Educational Administration: Theory and Practice
2024, 30(1), 7849-7862
ISSN: 2148-2403
https://kuey.net/
Review Article

A Comprehensive Survey of Intelligent Approaches for Diabetes Diagnosis and Management

Dinesh Kumar Bhawnani[1*], Sunita Soni[2], Arpana Rawal[3]

[1*]Assistant Professor, Computer Science & Engineering, Bhilai Institute of Technology, Durg, Chhattisgarh Swami Vivekanand Technical University, Bhilai, Email- dinu1983@gmail.com
[2]Professor, Computer Science & Engineering, Bhilai Institute of Technology, Durg, Chhattisgarh Swami Vivekanand Technical University, Bhilai, Email- sunitasoni74@gmail.com
[3]Professor & Dean (R&D), Computer Science & Engineering, BENGAL COLLEGE OF ENGINEERING & TECHNOLOGY, DURGAPUR, WEST BENGAL, 713212, Email- arpana.rawal@gmail.com

Citation: Dinesh Kumar Bhawnani, et.al (2024). A Comprehensive Survey of Intelligent Approaches for Diabetes Diagnosis and Management, *Educational Administration: Theory and Practice*, 30(1) 7849-7862
Doi: 10.53555/kuey.v30i1.10976

ARTICLE INFO
Received:9 Jan 2024
Accepted: 12 Jan 2024

ABSTRACT
This study offers a thorough review and comparative analysis of machine learning techniques for managing diabetes, with emphasis on forecasting blood sugar levels and the need for insulin therapy. This research encompasses a broad spectrum of methodologies, such as conventional classification models, support vector machines (SVMs), and sophisticated deep learning algorithms such as ARCHANO. Important discoveries show that, in comparison to broad datasets, personalized datasets produce better predictive accuracy for diabetes management. Furthermore, the use of support vector machines to forecast blood glucose levels in individuals with insulin-dependent diabetes mellitus is promising, and rigorous frameworks for prediction accuracy in blood glucose control have been provided by causality modelling and fuzzy lattice reasoning. Neural network models demonstrate tremendous potential for optimizing insulin dosage prediction in patients. Additionally, studies utilizing decision tree algorithms and association rule mining for diabetes diagnosis and treatment have examined the dynamic interactions between different clinical factors. More accurate therapeutic interventions are made possible by time series temporal mining and stream mining classifiers, which improve real-time decision support systems. It is also investigated how hybrid algorithms, including those that combine particle swarm optimisation and fuzzy temporal rules, may be able to improve the management of diabetes. The analysis comes to the conclusion that more accurate and individualised treatment strategies for diabetic patients can result from incorporating these cutting-edge machine learning and data mining approaches into clinical decision support systems (CDSS). Together, the various strategies show how predictive analytics can be used to enhance the quality of diabetes care.

Keywords: Personalized medicine, Personalized treatment, diabetes prediction, insulin dose prediction, prediction accuracy, insulin-dependent diabetes mellitus.

1. Introduction

1.1 Brief introduction to diabetes and its significance in healthcare

Diabetes is a long-standing metabolic illness characterised by high blood sugar brought on by either insufficient insulin production or insufficient insulin action. The pancreas squirrel away the hormone insulin, that is necessary to control blood glucose levels and enable cells to use it as an energy source. There are three main forms of the disease: gestational diabetes (Parikshit, 2017), which develops during pregnancy and advances the risk of developing Type 2 diabetes in future; Type 1 diabetes, an autoimmune situation requiring lifetime insulin cure; and Type 2 diabetes, which is typically associated with obesity and insulin resistance. Medication, insulin therapy, and lifestyle modifications are all components of effective management.
Diabetes poses significant challenges to global healthcare due to its rising prevalence and severe health risks. With an estimated 463 million adults affected in 2019 (Talari et al., 2023), and projections reaching 700 million

by 2045, the burden on healthcare systems is immense. Poorly managed diabetes can lead to life-threatening complications such as cardiovascular disease, kidney failure, and nerve damage. Effective diabetes management requires a multidisciplinary approach, combining medication, lifestyle adjustments, and patient education. Early detection and prevention efforts are increasingly important to reduce the disease's impact, highlighting the need for regular screenings and promoting healthy lifestyles.
In conclusion, diabetes is a complex and widespread condition that requires ongoing attention in healthcare. By focusing on prevention, early detection, effective management, and patient education, healthcare professionals can mitigate the impact of diabetes and improve the quality of life for those affected by this chronic disease.

1.2 Overview of the importance of intelligent techniques in diabetes diagnosis and management

Intelligent techniques play a significant role in diabetes diagnosis and management, providing valuable tools to enhance healthcare outcomes. Here's an overview of their importance:

1.2.1. Early diagnosis and risk prediction: Intelligent techniques, such as machine learning algorithms and data mining, can analyse huge dimensions of patient data to classify patterns and threats associated with diabetes. These techniques can help healthcare professionals predict the likelihood of developing diabetes in at-risk individuals and enable early intervention and preventive measures.

1.2.2. Personalized treatment plans: Diabetes management requires individualized approaches considering factors like age, lifestyle, comorbidities, and medication sensitivities. Intelligent techniques can analyse patient data, including medical history, genetic information, and lifestyle factors, to generate personalized treatment plans. This can lead to more targeted interventions, medication adjustments, and dietary recommendations tailored to the specific needs of each patient.

1.2.3. Decision support systems: Intelligent systems can assist healthcare professionals in making informed decisions regarding diabetes treatment. By integrating patient data, clinical guidelines, and the latest research, these systems can provide evidence-based recommendations on medication dosages, insulin regimens, and lifestyle modifications. Decision support systems help reduce errors, improve treatment efficacy, and enhance patient safety.

1.2.4. Continuous glucose monitoring: Intelligent techniques are employed in continuous glucose monitoring (CGM) systems. These systems use sensors to measure glucose levels continuously, providing real-time data that can be analysed by algorithms. Intelligent algorithms can detect patterns, trends, and fluctuations in glucose levels, alerting patients and healthcare providers to potential hypo or hyperglycaemic episodes. CGM systems help individuals with diabetes make timely adjustments to their treatment plans and improve glycaemic control.

1.2.5. Telemedicine and remote monitoring: Intelligent techniques facilitate remote monitoring and telemedicine solutions for diabetes management. With the integration of wearable devices, mobile applications, and telecommunication technologies, healthcare providers can remotely monitor patients' glucose levels, physical activity, medication adherence, and other relevant data. This allows for timely interventions, remote consultations, and enhanced patient engagement, particularly in situations where regular in-person visits are challenging or not feasible.

1.2.6. Data analysis and research: Intelligent techniques enable the analysis of large-scale datasets, including electronic health records, clinical trials, and genetic data, to gain deeper insights into diabetes. By applying advanced analytics, researchers can identify novel biomarkers, discover genetic associations, and explore the effectiveness of different treatments. These findings can contribute to the development of innovative therapies, improved diagnostic tools, and better overall management strategies for diabetes.
In summary, intelligent techniques have a profound impact on diabetes diagnosis and management. They empower healthcare professionals with tools for early detection, personalized treatment planning, decision support, continuous monitoring, telemedicine, and data-driven research. By harnessing the power of intelligent systems and algorithms, healthcare providers can improve patient outcomes, optimize care delivery, and ultimately improve the quality of life for individuals living with diabetes.

1.3 Objective and organization of the survey paper

The objective of this research paper is to explore the impact of machine learning and artificial intelligence approach on prediction of treatment like insulin doses required for diabetes care and to identify and assess the effectiveness of the vital factors contributing to personalized medical care.
The rest of the paper is organized into 3 sections, section 2 gives the detailed literature review of machine learning approaches used for diabetic care, section 3 gives the comparative analysis focusing on mythologies used, strengths, weakness and future scopes, section 4 finally concludes the approaches used and summary of key findings of the papers are summarized.

2. Review of Papers

(Parikshit, 2017) provides a comprehensive overview of the application of HIVE techniques in the diagnosis and management of diabetes. The paper explores the challenges faced in traditional diabetes diagnosis and record management and highlights the potential benefits offered by HIVE technologies. They discuss the significance of accurate and efficient diabetes diagnosis and record management due to the increasing prevalence of the disease. They highlight the limitations of conventional methods, such as paper-based records and physical data admittance, which can be time-consuming, error-prone, and ineffective. They introduce HIVE as a promising solution to address these challenges. HIVE leverages advanced visualization and exploration techniques to analyse and interpret large volumes of health data in an intuitive and interactive manner. By presenting complex information in a visually appealing format, HIVE enables healthcare professionals to gain valuable insights and make informed decisions more effectively. They delve into various aspects of diabetes diagnosis and record management where HIVE can play a transformative role. They discuss the use of HIVE in visualizing glucose levels, insulin dosages, dietary patterns, and physical activity data to identify trends, patterns, and anomalies. Furthermore, HIVE can assist in personalized treatment planning and monitoring of patients by integrating data from wearable devices, electronic health records (EHRs), and other sources. They explore the potential challenges and limitations associated with HIVE implementation in diabetes diagnosis and record management, such as data privacy concerns, interoperability issues, and the need for user-friendly interfaces. The authors emphasize the importance of collaboration between healthcare professionals, data scientists, and technology experts to overcome these challenges and maximize the benefits of HIVE. They concluded by highlighting the significant potential of HIVE technologies in revolutionizing diabetes diagnosis and record management. By leveraging advanced visualization and exploration techniques, HIVE can enhance the accuracy, efficiency, and personalized care provided to patients with diabetes, ultimately leading to improved health outcomes.

(Azar & Bitar, 2015) provides an overview of the use of artificial intelligence (AI) techniques in predicting the appropriate insulin dosage for individuals with diabetes. They explore the challenges associated with insulin dosing and highlights the potential benefits offered by AI-based prediction models. They begin by discussing the importance of accurate insulin dosing in managing diabetes effectively. They explain that incorrect dosing can lead to hyperglycaemia or hypoglycaemia, both of which can have serious health implications. Traditional methods of determining insulin doses rely on manual calculations, which can be complex and prone to errors, so they introduce AI as a promising approach to improve insulin dose prediction. AI models, such as machine learning and deep learning algorithms, can analyse large amounts of patient data, including glucose levels, carbohydrate intake, physical activity, and other relevant factors. By identifying patterns and relationships within the data, AI models can generate personalized insulin dose recommendations. They discuss various AI techniques employed in insulin dose prediction, including regression models, decision trees, support vector machines, and neural networks. They highlight the advantages of these models, such as their ability to handle nonlinear relationships and adapt to individual patient characteristics. Furthermore, the paper addresses the importance of data quality and feature selection in developing accurate AI models. High-quality and diverse datasets are crucial for training robust prediction algorithms. The selection of relevant features, such as time of day, glycaemic variability, and individual patient history, plays a significant role in improving the accuracy of insulin dose predictions. They also discuss the challenges associated with AI-based insulin dose prediction, including the need for large and representative datasets, model interpretability, and integration with existing clinical workflows. They emphasize the importance of transparency and explainability in AI models to gain the trust of healthcare professionals and ensure their effective adoption.

(Talari et al., 2023) presents a novel approach for developing an intelligent medical expert system. They combine temporal fuzzy rules and a neural classifier to enhance the system's diagnostic accuracy and decision-making capabilities. They highlight the importance of accurate and timely diagnosis in the field of medicine and the potential of expert systems to assist healthcare professionals in making informed decisions. They discuss the limitations of traditional rule-based expert systems that rely on static rules and do not consider temporal information. To address these limitations, they propose the integration of temporal fuzzy rules into an expert system framework. Temporal fuzzy rules capture the temporal relationships and trends in patient data, allowing for a more dynamic and comprehensive analysis. They also incorporate a neural classifier into the system to improve the accuracy of diagnostic predictions. They provide an in-depth explanation of the methodology used in the development of the intelligent medical expert system. It describes the process of constructing temporal fuzzy rules using patient data and the underlying fuzzy logic principles. The authors also discuss the design and training of the neural classifier, which is responsible for classifying patient cases based on the extracted features and temporal fuzzy rules. They evaluate the performance of the proposed system using a dataset of medical cases. They compare the diagnostic accuracy of their system with other existing approaches, including traditional rule-based systems and neural networks. The results demonstrate that the intelligent medical expert system combining temporal fuzzy rules and a neural classifier outperforms the other methods in terms of accuracy and reliability. They conclude by highlighting the potential applications of the proposed system in various medical domains. The integration of temporal fuzzy rules and neural classifiers allows the system to handle complex and dynamic medical data, leading to more precise diagnoses and enriched patient outcomes. They emphasize the need for further research and validation of the system's performance on larger datasets and in real-world clinical settings.

(Ganapathy et al., 2014) presents a novel approach for developing a temporal pattern classification system. They combine fuzzy temporal rules and particle swarm optimization (PSO) to improve the accuracy and effectiveness of classifying temporal patterns. They emphasize the importance of accurate classification of temporal patterns in various domains, such as time series analysis and medical diagnostics. They highlight the limitations of traditional classification approaches that do not consider the temporal nature of data and propose an intelligent system to overcome these limitations. They introduce the concept of fuzzy temporal rules, which capture both the fuzzy linguistic representation and the temporal relationships in the data. These rules allow for a more comprehensive and nuanced analysis of temporal patterns. Additionally, they incorporate PSO, a population-based optimization algorithm, to optimize the rule parameters and improve the system's classification performance. They provide a detailed explanation of the methodology used in the development of the intelligent temporal pattern classification system. It describes the process of constructing fuzzy temporal rules based on the input data and the principles of fuzzy logic and temporal reasoning. They also explain how PSO is utilized to optimize the rule parameters and enhance the system's accuracy. They evaluate the performance of the proposed system using benchmark datasets from various domains. They compare the classification accuracy of their system with other existing approaches, including traditional rule-based systems and optimization algorithms. The results demonstrate that the intelligent temporal pattern classification system using fuzzy temporal rules and PSO outperforms the other methods in terms of accuracy and robustness. They conclude by discussing the potential applications of the proposed system in various domains, including finance, healthcare, and environmental monitoring. The integration of fuzzy temporal rules and PSO enables the system to handle complex temporal data and make accurate classifications. They highlight the need for further research and validation of the system's performance on different datasets to establish its effectiveness in real-world scenarios.

(Jabez & Muthu Kumar, 2015) presents a study on the application of Support Vector Machines (SVM) for detecting anomalies in diabetes data. They focus on utilizing SVM as a robust and effective method to identify abnormal patterns and outliers in diabetes-related measurements. They emphasize the significance of anomaly detection in diabetes management as it can help identify critical events such as hypoglycaemia or hyperglycaemia, which require immediate attention. They highlight the limitations of traditional statistical approaches and propose SVM as a suitable alternative due to its ability to handle high-dimensional data and nonlinear relationships. They provide an overview of SVM and its principles in the context of anomaly detection. SVM is a supervised machine learning algorithm that can separate different classes of data by finding an optimal hyperplane in a high-dimensional feature space. They explain how SVM can be adapted for anomaly detection by treating it as a one-class classification problem. They describe the methodology used to apply SVM for anomaly detection in diabetes data. They discuss the process of data pre-processing, feature extraction, and model training. The SVM model is trained using a representative dataset of normal diabetes measurements, allowing it to identify abnormal patterns that deviate significantly from the norm. They evaluate the performance of the SVM-based anomaly detection system using real-world diabetes datasets. They compare the system's results with other anomaly detection techniques, such as clustering-based methods and statistical approaches. The results demonstrate that the SVM-based approach achieves higher accuracy and reliability in detecting diabetes anomalies. In conclusion, they highlight the effectiveness of SVM as a method for anomaly detection in diabetes data. By leveraging its ability to capture complex relationships and identify abnormal patterns, SVM offers valuable insights into critical events in diabetes management. They suggest further research to explore the integration of SVM-based anomaly detection systems into real-time monitoring and decision support systems for enhanced diabetes care.

(Vanathi & Khadir, 2017) present a novel algorithm called ARACHNO that utilizes deep inspection and predictive analysis techniques for analysing diabetic data. They focus on the application of ARACHNO in improving the understanding of diabetes and predicting its outcomes. They highlight the importance of accurate analysis and prediction in managing diabetes effectively. They discuss the limitations of traditional analysis methods and propose ARACHNO as an innovative approach to address these challenges. ARACHNO leverages deep inspection, which involves analysing various layers of data representations, to extract insightful patterns and relationships. They provide an in-depth explanation of the ARACHNO algorithm and its components. It describes how deep inspection techniques, such as deep learning models and neural networks, are utilized to uncover complex patterns and associations within diabetic data. They emphasize the interpretability of ARACHNO, which allows healthcare professionals to gain meaningful insights and make informed decisions. They discuss the procedure used to train and estimate ARACHNO. They explain the process of data pre-processing, feature extraction, and model training. ARACHNO is trained on a diverse dataset of diabetic records to learn the underlying patterns and relationships that contribute to diabetic outcomes. The algorithm is then tested and validated to assess its predictive accuracy. They evaluate the performance of ARACHNO using real-world diabetic data and compares it with other existing analysis methods. The results demonstrate that ARACHNO achieves higher accuracy in predicting diabetic outcomes, such as glucose levels, complications, and response to treatment. It outperforms traditional analysis methods, highlighting the efficacy of deep inspection techniques. In conclusion, they present ARACHNO as a powerful algorithm for analysing diabetic data. By leveraging deep inspection and predictive analysis, ARACHNO

provides valuable insights into diabetic patterns and outcomes. They suggest further research and application of ARACHNO in clinical settings to enhance diabetes management and improve patient care.
(Kamble et al., 2017) present a study on the association detection of regular insulin and NPH insulin using statistical features. They focus on identifying patterns and associations between these two types of insulin based on statistical analysis. They emphasize the importance of understanding the relationship between regular insulin and NPH insulin in diabetes management. They highlight the limitations of traditional approaches and propose a statistical feature-based method to detect associations between these insulin types. They describe the methodology used to analyse the association between regular insulin and NPH insulin. Statistical features, such as mean, standard deviation, skewness, and kurtosis, are calculated from the insulin data. They explain how these features capture important characteristics of the insulin profiles and can be used to assess the association between regular insulin and NPH insulin. They evaluate the performance of the statistical feature-based method using real-world insulin data. They compare the association detection results with other existing approaches, including correlation analysis and clustering techniques. The results demonstrate that the statistical feature-based method provides meaningful insights into the association between regular insulin and NPH insulin. They discuss the implications of the association detection results for diabetes management. Understanding the relationship between these insulin types can help optimize insulin dosage and treatment strategies. They suggest that the identified associations can be used to develop personalized insulin regimens and improve glycaemic control for individuals with diabetes. In conclusion, they present a statistical feature-based method for association detection of regular insulin and NPH insulin. By analysing the statistical features derived from insulin data, this method provides valuable insights into the relationship between these insulin types. They suggest further research to validate the findings and explore the practical applications of the identified associations in diabetes management.
(Aibinu et al., 2010) present a study on the application of intelligent-based modelling techniques for predicting blood glucose levels. They focus on utilizing advanced machine learning and artificial intelligence methods to develop accurate and reliable models for blood glucose prediction. They highlight the significance of accurate blood glucose level prediction in diabetes management. They discuss the limitations of traditional prediction methods and propose intelligent-based modelling techniques as a promising approach to overcome these challenges. They provide an overview of the intelligent-based modelling techniques used in blood glucose level prediction. These techniques include machine learning algorithms such as support vector machines (SVM), artificial neural networks (ANN), and genetic algorithms (GA). They explain how these techniques can analyse historical blood glucose data and learn the patterns and relationships to make accurate predictions. They describe the methodology used to develop the blood glucose level prediction models. They discuss data pre-processing techniques, feature selection, and model training and evaluation. The intelligent-based models are trained using a dataset of historical blood glucose measurements, and their performance is assessed based on metrics such as accuracy, sensitivity, and specificity. They evaluate the performance of the intelligent-based models using real-world blood glucose datasets. They compare the prediction results of their models with other existing approaches, including traditional statistical methods. The results demonstrate that the intelligent-based modelling techniques achieve higher accuracy and reliability in blood glucose level prediction. In conclusion, they highlight the effectiveness of intelligent-based modelling techniques for blood glucose level prediction. By leveraging advanced machine learning and artificial intelligence methods, these models provide accurate and reliable predictions, enabling improved diabetes management. They suggest further research and validation of the models on larger datasets and in real-world clinical settings to establish their practical utility.
(Ambedkar et al., 2017) present a study on the application of Support Vector Machine (SVM) for classifying blood glucose levels in individuals with Insulin Dependent Diabetes Mellitus (IDDM). They focus on utilizing SVM as a classification algorithm to accurately categorize blood glucose levels into different classes. They emphasize the importance of precise classification of blood glucose levels in managing IDDM effectively. They discuss the limitations of traditional classification methods and propose SVM as a suitable technique due to its ability to handle high-dimensional data and nonlinear relationships. They provide an overview of SVM and its principles in the context of blood glucose level classification. SVM is a supervised machine learning algorithm that constructs an optimal hyperplane to separate different classes of data based on support vectors. They explain how SVM can be trained using labelled blood glucose data to develop a classification model. They describe the methodology used to classify blood glucose levels using SVM. They discuss data pre-processing, feature extraction, and model training. SVM is trained on a dataset of blood glucose measurements along with corresponding class labels representing different glucose level ranges. They evaluate the performance of the SVM-based classification model using real-world IDDM blood glucose datasets. They compare the classification accuracy of their model with other existing classification techniques. The results demonstrate that the SVM-based approach achieves higher accuracy in classifying blood glucose levels into appropriate categories. In conclusion, they present SVM as an effective classification algorithm for categorizing blood glucose levels in individuals with IDDM. By leveraging SVM's ability to accurately separate different classes of data, the SVM-based classification model provides valuable insights into blood glucose level management. They suggest further research and application of SVM in real-world clinical settings to enhance IDDM management and improve patient care.
(Chandrakar, n.d.) present a comparative analysis of prediction accuracy between general and personalized datasets for classification models in the medical domain. They focus on evaluating the performance of

classification models using both general medical datasets and personalized datasets. They emphasize the importance of accurate prediction models in the medical domain for tasks such as disease diagnosis and treatment planning. They discuss the limitations of traditional models that rely on general medical datasets and propose the use of personalized datasets to improve prediction accuracy. They provide an overview of the methodology used in the comparative analysis. It describes the process of collecting and pre-processing both general and personalized medical datasets. The general dataset represents a wide range of patients, while the personalized dataset includes specific patient characteristics and medical history. They evaluate the performance of classification models using both datasets. They compare the prediction accuracy of the models and analyse the impact of personalized data on improving accuracy. Performance metrics such as accuracy, precision, recall, and F1 score are used to evaluate the models' effectiveness. They present the results of the comparative analysis, highlighting the differences in prediction accuracy between the general and personalized datasets. They discuss the advantages of using personalized datasets, which consider individual patient characteristics and medical history, leading to more accurate and tailored predictions. In conclusion, they emphasize the importance of personalized datasets for improving prediction accuracy in the medical domain. The comparative analysis demonstrates that personalized datasets enhance the performance of classification models, resulting in more accurate predictions compared to models trained on general datasets alone. They suggest further research and validation of personalized datasets in larger and diverse medical datasets to establish their effectiveness in real-world clinical settings.

(Fong, Zhang, et al., 2013) present a case study on the evaluation of stream mining classifiers for a real-time clinical decision support system. They focus on predicting blood glucose levels in diabetes therapy and assessing the performance of various stream mining classifiers. They emphasize the importance of real-time prediction and decision support in diabetes therapy to enable timely interventions and improve patient outcomes. They discuss the limitations of traditional prediction models and propose the use of stream mining classifiers that can handle high-velocity, evolving data streams. They provide an overview of the stream mining classifiers used in the evaluation. These classifiers include algorithms such as VFDT, iOVFDT, and Bayes. They explain how these classifiers are specifically designed for stream data and can adapt and update their models in real-time. They describe the methodology used in the case study for blood glucose prediction. They discuss the process of data collection, pre-processing, and feature extraction. The stream mining classifiers are trained and evaluated using real-time blood glucose data, with performance metrics such as accuracy, precision, recall, and F1 score used to assess their effectiveness. They present the results of the evaluation, comparing the performance of different stream mining classifiers. They analyse the accuracy and speed of prediction, as well as the adaptability of the classifiers to changing data patterns. They discuss the strengths and limitations of each classifier in the context of real-time clinical decision support. In conclusion, they highlight the suitability of stream mining classifiers for real-time clinical decision support systems in diabetes therapy. The case study demonstrates the effectiveness of these classifiers in predicting blood glucose levels accurately and rapidly. They suggest further research and validation of stream mining classifiers in larger-scale studies and their integration into practical clinical settings to enhance diabetes management and patient care.

(Sivarathri & A, 2014) presents a study that investigates the hypothesis that Fuzzy K-means is superior to traditional K-means clustering algorithm. They focus on conducting experiments to compare the performance of both algorithms in clustering tasks. They introduce the importance of clustering algorithms in various domains, such as data analysis, pattern recognition, and machine learning, highlight the limitations of the K-means algorithm, which assigns data points to a single cluster, and propose Fuzzy K-means as an alternative that allows data points to have partial membership to multiple clusters. They describe the methodology used to evaluate and compare the performance of Fuzzy K-means and K-means clustering algorithms. They discuss the experimental setup, including the selection of datasets and evaluation metrics. They explain how the algorithms are implemented and applied to the datasets to generate clusters and present the results of the experiments, analysing the performance of Fuzzy K-means and K-means algorithms based on evaluation metrics such as clustering accuracy, compactness, and separation. They discuss the strengths and weaknesses of each algorithm and compare their ability to handle different types of datasets. In conclusion, the research paper provides insights into the hypothesis that Fuzzy K-means is better than K-means for clustering. The experimental results suggest that Fuzzy K-means algorithm can offer advantages in scenarios where data points exhibit uncertain or overlapping memberships to multiple clusters. However, they acknowledge that the superiority of one algorithm over the other may depend on the specific characteristics of the dataset and the clustering task at hand. They suggest further research and exploration of the performance of both algorithms on diverse datasets and real-world applications to gain a deeper understanding of their comparative effectiveness.

(Jain et al., 2015) focuses on enhancing the prediction accuracy of diabetes by employing a fuzzy expert system. The paper emphasizes the importance of accurate diabetes prediction for effective management and proposes the utilization of fuzzy logic to improve prediction rates. They discuss the limitations of traditional prediction methods and highlight the advantages of fuzzy expert systems in handling the complexity and uncertainty inherent in diabetes diagnosis. They explain how fuzzy logic allows for the incorporation of expert knowledge and linguistic variables to capture the vagueness and imprecision associated with diabetes data. The paper describes the methodology used to develop the fuzzy expert system for diabetes prediction. It outlines the process of acquiring and pre-processing the necessary input data, which typically includes patient

demographics, medical history, and laboratory test results. The authors detail how fuzzy logic rules and membership functions are defined to capture the relationship between input variables and diabetes prediction. They evaluate the performance of the fuzzy expert system using real-world diabetes datasets. They compare the prediction results of their system with other existing prediction methods, such as logistic regression or decision trees. The evaluation metrics, such as accuracy, sensitivity, specificity, and F1 score, are used to assess the system's effectiveness in predicting diabetes. The paper presents the results of the evaluation, demonstrating the improved prediction rate achieved by the fuzzy expert system. They discuss the advantages of the system, such as its ability to handle uncertain or incomplete data and its interpretability, which allows healthcare professionals to gain insights into the reasoning behind the predictions. In conclusion, the research paper highlights the efficacy of using a fuzzy expert system to enhance the prediction rate of diabetes. By incorporating fuzzy logic and expert knowledge, the system provides more accurate and reliable predictions, aiding in the early detection and management of diabetes. They suggest further research to validate the system's performance on larger and diverse datasets and its integration into clinical settings to improve patient care.
(Nath & Jain, 2014) presents a study on utilizing the Hidden Markov Model (HMM) for predicting insulin charts for diabetic patients. They focus on developing a model that can accurately predict the optimal insulin dosage and administration schedule based on patient-specific data. They emphasize the importance of precise insulin chart prediction in diabetes management to ensure proper glycaemic control. They discuss the limitations of traditional approaches and propose the application of HMM, a statistical model, to capture the underlying dynamics and patterns in the insulin requirements of diabetic patients. The paper provides an overview of the HMM and its application in insulin chart prediction. HMM is a probabilistic model that utilizes a set of hidden states and observable outcomes to represent the system's behaviour. They explain how HMM can be trained using historical insulin and glucose data to learn the transitions between states and make predictions about future insulin dosages. They describe the methodology used in developing the insulin chart prediction model. They discuss data pre-processing techniques, feature extraction, and model training. The HMM is trained using a dataset of insulin and glucose measurements, and its parameters are estimated using the Baum-Welch algorithm. The paper evaluates the performance of the insulin chart prediction model using real-world diabetic patient data. They compare the predicted insulin charts with the actual charts and assess the accuracy of the model in capturing the individual patient's insulin requirements. In conclusion, the research paper demonstrates the effectiveness of using the Hidden Markov Model for insulin chart prediction in diabetic patients. By leveraging the probabilistic nature of HMM, the model provides accurate predictions of optimal insulin dosage and administration schedule. They suggest further research to validate the model's performance on larger datasets and explore its potential integration into clinical decision support systems for personalized diabetes management.
(Froelich & Wakulicz-deja, 2009) presents a study on the application of adaptive fuzzy cognitive maps (AFCMs) for mining temporal medical data. They focus on developing a model that can capture the temporal dynamics and relationships within medical data, enabling valuable insights and predictions in the healthcare domain. They emphasize the significance of temporal analysis in medical data, as patient conditions and healthcare variables often evolve over time. They discuss the limitations of traditional mining techniques and propose the use of AFCMs, which combine fuzzy logic and cognitive mapping, to effectively handle temporal medical data. The paper provides an overview of AFCMs and their application in mining temporal medical data. AFCMs are a knowledge representation and inference model that utilize fuzzy sets and cognitive mapping to capture the relationships and dynamics among variables. They explain how AFCMs can be adapted to incorporate temporal information and learn from historical medical data and describe the methodology used in developing the AFCM model for mining temporal medical data. They discuss the process of data pre-processing, feature extraction, and AFCM construction. The AFCM is trained using a dataset of temporal medical records, and its parameters are updated iteratively based on the feedback from the healthcare experts. The paper evaluates the performance of the AFCM model using real-world temporal medical datasets. They analyse the model's ability to capture the temporal dependencies, make predictions, and provide insights into the medical data. They compare the results of the AFCM model with other existing mining techniques to demonstrate its effectiveness. In conclusion, the research paper highlights the utility of adaptive fuzzy cognitive maps in mining temporal medical data. The AFCM model allows for the capture of temporal dynamics and relationships, enabling valuable knowledge extraction and prediction in the healthcare domain. They suggest further research to explore the scalability and generalizability of the AFCM model on larger and diverse medical datasets and its integration into clinical decision support systems for improved patient care.
(Janakiraman & Arumugam, 2020) presents a study on developing personalized nutrition recommendations for diabetic patients using optimization techniques. They focus on tailoring dietary plans based on individual patient characteristics and optimizing them to improve glycaemic control and overall health. They emphasize the importance of personalized nutrition in diabetes management, as dietary choices play a significant role in regulating blood glucose levels. They discuss the limitations of generic dietary guidelines and propose the application of optimization techniques to generate personalized nutrition recommendations. The paper provides an overview of the optimization techniques used in developing personalized nutrition recommendations. These techniques, such as genetic algorithms or particle swarm optimization, aim to find optimal dietary plans that satisfy individual patient requirements, preferences, and nutritional constraints. They describe the methodology used in the study and discuss the process of collecting patient-specific data,

including medical history, dietary preferences, and nutritional needs. The optimization algorithm is then applied to search for the optimal combination of foods and meal plans that meet these requirements. The paper evaluates the performance of the personalized nutrition recommendation system using real-world diabetic patient data and assess the quality of the generated dietary plans in terms of nutritional balance, adherence to dietary restrictions, and glycaemic control. They compare the results with standard dietary recommendations to demonstrate the effectiveness of personalized nutrition. In conclusion, the research paper highlights the benefits of utilizing optimization techniques for generating personalized nutrition recommendations for diabetic patients. By considering individual patient characteristics and nutritional requirements, the personalized dietary plans can better support glycaemic control and overall health. They suggest further research to refine and validate the optimization algorithms on larger patient populations and explore the integration of such personalized nutrition systems into clinical practice for improved diabetes management.

(Kaur & Ahuja, 2016) presents a study on predicting and simulating the prevalence of diabetes in a specific region using complex networks. They focus on utilizing network analysis techniques to model and predict the spread and impact of diabetes across the population. They emphasize the importance of understanding the regional dynamics of diabetes to develop effective prevention and intervention strategies. They discuss the limitations of traditional prediction methods and propose the use of complex networks to capture the intricate relationships between various factors contributing to diabetes prevalence. The paper provides an overview of complex networks and their application in predicting and simulating diabetes levels. Complex networks are mathematical representations of interconnected elements, where each element represents a region or an individual. They explain how network analysis techniques, such as network centrality and diffusion models, can be employed to understand the spread and impact of diabetes within the region. They describe the methodology used in the study and discuss the process of data collection, including demographic information, health records, and environmental factors, for constructing the regional network. They explain how network metrics and predictive models are employed to forecast future diabetes prevalence and simulate the impact of various interventions. The paper evaluates the performance of the complex network-based prediction and simulation model using real-world data from the point of interest. They analyse the accuracy of the model in predicting the level of diabetes and assess its usefulness in simulating the outcomes of different intervention strategies. In conclusion, the research paper highlights the potential of complex networks in predicting and simulating the level of diabetes over a region. By capturing the intricate relationships and dynamics within the population, the model provides insights into the spread and impact of diabetes and assists in developing targeted preventive measures. They suggest further research to refine the model and validate its accuracy on larger and diverse datasets, as well as the integration of complex network analysis into regional public health planning and policy-making for effective diabetes management.

(Rajeswari et al., 2018) focuses on developing a prediction model for identifying individuals at risk of developing prediabetes using fuzzy logic-based association classification. They aim to improve early discovery and intervention policies for prediabetes, a precursor to type 2 diabetes. They emphasize the significance of early prediction and intervention in preventing the progression to full-blown diabetes. They discuss the limitations of traditional classification methods and propose the use of fuzzy logic-based association classification to handle the uncertainty and vagueness associated with prediabetes data. They provide an overview of fuzzy logic-based association classification and its application in predicting prediabetes. Fuzzy logic allows for the representation of uncertain and imprecise data, while association classification techniques identify patterns and relationships among various risk factors associated with prediabetes. They describe the methodology used in developing the prediction model. They discuss the process of data collection, including demographic information, lifestyle factors, and biomarkers, to build a dataset for training the fuzzy logic-based association classification model. The model captures the fuzzy rules and membership functions to assess the likelihood of individuals developing prediabetes. The paper evaluates the performance of the prediction model using real-world prediabetes datasets. They analyse the accuracy, sensitivity, specificity, and other evaluation metrics to assess the usefulness of the model in classifying individuals at risk of prediabetes and then compare the results with other traditional classification techniques to demonstrate the superiority of the fuzzy logic-based approach. In conclusion, the research paper highlights the potential of fuzzy logic-based association classification in predicting prediabetes. By considering the uncertainty and vagueness inherent in prediabetes data, the model provides improved accuracy in identifying individuals at risk. They suggest further research to validate the model's performance on larger and more diverse datasets and explore its integration into clinical practice for early prediabetes detection and intervention.

(Fong, Mohammed, et al., 2013) presents a study on utilizing causality modelling and the Fuzzy Lattice Reasoning algorithm for predicting blood glucose levels. They aim to improve the accuracy and reliability of blood glucose prediction for effective diabetes management. They emphasize the significance of precise blood glucose prediction in diabetes control to prevent complications and optimize treatment strategies. They discuss the limitations of traditional prediction methods and propose the integration of causality modelling and the Fuzzy Lattice Reasoning algorithm to capture the complex relationships between various factors affecting blood glucose. They provide an overview of causality modelling and the Fuzzy Lattice Reasoning algorithm and their application in predicting blood glucose levels. Causality modelling enables the identification of cause-effect relationships between different variables, while the Fuzzy Lattice Reasoning algorithm utilizes fuzzy logic to handle uncertainty and linguistic variables in the prediction process. They describe the methodology used in developing the blood glucose prediction model. They discuss the process of data collection, including patient demographics, medical history, dietary information, and insulin dosage, to build a dataset for training the model. Causality modelling is employed to identify the influential factors, and the Fuzzy Lattice Reasoning algorithm is used to make accurate predictions. They estimate the performance of the prediction model using real-world blood glucose datasets. They analyse the accuracy and reliability of the model's predictions, comparing them with actual blood glucose measurements. They assess the effectiveness of the causality modelling and the Fuzzy Lattice Reasoning algorithm in capturing the complex relationships and making precise predictions. In conclusion, the research paper highlights the potential of using causality modelling and the Fuzzy Lattice Reasoning algorithm for forecasting blood glucose levels. By considering cause-effect relationships and incorporating fuzzy logic, the model provides improved accuracy and reliability in blood glucose prediction. They suggest further research to validate the model's performance on larger and diverse datasets and explore its integration into real-time clinical decision support systems for personalized diabetes management.

3. Comparative Analysis and Discussion

3.1 Comparative analysis of the surveyed papers based on methodologies, performance metrics, strengths, limitations, and future directions.

Paper	Methodologies	Performance Metrics	Strengths	Limitations	Future Scopes
(Parikshit, 2017)	Literature review	N/A	Comprehensive overview of diabetes diagnosis and record management	Lack of Industry and Academia Support in terms of its interface & Performance.	Investigating the implementation and effectiveness of HIVE in real-world healthcare data
(Azar & Bitar, 2015)	Artificial intelligence (AI) methods like C4.5, CBR & GA	Prediction accuracy, 10 fold cross validation	Utilizes artificial intelligence methods like C4.5, CBR & GA for accurate insulin dose prediction	Dependency on accurate input data and patient-specific factors specially new patient where there is no historical data exist.	1. Incorporating additional patient factors and real-time data to improve insulin dose prediction models. 2. Combine CBR with GA and take benefits of strength of both algorithms.
(Talari et al., 2023)	Temporal fuzzy rules, neural classifier	Detection Accuracy and Prediction Accuracy	Incorporates temporal fuzzy rules and neural classifier for intelligent decision-making	Limited explanation capability of the fuzzy rules	1. Enhancing the interpretability of the fuzzy rules and evaluating the system's performance in real-world clinical settings 2. Proposal of temporal logic for better reasoning.
(Ganapathy et al., 2014)	Fuzzy temporal rules, particle swarm optimization	Accuracy	Uses fuzzy temporal rules with particle swarm optimization for temporal pattern classification	Limited generalizability of the system to diverse datasets and contexts	Evaluating the performance on different datasets and exploring hybrid optimization techniques for improved accuracy

Paper	**Methodologies**	**Performance Metrics**	**Strengths**	**Limitations**	**Future Scopes**
(Jabez & Muthu Kumar, 2015)	Support Vector Machine (SVM)	Detection rate, False alarm rate, Area Under the Curve (AUC)	Effective anomaly detection using Support Vector Machines (SVM)	Reliance on labelled data for training the SVM	Exploring unsupervised anomaly detection techniques and evaluating the system's performance on a larger and more diverse dataset
(Vanathi & Khadir, 2017)	Deep inspection predictive analysis algorithm	Prediction Score Value	Deep inspection algorithm for predictive analysis of diabetic data	Limited explanation capability of the algorithm	1. Investigating the integration of interpretability techniques and evaluating the algorithm's performance in real-world scenarios 2. predict the onset of diabetes at early stage and improves in medication plans.
(Kamble et al., 2017)	Statistical features	Correlation, Mean, Variance	Utilizes statistical features for association redetection of insulin types	Limited validation on different datasets or clinical scenarios	Validating the approach on diverse datasets and expanding it to include other types of insulin
(Aibinu et al., 2010)	Intelligent modelling techniques like ARMA	Prediction accuracy, MEE (Model Error Energy), RMSE	Employ intelligent modelling techniques for accurate blood glucose level prediction	Dependency on accurate input data and patient-specific factors	Incorporating real-time data and physiological factors to increase the accurateness of blood glucose level prediction models
(Ambedkar et al., 2017)	Support Vector Machine (SVM)	Accuracy	Effective classification of blood glucose levels using Support Vector Machines (SVM)	Limited evaluation on a diverse range of patients and external datasets	Conducting external validation on diverse patient populations and comparing the system's performance with other classification models
(Chandrakar, n.d.)	Comparative analysis of classification models based on general and personalized datasets	Average Prediction Accuracy	Comparative analysis of general and personalized datasets for prediction accuracy	Lack of detailed information on the specific datasets used and potential biases	Conducting a more extensive evaluation of various datasets and exploring additional performance metrics
(Fong, Zhang, et al., 2013)	Stream mining classifiers	Prediction accuracy,	Evaluation of stream mining	Limited evaluation of	Conducting real-time evaluations

Paper	Methodologies	Performance Metrics	Strengths	Limitations	Future Scopes
		Sensitivity, Specificity, Precision, F1 score, Delay, Memory usage	classifiers for real-time blood glucose prediction	the system's performance in real-time clinical decision support scenarios	in clinical settings and investigating the system's impact on clinical decision-making
(Sivarathri & A, 2014)	Fuzzy K-means clustering	Number of clusters, fuzziness, maximum iterations, precision, CPU time and compactness.	Experimental investigation of fuzzy K-means clustering hypothesis	Limited generalizability of the hypothesis to different datasets and clustering scenarios	Evaluating the hypothesis on diverse datasets and exploring alternative clustering algorithms for improved performance
(Jain & Raheja, 2015)	Fuzzy expert system, Triangular Membership function	Prediction accuracy	Utilizes a fuzzy expert system to improve the prediction rate of diabetes	Limited evaluation on external datasets or comparisons with other prediction methods	Validating the system on diverse datasets and comparing its performance with other prediction approaches
(Nath & Jain, 2014)	Hidden Markov Model (HMM)	Prediction accuracy	Application of Hidden Markov Models (HMM) for insulin chart prediction	Dependency on accurate input data and limited consideration of external factors	Incorporating additional patient factors, optimizing model parameters, and evaluating the system's performance on a larger dataset
(Froelich & Wakulicz-deja, 2009)	Adaptive Fuzzy Cognitive Maps	Prediction accuracy, Sensitivity, Specificity, Precision, F1 score, AUC	Adaptive Fuzzy Cognitive Maps for mining temporal medical data	1. Limited evaluation of the system's performance on real-world medical datasets 2. Temporal concept have limited scope in this algorithm.	1. Evaluating the system on larger and diverse medical datasets and exploring the incorporation of external knowledge 2. Temporal features of FCM needs further analysis.
(Janakiraman & Arumugam, 2020)	Optimization techniques such as Ant Colony and Particle Swarm Optimization	Recommendation accuracy, Precision, Recall, F1 score, Miss rate, fallout rate	Personalized nutrition recommendation using optimization techniques like ant colony and particle swarm optimization	Limited validation on diverse patient populations and consideration of other dietary factors	Validating the recommendations on a larger and diverse patient population and incorporating additional dietary factors
(Kaur & Ahuja, 2016)	Complex networks	Plasma compartment, gain constant	Utilizes complex networks for predicting and simulating	Limited validation on real-world data and risk factors	Validating the predictions using real-world data and investigating the impact of

Paper	Methodologies	Performance Metrics	Strengths	Limitations	Future Scopes
			diabetes levels over a region		external factors on diabetes levels
(Rajeswari et al., 2018)	Fuzzy Logic, Association classification	Accuracy, Sensitivity, Specificity, Precision, F1 score	1. Use of fuzzy logic-based association classification for prediction of prediabetes. 2. Ability to predict outliers.	Limited validation on external datasets or comparisons with other prediction methods	Validating the approach on diverse datasets and comparing its performance with other prediction techniques
(Fong, Mohammed, et al., 2013)	Causality modelling, Fuzzy Lattice Reasoning algorithm	Prediction accuracy, Kappa Statistics, Normalized Gain	Utilizes causality modelling with Fuzzy Lattice Reasoning algorithm for predicting blood glucose	Limited evaluation on external datasets or comparisons with other prediction methods	Validating the approach on diverse datasets and comparing its performance with other prediction approaches

4. Conclusion

4.1 Summary of the key findings from the surveyed papers

(Parikshit, 2017) finds that HIVE proves efficient in managing large-scale diabetic data, providing scalable and streamlined record keeping for diagnosis. (Azar & Bitar, 2015) finds that Neural networks and other AI models are good at predicting insulin dosages, which improves diabetes control and patient care. (Talari et al., 2023) finds that treatment planning is improved and diabetes progression prediction accuracy is increased when fuzzy rules and neural classifiers are combined.(Ganapathy et al., 2014) finds better pattern recognition results from the classification of diabetic patient data using fuzzy temporal rules optimised by particle swarm optimisation. (Jabez & Muthu Kumar, 2015) gives an study that Data from diabetes patients can be effectively analysed using SVM-based anomaly detection to spot unusual trends and avert problems. (Vanathi & Khadir, 2017) finds that The ARACHNO system reliably forecasts diabetic data trends, enhancing clinical decision-making and patient outcomes. (Kamble et al., 2017) finds that the study contributes to the optimisation of insulin control techniques by reaffirming the substantial associations between normal and NPH insulin. (Aibinu et al., 2010) finds the accuracy of blood glucose level predictions is increased for better diabetes management by the use of intelligent modelling approaches like machine learning. (Ambedkar et al., 2017) finds that when it comes to accurately identifying blood glucose levels in insulin-dependent diabetic patients, support vector machines do remarkably well. (Chandrakar, n.d.) finds Individual data is crucial for more precise diabetes predictions, as demonstrated by the superior performance of personalised models over generic ones. (Fong, Zhang, et al., 2013) finds stream mining classifiers greatly improve decision support systems in the treatment of diabetes by offering precise, real-time blood glucose predictions. (Sivarathri & A, 2014) finds that when it comes to managing uncertainty in the clustering of diabetic data, fuzzy K-means clustering outperforms regular K-means clustering. (Jain & Raheja, 2015) finds that the fuzzy expert system increases diabetes prediction rates, providing more accurate diagnostic and treatment recommendations. (Nath & Jain, 2014) finds that HMM precisely forecasts insulin chart patterns, assisting in the management of insulin dosages for diabetic patients. (Froelich & Wakulicz-deja, 2009) finds an efficient framework for assessing temporal patterns in diabetes patient data is offered by adaptive fuzzy cognitive maps, which enhances understanding of how the disease progresses. (Janakiraman & Arumugam, 2020) finds that Optimising strategies for personalised nutrition lead to better dietary recommendations for people with diabetes, improving overall health and glucose management. (Kaur & Ahuja, 2016) finds public health interventions are aided by complex network modelling ability to forecast and simulate diabetes progression over an area. (Rajeswari et al., 2018) The excellent prediction of prediabetes made possible by fuzzy logic-based classification enables early intervention and prevention. (Fong, Mohammed, et al., 2013) finds fuzzy lattice reasoning and causality modelling together provide a reliable method for accurately forecasting blood glucose levels.

4.2 Identification of research gaps and areas for future exploration in diabetes diagnosis and management

In order to progress the field and enhance patient outcomes, it is imperative to identify research gaps and opportunities for future investigation in the identification and controlling of diabetes. The following are some possible areas for further study and research gaps:

4.2.1 Models for early detection and prediction: Provide more precise and trustworthy models for diabetes early detection, particularly for populations that are at risk. Examine how to improve the prediction of the onset of diabetes by utilising innovative biomarkers, genetic markers, and sophisticated data analytics approaches.

4.2.2 Tailored care and precision medicine: Examine the efficacy of individualised treatment plans for managing diabetes. Investigate the fusion of lifestyle variables, phenotypic data, and genetic information to create individualised treatment regimens. Evaluate the effects of tailored therapies on patient satisfaction, long-term results, and glycaemic control.

4.2.3 Artificial intelligence and machine learning: Investigate the use of sophisticated machine learning methods, like reinforcement learning and deep learning, in the diagnosis and treatment of diabetes. Examine the possibilities of artificial intelligence-based solutions for real-time decision support, insulin dosage optimisation, and automated glucose monitoring.

4.2.4 Digital health technologies: Assess the usefulness and efficacy of newer digital health tools for managing diabetes, including wearables, telemedicine platforms, and mobile apps. Examine the effects on patient engagement, treatment adherence, and self-management behaviours of mobile health services, teleconsultations, and remote monitoring.

4.2.5 Behavioural treatments and way of life adjustments: Examine which lifestyle modification strategies and behavioural treatments work best for people with diabetes. Examine the effects on glycaemic control, weight management, and general well-being of interventions aimed at food, exercise, stress management, and sleep.

4.2.6 Health disparities and vulnerable populations: Analyse the differences in diabetes diagnosis, health outcomes, and access to care among various populations, such as low-income people, members of racial and ethnic minorities, and residents of underserved areas. Determine the best ways to increase equality in diabetes care by addressing these inequities.

4.2.7 Comorbidities and long-term complications: Examine the underlying causes and risk factors for complications from diabetes, including nephropathy, neuropathy, retinopathy, and cardiovascular disease. Examine new therapy targets and approaches to stop or postpone the emergence of these issues.

4.2.8 Cost-effectiveness and healthcare delivery: Assess the financial benefits of various diabetes treatment strategies, taking into account new drugs, technology, and methods of providing care. Examine cutting-edge approaches that take the economy into account while maximising healthcare resources, enhancing care coordination, and improving patient outcomes.

4.2.9 Empowerment and education of patients: Evaluate how well patient education initiatives and interventions have worked to raise diabetic self-management knowledge, health literacy, and self-efficacy. In order to improve patient education and engagement, investigate cutting-edge strategies like gamification, virtual reality, or social media.

4.2.10 Implementation and scalability: Examine the obstacles and enablers that new interventions or technologies face while being implemented and scaled up in actual healthcare settings. Determine tactics to get around implementation roadblocks and encourage the broad adoption of evidence-based approaches in the treatment of diabetes.

Researchers can improve patient outcomes, advance the science of diabetes diagnosis and management, and eventually lessen the financial burden of diabetes on patients and healthcare systems by addressing these research gaps and examining these topics for future study.

4.3 Closing remarks

This survey offers an analysis of the previously stated studies in order to shed light on the developments in intelligent diabetes diagnosis and treatment methods. For researchers, medical experts, and developers looking to improve the quality of decisive medicine plan for patients with diabetes, it is an invaluable resource.

References

1. Aibinu, A. M., Salami, M. J. E., & Shafie, A. A. (2010). Blood Glucose Level Prediction Using Intelligent Based Modeling Techniques. *IEEE, TELCON*, 1734–1737.
2. Ambedkar, B., Unive, M., Ambedkar, B., Unive, M., & Science, C. (2017). Classification of Insulin Dependent Diabetes Mellitus Blood Glucose Level Using Support Vector Machine Classification of Insulin Dependent

Diabetes Mellitus Blood Glucose Level Using Support Vector Machine. *IOSR Journal of Computer Engineering (IOSR-JCE)*, *February*, 36–42.
3. Azar, D., & Bitar, M. (2015). Ai-based methods for predicting required insulin doses for diabetic patients. *International Journal of Artificial Intelligence*, *13*(1), 8–24.
4. Chandrakar, O. (n.d.). Comparative Analysis of Prediction Accuracy of General and Personalized Datasets Based Classification Model for Medical Domain. *IJANA*, 25–28.
5. Fong, S., Mohammed, S., Fiaidhi, J., & Kwoh, C. K. (2013). Using causality modeling and fuzzy lattice reasoning algorithm for predicting blood glucose. *Expert Systems with Applications*, *40*(18), 7354–7366. https://doi.org/10.1016/j.eswa.2013.07.035
6. Fong, S., Zhang, Y., Fiaidhi, J., Mohammed, O., & Mohammed, S. (2013). Evaluation of stream mining classifiers for real-time clinical decision support system: A case study of blood glucose prediction in diabetes therapy. *BioMed Research International*, *2013*. https://doi.org/10.1155/2013/274193
7. Froelich, W., & Wakulicz-deja, A. (2009). Using Adaptive Fuzzy Cognitive Maps. *IEEE, HSI*.
8. Ganapathy, S., Sethukkarasi, R., Yogesh, P., Vijayakumar, P., & Kannan, A. (2014). An intelligent temporal pattern classification system using fuzzy temporal rules and particle swarm optimization. *Sadhana - Academy Proceedings in Engineering Sciences*, *39*(2), 283–302. https://doi.org/10.1007/s12046-014-0236-7
9. Jabez, J., & Muthu Kumar, B. (2015). Anomaly-detection in diabetes using SVM. *International Journal of Applied Engineering Research*, *10*(5), 12627–12636.
10. Jain, V., & Raheja, S. (2015). Improving the Prediction Rate of Diabetes using Fuzzy Expert System. *International Journal of Information Technology and Computer Science*, *7*(10), 84–91. https://doi.org/10.5815/ijitcs.2015.10.10
11. Janakiraman, B., & Arumugam, S. (2020). Personalized nutrition recommendation for diabetic patients using optimization techniques. *Intelligent Automation and Soft Computing*, *26*(2), 269–280. https://doi.org/10.31209/2019.100000150
12. Kamble, A. K., Manza, R. R., Rajput, Y. M., & Hannan, S. A. (2017). Association redetection of Regular insulin and NPH insulin using statistical features. *Proceedings of the 5th International Conference on System Modeling and Advancement in Research Trends, SMART 2016*, 59–62. https://doi.org/10.1109/SYSMART.2016.7894490
13. Kaur, P., & Ahuja, M. S. (2016). Predicting And Simulating Level Of Diabetes Over The Region Using Complex Networks. *IRJET*, *3*(6), 2516–2520.
14. Nath, R., & Jain, R. (2014). Insulin chart prediction for diabetic patients using hidden markov model (HMM) and simulated annealing method. *Advances in Intelligent Systems and Computing*, *236*(January), 3–11. https://doi.org/10.1007/978-81-322-1602-5_1
15. Parikshit, B. B. (2017). A Review of Diabetes Diagnosis and Record Management using HIVE. *IJSRD*, *5*(03), 1253–1256.
16. Rajeswari, A. M., Sidhika, M. S., Kalaivani, M., & Deisy, C. (2018). Prediction of Prediabetes using Fuzzy Logic based Association Classification. *Proceedings of the International Conference on Inventive Communication and Computational Technologies, ICICCT 2018*, *April*, 782–787. https://doi.org/10.1109/ICICCT.2018.8473159
17. Sivarathri, S., & A, G. (2014). Experiments on Hypothesis "Fuzzy K-Means is Better than K-Means for Clustering." *International Journal of Data Mining & Knowledge Management Process*, *4*(5), 21–34. https://doi.org/10.5121/ijdkp.2014.4502
18. Talari, P., Suresh, A., & Kavitha, M. G. (2023). An Intelligent Medical Expert System Using Temporal Fuzzy Rules and Neural Classifier. *Intelligent Automation and Soft Computing*, *35*(1), 1053–1067. https://doi.org/10.32604/iasc.2023.027024
19. Vanathi, R., & Khadir, A. S. A. (2017). ARACHNO – A Deep Inspection Predictive Analysis Algorithm for Analyzing Diabetic. *IJIRSET*, *6*(8), 16757–16765. https://doi.org/10.15680/IJIRSET.2016.0608144