International Journal of Public Health Excellence (IJPHE)
Vol. 4, No. 1, July-December 2024, pp. 021~028
Journal Homepage: https://ejournal.ipinternasional.com/index.php/ijphe
ISSN: 2809-9826, DOI: 10.55299/ijphe.v4i1.906

Risk Factors of Death in the Decision to Install Artificial Intelligence Systems in the Management of Diabetes

Asbath [1], Prima Dewi Kusumawati [2], Pius Weraman [3], Eli Sabrifha [4], Ahmad Zil Fauzi [5]
[1] Universitas Mandala Waluya, Indonesia
[2] Institut Ilmu Kesehatan STRADA Indonesia, Indonesia
[3] Society Health, Nusa Cendana University, Indonesia
[4] Universitas Islam Negeri Sultan Syarif Kasim Riau, Indonesia
[5] Poltekkes Kemenkes Kendari, Indonesia

Article Info

Article history:

Received June 02, 2024
Revised June 05, 2024
Accepted June 24, 2024

Corresponding Author:

Asbath
Universitas Mandala Waluya, Indonesia
asbath.mw@gmail.com

ABSTRACT

Diabetes represents a significant public health concern, affecting millions of individuals worldwide. Its prevalence is increasing, driven in part by lifestyle factors and the aging of the global population. This systematic review explores the potential of artificial intelligence (AI) in enhancing diabetes prevention, diagnosis, and management. The review highlights the promise of personalized and proactive healthcare enabled through AI. The research methodology employed an exhaustive review of the literature, the formulation of specific inclusion and exclusion criteria, a data extraction process from selected studies that focused on the role of AI in diabetes, and a comprehensive analysis to identify the specific domains and functions in which AI makes a significant contribution. The results of the conducted literature review indicate that artificial intelligence (AI) can be regarded as a transformative force in the following eight key areas within the field of diabetes care: 1) Management and Care of Diabetes, 2) Diagnostic and Imaging Technologies, 3) Health Monitoring Systems, 4) Development of Predictive Models, 5) Public Health Interventions, 6) Lifestyle and Dietary Management, 7) Enhancement of Clinical Decision Making, and 8) Engagement and Self-Management of Patients. Additionally, the utilization of AI may result in a reduction in the risk of mortality from diabetes.

Keywords: AI, diabetes, death, management

1. INTRODUCTION

Diabetes represents a significant public health concern, affecting millions of individuals worldwide. Its prevalence is increasing, driven in part by lifestyle factors and the aging of the global population. This systematic review explores the potential of artificial intelligence (AI) in enhancing diabetes prevention, diagnosis, and management. The review highlights the promise of personalized and proactive healthcare enabled through AI. The research methodology employed an exhaustive review of the literature, the formulation of specific inclusion and exclusion criteria, a data extraction process from selected studies that focused on the role of AI in diabetes, and a comprehensive analysis to identify the specific domains and functions in which AI makes a significant contribution. [1]

The results of the conducted literature review indicate that artificial intelligence (AI) can be regarded as a transformative force in the following eight key areas within the field of diabetes care: 1) Management and Care of Diabetes, 2) Diagnostic and Imaging Technologies, 3) Health Monitoring Systems, 4) Development of Predictive Models, 5) Public Health Interventions, 6) Lifestyle and Dietary Management, 7) Enhancement of Clinical Decision Making, and 8) Engagement and Self-Management of Patients. [2]

Each domain showcases the potential of AI to revolutionize care. This includes the ability to personalize care plans, improve diagnostic accuracy, enhance patient engagement, and predict healthcare outcomes, all of which are crucial for the management of diabetes. The integration of AI into diabetes care offers personalized, efficient, and

proactive solutions, which improve treatment accuracy, empower patients to take an active role in their healthcare, and provide better understanding of diabetes management.

However, implementing AI technology requires ongoing research and development, data security, interdisciplinary collaboration, and a focus on patient-centered care. It is similarly important to educate healthcare professionals and establish appropriate regulatory frameworks to address challenges such as algorithmic and ethical biases. The findings of this study indicate that AI in the context of diabetes care can lead to improved health outcomes and quality of life through the provision of personalized and proactive healthcare. In the future, it is recommended that further investment be made to ensure the security of data, to encourage interdisciplinary collaboration, and to prioritize patient-centered solutions. Regular monitoring and evaluation of the impact of AI on healthcare is also crucial to allow strategies to be adjusted and to enable long-term understanding of the impact. Finally, it is essential that ethical considerations are at the forefront of the integration of AI into healthcare. Additionally, the utilization of AI may result in a reduction in the risk of mortality from diabetes.

Diabetes mellitus is a chronic metabolic disorder in which the body is unable to process glucose from the bloodstream in an effective manner, resulting in elevated levels of glucose in the bloodstream. This condition is further classified into two main categories, Type 1 and Type 2. Type 1 diabetes is characterized by insufficient insulin production, while in Type 2 diabetes, there is insulin resistance. Hyperglycemia, or high blood sugar levels, is a common consequence of both types of diabetes. This condition can potentially lead to a wide range of health issues. Inadequate control of blood glucose levels can result in acute complications, including diabetic ketoacidosis and hyperosmolar hyperglycemic syndrome. Moreover, numerous severe, long-term health issues may result from poorly managed diabetes, including cardiovascular disease, nerve damage, kidney failure, vision impairment, and an elevated risk of infection. Additionally, diabetes is one of the primary causes of premature mortality. As a significant global health concern, diabetes impacts millions due to factors such as obesity, physical inactivity, and aging. According to the World Health Organization (WHO), there were approximately 422 million cases of diabetes in 2014, representing a fourfold increase since 1980, with 2 million associated deaths in 2019. This epidemic poses a significant challenge to healthcare systems, underscoring the need for effective prevention and management.[3], [4]

In recent decades, technological advancements in the healthcare field have opened up promising avenues for more effective management of diabetes. The disease's complexity and the necessity for continuous assessment and modification of treatment plans make this particularly crucial. These technologies encompass advanced glucose monitoring devices and software applications that facilitate the tracking and analysis of patient data, thereby contributing to more personalised and effective diabetes care. [5], [6] In this domain, artificial intelligence is transforming diabetes care, providing advances in early risk assessment, diagnosis, and personalised management. AI is employed to analyze large data sets, thereby enabling the prediction of risk, the accurate interpretation of test results, and the customization of treatment plans. These advances facilitate improvements in patient care and outcomes. The incorporation of AI into the healthcare system offers the potential for a significant reduction in the burden associated with diabetes care, with a shift towards a more proactive and personalized approach. This systematic review explores the impact of AI in improving diabetes prevention, diagnosis, and management, assesses its readiness for integration into healthcare, identifies research gaps, and guides future developments.

2. METHOD

The systematic review was conducted in accordance with four defined steps, an exhaustive search was conducted across a range of databases, including PubMed, Embase, and Google Scholar. The search period spanned from the year 2019 onwards, and the search terms employed were "artificial intelligence", "machine learning" and "diabetes mellitus". The objective of this search was to collect experimental studies that examined the role of AI in diabetes prevention, diagnosis, or management. Based on the established criteria, studies were included in the review if they investigated AI's potential for improving the prevention, diagnosis, prognosis, monitoring, or management of diabetes. Studies were excluded if they were irrelevant, lacked methodological clarity, or did not meet other inclusion criteria. Essential data were then extracted from each study, focusing on the study's purpose, AI techniques utilized, key findings, and conclusions. Subsequently, the aggregated and synthesized data were employed to elucidate the pivotal domains where AI plays a pivotal role in the prevention, diagnosis, or management of diabetes. Finally, a meticulous examination of the collected data was conducted, with the objective of delineating the particular domains and functions in which AI exerts a beneficial impact in the management of diabetes and delineating these into discrete domains and functions. [7]

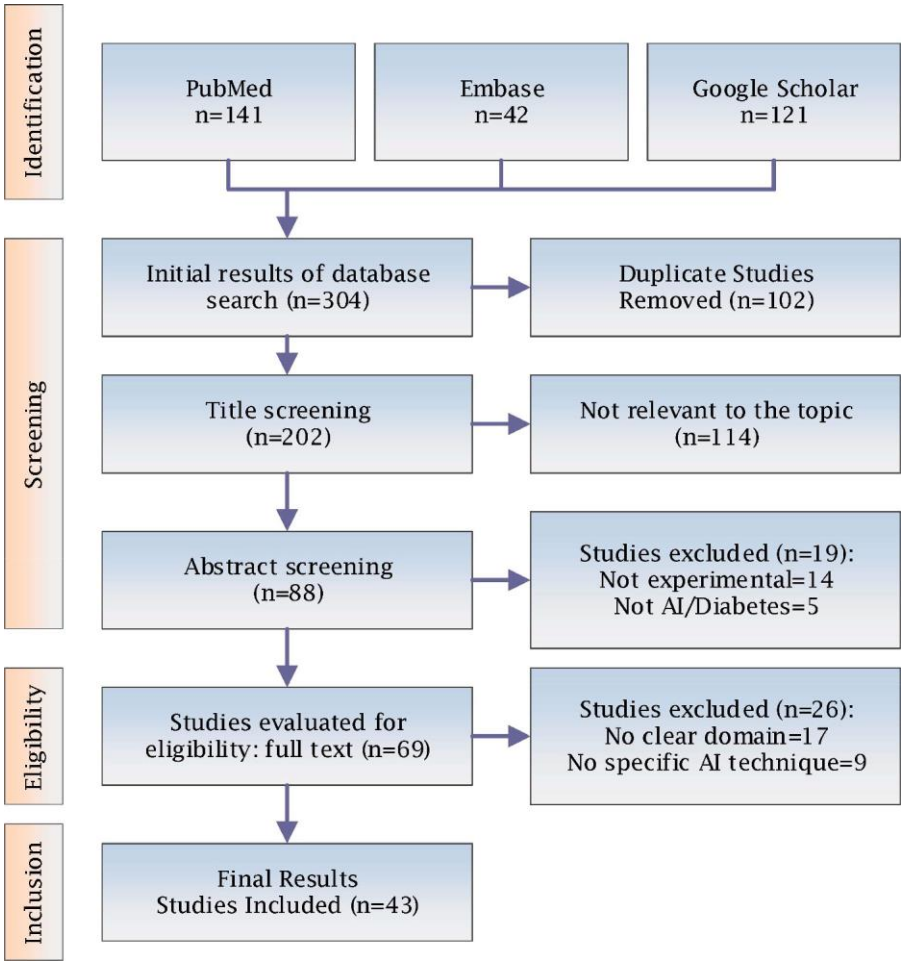

Figure 1. PRISMA flowchart for study selection and inclusion process.

3. RESULTS AND DISCUSSION

A review of published papers yielded 304 studies. Following the removal of duplicates, 202 unique studies were identified. After the application of the inclusion and exclusion criteria, 114 studies were excluded following a title screening. Additionally, 19 studies were excluded following an abstract screening. Following a full-text screening, 43 studies, out of 88 studies, were included in the final selection. Fig. 1 depicts the process of study selection and inclusion. Qualitative data analysis revealed that AI holds the potential to transform the landscape of diabetes management, offering more accurate, personalised, and effective outcomes. [8]

AI algorithms have emerged as key players in the domain of diabetes management and treatment, where their ability to personalise management strategies and optimize insulin doses has been widely recognized. These advanced algorithms continuously analyse patient data, leading to the development of more tailored and efficient management plans. Among the 43 studies included in this review, 19 studies addressed the role of AI in this domain. In the Diagnostic and Imaging Technology domain, AI has been found to significantly improve the precision and efficiency of diagnostic tools.

Its application in medical imaging, including magnetic resonance imaging (MRI) scanning, plays an important role in the early detection and ongoing monitoring of diabetes-related complications. The technological advancements ensure the early identification of subtle changes in a patient's health, which in turn facilitates prompt intervention. This domain was addressed by eight studies, with the integration of AI with various devices, including continuous glucose monitors, representing a significant advancement in real-time blood glucose tracking. [9] These AI-enhanced systems not only monitor fluctuations in glucose levels but also predict potential health problems. This integration significantly contributes to proactive diabetes management and represents a significant advancement in the field. Three studies address this domain. AI also makes an important contribution to developing predictive models. The use of artificial intelligence (AI) in the field of diabetes research is becoming increasingly prominent, with the capacity to facilitate the forecasting of diabetes onset or progression, as well as the identification of associated risks. By analyzing extensive health data, these models can determine risk factors and predict patient responses to various treatments, paving the way for more personalized and preventive healthcare approaches. This domain was the subject of 33 studies.

The role of AI also extends to public health interventions, where AI helps create tools for risk assessment of conditions such as stroke in diabetic patients. These AI-driven tools are critical in formulating prevention strategies, thus playing a key role in public health initiatives aimed at reducing the impact of diabetes-related complications.

This domain was addressed by eight studies. Additionally, in the area of lifestyle and diet management, AI applications are revolutionizing the way dietary and lifestyle advice is delivered to diabetic patients. The tailoring of recommendations based on individual health profiles and preferences allows AI to facilitate more effective and patient-centered approaches to lifestyle interventions. This domain was addressed by 15 studies. AI is also a powerful ally for healthcare professionals engaged in improving clinical decision-making. AI assists in the sorting of patient data to suggest the most effective treatment options. The overall quality of care improves as a result, and clinical decisions become more accurate and efficient. This domain was addressed by 22 studies.

Finally, in the domain of patient engagement and self-management, AI-based tools and platforms facilitate patient involvement in their healthcare. These tools not only provide personalized management advice but also track adherence to treatment plans, empowering patients to effectively manage their conditions, thereby improving health outcomes. This domain was addressed by 20 studies. In conclusion, the integration of AI across these domains signals a transformative shift in the management and treatment of diabetes, offering a more nuanced and data-driven approach that holds great promise for patient care and outcomes.

Diabetes Management and Care encompasses novel approaches to healthcare, leveraging AI to revolutionize diabetes management. Recently conducted studies in this domain have demonstrated the versatility and efficacy of AI algorithms in diverse applications. AI-based solutions are now capable of personalizing diabetes management through the precise prediction of blood glucose levels, optimal insulin dosage, and the customization of treatment plans based on individual patient characteristics. Key findings from these studies underscore the multifaceted nature of AI applications in diabetes care. For instance, Liu et al. (2020) and Khor-Raminezhad et al. (2021) illustrate the significant impact of lifestyle factors, such as exercise and diet, on glucose homeostasis. AI algorithms assist in understanding and predicting these complex interactions. [10], [11]

Rein et al. (2022) and Joshi et al. (2023) This further underscores the efficacy of personalized nutrition plans developed through AI in improving glycemic control and metabolic health outcomes, thus reinforcing the value of this approach in the field of nutrition and healthcare. [12], [13] Innovations in machine learning, as demonstrated in the work of Zhang et al. (2022) and Oikonomou et al. (2022), have enabled risk prediction of adherence and personalization of treatment effects, respectively. [14], [15] This illustrates the capacity of AI to adapt treatment to individual patient profiles, thereby facilitating more efficacious management of diabetes. Furthermore, the integration of AI into medical devices and digital platforms, as evidenced by studies conducted by Faruqui et al. (2019), Avari et al. (2021), and Lee et al. (2023), offers a novel dimension of real-time data-driven management. These platforms facilitate continuous monitoring and customization of treatment plans, which has a significant impact on patient outcomes. [16], [17], [18]

AI in diagnostic and imaging technologies primarily examines the ways in which artificial intelligence enhances the accuracy and efficiency of diagnostic tools, particularly in medical imaging such as MRI, for the identification and monitoring of diabetes-related complications. Studies such as those by Roberts et al., 2020, have demonstrated the ability of AI to improve diagnostic accuracy for diabetic macular edema (DME) and the automatic segmentation of fluid in DME. Such advances have the potential to facilitate a deeper understanding of treatment response and support the implementation of personalized healthcare strategies, as discussed in reference. [19]

Furthermore, Habes et al. (2023) have highlighted the role of AI in functional magnetic resonance imaging (fMRI) and the detection of early signs of cognitive decline in diabetic individuals. [20] These advances demonstrate the potential of AI in early intervention and the reduction of diagnostic errors. Similarly, Sarici et al. (2023) and Abraham et al. (2021) focused on ultrawide-field angiographic graph parameters and identified biomarkers for therapy response in DME, indicating the contribution of AI in improving treatment efficacy. [21], [22]

Furthermore, studies conducted by Wang et al. (2022) and Zhao et al. (2022) demonstrated the utilization of AI in the evaluation of therapeutic interventions for diabetic foot disease and in the monitoring of renal function in diabetic kidney disease. [23] These findings indicate that AI not only enhances the precision of existing diagnostic techniques but also paves the way for continuous monitoring and treatment optimization. This marks a notable transition towards more precise and effective diabetes management.

The integration of artificial intelligence with health monitoring devices represents a significant advancement in the field of health monitoring systems. This integration has the potential to improve the real-time tracking and management of blood glucose levels, which is of particular importance in the context of diabetes care. The potential of AI in creating a more responsive and personalized experience is illustrated by research in this area.

As an illustrative example, Zhang et al. (2022) demonstrated the application of machine learning techniques to predict self-management adherence among individuals with Type 1 Diabetes. [24] The authors demonstrated how AI could be utilized to identify individual barriers to self-management and to tailor interventions accordingly. This level of personalization is crucial for effective diabetes management, as it accounts for the unique challenges that individuals face and enhances their ability to proactively manage their condition. Similarly, Faruqui et al. (2019) advanced this domain with the development of a deep learning model that utilizes mobile health data to dynamically

forecast blood glucose levels. [16] Their work constitutes a significant step towards predictive health monitoring and represents a significant advancement in the ability of patients with Type 2 Diabetes to anticipate and adjust their lifestyle and treatment options in advance, thereby preventing potential complications. Lastly, the study by Reddy et al. (2019) addressed the issue of exercise-induced hypoglycemia, a significant challenge for individuals with Type 1 diabetes. [17] By developing an algorithm to predict hypoglycemic events during aerobic exercise, they provided a tool that enhances the safety of physical activity, which contributes to better diabetes management overall and an improved quality of life for individuals with diabetes. Collectively, these studies demonstrate the transformative role of AI in health monitoring systems, offering more accurate and real-time insights and predictions that empower individuals with diabetes to manage their diabetes health more effectively and safely.

The ability of AI to analyze vast amounts of data, predict potential health issues, and provide personalized monitoring enhances diagnostic precision, integrates diverse health data, and strengthens remote monitoring. This evolution leads to a proactive and efficient health system.

The application of AI in the construction of predictive models marks a pivotal transition in the field of healthcare, with a particular impact on diabetes management. This domain of inquiry examines the potential of AI to anticipate the emergence and evolution of diabetes-related conditions, assess the risk of associated complications, and predict the individual responses to diverse therapeutic and dietary interventions. By analysing a wide range of data sources, including lifestyle habits, environmental factors, and medical interventions, AI enables the identification of early indicators of diabetes risk. For instance, studies have demonstrated that AI is capable of predicting the onset of diabetes by analyzing changes in the gut microbiome.

This predictive power extends to the customization of dietary strategies, as evidenced by the ability of AI to forecast responses to a Mediterranean diet.

Furthermore, AI plays a pivotal role in the development of personalized nutrition plans, thereby improving glycemic control. Additionally, it is instrumental in patient stratification, enabling healthcare professionals to customize treatment plans based on individual risk or likelihood of disease progression. This not only facilitates preventive care but also ensures effective management of existing conditions. Moreover, AI contributes significantly to the innovation of medical devices, enhancing their functionality to make diabetes management more personalized. It is also of paramount importance in predicting

Such applications include the prediction of hypoglycemia, which is crucial for the safe daily management of diabetes. Finally, the scope of AI includes the forecasting of long-term complications and the evaluation of the efficacy of interventions on insulin.

This resistance will set the stage for a future where healthcare is proactive, personalized, and predictive.

The application of artificial intelligence (AI) in public health interventions aims to enhance the efficacy of public health strategies, particularly in the assessment and management of the risk of diabetes and associated cardiovascular complications. Findings from studies in this domain provide valuable insights into preventive health measures. For instance, Liu et al. (2020) highlighted the significance of exercise-induced alterations in gut microbiota, demonstrating a correlation between these changes and improved glucose homeostasis and insulin sensitivity in prediabetes. [25] This study underscores the role of lifestyle factors in diabetes prevention and the capacity of AI to facilitate the identification of effective prevention strategies based on individual microbiomes. Additionally, Wei et al. (2022) demonstrated the prognostic value of environmental chemical exposure in the onset of diabetes mellitus through the utilization of machine learning. [26] This approach emphasizes the potential of machine learning in the identification of broader environmental risk factors for diabetes, aiding in the formulation of more comprehensive public health strategies. Conversely, Zou et al. (2024) and Sampedro et al. (2020)The study focused on applying AI to categorize patients based on their risk of diabetes progression and to predict potential complications, such as stent restenosis. [24], [27] These models facilitate the tailoring of interventions and preventive measures in a more effective manner. Similarly, Oikonomou et al. (2022) and Wang et al. (2023) employed AI to personalize cardiovascular care, demonstrating its efficacy in reducing the risk of heart failure and optimizing blood pressure control in patients with or without type 2 diabetes. [5], [15] Khanji et al. (2019) conducted a comparable study and identified predictive indicators for cardiovascular disease prevention, emphasizing the role of AI in enhancing the accuracy of diabetes management. [28]

The development of prediction models for cardiovascular health management in diabetic patients represents a significant advancement in the field of artificial intelligence. In a similar vein, Gastaldelli et al. (2021) also explored the impact of PPAR-γ agonists on steatohepatitis in patients with NASH, linking the potential of AI in understanding complex biological responses to treatment. [29]

The application of Artificial Intelligence (AI) in the fields of Prevention, Lifestyle, and Dietary Management represents a significant advance in personalized healthcare, where AI is employed to tailor dietary and lifestyle interventions to the specific needs and preferences of individual patients. Research in this domain has demonstrated that AI has the potential to improve the management of diabetes and related metabolic disorders through the use of personalized nutrition and lifestyle modifications. The ability of AI to analyse large amounts of data, including dietary patterns and the compositions of gut microbiomes, allows it to provide highly individualized recommendations.

The creation of highly individualized dietary recommendations is a notable outcome of this approach. For instance, the use of digital twin technology and machine learning algorithms, as exemplified in studies such as Joshi et al. (2023), enables the customization of nutrition plans that effectively address specific issues. [13]

The integration of AI with mobile health technologies, exemplified by the Keenoa app, as evaluated by Moyen et al. 2022, facilitates real-time tracking and assessment of food intake, which provides actionable insights to both patients and healthcare providers to enable the management of diabetes. [30] The aforementioned tools are made possible through the use of image recognition and other advanced technologies, thereby making the monitoring of dietary habits more accessible and accurate. Furthermore, studies such as those by Seethaler and colleagues (Seethaler, et al., 2022) and Popp and colleagues (Popp, et al., 2022) exemplify the capacity of AI to elucidate the intricate interconnections between dietary patterns, metabolic health, and individual physiological responses. [23], [31] This understanding enables the development of more efficacious lifestyle modifications that are tailored to each individual's unique health profile.

Furthermore, AI-based dietary recommendations are not only based on general dietary guidelines but also customized to each person's unique health profile. The ability of AI to predict long-term outcomes, as demonstrated by SAUX et al., (2022), furthermore, it adds value by assisting patients and healthcare providers in setting realistic goals and tracking progress over time. [32]

The use of AI in clinical decision-making is a growing field of research. It explores how AI can assist healthcare professionals in making more informed, precise, and customized clinical decisions, which can significantly improve the quality of care for diabetic patients. For instance, Liu et al. (2020) demonstrated how AI can discern the intricate relationship between exercise-induced alterations in the gut microbiome and improved glucose homeostasis, which facilitates the design of efficacious exercise programs. [25] Similarly, Rein et al. (2022) illustrated the potential of AI in personalizing diets to enhance glycemic control, offering a more nuanced approach to managing type 2 diabetes. [12] Furthermore, studies such as that by Zou et al. (2024) demonstrate the capacity of AI-based models to stratify patients based on their risk of diabetes progression, thereby optimizing intervention strategies. [24] Varga et al. (2021) compared different biomarkers for diabetes prediction, assessing the added value of AI in risk stratification over traditional methods. [33] Furthermore, machine learning models, such as those developed by Faruqui et al. (2019) and Oikonomou et al. (2022), enable dynamic forecasting of blood glucose levels and individualized cardiovascular care of diabetic patients, respectively. This improves the ability to anticipate and respond to the needs of patients. [16], [33]

These studies collectively highlight the potential of AI in improving clinical decision-making by providing healthcare professionals with deeper insights and predictive capabilities. Furthermore, AI has the potential to facilitate the development of more personalized treatment strategies, thereby improving the standard and effectiveness of diabetes care.

The field of artificial intelligence (AI) in patient engagement and self-management encompasses the utilization of AI-driven tools and platforms with the objective of improving patient engagement, adherence to care plans, and effective self-management for diabetes. Studies conducted in this domain demonstrate various innovative approaches that leverage AI in order to empower patients and personalize their care. As illustrated by Liu et al. (2020), AI can be used to analyze complex biological and behavioral data in order to provide tailored advice. [25] One example of such advice is a personalized exercise program that considers changes in gut microbiota, or that identifies barriers to self-management in individuals with Type 1 Diabetes. This personalized feedback has been shown to encourage patients to adhere better to their management plans. Similarly, Rein et al. (2022) and Nayak et al. (2023) demonstrated that AI has the capacity to personalize dietary advice and insulin titration. AI can accomplish this by offering customized recommendations based on an individual's glycemic response or by providing voice-based conversational support for insulin management. [12], [34]

The potential to improve patients' ability to make decisions and actively engage in their health management has been identified as a key area of focus. Tools such as PEPPER Adaptive Bolus Advisor, by Avari et al., 2021, and Advanced Bolus Calculator for Type 1 Diabetes, by Unsworth et al., 2023, exemplify how AI can aid in informed and adaptive treatment decision-making, thereby supporting better glycemic outcomes. [17], [35] Furthermore, a system integrating an intelligent dietary management program and continuous glucose monitoring by Park et al. 2020 offers users actionable real-time insights, encouraging a proactive approach to diabetes self-management. In essence, Domain 8 reflects a shift towards more engaging and personalized diabetes care, in which AI tools not only inform and guide patients but also adapt to their individual needs and preferences, thus promoting improved health outcomes through increased engagement and self-management. [36]

4. CONCLUSION

The incorporation of AI into diabetes care represents a significant transformative shift, offering patients personalized, efficient, and proactive solutions. This review identifies eight key domains in which AI-driven diabetes management has been shown to improve, enhancing the accuracy and efficiency of healthcare. AI empowers patients with superior self-management tools and deepens the understanding of diabetes as a complex condition. Therefore, this review makes the following recommendations: (1) there should be investment in research,

development, and large-scale implementation studies to successfully integrate AI into healthcare. 2) It is of the utmost importance to ensure the robust protection of data and the confidentiality of individuals' information, which necessitates the establishment of standardized procedures for the handling of data. 3) Interdisciplinary collaboration is vital, involving healthcare professionals, AI researchers, and policy makers in the development of AI tools that are user-friendly, clinically relevant, and aligned with healthcare policies. 4) AI solutions must be designed with the specific needs of patients in mind. In addition, regulatory frameworks should be established to oversee ethical implementation, addressing issues such as algorithmic bias and accountability. It is of paramount importance to provide education and training for healthcare professionals in order to facilitate the effective integration of AI into clinical practice and to communicate the benefits and limitations of such technology to patients. It is similarly crucial to engage in continuous monitoring and evaluation of AI applications in order to identify areas for improvement, understand the long-term impact of such technology, and adjust strategies accordingly, in response to the emergence of new data sources and technologies. Furthermore, the study indicated that the integration of AI in diabetes management has the potential to reduce mortality risk factors by employing a multitude of mechanisms. These include enhanced glycemic monitoring, the early identification of complications, the tailoring of treatments to individual patient needs, the management of comorbid conditions, the fostering of patient engagement, and the implementation of predictive models. To fully leverage the benefits of AI in the context of diabetes management, it will be essential to maintain ongoing investment in technological advancement, data security and education for health care providers, while also prioritising patient-centric solutions.

ACKNOWLEDGEMENTS

Author thanks to all people and institution in most cases, sponsor and financial support acknowledgments.

REFERENCES

[1] A. E. \ Gosmanov, A. R., Gosmanova, E. O., & Kitabchi, "Hyperglycemic crises: diabetic ketoacidosis and hyperglycemic hyperosmolar state.," *Endotext [Internet].*, 2021.

[2] D. J. Magliano, J. W. Sacre, J. L. Harding, E. W. Gregg, P. Z. Zimmet, and J. E. Shaw, "Young-onset type 2 diabetes mellitus — implications for morbidity and mortality," *Nat. Rev. Endocrinol.*, vol. 16, no. 6, pp. 321–331, Jun. 2020, doi: 10.1038/s41574-020-0334-z.

[3] K. I. Galaviz, K. M. V. Narayan, F. Lobelo, and M. B. Weber, "Lifestyle and the Prevention of Type 2 Diabetes: A Status Report," *Am. J. Lifestyle Med.*, vol. 12, no. 1, pp. 4–20, Jan. 2018, doi: 10.1177/1559827615619159.

[4] A. Daly and R. Hovorka, "Technology in the management of type 2 diabetes: Present status and future prospects," *Diabetes, Obes. Metab.*, vol. 23, no. 8, pp. 1722–1732, Aug. 2021, doi: 10.1111/dom.14418.

[5] Z. Guan *et al.*, "Artificial intelligence in diabetes management: Advancements, opportunities, and challenges," *Cell Reports Med.*, vol. 4, no. 10, p. 101213, Oct. 2023, doi: 10.1016/j.xcrm.2023.101213.

[6] J. Huang *et al.*, "Artificial Intelligence for Predicting and Diagnosing Complications of Diabetes," *J. Diabetes Sci. Technol.*, vol. 17, no. 1, pp. 224–238, Jan. 2023, doi: 10.1177/19322968221124583.

[7] O. Ali, W. Abdelbaki, A. Shrestha, E. Elbasi, M. A. A. Alryalat, and Y. K. Dwivedi, "A systematic literature review of artificial intelligence in the healthcare sector: Benefits, challenges, methodologies, and functionalities," *J. Innov. Knowl.*, vol. 8, no. 1, p. 100333, Jan. 2023, doi: 10.1016/j.jik.2023.100333.

[8] M. Avanzo *et al.*, "Artificial intelligence applications in medical imaging: A review of the medical physics research in Italy," *Phys. Medica*, vol. 83, pp. 221–241, Mar. 2021, doi: 10.1016/j.ejmp.2021.04.010.

[9] M. Vettoretti, G. Cappon, A. Facchinetti, and G. Sparacino, "Advanced Diabetes Management Using Artificial Intelligence and Continuous Glucose Monitoring Sensors," *Sensors*, vol. 20, no. 14, p. 3870, Jul. 2020, doi: 10.3390/s20143870.

[10] Y. Liu *et al.*, "Gut Microbiome Fermentation Determines the Efficacy of Exercise for Diabetes Prevention," *Cell Metab.*, vol. 31, no. 1, pp. 77-91.e5, Jan. 2020, doi: 10.1016/j.cmet.2019.11.001.

[11] L. Khorraminezhad *et al.*, "Dairy product intake modifies gut microbiota composition among hyperinsulinemic individuals," *Eur. J. Nutr.*, vol. 60, no. 1, pp. 159–167, Feb. 2021, doi: 10.1007/s00394-020-02226-z.

[12] O. Ben-Yacov *et al.*, "Gut microbiome modulates the effects of a personalised postprandial-targeting (PPT) diet on cardiometabolic markers: a diet intervention in pre-diabetes," *Gut*, vol. 72, no. 8, pp. 1486–1496, Aug. 2023, doi: 10.1136/gutjnl-2022-329201.

[13] S. Joshi *et al.*, "Digital Twin-Enabled Personalized Nutrition Improves Metabolic Dysfunction-Associated Fatty Liver Disease in Type 2 Diabetes: Results of a 1-Year Randomized Controlled Study," *Endocr. Pract.*, vol. 29, no. 12, pp. 960–970, Dec. 2023, doi: 10.1016/j.eprac.2023.08.016.

[14] P. Zhang, C. Fonnesbeck, D. C. Schmidt, J. White, S. Kleinberg, and S. A. Mulvaney, "Using Momentary Assessment and Machine Learning to Identify Barriers to Self-management in Type 1 Diabetes: Observational Study," *JMIR mHealth uHealth*, vol. 10, no. 3, p. e21959, Mar. 2022, doi: 10.2196/21959.

[15] E. K. Oikonomou, M. A. Suchard, D. K. McGuire, and R. Khera, "Phenomapping-Derived Tool to Individualize the Effect of Canagliflozin on Cardiovascular Risk in Type 2 Diabetes," *Diabetes Care*, vol. 45, no. 4, pp. 965–974, Apr. 2022, doi: 10.2337/dc21-1765.

[16] S. H. A. Faruqui *et al.*, "Development of a Deep Learning Model for Dynamic Forecasting of Blood Glucose Level for Type 2 Diabetes Mellitus: Secondary Analysis of a Randomized Controlled Trial," *JMIR mHealth uHealth*, vol. 7, no. 11, p. e14452, Nov. 2019, doi: 10.2196/14452.

[17] P. Avari *et al.*, "Safety and Feasibility of the PEPPER Adaptive Bolus Advisor and Safety System: A Randomized Control Study," *Diabetes Technol. Ther.*, vol. 23, no. 3, pp. 175–186, Mar. 2021, doi: 10.1089/dia.2020.0301.

[18] Y.-B. Lee *et al.*, "An Integrated Digital Health Care Platform for Diabetes Management With AI-Based Dietary Management: 48-Week Results From a Randomized Controlled Trial," *Diabetes Care*, vol. 46, no. 5, pp. 959–966, May 2023, doi: 10.2337/dc22-1929.

[19] P. K. Roberts *et al.*, "Quantification of Fluid Resolution and Visual Acuity Gain in Patients With Diabetic Macular Edema Using Deep

Learning," *JAMA Ophthalmol.*, vol. 138, no. 9, p. 945, Sep. 2020, doi: 10.1001/jamaophthalmol.2020.2457.
[20] M. Habes *et al.*, "Patterns of Regional Brain Atrophy and Brain Aging in Middle- and Older-Aged Adults With Type 1 Diabetes," *JAMA Netw. Open*, vol. 6, no. 6, p. e2316182, Jun. 2023, doi: 10.1001/jamanetworkopen.2023.16182.
[21] K. Sarici *et al.*, "Longitudinal Quantitative Ultrawide-field Fluorescein Angiography Dynamics in the RUBY Diabetic Macular Edema Study," *Ophthalmol. Retin.*, vol. 7, no. 6, pp. 543–552, Jun. 2023, doi: 10.1016/j.oret.2023.01.018.
[22] J. R. Abraham *et al.*, "Aqueous Cytokine Expression and Higher Order OCT Biomarkers: Assessment of the Anatomic-Biologic Bridge in the IMAGINE DME Study," *Am. J. Ophthalmol.*, vol. 222, pp. 328–339, Feb. 2021, doi: 10.1016/j.ajo.2020.08.047.
[23] C. J. Popp *et al.*, "Effect of a Personalized Diet to Reduce Postprandial Glycemic Response vs a Low-fat Diet on Weight Loss in Adults With Abnormal Glucose Metabolism and Obesity," *JAMA Netw. Open*, vol. 5, no. 9, p. e2233760, Sep. 2022, doi: 10.1001/jamanetworkopen.2022.33760.
[24] X. Zou *et al.*, "Differential effect of interventions in patients with prediabetes stratified by a machine learning-based diabetes progression prediction model," *Diabetes, Obes. Metab.*, vol. 26, no. 1, pp. 97–107, Jan. 2024, doi: 10.1111/dom.15291.
[25] J. Li *et al.*, "Inflammation-related downregulation of zonula Occludens-1 in fetal membrane contributes to development of prelabor rupture of membranes," *Placenta*, vol. 99, pp. 173–179, Sep. 2020, doi: 10.1016/j.placenta.2020.07.029.
[26] X. Sun *et al.*, "Effects of Endurance Exercise and Vitamin D Supplementation on Insulin Resistance and Plasma Lipidome in Middle-Aged Adults with Type 2 Diabetes," *Nutrients*, vol. 15, no. 13, p. 3027, Jul. 2023, doi: 10.3390/nu15133027.
[27] J. Sampedro-Gómez *et al.*, "Machine Learning to Predict Stent Restenosis Based on Daily Demographic, Clinical, and Angiographic Characteristics," *Can. J. Cardiol.*, vol. 36, no. 10, pp. 1624–1632, Oct. 2020, doi: 10.1016/j.cjca.2020.01.027.
[28] C. Khanji, L. Lalonde, C. Bareil, M.-T. Lussier, S. Perreault, and M. E. Schnitzer, "Lasso Regression for the Prediction of Intermediate Outcomes Related to Cardiovascular Disease Prevention Using the TRANSIT Quality Indicators," *Med. Care*, vol. 57, no. 1, pp. 63–72, Jan. 2019, doi: 10.1097/MLR.0000000000001014.
[29] A. Gastaldelli *et al.*, "PPAR-γ-induced changes in visceral fat and adiponectin levels are associated with improvement of steatohepatitis in patients with NASH," *Liver Int.*, vol. 41, no. 11, pp. 2659–2670, Nov. 2021, doi: 10.1111/liv.15005.
[30] A. Moyen, A. I. Rappaport, C. Fleurent-Grégoire, A.-J. Tessier, A.-S. Brazeau, and S. Chevalier, "Relative Validation of an Artificial Intelligence–Enhanced, Image-Assisted Mobile App for Dietary Assessment in Adults: Randomized Crossover Study," *J. Med. Internet Res.*, vol. 24, no. 11, p. e40449, Nov. 2022, doi: 10.2196/40449.
[31] B. Seethaler *et al.*, "Short-chain fatty acids are key mediators of the favorable effects of the Mediterranean diet on intestinal barrier integrity: data from the randomized controlled LIBRE trial," *Am. J. Clin. Nutr.*, vol. 116, no. 4, pp. 928–942, Oct. 2022, doi: 10.1093/ajcn/nqac175.
[32] P. Saux *et al.*, "Development and validation of an interpretable machine learning-based calculator for predicting 5-year weight trajectories after bariatric surgery: a multinational retrospective cohort SOPHIA study," *Lancet Digit. Heal.*, vol. 5, no. 10, pp. e692–e702, Oct. 2023, doi: 10.1016/S2589-7500(23)00135-8.
[33] T. V Varga *et al.*, "Predictive utilities of lipid traits, lipoprotein subfractions and other risk factors for incident diabetes: a machine learning approach in the Diabetes Prevention Program," *BMJ Open Diabetes Res. Care*, vol. 9, no. 1, p. e001953, Mar. 2021, doi: 10.1136/bmjdrc-2020-001953.
[34] A. Nayak *et al.*, "Use of Voice-Based Conversational Artificial Intelligence for Basal Insulin Prescription Management Among Patients With Type 2 Diabetes," *JAMA Netw. Open*, vol. 6, no. 12, p. e2340232, Dec. 2023, doi: 10.1001/jamanetworkopen.2023.40232.
[35] R. Unsworth *et al.*, "Safety and Efficacy of an Adaptive Bolus Calculator for Type 1 Diabetes: A Randomized Controlled Crossover Study," *Diabetes Technol. Ther.*, vol. 25, no. 6, pp. 414–425, Jun. 2023, doi: 10.1089/dia.2022.0504.
[36] S.-M. Park *et al.*, "Biportal endoscopic versus microscopic lumbar decompressive laminectomy in patients with spinal stenosis: a randomized controlled trial," *Spine J.*, vol. 20, no. 2, pp. 156–165, Feb. 2020, doi: 10.1016/j.spinee.2019.09.015.