providing efficient and reliable evaluations of insulin dosing (16). In a more continuous, asynchronous care model, patients, clinicians, and diabetes care teams will be able to make increasingly data-driven choices and recommendations during scheduled visits. To allow the successful engagement of the entire diabetes care team, the study underlines the necessity for accessible, open, and continuous data interchange amongst the rising number of diabetic devices (13). SIPs operate by collecting the dose of insulin administered and wirelessly transferring this information to a mobile app or cloud-based platform. SIPs can also be combined with glucose-sensing devices to provide a fuller view of a patient's diabetes treatment (14). Moreover, SIPs have the capability to capture precise insulin injection doses and integrate personalized dosing decision support, which can further enhance treatment efficacy. In addition, SIPs have demonstrated the potential to improve patient engagement by providing immediate feedback and support. The ease of access and effective utilization of diabetes data by healthcare providers is also facilitated by the use of SIPs, making them a valuable tool for diabetes management (15).

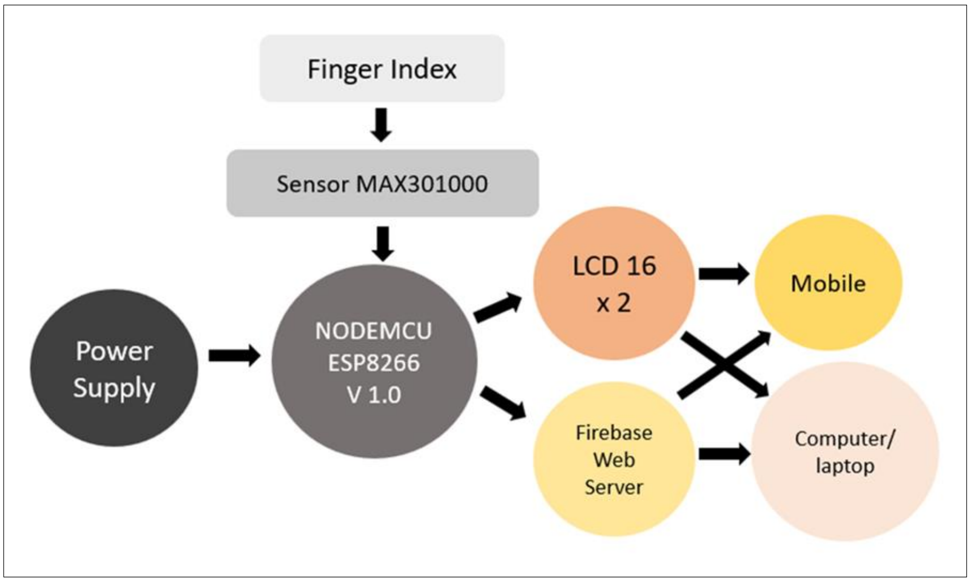

Figure 1 Block diagram of a system for measuring blood sugar

Attaching a MAX30100 sensor to the index finger and displaying the findings on an LCD screen and an Android smartphone is an effective non-invasive approach for detecting blood sugar levels (17). The accuracy test findings showed that the non-invasive blood sugar detecting apparatus had a rate of 90.3% accuracy with a variance of 1.2 - 39.6 mg/dL. Furthermore, as long as the system is connected to the internet, the reading distance of the system with an Android smartphone can reach up to 823 km (17). The suggested non-invasive blood sugar detection apparatus has various advantages, including less pain and more patient convenience, a low-cost and widely available MAX30100 sensor, an easy-to-read LCD screen, and an Android smartphone display. It also makes use of IoT technology for remote monitoring of blood sugar levels, which can assist medical officers in monitoring the condition of diabetics (17).

Understanding the intricate interplay between genetic factors, gut microbiome, and nutrition may be beneficial in the prevention and management of T2DM. Personalized dietary programs can be designed to effectively prevent and manage T2DM by taking genetic variables and gut microbiota of individuals into account. Overall, this knowledge can lead to more tailored and successful methods for T2DM prevention and management (19).

Diabetes patients engage with one another using social media platforms such as discussion forums, blogs, microblogs, and group chats for health-related purposes such as support, guidance, and education. While the use of social media for diabetic self-care is still in its early stages, the review indicates that it has significant potential. The research included in the study yielded excellent results on both primary and secondary variables, including improved clinical outcomes, behavioural outcomes, quality of life, and self-efficacy (20). Diabetes patients can use nutritional tracking mobile apps for the Apple iOS, Android, and Windows platforms to help with dietary logging and other lifestyle and health data tracking (22). Some of the criteria utilized to evaluate the apps included food databases, logging capabilities, additional tracking options, interoperability, and user interfaces (21).

AI approaches can be applied to create enhanced diabetes management decision support systems. These systems assess patient data collected by wearable devices such as CGM sensors and deliver individualized therapy suggestions. Machine learning algorithms, deep learning models, and fuzzy logic systems are among the AI techniques used in these systems. These methods are used to evaluate vast volumes of patient data in order to make individualized recommendations for insulin dose, glucose prediction, and other medication modifications. The use of artificial intelligence in decision support systems has the potential to improve diabetes management and lower the risk of adverse outcomes such as hypo-/hyperglycaemia (24).

The MobiGuide Project's mobile decision-support system for GDM comprises computer-interpretable clinical practice recommendations as well as access to data from the electronic health record as well as glucose, blood pressure, and activity sensors. The system aids in diabetes management by giving decision support to healthcare practitioners and patients, allowing for more effective and extensive medical treatment for GDM. The device also aids in the monitoring of blood glucose levels, blood pressure, and activity levels of patients. The pilot trial with 20 patients demonstrated that the technology is viable and well-accepted (25).

Diabetes education is the process of providing people with diabetes the knowledge, skills, and support they need to manage their condition effectively. Digital technologies have been found to be beneficial and effective in diabetes education, both for professional continuing education and for educating patients on how to manage their diabetes. In many regions, especially developing countries, digital education appears to be more effective than traditional education at improving knowledge and skills related to diabetes management and its impacts (27). The benefits of an 8-hour diabetes education session on glycaemic control and weight in adults with T2DM were evaluated using a retrospective assessment of 86 charts. The values of Haemoglobin A1C and weights were recorded before and after the intervention. The average A1C and weight of those who participated in the program decreased after the program. Counselling from a diabetes educator or a team of diabetes educators delivered in various methods may lower A1C readings by 0.2 to 0.8 when compared to standard care (28).

According to one study, electronic health (eHealth) technology can help with nutrition and physical activity behaviours for diabetic self-management (DSM). As examples of tools used to encourage DSM behaviours, web-based programs, mobile applications, virtual and augmented reality, video games, computer vision, and wearable technology are highlighted. The authors emphasize a feasibility study of the 'Diabetes Diary' wearable app, which allowed users to track carbohydrate intake, physical activity, insulin usage, and blood glucose levels. Vibrational signals on the smartwatch also served as reminders for mealtime and blood glucose testing (29). Smart gadgets capture data such as blood glucose levels, physical activity, and food intake to monitor and treat diabetes. This information is then evaluated using machine learning algorithms to provide insights and recommendations for improved diabetes care. Wearable gadgets such as continuous glucose monitors, insulin pumps, and smartwatches are frequently utilized in conjunction with AI approaches to help with diabetes control. Wearable gadgets, for example, can forecast blood glucose levels and inform patients to take the necessary steps to avoid hypo/hyperglycaemia. Machine learning algorithms can also be used to automatically alter insulin doses based on the patient's blood glucose levels. Diabetes management could be transformed by machine learning and smart devices (26).

Virtual reality (VR) is a computer-generated simulation of a three-dimensional environment that may be interacted with in a physical or presumably real manner. The authors give examples of VR technologies that have been used to support DSM behaviours, such as a VR game that simulates a grocery store and allows participants to practice making healthy food choices, and a VR exercise program that is more engaging and immersive than traditional exercise programs. Additional study is needed to determine their usefulness and viability in real-world situations (30).

3. Benefits and limitations

Using modern methods to manage diabetes has several advantages. Technology that is user-friendly for patients has been shown to significantly reduce healthcare spending and complications. Telemedicine is increasingly being used in diabetology to improve clinical, socio-emotional, and economic results for patients. Texting and other forms of mobile communication can be easy and inexpensive tools to encourage positive lifestyle choices. The long-term vascular effects of diabetes can be mitigated with the help of wearable technology, continuous glucose monitoring, and blood pressure and glucose monitoring in the comfort of one's own home. These developments have the potential to improve patient well-being while decreasing healthcare costs generally. Although there are many digital tools for diabetes management, it's important to keep in mind that only a subset of those is recommended by medical professionals due to a lack of sufficient evidence of their safety and efficacy (31).

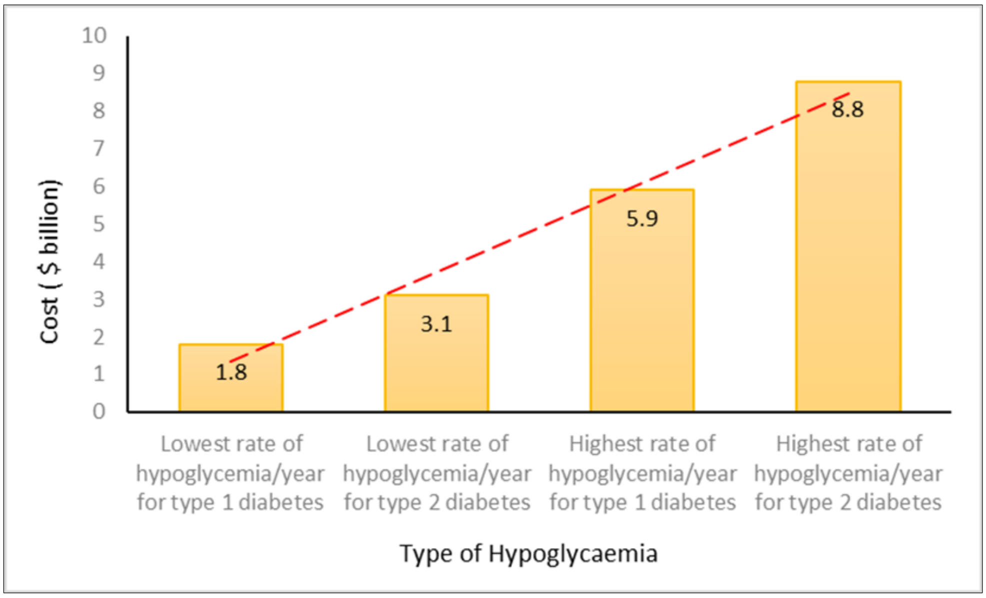

Figure 2 Estimate cost of different types of Hypoglycaemia treatments for patients with T1DM and T2DM

The technological application in diabetes has the potential to greatly benefit glycaemic control (as measured by haemoglobin A1c) and lower the incidence, severity, and financial burden of hypoglycaemia. In the case of individuals with diabetes, real-time glucose readings from continuous glucose monitoring (CGM) devices might help them make better decisions regarding their insulin dosing and nutritional options. SAP systems integrate continuous glucose monitoring (CGM) with insulin pump therapy to improve dosage accuracy and decrease hypoglycemics episodes. Insulin administration automation, such as closed-loop systems, can further enhance glycaemic control and lessen the emotional and physical tolls of managing diabetes (32).

The use of technology in the treatment of diabetes has led to vast improvements in patient outcomes. To fully exploit their potential and improve the quality of life for diabetes patients, it is essential to identify the most favourable and efficient platforms as their use increases. Though sometimes it is difficult to rely on technology, the modern technologies are also explaining their decisions in human understandable format so that people can judge the AI build decision before considering it (8).

Although technology has many advantages for managing diabetes, there are some drawbacks that must be taken into account. The price of technology, which may be out of reach for some people, is a significant barrier. Another factor contributing to the digital divide in diabetes management is the absence of access to or comfort with technology. The accuracy of some technologies, such as continuous glucose monitors, which can be impacted by elements like temperature and humidity, is another technological constraint. Therefore, it is crucial to frequently check on these devices and to calibrate them properly. It's also crucial to remember that, even though technology can be a helpful tool in managing diabetes, it shouldn't take the place of routine medical exams and professional consultations. Finally, it's important to note that while there are hundreds of tech platforms available for managing diabetes, only a limited few that have been shown to be safe and effective are suggested by medical professionals (31).

The necessity for larger studies to evaluate the reliability of hardware and software in automated systems and the effectiveness of alarms in these systems is one of the drawbacks of adopting technology in diabetes. The restrictions listed for RT-CGM (real-time continuous glucose monitoring) and CSII (continuous subcutaneous insulin infusion) separately also apply to SAP (sensor-augmented pump) devices (32).

4. Conclusion

Modern technologies offer a range of promising opportunities for improving diet and diabetes management. Wearable devices for continuous glucose monitoring, smart insulin pens and pumps, and IoT devices for monitoring and controlling food intake and blood sugar levels have shown great potential in diabetes management. Artificial intelligence and machine learning have the potential to personalize nutrition recommendations for people with diabetes, while telemedicine and virtual reality offer new avenues for diabetes education and self-management skills training. Mobile apps and social media platforms can help people with diabetes track food intake and blood sugar levels and provide peer support and diabetes self-management education. Nutrigenomics and personalized nutrition represent an exciting avenue for diabetes prevention and management. While these technologies offer significant benefits, there are also potential limitations and challenges that need to be considered. These include concerns about data privacy and security, the need for user training and support, and the cost and accessibility of these technologies. Future research should continue to explore the efficacy and feasibility of these technologies and address these limitations and challenges to ensure that they can be effectively integrated into diabetes management programs and ultimately improve health outcomes for people with diabetes.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

Author's contribution

Rhidi Barma: Conceptualization, Writing - original draft, Investigation, Editing, Validation., Md Saddam Hossen: Writing - original draft, Editing, Validation.

References

[1] Baena-Díez, Jose Miguel, et al. Risk of cause-specific death in individuals with diabetes: a competing risks analysis. Diabetes care 39.11 (2016): 1987-1995.

[2] WHO Diabetes. [(accessed on 15 November 2021)]. Available online: https://www.who.int/health-topics/diabetes#tab=tab_1

[3] Garg, Satish K., Amanda H. Rewers, and Halis Kaan Akturk. Ever-increasing insulin-requiring patients globally. Diabetes technology & therapeutics 20.S2 (2018): S2-1.\

[4] Radermecker, Régis Pierre. Continuous glucose monitoring in the management of diabetes: state-of-the art and perspectives. Revue Medicale Suisse 15.659 (2019): 1444-1447.

[5] Cappon, Giacomo, et al. Continuous glucose monitoring sensors for diabetes management: a review of technologies and applications. Diabetes & metabolism journal 43.4 (2019): 383-397.

[6] Zafar, Hima, et al. Comprehensive review on wearable sweat-glucose sensors for continuous glucose monitoring. Sensors 22.2 (2022): 638.

[7] Kim, Jayoung, Alan S. Campbell, and Joseph Wang. Wearable non-invasive epidermal glucose sensors: A review. Talanta 177 (2018): 163-170.

[8] Roy, Mrinmoy, Srabonti Das, and Anica Tasnim Protity. OBESEYE: Interpretable Diet Recommender for Obesity Management using Machine Learning and Explainable AI. arXiv preprint arXiv: 2308.02796 (2023).

[9] Michie, Susan et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. Annals of behavioral medicine : a publication of the Society of Behavioral Medicine vol. 46,1 (2013): 81-95. doi:10.1007/s12160-013-9486-6

[10] Reading Turchioe, Meghan et al. Adapting the stage-based model of personal informatics for low-resource communities in the context of type 2 diabetes. Journal of biomedical informatics vol. 110 (2020): 103572. doi:10.1016/j.jbi.2020.103572

[11] Roy, Mrinmoy, et al. Machine Learning Applications In Healthcare: The State Of Knowledge and Future Directions. arXiv preprint arXiv:2307. 14067 (2023).

[12] Polisena, J., et al. Home telehealth for diabetes management: a systematic review and meta-analysis. Diabetes, Obesity and Metabolism 11.10 (2009): 913-930.

[13] Kompala, Tejaswi, and Aaron B. Neinstein. Smart insulin pens: advancing digital transformation and a connected diabetes care ecosystem. Journal of Diabetes Science and Technology 16.3 (2022): 596-604.

[14] Sangave NA, Aungst TD, Patel DK. Smart connected insulin pens, caps, and attachments: a review of the future of diabetes technology. Diabetes Spectr Publ Am Diabetes Assoc. 2019; 32(4):378-384.

[15] Toschi E, Slyne C, Greenberg JM, et al. Examining the relationship between pre- and postprandial glucose levels and insulin bolus timing using bluetooth-enabled insulin pen cap technology and continuous glucose monitoring. Diabetes Technol Ther. 2020; 22(1):19-24.

[16] Mall, Shreejay et al. Diet monitoring and management of diabetic patient using robot assistant based on Internet of Things. 2017 International Conference on Emerging Trends in Computing and Communication Technologies (ICETCCT) (2017): 1-8.

[17] Suprayitno, E. Agus, Akhmad Setiawan, and Rohman Dijaya. Design of Instrumentation in Detecting Blood Sugar Levels with Non-Invasive Technique Base on IoT (Internet of Things). Int J Eng Technol 2018 7 (2018): 440-2.

[18] Belmon, Anchana P., and Jeraldin Auxillia. IoT-Based Continuous Glucose Monitoring System for Diabetic Patients Using Sensor Technology. Machine Learning and Internet of Things for Societal Issues. Singapore: Springer Nature Singapore, 2022. 35-41.

[19] Tanisawa, Kumpei, and Mitsuru Higuchi. Nutrigenomics and personalized nutrition for the prevention of hyperglycemia and type 2 diabetes mellitus. Molecular Nutrition: Carbohydrates. Academic Press, 2019. 339-352.

[20] Elnaggar, Abdelaziz, et al. Patients' use of social media for diabetes self-care: systematic review. Journal of medical Internet research 22.4 (2020): e14209.

[21] Darby, Alaina, et al. A review of nutritional tracking mobile applications for diabetes patient use. Diabetes technology & therapeutics 18.3 (2016): 200-212.

[22] Ulfa, Maria, et al. Nutrition-Related Mobile Application for Daily Dietary Self-Monitoring. Journal of Nutrition and Metabolism 2022 (2022).

[23] Cappon, Giacomo, et al. Continuous glucose monitoring sensors for diabetes management: a review of technologies and applications. Diabetes & metabolism journal 43.4 (2019): 383-397.

[24] Vettoretti, Martina, et al. Advanced diabetes management using artificial intelligence and continuous glucose monitoring sensors. Sensors 20.14 (2020): 3870.

[25] Mercedes, Rigla., Iñaki, Martínez-Sarriegui., Gema, García-Sáez., Belén, Pons., María, Hernando. Gestational Diabetes Management Using Smart Mobile Telemedicine. Journal of diabetes science and technology, 12 (2018).:260-264. doi: 10.1177/1932296817704442

[26] Makroum, Mohammed Amine, et al. Machine learning and smart devices for diabetes management: Systematic review. Sensors 22.5 (2022): 1843.

[27] Moreira, Tatiana Rebouças, et al. Digital technology and its effects on knowledge improvement for diabetes management: An integrative review. International Journal of Nursing Practice 29.1 (2023): e13029.

[28] Copeland, Miriam, et al. The Impact of Diabetic Education on Diabetes Management: A Retrospective Chart Review. Journal of Christian Nursing 40.1 (2023): 42-47.

[29] Karimi, Nazgol, et al. Participants' and Health Care Providers' Insights Regarding a Web-Based and Mobile-Delivered Healthy Eating Program for Disadvantaged People with Type 2 Diabetes: Descriptive Qualitative Study. JMIR Formative Research 7.1 (2023): e37429.

[30] Neter, Efrat, and Esther Brainin. eHealth literacy: extending the digital divide to the realm of health information. Journal of medical Internet research vol. 14,1 e19. 27 Jan. 2012, doi:10.2196/jmir.1619

[31] Kesavadev, Jothydev, and Viswanathan Mohan. Reducing the Cost of Diabetes Care with Telemedicine, Smartphone, and Home Monitoring. Journal of the Indian Institute of Science (2023): 1-12.

[32] Vigersky, Robert A. The benefits, limitations, and cost-effectiveness of advanced technologies in the management of patients with diabetes mellitus. Journal of diabetes science and technology 9.2 (2015): 320-330.

[33] Atlas, Diabetes. IDF diabetes atlas. International Diabetes Federation (9th editio). Retrieved from http://www. idf. org/about-diabetes/facts-figures (2019).

[34] International Diabetes Federation. IDF diabetes atlas. International Diabetes Federation, Executive Office, 2011.

[35] Shahid, Sadaf. A Review of Diabetic Management in Primary Health Care. THE STETHO 2.6 (2021): 1-5.

[36] Evert, Alison B et al. Nutrition therapy recommendations for the management of adults with diabetes. Diabetes care vol. 36,11 (2013): 3821-42. doi:10.2337/dc13-2042

[37] Gonder-Frederick, Linda A et al. Psychology, technology, and diabetes management. The American psychologist vol. 71,7 (2016): 577-589. doi:10.1037/a0040383

[38] Hirsch, Irl B. Realistic expectations and practical use of continuous glucose monitoring for the endocrinologist. The Journal of Clinical Endocrinology & Metabolism 94.7 (2009): 2232-2238.

[39] Lind, Marcus, et al. Continuous glucose monitoring vs conventional therapy for glycemic control in adults with type 1 diabetes treated with multiple daily insulin injections: the GOLD randomized clinical trial. Jama 317.4 (2017): 379-387.

[40] Rodriguez-León, Ciro et al. Mobile and Wearable Technology for the Monitoring of Diabetes-Related Parameters: Systematic Review. JMIR mHealth and uHealth vol. 9,6 e25138. 3 Jun. 2021, doi:10.2196/25138

[41] Molife, Cliff, et al. Assessment of patient-reported outcomes of insulin pen devices versus conventional vial and syringe. Diabetes technology & therapeutics 11.8 (2009): 529-538.

[42] Brunton, Stephen. Insulin delivery systems: reducing barriers to insulin therapy and advancing diabetes mellitus treatment. The American journal of medicine 121.6 (2008): S35-S41.