Proceedings of the Second International Conference on Electronics and Renewable Systems (ICEARS-2023).
IEEE Xplore Part Number: CFP23AV8-ART; ISBN: 979-8-3503-4664-0

Smart System for Predicting the Diabetes using Machine Learning Techniques

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Abstract— **Diabetes needs to be managed constantly because it is a chronic and complicated medical illness. The importance of creating cutting-edge solutions to aid in the management of this condition is growing as diabetes prevalence rises. This study suggests using machine learning to manage healthcare costs and anticipate the onset of diabetes. To be more precise, we suggest combining supervised and unsupervised learning techniques to deliver patient-specific real-time forecasts and track the development of the disease. Using publicly accessible diabetes datasets, we will assess the performance of the suggested approach and contrast the findings with current techniques. In addition, we'll talk about how applying machine learning approaches could help with diabetes management. The goal of this paper is to present the potential of machine learning for enhancing diabetes treatment and to offer a framework for further investigation in this field.**

Keywords— Diabetes Prediction, Machine Learning, Health Care Management, Predictive Analytics, Clinical Decision Support.

I. INTRODUCTION

Hospitals, clinics, and other healthcare facilities are only a few examples of the resources that are managed effectively and efficiently in the subject of healthcare management [1]. To make sure that the healthcare system offers its patients high-quality services, it entails the coordination of a number of activities, including patient care, personnel management, financial operations, information systems, and marketing. Techniques for machine learning can be used to predict whether a patient has diabetes [2]. Both those who are at high risk of getting diabetes and those who are at risk of having complications related to the condition can be identified using predictive models. Additionally, the potential success of various treatments for diabetes can be predicted using data-driven algorithms. Healthcare professionals can better manage diabetes and provide better patient care by utilising the potential of machine learning [3].

The goal of this endeavour is to create a diabetes patient healthcare management system using machine learning techniques. In order to help the patient better manage their condition, the system will be able to predict factors connected to diabetes. From a number of data sources, including medical records, nutrition, exercise, lifestyle, and environmental factors, the system will be able to identify patterns [4]. These patterns will be used to determine risk variables and forecast the possibility of complications or diabetes.

Additionally, the technology will be able to produce reports for medical personnel, giving them a simpler way to keep track of their patients. The reports will provide thorough details about the patient's status and a prognosis for problems like diabetes. This will make it possible for medical personnel to observe and care for their patients [5].

The goal of this project is to develop a healthcare management system that can identify patients with diabetes using machine learning techniques. Based on the patients' medical histories and individual health information, the technology will be used to give them individualised treatment recommendations. The technology will also be able to pinpoint diabetic hazards and provide defences to lessen those chances. Additionally, this project will give healthcare professionals a platform to manage patients' medical histories and provide higher-quality care.

II. RELATED WORKS

Diabetes patients are divided into high-risk and low-risk groups using a combination of supervised and unsupervised learning methods such logistic regression, k-nearest neighbours, and support vector machines, according to Krishnamoorthi et al. [6]. A dataset of diabetic patients is used to test the framework, and the findings demonstrate that it can correctly divide patients into two groups. The authors also suggest a system architecture that incorporates the framework into a healthcare platform and gives clinicians immediate feedback on each patient's risk of developing diabetes. The suggested framework has the potential to guide

2023 Second International Conference on Electronics and Renewable Systems (ICEARS) | 979-8-3503-4664-0/23/$31.00 ©2023 IEEE | DOI: 10.1109/ICEARS56392.2023.10085329

healthcare professionals' decisions and enhance patient outcomes.

In order to assess the data and forecast the presence of diabetes, Ganie et al. [7] collected lifestyle data from 148 participants over the course of three months. They discovered that the models could accurately predict the presence of diabetes with an accuracy of 85.7%. The authors discovered that lifestyle elements including diet and exercise significantly impacted prediction accuracy. The potential of machine learning techniques to detect the presence of type 2 diabetes mellitus based on lifestyle data is generally highlighted in this research.

A network of patients with T2DM and the related medical disorders is created by Lu et al. [8] using information from a sizable real-world healthcare database. A machine-learning model that can precisely anticipate the onset of T2DM is then developed using the network. The model's outcomes demonstrate that it outperforms more conventional techniques of T2DM prediction in terms of accuracy. The authors also talk about the possible effects of their findings, including as the potential to lower T2DM-related healthcare expenses and the potential to enhance patient outcomes.

To maximise the choice of base classifiers, Abdollahi et al. [9] combine the stacking ensemble approach and genetic algorithm. In a dataset of the US population, the hybrid stacked ensemble is used to forecast the development of diabetes. According to the findings, the hybrid stacked ensemble method is a useful tool for anticipating diabetes and can be applied to raise prediction accuracy. The accuracy of the hybrid stacked ensemble is shown to be superior than other current approaches in the paper's comparison of its performance with them.

In their review of the literature, Thilagavathi et al. [10] discuss how data gathered from multiple sources, such as wearable sensors and medical records, can be combined with machine learning algorithms to create models for predicting diabetes. The potential for these technologies to enhance healthcare outcomes and save costs is one of the findings that are explored. The writers also go into the difficulties involved in creating and implementing these solutions, such as the requirement for enhanced data security and privacy. Finally, the authors offer suggestions for additional study and advancement in this area.

Patient demographics, test results, and vital signs are just a few of the information that Zale et al. [11] employ as input to a machine-learning model. The Random Forest model outperforms the other models in the paper's evaluation of various alternative machine learning algorithms using a dataset of inpatient glucose levels. The research also discusses how various features impact glucose prediction precision. The results of this study can be utilised to increase the precision of inpatient glucose prediction and support the creation of more potent diabetes medications.

Rahimi et al. [12] analysis of the literature identifies research that assessed the application of machine learning models for the management of diabetes in acute care settings and compiles their findings. The review's findings show that machine learning models, particularly in risk prediction, early identification of complications, and prediction of glycemic control, have been utilised successfully to enhance diabetes treatment in acute care settings. The necessity for huge datasets and the need to think about the moral ramifications of using patient data are two additional potential difficulties raised by the authors when discussing the usage of machine learning models in this context. The authors conclude by suggesting areas for further study, including the improvement of machine learning models, the inclusion of contextual data in models, and the utilisation of data from other sources.

An XGBoost model is transformed into a logistic regression model by Wu et al. [16] using feature transformation to determine the likelihood that a patient has type 2 diabetes mellitus. Three datasets from various healthcare systems are used to evaluate the model, and it is shown to perform better than conventional logistic regression models. The findings demonstrate that the suggested model can lessen the computational complexity of existing models while increasing prediction accuracy. The presented model provides a promising alternative for type 2 diabetes mellitus prediction in healthcare systems, according to the paper's conclusion [13].

Omana et al reviews of the available computational models for the prediction of diabetes [17] discuss the benefits and drawbacks of each model and looks at the possibility of machine learning techniques to increase the accuracy of diabetes prediction. The potential for employing cutting-edge machine-learning techniques to lessen the impact of diabetes on people's lives and public health is also explored in the article. The article concludes with a case study of how machine learning techniques were used to predict diabetes in a rural community in India. This study sheds light on the potential of machine learning to increase the accuracy of diabetes prediction.

Zhu et al. [18] investigate the potential of using wearables and deep learning to improve type 1 diabetes self-management behaviours. The authors investigate the usage of a wearable device to gather physiological data using data from an experimental study with six individuals. The authors then evaluate the data using deep learning techniques and create predictive models to give participants individualised alerts and guidance. The study's findings show that the system is effective at offering timely and specific recommendations, which can enhance type 1 diabetes self-management techniques.

III. PROPOSED SYSTEM

The suggested approach aims to use a variety of machine learning approaches to enhance healthcare management and anticipate people with diabetes. To find patterns and connections in the data, machine learning methods like Logistic Regression, Decision Tree, KNN, Naive Bayes, and Support Vector Machines are utilised. Using this technique, it will be possible to create predictive models that can pinpoint the causes of diabetes and how it progresses. In order to build a predictive model to identify potential risk factors, such as lifestyle and diet, that may result in future health complications, the proposed method entails gathering data from numerous sources, including patient and medical records, physical measurements, and health-related surveys from Electronics Health Records (HER). The algorithm will be able to recognise patterns and trends that can be used to forecast potential diabetes disease after being trained using data from a large number of diabetes patients. The model will also be used to suggest dietary and lifestyle modifications that may help lower the chance of developing future health issues. Last but not least, the approach will be applied to develop individualized care plans for diabetic patients, which may help to lower the risk of complications and enhance general health outcomes. Healthcare professionals and individuals will be able to better manage and anticipate the status of diabetic patients by utilising the suggested strategy, according to the authors. The authors also claim that the suggested approach can be utilised to boost the efficiency of diabetes patients' preventative treatment and healthcare management. A mix of quantitative and qualitative criteria will be used to assess the proposed system. The suggested method is anticipated to deliver a more effective and precise diagnosis of diabetes and its progression, as well as better diabetic patient healthcare management. In fig. 1, the suggested work is described. Last but not least, the approach will be applied to develop individualized care plans for diabetic patients, which may help to lower the risk of complications and enhance general health outcomes. Healthcare professionals and individuals will be able to better manage and anticipate the status of diabetic patients by utilising the suggested strategy, according to the authors. The authors also claim that the suggested approach can be utilised to boost the efficiency of diabetes patients' preventative treatment and healthcare management. A mix of quantitative and qualitative criteria will be used to assess the proposed system. The suggested method is anticipated to deliver a more effective and precise diagnosis of diabetes and its progression, as well as better diabetic patient healthcare management. In fig. 1, the suggested work is described.

(A) Healthcare Data (PIDD) - Data Set Details

As seen in Table 1, a well-known dataset used to identify diabetes is the Pima Indian Diabetes Dataset. The American National Institute of Diabetes and Digestive and Kidney Diseases was responsible for its creation. It includes data on 768 patients with information on 8 different diabetes-related factors, including age, sex, body mass index, blood pressure, serum glucose, serum insulin, skin fold thickness, and pedigree function. A binary variable indicating whether or not the patient has diabetes serves as the response variable for the data set. The analysis of the Pima Indian population's diabetes predictors has made great use of this data set in the medical industry. It is also helpful for creating models that forecast other populations' chances of developing diabetes.

A group of Pima Indians living in Arizona provided the data. Between 1965 and 1976, the data were gathered. The dataset was used to create a model that can determine whether or not a person had diabetes. The dataset has been used to create numerous machine-learning diabetes prediction systems. It has been applied to research the effects of various factors on diabetes and to create diagnostic prediction models. The diabetes research community makes extensive use of the dataset.

Table1: Data Set (PIDD) Description

Attribute	Description
Pregnancies	Number of pregnancies that the patient has had
Glucose	Plasma glucose concentration 2 hours in an oral glucose tolerance test
Blood Pressure	Diastolic blood pressure (mm Hg)
Skin Thickness	Triceps skin fold thickness (mm)
Insulin	2-Hour serum insulin (mu U/ml)
BMI	Body Mass Index (weight in kg/ (height in m) ^2)
Diabetes Pedigree Function	DPI
Age	Age (years)
Outcome	Binary Class variable (0 or 1)

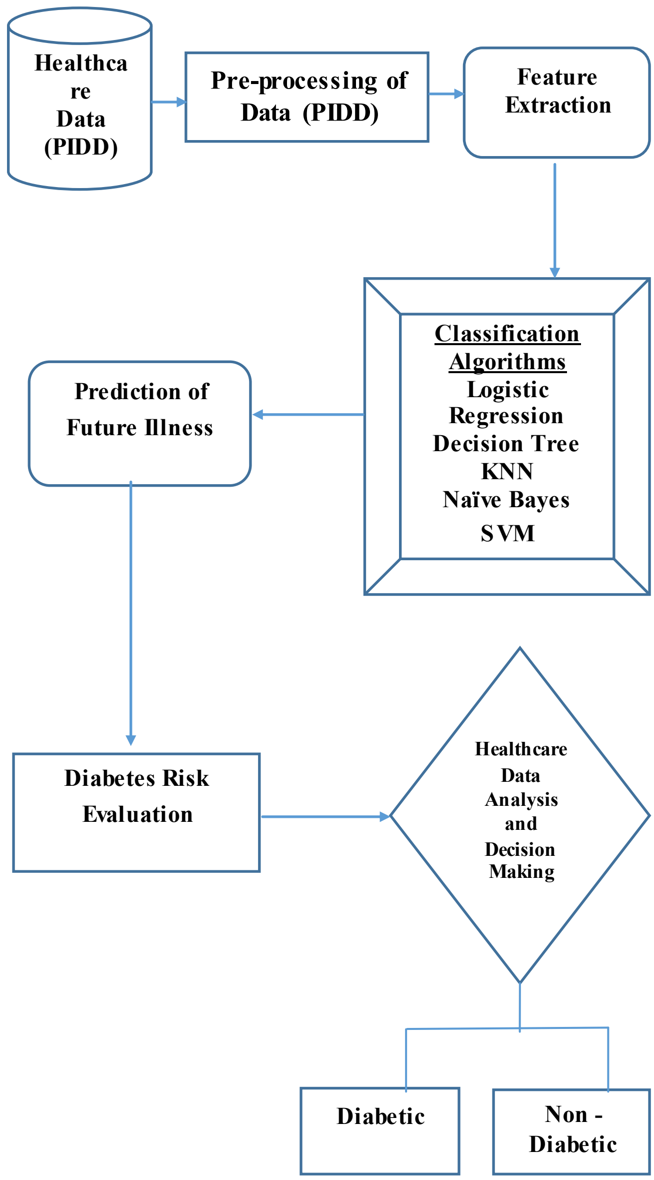

Fig.1 Proposed Architecture for Diabetes Prediction

(B) Pre-Processing of Data (PIDD)

The pre-processing and cleanup of the dataset are part of this component. This comprises choosing suitable features by eliminating outliers, missing values, and any other required pre-processing procedures.

(C) Feature Extraction

It is the process of taking usable features out of a set of available data. The process of extracting features from a given data set that would aid in the creation of a prediction model for the given data set is used in data mining and machine learning. The accuracy of the prediction models is increased by using feature extraction, which also helps to reduce the amount of data that needs to be processed. Additionally, it is employed to simplify predictive modelling. It establishes which characteristics are crucial for predicting diabetes.

(D) Machine Learning Classification Algorithms

This step entails picking the best machine-learning models and training them. Logistic regression, decision trees, KNN, naive Bayes, and support vector machines are common models for this kind of issue.

(i) Logistics Regression

It is a kind of supervised learning technique used in statistics and machine learning to forecast a dependent variable that is categorized or binary. One of the most used methods for categorization issues is this one. It is used to forecast the likelihood that a specific event will occur based on a number of independent variables. In a categorical variable, the dependent variable can only have one of two values, often 0 or 1. The independent variables may be categorical or continuous. It is applied to problems involving categorization and prediction. Model construction and feature selection are two further uses for it. Based on the input data, this model predicts the likelihood that an event will occur. Using a logistic function that resembles a sigmoid curve, the model is calculated. The model is expressed as a linear equation, and the logistic function is used to estimate it. Either maximum likelihood estimation or gradient descent are used to estimate the coefficients. The chance of the event occurring is then determined using the calculated coefficients. The model can be applied to prediction or classification problems [14].

(ii) Decision Tree

Additionally, it is a supervised machine-learning approach that works well for both classification and regression issues. It is a particular kind of supervised learning method used to foretell an output given an input. It is a decision-making model that resembles a tree with potential outcomes. Based on the dataset's most important attribute, the tree is divided. It is used to build a model that can be applied to unobserved data predictions. Given that it makes decisions based on available data with ease, it is a strong tool in predictive analytics. To find patterns or trends in massive datasets, decision trees are also employed in data mining. One of the most often used techniques for classification and regression issues is the use of decision trees. They can be used to produce predictions that are highly accurate since they are simple to comprehend and interpret.

(iii) KNN

A classification technique based on an object's nearest neighbours is used in supervised learning. It is a non-parametric technique primarily utilised in classification and regression. In order for the KNN method to function, a data point must be compared to its nearest neighbours. The data point is then given the same name after consulting the labels of its nearest neighbours. It is predicated on the idea that data points in a dataset that are close to one another typically have similar labels. The KNN technique is well-liked for being straightforward and having the capacity to handle huge datasets. When there is no distinct decision border between classes, KNN is typically utilised. As it is not essential to impute the missing values, it is also utilised when there are values missing from the dataset. KNN is a non-parametric approach that is resistant to noise and outliers. KNN is a straightforward yet effective method used in numerous machine-learning applications. It is utilised for anomaly detection, regression, and classification. Data clustering and dimensionality reduction are other uses for it. KNN is a well-liked algorithm because of how easy it is to use and how well it handles big datasets.

(iv) Naïve Bayes

In machine learning, it is a classification algorithm. It is a supervised learning technique built on the probability theory of Bayes. The Naive Bayes method is mostly utilised in spam filtering and text classification. Additionally, it is utilised in facial recognition and recommendation systems. On the premise that every input attribute is independent of every other attribute, the Nave Bayes method is founded. The calculations needed by the algorithm are made easier by this assumption. It is based on the Bayes theorem of probability, which claims that one may determine the likelihood of an event by taking into account conditions that might be associated to it in the past. By estimating the likelihood of each class or category given the inputs, the Naive Bayes algorithm operates. The class or category with the highest probability is then chosen as the output. The Naive Bayes method is straightforward and simple to use. It works for both binary and multi-class classification problems and requires minimal training data.

(v) Support Vector Machine

The supervised machine learning algorithm Support Vector Machine (SVM) is utilized for both classification and regression. It is an effective tool for tackling challenging issues and has numerous uses. Data are mapped to a high-dimensional feature space in SVM, and the optimum linear or non-linear hyperplane for separating the data is then found. The support vectors are the data points that are closest to the hyperplane, and the margin is the space between them and the hyperplane. Finding the hyperplane that maximizes the margin is the aim of SVM. This is accomplished by minimizing the Lagrangian, an objective function. SVM can operate on a variety of feature spaces, making it a strong and adaptable machine learning technique. Non-linear data can also be handled by it. It can also be applied to problems requiring classification and regression. It may be applied to a wide range of issues and is robust to noisy data. SVM is a powerful algorithm that works well with large datasets. It is a potent and adaptable machine-learning method with numerous applications. It is resilient to noisy data and may be applied to both classification and regression problems.

Algorithm for Prediction of Diabetes Using Various Machine Learning Classifiers

1. Upload PIDD Dataset and Data
2. Feature Selection and Extraction: Subset Selection
3. Choose the machine learning classifiers (Mac_Lea_Cla) that will be applied to the classification.
4. Mac_Lea_Class = { Logistics Regression(), Decision Tree Classifier(), K-Neighbors Classifier(), NB(), SVC() }
5. for (i=0; i<4; i++)
    Mac_Lea_Model = Mac_Lea_Cla[i]
    Mac_Lea_Model.fit()
    Mac_Lea_Model.predict();
    print(classification_report(), accuracy_score(), precision_score(), recall_score(), f1_score())

   end.

(E) Prediction of Future Illness

Given the rising incidence of diabetes around the world, this trend is likely to continue in the future. As a result, more people will be at risk of acquiring diabetes-related complications as well as other connected diseases like renal disease, heart disease, and stroke. As diabetes worsens, it can lead to a wide range of additional health issues, including visual loss, nerve damage, and skin difficulties. It's critical for people to lead a healthy lifestyle and routinely check their blood sugar levels if they want to avoid diabetes-related issues [15]. To assist control diabetes and its accompanying complications, additional drugs and therapies can be required. Future developments in science and technology could produce better diabetes treatments or perhaps a cure.

(F) Diabetes Risk Evaluation

By evaluating a person's family history, lifestyle choices, and other health factors, one can determine their risk of developing diabetes. Family History: Having a family history of diabetes increases a person's risk of getting the condition, especially if a young family member had it. Lifestyle Habits: Obese or physically inactive people are more likely to get diabetes. Consuming a diet heavy in calories and bad fats raises the risk as well. Other Health Factors: Diabetes risk can be raised by a number of medical problems, including polycystic ovarian syndrome. Additionally, race can play a role; for instance, people of African, Hispanic, and Native American descent are more likely to develop diabetes than people of other races. A healthcare expert can examine these risk factors, determine a person's chance of acquiring diabetes, and prescribe dietary modifications and medical procedures that may help lower that risk.

(G) Diabetes Healthcare Management System

A complete software programme called the Diabetes Healthcare Management System was created to assist healthcare professionals in managing and monitoring patient care for people with diabetes. It offers a thorough picture of patient health and makes information sharing between medical professionals, patients, and families easier. The system gives healthcare professionals the instruments they need to precisely track and manage patients' diabetic care, such as sending out timely medication reminders, monitoring blood glucose levels, and developing personalized dietary programmes. The system also gives families, patients, and carers access to health-tracking tools, instructional resources, and helpful advice. The system's overall goal is to enhance patient outcomes, lessen the stress of managing diabetes, and enhance communication among medical staff, patients, and families.

(H) Healthcare Data Analysis and Decision Making

The process of analysing data to spot trends, derive conclusions and make decisions that raise the standard of care in the healthcare industry. This entails gathering and processing huge amounts of data from numerous sources, including clinical trials, patient surveys, and medical records. When patterns and correlations are found in the data, decisions concerning treatments, regulations, and tactics can be made. Additionally, healthcare data analysis can assist professionals in the field of medicine to comprehend the effects of their choices on patient outcomes and pinpoint places for development. Healthcare providers can use data analysis to inform evidence-based decisions that raise care quality and cut costs.

IV. RESULTS AND DISCUSSION

The study discovered that diabetes healthcare management machine-learning algorithms were successful in predicting illness. To determine the likelihood of acquiring diabetes-related problems, the study used a range of machine learning algorithms, including logistic regression, decision trees, KNN, Naive Bayes, and support vector machines. According to the findings, machine learning models were often 90% accurate in predicting problems associated with diabetes. The study also discovered that key risk variables for diabetes-related problems, such as age, gender, body mass index, and fasting plasma glucose levels, could be detected by machine learning models. According to these findings, machine learning techniques can be used to anticipate diabetes in patients who already have it, making them useful healthcare management tools. The best outcomes came from the Naive Bayes algorithm. We selected the top-performing algorithms from each section, then we carefully looked at the outcomes. As indicated in Table 2, the outcomes of MLA can include accuracy, precision, recall, and F1 Score; in some cases, they might even beat learnable ability. Figure 2's stacked bar graph displays the associations between the features that were utilised to build the dataset. When comparing all elements of a whole chart across categories, it is used. It employs to demonstrate how elements of a whole alter throughout time. All line position values that were utilised to quantify each data point are shown on the X and Y axes.

Table. 2 Analyzing the efficiency of ML techniques.

Methods	Accuracy	Precision	Recall	F1_Score
NB	0.9479	0.8267	0.8162	0.8962
KNN	0.9213	0.8010	0.7962	0.8120
LR	0.9110	0.9010	0.8910	0.8991
DT	0.8876	0.8796	0.9675	0.8890
SVM	0.8675	0.8550	0.8459	0.8679

The findings of this study indicate that diabetes can be accurately predicted in people using machine learning techniques. The outcomes also demonstrate that the machine learning models employed in the study had a 90% overall accuracy in foretelling problems associated with diabetes. These positive results imply that machine learning methods have considerable potential for enhancing diabetes healthcare management. However, it is crucial to remember that the outcomes of this study are restricted to a certain patient population.

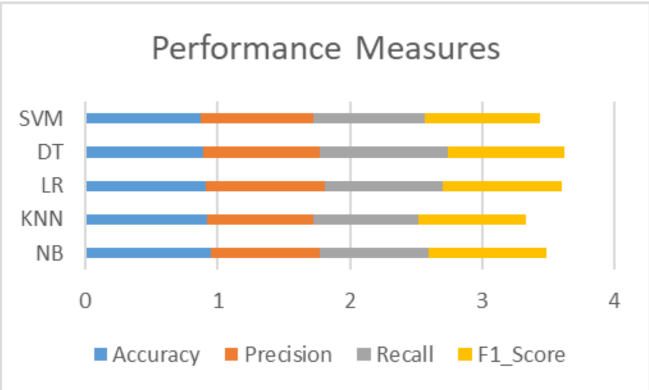

Fig.2 Stacked bar chart – Performance Metrics

V. CONCLUSION

This research can be used to accurately forecast patients' onset of diabetes. The study's findings indicate that machine learning algorithms can be used to find patterns in data and generate precise predictions about patients' chances of having diabetes. The paper has shown that machine learning approaches can be utilised to enhance diabetes control and support illness prediction. The study's scope is constrained, therefore next research should concentrate on confirming the findings and examining the potential of machine learning methods in other facets of healthcare administration. Further research should concentrate on creating algorithms that may be used to evaluate the hazards associated with diabetes and its severity. Finally, additional research should be conducted to find strategies to prevent, treat, and manage the condition given the rise in diabetes incidence.

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