Journal of Health Informatics in Developing Countries
http://www.jhidc.org/
Vol. 17 No. 2, 2023

Submitted: June 27th, 2023 Accepted: Aug 08th, 2023

The Role of Artificial Intelligence in Diabetes Research, Diagnosis and Prognosis: A Narrative Review

Samar Fahad Binhowemel [1,*], Mohammed Omar Alfakhri [1], Khoolod Mohammed AlReshaid [1], Abdulrahman Mohammed Alyani[2]

[1] *Family medicine, King Fahad Medical City, Riyadh, Saudi Arabia.*

[2] *General practitioner (GP), King Saud bin Abdulaziz University for Health Sciences (KSAU-HS), College of Medicine, Riyadh, Saudi Arabia*

Abstract

The use of artificial intelligence (AI) has proven to be valuable and transformative in the treatment of diabetes. With the ability to process large amounts of data, AI can draw significant conclusions that improve the accuracy of diagnostics and prognostic decision-making. Machine learning and deep learning are the most commonly used technologies in the field, as they have made remarkable advancements due to enhanced computer speed and more resources for computation. A narrative review of the research on the use of AI in diabetes treatment is presented, demonstrating the critical relevance of precise diabetes diagnosis, and prognosis and investigating the potential for artificial intelligence to revolutionize this specialized medical profession. Insights from prestigious journals demonstrate artificial intelligence's effective application in identifying various types of diabetes by harnessing extensive data sets and advanced algorithms to improve decision-making in healthcare. The paper also looks at the medical implications of AI-driven diabetic assessment and prognosis, such as earlier detection, fewer errors in diagnosis, and better outcomes for patients. The combination of AI with innovative imaging technology improves diagnostic accuracy and equips healthcare professionals to make informed decisions. Despite significant progress in technology and medical science, the assessment highlights potential hurdles and restrictions in using machine learning in diabetes investigations and treatment. Artificial Intelligence, like any other discipline, has constraints, and understanding these constraints is critical for effective deployment in diabetic management. Integrating artificial intelligence into diabetes investigation and treatment has significant promise for increasing diabetes care. Disease forecasting algorithms for diabetes will see a huge boost in accuracy as the forecasting capacity of artificial intelligence is optimized with organized data and ample computational capacity. Addressing potential barriers and ensuring appropriate adoption, on the other hand, are critical for realizing the full promise of machine learning in diabetes studies and treating patients.

Keywords: Diabetes, Artificial Intelligence, machine learning, diagnosis, prognosis, narrative review.

*Samar Fahad Binhowemel - Family medicine, King Fahad Medical City, Riyadh, Saudi Arabia ; Email: Samaralhuwaimel@gmail.com.

1. Introduction

Diabetes, an explosively expanding and common disease around the world, provides enormous problems to both medical institutions and patients. Diabetes continues to have a significant influence on worldwide health, with a total of four hundred sixty-three million living with the disease in the year 2019 (Saeedi et al., 2019). It is characterized by the human body being unable to produce enough insulin to effectively control blood sugar levels properly, resulting in a variety of health issues. Risks related to diabetes, such as chronic kidney disease and amputation, highlight the crucial importance of rapid and precise diagnosis, as well as effective prognosis, in managing diabetes and avoiding serious consequences (Better Health, 2020).

The introduction of machine learning in diabetes clinical research and treatment represents a possible solution for improving accuracy as well as effectiveness in the assessment of the disease and suggesting better management for the disease (Aberer et al., 2022). The transformational potential of artificial intelligence is demonstrated by its capacity to analyze massive volumes of information about patients, uncover delicate trends, and generate important insights using sophisticated techniques and deep learning approaches (Davenport & Kalakota, 2019). This useful tool enables healthcare practitioners to engage in choices based on data, resulting in improved outcomes for patients and more successful diabetes control. Diabetes is a major international health issue, and the number of cases is expected to climb further in the future years, according to statistics. Diabetes is expected to affect 9% of the total world's population in 2019 (463 million people), increasing to 10% (578 million) around 2030 and 11% (approximately seven hundred million) by 2045. The number of cases is higher in cities (10%) than in remote areas (7%) and in countries with high incomes (10%) than in countries with low incomes (4.0%) (Saeedi et al., 2019). Diabetes imposes an enormous financial burden on individuals availing them, with yearly costs in hundreds of millions of dollars. This highlights the importance of pursuing novel technologies, such as artificial intelligence, to address the complications of diabetes, improve patient care and minimize related costs (Zawudie et al., 2022).

This study emphasizes the critical role of artificial intelligence in diabetes analysis, diagnosis, and treatment in this extensive study. This comprehensive review investigates the use of artificial intelligence in analyzing varied information sets, including medical records of patients to genetic data, by diving into innovative uses of artificial intelligence. AI can detect patients with elevated risk, forecast the progression of the disease, and personalize treatment regimens. These innovations can revolutionize the management of diabetes by providing unparalleled insights and effectiveness to both healthcare practitioners and patients (Saeedi et al., 2019). While artificial intelligence shows enormous promise, its use in diabetes care raises major challenges and ethical concerns. These issues must be addressed to ensure the

appropriate and advantageous use of artificial intelligence in medical practice. Collaboration between healthcare practitioners, specialists, and artificial intelligence (AI) specialists is critical to maximizing results (Zawudie et al., 2022). Finally, the incorporation of AI in diabetes studies, prediction, and treatment is a light of hope in addressing the difficulties of this ubiquitous chronic disease. It can harness AI's powers by utilizing its strengths to fight against diabetes.

Diabetes continues to be a global epidemic that is impacting around 425 million individuals worldwide. This chronic illness accounts for around 12% of global health expenses. However, half of all diabetics go undetected and untreated (Dankwa-Mullan et al., 2019). The worldwide obesity pandemic and a lack of physical activity have a significant impact on diabetes, especially type 2 diabetes. These variables interfere with the body's natural glucose management, necessitating the use of exogenous insulin for controlling blood sugar levels (Wu et al., 2014). Gestational diabetes is a unique form of diabetes that can develop during pregnancy in individuals who have not previously experienced diabetes. This condition impacts approximately two to ten percent of births annually in the United States (Rafat, 2022). Permanent administration of insulin is required for children diagnosed with type 1 diabetes, a form of diabetes in which the body is unable to manufacture insulin (CDC, 2022). Diabetes affected 8.3% of persons over the age of Eighteen in the Americas region in 2016. Untreated diabetes is a leading cause of blindness, renal failure, cardiac arrest, strokes, and amputation. Diabetes claimed the lives of 342,603 persons in the Region in 2016. In 2016, diabetes killed 33 persons per 100,000 Americans (Sanchez, 2019). Years of well-conducted research have shown that intensive treatment significantly delays and decreases the complications related to diabetes. Intensive treatment for diabetes improved metabolic regulation and a lower risk of low blood sugar levels and ongoing complications (Aberer et al., 2022).

Artificial Intelligence involvement in treating diabetes has transformed therapy and monitoring powered by artificial intelligence technologies, such as computer learning and algorithms for better understanding, which have aided in early assessment, allowing for prompt attention and personalized treatment programs. Artificial Intelligence analysis of patient information has improved the accuracy of diabetes prognosis, leading to personalized treatment options and improved medical results. In addition, artificial intelligence has rapidly accelerated the development of drugs for treating diabetes, resulting in more therapeutic choices. Based on artificial intelligence systems for decision-making and tools for self-management have enabled patient-focused care, allowing patients to play a leading part in their diabetes control. To enable ethical artificial intelligence application in medical institutions, however, concerns connected to data protection and comprehension must be addressed. Overall, artificial intelligence has the potential to transform diabetes care and improve world health.

2. Subjects and Methods

This exhaustive research thoroughly assessed a variety of online scientific journals with a particular focus on PubMed, a widely available knowledge source. The study focused particularly on the terms "diabetes," "machine learning," "diagnosis," and "prognosis." The major contribution of artificial intelligence to improving the diagnosis and prognosis of diabetes was underlined by several clinically noteworthy discoveries within the body of gathered research publications. The results of these research articles were thoroughly reviewed for the understanding of the application of AI in diabetes research diagnosis and prognosis.

3. Results

The results indicated various advantages of using artificial intelligence in diabetes research and therapy for diagnosis and prognosis. Due to the difficulties connected with managing and diagnosing diabetes, machine learning has become an essential tool for developing treatments that assist both patients and their caregivers in their daily lives. AI can not only significantly facilitate the diagnosis and prognosis of diabetes but also strengthen the field by offering better research opportunities.

Artificial Intelligence Predicting Diabetic Retinopathy:

The most prevalent consequence of the disease is retinopathy from diabetes. Conventional diabetes and retinopathy from diabetes care are divided, unorganized, and administered in stages, sometimes among the costliest and high resources needed for cure. To bridge these discrepancies in medical treatment, revolutionary approaches embracing digital technologies are required (Gunasekeran et al., 2020). Systems using artificial intelligence have shown exceptional sensitivity in diagnosing retinopathy caused by diabetes. Algorithms using artificial intelligence can detect the earliest signs of acute retinopathy at the same accuracy as endocrinologists by analyzing the datasets of patients. A set of automated deep-learning-based DR screening algorithms have been presented, with significant specificity and sensitivity (> 90%). However, due to the limits of the open-access datasets, such deep-learning algorithms fail to function well in clinical scenarios (T. Li et al., 2019).

Artificial Intelligence in Early Diagnosis of Type 2 Diabetes:

Diabetes mellitus that is not reliant on insulin (type 2- diabetes mellitus) is the most common type of diabetes, accounting for between 90 percent and 95 percent of all diabetic individuals, and is anticipated to reach a population of 439 million before 2030 (Wu et al., 2014). Artificial intelligence models showed promise in predicting the onset of diabetes of the second type in patients at high risk. The ability of complex correlations between unique individual measures and binary classification algorithms developed from zero to generalize the beginning of diabetes. A group of binary classification algorithms with a basic

structure optimized using the Adam method achieved a reasonable level of accuracy (about 86%). This artificial network-based technique has the potential to deliver precise data for personalized treatment, making it an essential tool for choice-making resources.

Artificial Intelligence for Personalized Diabetes Management:

It is widely acknowledged that managing oneself is critical for lowering the likelihood of long-term consequences in patients with diabetes. Education about diabetes represents a broad scope and individualized approach to ensuring the efficacy of individual patient management decisions (J. Li et al., 2020). Patients ought to be trained with modified expertise and abilities suitable for their circumstances, considering the range of individual needs, aspirations, and life events. Powered by artificial intelligence systems that support decisions may customize diabetes care strategies based on specific individuals' features and reactions to the therapy field (T. Li et al., 2019). To optimize diabetes care, these artificially intelligent solutions analyze ongoing glucose info, insulin doses, eating habits, and activity levels. Patients can obtain improved glucose control and lower their risk of adverse effects by implementing artificial intelligence guidelines. The accessibility of constantly changing data on blood sugar levels from CGM sensors enables not just the identification but additionally predicting the adverse outcomes. The most modern CGM sensors use extremely simple forecasting algorithms, such as linear estimation, to forecast future interstitial levels of glucose in actual time (for instance, fifteen to thirty minutes ahead) and emit anticipatory warnings when a hypoglycemic or hyperglycemic episode is anticipated (Vettoretti et al., 2020).

Integration of AI in Drug Development:

Artificial intelligence has quickened drug advancement for the treatment of diabetes. Large-scale genomic information and proteomic data sets can be analyzed by algorithms that use machine learning to find possible targets for therapy and predict the effectiveness of treatments. Similar algorithms based on machine learning were used to find a brief linear new peptide therapy for Type 2 diabetes. The objective of this experiment was to find a peptide that could adjust blood sugar levels and hemoglobin concentrations while being harmless and having no adverse reactions. To guarantee these qualities, the peptide options have been verified in vitro (research done in laboratory dishes) and in vivo (living organisms) experiments. Small linear peptides having the regulating action of glucose provide an empirical demonstration that artificial intelligence techniques can uncover truly distinctive compounds that can display significant and clinically pertinent biological consequences in the setting of Type 2 Diabetes Mellitus. Notably, an effective short linear polypeptide with acceptable in vivo (living organism) tolerance offers a possibility for the healthcare industry due to the less expensive production (Casey et al.,

2021).

Limitations of AI in Diabetes Research and Care:

Beyond a shadow of a doubt, artificial intelligence (AI) represents one of the most hotly debated topics in the medical field today. Some experts feel that artificial intelligence holds enormous promise for better diabetes control. Artificial intelligence-powered devices, such as glucose meters (CGMs) and pumps for insulin, aid in diabetes management and the reduction of elevated blood sugar levels. Artificial intelligence could potentially be used to forecast which patients are more likely to suffer issues that include diabetic ketoacidosis. Moreover, artificial intelligence could aid in diabetes management by alerting patients to periodically monitor their blood sugar levels, consume their diabetic medication, engage in vigorous physical activity, meal planning, consume nutritious food, and make additional lifestyle adjustments. While such apps are nonetheless in the early phases of growth, they have a chance to help patients better control diabetes while preventing serious complications (Navin Khosla, 2023).

If human beings do not know ways to deal with an issue, then machine learning cannot miraculously manufacture the necessary expertise for humans to resolve it. We are familiar with robotic automobiles since humans understand how driving works. Because humans understand how to play games of chess robots are international chess experts. Humans possess industrial robots since they understand how to use them (Ben Dickson, 2013). There are multiple explanations why machine learning and AI will not be able to cure the diabetic crisis fully. To begin, artificial intelligence relies on enormous amounts of information to learn and grow. Addressing diabetes, the professionals simply do not have sufficient information. We require data on individuals' everyday life behaviors, genetic makeup, and other medical issues such as coronary artery disease, and kidney disease, among others to be able to construct a machine-learning algorithm that can predict which individuals are likely to develop diabetes. Even if humans had all this information, getting it all into a manner that artificial intelligence could comprehend would be extremely hard.

Machine learning algorithms are only as effective as the information that they are fed, and the information the healthcare database provides is not ideal. There often exist gaps and flaws in the collected information, which might lead to incorrect assertions by the artificial intelligence system. That is why artificial intelligence ultimately needs human beings to examine and evaluate the outcomes. If this is true, artificial intelligence will not be capable to substitute healthcare professionals. The majority of diabetic patients are not using these devices; instead, they rely on the classical method of finger prick to check the blood glucose level by a glucometer (Olansky & Kennedy, 2010). Since they are expensive yet not available to all, devices can impose significant costs, such as accessibility and constant notification of

your condition. Wearable technologies may restrict the clothes you wear, jeopardize intimacy, and attract unwelcoming attention in a work gathering. These kinds of worries gently affect the way other people evaluate your capacity to handle your well-being or perform your work (Williams, 2022).

4. Discussion

The use of machine learning in diabetes studies, outlook, and treatment has shown significant promise in changing the diabetic treatment environment. The research examined gives persuasive proof of artificial intelligence's ability to revolutionize the management of diabetes by providing precise diagnostic knowledge, personalized therapies, and early detection of people at risk. One of artificial intelligence's primary assets in the treatment of diabetes is its capacity to analyze massive volumes of patient data, allowing it to find fragile patterns and connections that ordinary practitioners may miss. For example, by analyzing the fine details of patients, AI-powered systems have demonstrated outstanding precision for forecasting diabetic retinopathy, which is a major consequence of diabetes. These findings imply that AI can supplement, if not outperform, the diagnostic skills of human professionals in some situations.

Additionally, the ability of artificial intelligence to foresee the onset of type 2 diabetes in patients at risk can have a significant impact on prevention and early intervention strategies (Li et al., 2020). Machine learning algorithms may detect indicators of risk and send early alerts to medical professionals by analyzing electronic medical records and behavioral data, allowing for the active management of diabetes. Prognostic capabilities like these can lead to better outcomes for patients and lower healthcare expenditures associated with complications of diabetes. AI systems can find prospective drug targets and predict treatment efficacy by analyzing massive genetic and proteome data. This method speeds up the search for novel medicinal compounds and promotes the manufacturing of more successful diabetes drugs, potentially improving avenues for therapy for diabetic patients.

Additionally, AI-driven decision support systems offer the potential to tailor diabetes management plans to individual patients' unique characteristics and responses to treatment. By analyzing continuous glucose monitoring data, insulin dosing, dietary patterns, and physical activity levels, AI can optimize diabetes management for each patient, leading to better glycemic control and reduced risk of complications. Despite the tremendous benefits that artificial intelligence offers in diabetic study and treatment, several obstacles and limits must be addressed. One key challenge is the need for vast, reliable data sets for properly educating machine learning algorithms. While medical data collection has progressed, obtaining complete and standardized datasets remained a challenge. Incomplete or faulty data can result in inferior artificial intelligence performance and jeopardize the accuracy of generated insights.

In addition, the comprehensibility of artificial intelligence (AI) models in diabetes treatment is critical for obtaining the confidence and approval of medical professionals as well as patients. Black-box artificial intelligence algorithms which generate precise forecasts without disclosing the reasons behind them could hinder acceptance and limit artificial intelligence's potential in medical care. Efforts to create accessible and comprehensible artificial intelligence (AI) models can improve their clinical utility and ease inclusion into the management of diabetes.

Another critical factor to consider is the security and confidentiality of data. Because artificial intelligence (AI) algorithms rely on delicate patient data, data privacy is critical. Maintaining the confidence of patients and upholding ethical norms in artificial intelligence-driven treatment for diabetes requires ensuring that patients comply with privacy rules and implementing effective data protection mechanisms. Furthermore, the applicability of artificial intelligence (AI) algorithms across varied patient groups and healthcare contexts is also an issue. When applied to diverse cohorts, AI systems educated on information collected from groups may reveal biases and mistakes. Overall, this narrative review demonstrates AI's transformative promise in diabetic diagnosis and prognosis. The papers examined highlight AI's ability to analyze huge amounts of data, provide accurate diagnosis knowledge, and enable personalized therapies. The incorporation of artificial intelligence in the treatment of diabetes has the potential to improve patients' wellbeing and prognosis of this common chronic condition.

However, it is important to recognize the difficulties and constraints associated with artificial intelligence execution, such as quality of data, comprehension, security issues, and universality. To ensure artificial intelligence's full potential in the management of diabetes, it will be crucial to address these issues through ongoing research and coordinated efforts of healthcare professionals, academics, and AI experts (Petersson et al., 2022). Undertaking so, medical professionals can take advantage of AI's transformational capacity to advance diabetes investigation, better prediction, and improve patient-oriented care, which will lead to improved outcomes for people living with diabetes around the world.

5. Conclusion

Artificial intelligence integration in diabetes diagnosis, investigation and prognosis offers significant promise for revolutionizing the research of diabetes diagnosis and prognosis. Algorithms using artificial intelligence have shown outstanding precision in diabetes prediction and diagnosis, allowing for prompt action and personalized treatment strategies. Furthermore, AI's participation in medication discovery opens new treatment avenues for efficiently controlling diabetes. While dealing with issues like quality of data, comprehension, and privacy problems remain, continual advances in artificial intelligence and increased research efforts are tackling these limits. The foreseeable future of diabetes treatment

appears hopeful, with enhanced outcomes for patients and improved control of a highly widespread chronic condition, by using the potential artificial intelligence and cooperating with healthcare experts.

6. Declarations

6.1 Conflict of Interest Statement

The authors have no conflict of interests to declare.

6.2 Funding Disclosure

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

7. References

[1]. "AI + ECG Heart Trace Can Accurately Predict Diabetes and Pre-Diabetes | BMJ," accessed July 26, 2023, https://www.bmj.com/company/newsroom/ai-ecg-heart-trace-can-accurately-predict-diabetes-and-pre-diabetes/.

[2]. Aberer, F., Pieber, T. R., Eckstein, M. L., Sourij, H., & Moser, O. (2022). Glucose-lowering therapy beyond insulin in type 1 diabetes: A narrative review on existing evidence from randomized controlled trials and Clinical Perspective. Pharmaceutics, 14(6), 1180. https://doi.org/10.3390/pharmaceutics14061180

[3]. "Application of Artificial Intelligence in Discovery and Development of Anticancer and Antidiabetic Therapeutic Agents," accessed July 26, 2023, https://www.hindawi.com/journals/ecam/2022/6201067/.

[4]. "Crayon | How AI helps those with diabetes - Crayon," accessed July 26, 2023, https://www.crayon.com/resources/insights/how-is-ai-helping-those-with-diabetes/.

[5]. Davenport, T., & Kalakota, R. (2019). The potential for artificial intelligence in Healthcare. Future Healthcare Journal, 6(2), 94–98. https://doi.org/10.7861/futurehosp.6-2-94

[6]. "Diabetes Control and Complications Trial," American College of Cardiology, accessed July 26, 2023, https://www.acc.org/latest-in-cardiology/clinical-trials/2010/02/23/19/01/http%3a%2f%2fwww.acc.org%2flatest-in-cardiology%2fclinical-trials%2f2010%2f02%2f23%2f19%2f01%2fdcct.

[7]. "Diabetes Prediction Using Machine Learning — Part 1 | by Adeniran Opeyemi Adewale | Level Up Coding," accessed July 26, 2023, https://levelup.gitconnected.com/diabetes-prediction-using-machine-learning-part-1-91cb6a351c9c.

[8]. "Gestational Diabetes," Centers for Disease Control and Prevention, March 2, 2022, https://www.cdc.gov/diabetes/basics/gestational.html.

[9]. Akihiro Nomura et al., "Artificial Intelligence in Current Diabetes Management and Prediction," Current Diabetes Reports 21, no. 12 (2021): 61, https://doi.org/10.1007/s11892-021-01423-2.

[10]. Andrzej Grzybowski et al., "Artificial Intelligence for Diabetic Retinopathy Screening: A Review," Eye (London, England) 34, no. 3 (March 2020): 451–60, https://doi.org/10.1038/s41433-019-0566-0.

[11]. Antonio Agliata et al., "Machine Learning as a Support for the Diagnosis of Type 2 Diabetes," International Journal of Molecular Sciences 24, no. 7 (April 5, 2023): 6775, https://doi.org/10.3390/ijms24076775.

[12]. Beatriz López, Clare Martin, and Pau Herrero Viñas, "Special Section on Artificial Intelligence for Diabetes," Artificial Intelligence in Medicine 85 (April 2018): 26–27, https://doi.org/10.1016/j.artmed.2017.09.008.

[13]. Chunyan Zhu et al., "Artificial Intelligence and Network Pharmacology Based Investigation of Pharmacological Mechanism and Substance Basis of Xiaokewan in Treating Diabetes," Pharmacological Research 159 (September 2020): 104935, https://doi.org/10.1016/j.phrs.2020.104935.

[14]. David Simmons et al., "Treatment of Gestational Diabetes Mellitus Diagnosed Early in Pregnancy," The New England Journal of Medicine 388, no. 23 (June 8, 2023): 2132–44, https://doi.org/10.1056/NEJMoa2214956.

[15]. David T. Broome, C. Beau Hilton, and Neil Mehta, "Policy Implications of Artificial Intelligence and Machine Learning in Diabetes Management," Current Diabetes Reports 20, no. 2 (February 1, 2020): 5, https://doi.org/10.1007/s11892-020-1287-2.

[16]. Dinesh V. Gunasekeran et al., "Artificial Intelligence for Diabetic Retinopathy Screening, Prediction, and Management," Current Opinion in Ophthalmology 31, no. 5 (September 2020): 357–65, https://doi.org/10.1097/ICU.0000000000000693.

[17]. G. Fagherazzi and P. Ravaud, "Digital Diabetes: Perspectives for Diabetes Prevention, Management and Research," Diabetes & Metabolism 45, no. 4 (September 2019): 322–29, https://doi.org/10.1016/j.diabet.2018.08.012.

[18]. Irene Dankwa-Mullan et al., "Transforming Diabetes Care Through Artificial Intelligence: The Future Is Here," Population Health Management 22, no. 3 (June 2019): 229–42, https://doi.org/10.1089/pop.2018.0129.

[19]. Ivan Contreras and Josep Vehi, "Artificial Intelligence for Diabetes Management and Decision Support: Literature Review," Journal of Medical Internet Research 20, no. 5 (May 30, 2018): e10775, https://doi.org/10.2196/10775.

[20]. Jill M. Norris, Randi K. Johnson, and Lars C. Stene, "Type 1 Diabetes-Early Life Origins and Changing Epidemiology," The Lancet. Diabetes & Endocrinology 8, no. 3 (March 2020): 226–38, https://doi.org/10.1016/S2213-8587(19)30412-7.
[21]. Jingtong Huang et al., "Artificial Intelligence for Predicting and Diagnosing Complications of Diabetes," Journal of Diabetes Science and Technology 17, no. 1 (January 2023): 224–38, https://doi.org/10.1177/19322968221124583.
[22]. Juan David Sanchez and https://www.facebook.com/pahowho, "PAHO/WHO | About Diabetes," Pan American Health Organization / World Health Organization, accessed July 26, 2023, https://www3.paho.org/hq/index.php?option=com_content&view=article&id=6717:2012-about-diabetes&Itemid=0&lang=en#gsc.tab=0.
[23]. Juan Li et al., "Application of Artificial Intelligence in Diabetes Education and Management: Present Status and Promising Prospect," Frontiers in Public Health 8 (2020): 173, https://doi.org/10.3389/fpubh.2020.00173.
[24]. Kausik Umanath and Julia B. Lewis, "Update on Diabetic Nephropathy: Core Curriculum 2018," American Journal of Kidney Diseases: The Official Journal of the National Kidney Foundation 71, no. 6 (June 2018): 884–95, https://doi.org/10.1053/j.ajkd.2017.10.026.
[25]. Martina Vettoretti et al., "Advanced Diabetes Management Using Artificial Intelligence and Continuous Glucose Monitoring Sensors," Sensors (Basel, Switzerland) 20, no. 14 (July 10, 2020): 3870, https://doi.org/10.3390/s20143870.
[26]. Ming Wu and Yan Zhang, "Combining Bioinformatics, Network Pharmacology, and Artificial Intelligence to Predict the Mechanism of Celastrol in the Treatment of Type 2 Diabetes," Frontiers in Endocrinology 13 (2022): 1030278, https://doi.org/10.3389/fendo.2022.1030278.
[27]. Mohammad Hasan Shahriari et al., "Artificial Intelligence in Screening, Diagnosis, and Classification of Diabetic Macular Edema: A Systematic Review," Survey of Ophthalmology 68, no. 1 (2023): 42–53, https://doi.org/10.1016/j.survophthal.2022.08.004.
[28]. Navin Khosla, "Why AI Won't Solve Diabetes Yet: Healthy Living & Wellness" Now patient (June 2023) https://nowpatient.com/healthy-living-and-wellness/why-ai-wont-solve-diabetes-yet.
[29]. Nayana Khurana et al., "Novel Therapies for Kidney Disease in People with Diabetes," The Journal of Clinical Endocrinology and Metabolism 107, no. 1 (January 1, 2022): e1–24, https://doi.org/10.1210/clinem/dgab639.
[30]. Petersson, L., Larsson, I., Nygren, J. M., Nilsen, P., Neher, M., Reed, J. E., Tyskbo, D., & Svedberg, P. (2022). Challenges to implementing artificial intelligence in Healthcare: A qualitative interview study with healthcare leaders in Sweden. BMC Health Services Research, 22(1). https://doi.org/10.1186/s12913-022-08215-8
[31]. Qiongyu Hao et al., "A Novel Metabolic Reprogramming Strategy for the Treatment of Diabetes-Associated Breast Cancer," Advanced Science (Weinheim, Baden-Wurttemberg, Germany) 9, no. 6 (February 2022): e2102303, https://doi.org/10.1002/advs.202102303.
[32]. Ram D. Sriram and S. Sethu K. Reddy, "Artificial Intelligence and Digital Tools: Future of Diabetes Care," Clinics in Geriatric Medicine 36, no. 3 (August 2020): 513–25, https://doi.org/10.1016/j.cger.2020.04.009.
[33]. Rafat, D. (2022). Gestational diabetes mellitus and maternal microbiome alterations. Gestational Diabetes Mellitus - New Developments. https://doi.org/10.5772/intechopen.101868
[34]. Rory Casey et al., "Discovery through Machine Learning and Preclinical Validation of Novel Anti-Diabetic Peptides," Biomedicines 9, no. 3 (March 2021): 276, https://doi.org/10.3390/biomedicines9030276.
[35]. Samer Ellahham, "Artificial Intelligence: The Future for Diabetes Care," The American Journal of Medicine 133, no. 8 (August 2020): 895–900, https://doi.org/10.1016/j.amjmed.2020.03.033.
[36]. Tao Li et al., "Diagnostic Assessment of Deep Learning Algorithms for Diabetic Retinopathy Screening," Information Sciences 501 (October 1, 2019): 511–22, https://doi.org/10.1016/j.ins.2019.06.011.
[37]. Thibault Gautier et al., "Artificial Intelligence and Diabetes Technology: A Review," Metabolism: Clinical and Experimental 124 (November 2021): 154872, https://doi.org/10.1016/j.metabol.2021.154872.
[38]. Tien-En Tan and Tien Yin Wong, "Diabetic Retinopathy: Looking Forward to 2030," Frontiers in Endocrinology 13 (2022): 1077669, https://doi.org/10.3389/fendo.2022.1077669.
[39]. Xuan Huang et al., "Artificial Intelligence Promotes the Diagnosis and Screening of Diabetic Retinopathy," Frontiers in Endocrinology 13 (2022): 946915, https://doi.org/10.3389/fendo.2022.946915.

[40]. Yanling Wu et al., "Risk Factors Contributing to Type 2 Diabetes and Recent Advances in the Treatment and Prevention," International Journal of Medical Sciences 11, no. 11 (September 6, 2014): 1185–1200, https://doi.org/10.7150/ijms.10001.