HealthCare Analysis - Diabetes Dataset

An in-depth analysis of the Diabetes dataset, exploring various factors that contribute to the prevalence and prediction of diabetes.

Section 1

Introduction, Project Goals, Implications

Introduction - Diabetes

What is Diabetes?

Diabetes is a chronic condition characterized by high levels of blood sugar (glucose) due to the body's inability to produce or use insulin effectively.

Importance of Prediction

Early prediction and diagnosis of diabetes can help individuals take proactive steps to manage the condition and prevent or delay the onset of complications.

Diabetes Diagnosis

Accurate diagnosis of diabetes is crucial for effective treatment and management, including blood tests to measure glucose levels and assessing risk factors.

Diabetes Treatment

Effective treatment of diabetes involves a combination of lifestyle changes, medication, and regular monitoring to maintain healthy blood sugar levels and prevent complications.

Predicting, diagnosing, and treating diabetes are essential for improving patient outcomes and reducing the burden of this chronic condition on healthcare systems.

Business Problems

- ## Predicting Diabetes Onset
  Use the dataset to develop predictive models that can identify individuals at risk of developing diabetes based on various health and lifestyle factors.

- ## Assessing Risk Factors
  Analyze the dataset to understand the key risk factors and associated with diabetes, informing prevention and early intervention strategies.

- ## Personalizing Treatment Plans
  Leverage the dataset to create personalized treatment plans and recommendations for individuals with diabetes or those identified as at risk.

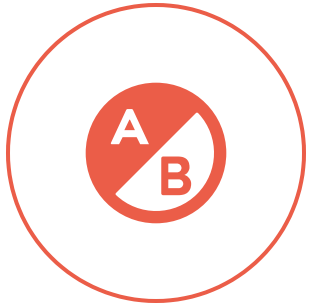
- ## Optimizing Healthcare Resource Allocation
  Use insights from the dataset to help healthcare providers and policymakers allocate resources more effectively, such as targeting high-risk populations or focusing on preventive measures.

- ## Improving Patient Outcomes
  Develop models and strategies based on the dataset to help healthcare professionals better monitor, manage, and improve the health outcomes of individuals with diabetes.

Project Goals and Implications

Project Goals

The primary goal of this project is to develop a model that can accurately predict the risk of diabetes based on various medical and laboratory parameters. This model will help healthcare professionals identify individuals at high risk of developing diabetes, enabling early intervention and preventive measures...



Implications

Early identification of individuals at risk of diabetes can lead to proactive lifestyle modifications, regular monitoring, and timely treatment, ultimately reducing the burden of diabetes-related complications and healthcare costs.

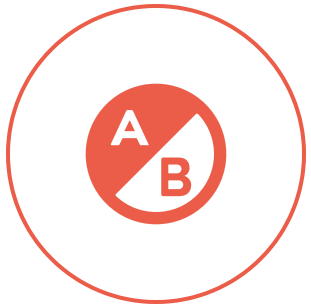
Section 2

Dataset

Dataset Description

Dataset Overview

The dataset was collected from the Iraqi society, specifically from the laboratory of Medical City Hospital and the Specializes Center for Endocrinology and Diabetes-Al-Kindy Teaching Hospital. Patient files were used to extract relevant medical information..



Dataset Variables

The dataset includes dataset include ID, No. of Patient, Age, Gender, Creatinine ratio (Cr), Body Mass Index (BMI), Urea, Cholesterol (Chol), Fasting lipid profile (including total, LDL, VLDL, Triglycerides (TG), and HDL Cholesterol), and HBA1C.

Output Variable

The output variable is 'Class', which represents the patient's diabetes disease class (Diabetic, Non-Diabetic, or Predict-Diabetic).

Data Size

The dataset consists of 1400 records

Section 3

Descriptive Analysis and Visualizations

Descriptive Statistics

The dataset consists of 14 columns and 1,000 rows, providing information about various medical and laboratory parameter related to diabetes. There were 5 missing values in the output column "Class", representing .5% of the values in the column. No other values in any other columns were missing.

Descriptive statistics:

	ID	No_Pation	Gender	AGE	Urea
count	1000.000000	1.000000e+03	1000.000000	1000.000000	1000.000000
mean	340.500000	2.705514e+05	0.565000	53.528000	5.124743
std	240.397673	3.380758e+06	0.496005	8.799241	2.935165
min	1.000000	1.230000e+02	0.000000	20.000000	0.500000
25%	125.750000	2.406375e+04	0.000000	51.000000	3.700000
50%	300.500000	3.439550e+04	1.000000	55.000000	4.600000
75%	550.250000	4.538425e+04	1.000000	59.000000	5.700000
max	800.000000	7.543566e+07	1.000000	79.000000	38.900000

	Cr	HbA1c	Chol	TG	HDL
count	1000.000000	1000.000000	1000.000000	1000.000000	1000.000000
mean	68.943000	8.281160	4.862820	2.349610	1.204750
std	59.984747	2.534003	1.301738	1.401176	0.660414
min	6.000000	0.900000	0.000000	0.300000	0.200000
25%	48.000000	6.500000	4.000000	1.500000	0.900000
50%	60.000000	8.000000	4.800000	2.000000	1.100000
75%	73.000000	10.200000	5.600000	2.900000	1.300000
max	800.000000	16.000000	10.300000	13.800000	9.900000

	LDL	VLDL	BMI
count	1000.000000	1000.000000	1000.000000
mean	2.609790	1.854700	29.578020
std	1.115102	3.663599	4.962388
min	0.300000	0.100000	19.000000
25%	1.800000	0.700000	26.000000
50%	2.500000	0.900000	30.000000
75%	3.300000	1.500000	33.000000
max	9.900000	35.000000	47.750000

Missing values percentage:

ID	0.0
No_Pation	0.0
Gender	0.0
AGE	0.0
Urea	0.0
Cr	0.0
HbA1c	0.0
Chol	0.0
TG	0.0
HDL	0.0
LDL	0.0
VLDL	0.0
BMI	0.0
Class	0.5

dtype: float64

Correlation Matrix

The variable 'HbA1c' has the highest correlation with the 'Class' variable (0.760241), indicating a strong positive relationship. This suggests that 'HbA1c' is likely to be an important predictor of diabetes. Other variables that have a relatively higher correlation with 'Class' include 'AGE' (0.185737), 'Urea' (0.141201), 'VLDL' (0.133819), and 'TG' (0.102260).

Correlation Matrix:

	ID	No_Pation	Gender	AGE	Urea	Cr
ID	1.000000	0.064840	0.016605	-0.060606	-0.094569	-0.103068
No_Pation	0.064840	1.000000	0.051977	-0.088837	-0.018968	0.000732
Gender	0.016605	0.051977	1.000000	0.029524	0.116189	0.155104
AGE	-0.060606	-0.088837	0.029524	1.000000	0.107177	0.055786
Urea	-0.094569	-0.018968	0.116189	0.107177	1.000000	0.624252
Cr	-0.103068	0.000732	0.155104	0.055786	0.624252	1.000000
HbA1c	-0.009334	-0.032621	-0.008212	0.383224	-0.021599	-0.036998
Chol	0.046287	-0.030176	-0.063230	0.034076	0.001807	-0.006978
TG	-0.054960	-0.040026	0.054170	0.145852	0.041747	0.056836
HDL	0.028104	-0.013228	-0.129758	-0.022007	-0.037577	-0.023730
LDL	-0.063631	-0.003092	0.054320	0.016028	-0.007418	0.039512
VLDL	0.144420	0.114998	0.189987	-0.070108	-0.010498	0.010579
BMI	0.051121	0.017640	0.069910	0.386418	0.047118	0.055939
Class	-0.056995	-0.047957	0.105021	0.447322	0.068194	0.038369

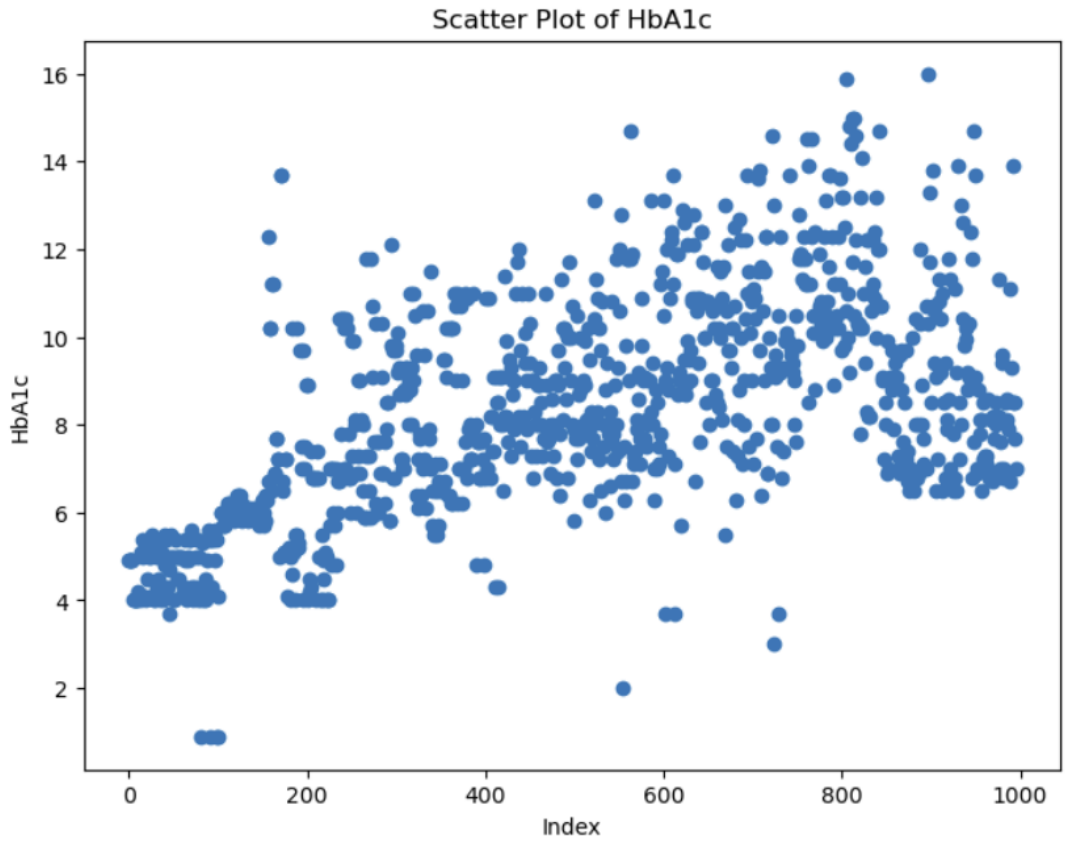
	HbA1c	Chol	TG	HDL	LDL	VLDL
ID	-0.009334	0.046287	-0.054960	0.028104	-0.063631	0.144420
No_Pation	-0.032621	-0.030176	-0.040026	-0.013228	-0.003092	0.114998
Gender	-0.008212	-0.063230	0.054170	-0.129758	0.054320	0.189987
AGE	0.383224	0.034076	0.145852	-0.022007	0.016028	-0.070108
Urea	-0.021599	0.001807	0.041747	-0.037577	-0.007418	-0.010498
Cr	-0.036998	-0.006978	0.056836	-0.023730	0.039512	0.010579
HbA1c	1.000000	0.178072	0.217905	0.029994	0.011817	0.071413
Chol	0.178072	1.000000	0.321233	0.103041	0.417075	0.079197
TG	0.217905	0.321233	1.000000	-0.083333	0.015510	0.149241
HDL	0.029994	0.103041	-0.083333	1.000000	-0.142350	-0.059465
LDL	0.011817	0.417075	0.015510	-0.142350	1.000000	0.064012
VLDL	0.071413	0.079197	0.149241	-0.059465	0.064012	1.000000
BMI	0.414106	0.013944	0.111510	0.072275	-0.068073	0.189284
Class	0.555931	0.168110	0.182597	-0.002399	0.004642	0.098799

	BMI	Class
ID	0.051121	-0.056995
No_Pation	0.017640	-0.047957
Gender	0.069910	0.105021
AGE	0.386418	0.447322
Urea	0.047118	0.068194
Cr	0.055939	0.038369
HbA1c	0.414106	0.555931
Chol	0.013944	0.168110
TG	0.111510	0.182597
HDL	0.072275	-0.002399
LDL	-0.068073	0.004642
VLDL	0.189284	0.098799
BMI	1.000000	0.570376
Class	0.570376	1.000000

Hemoglobin A1c (HbA1c), also known as glycated hemoglobin, is a blood test that measures a person's average blood sugar levels over the past 2–3 months.

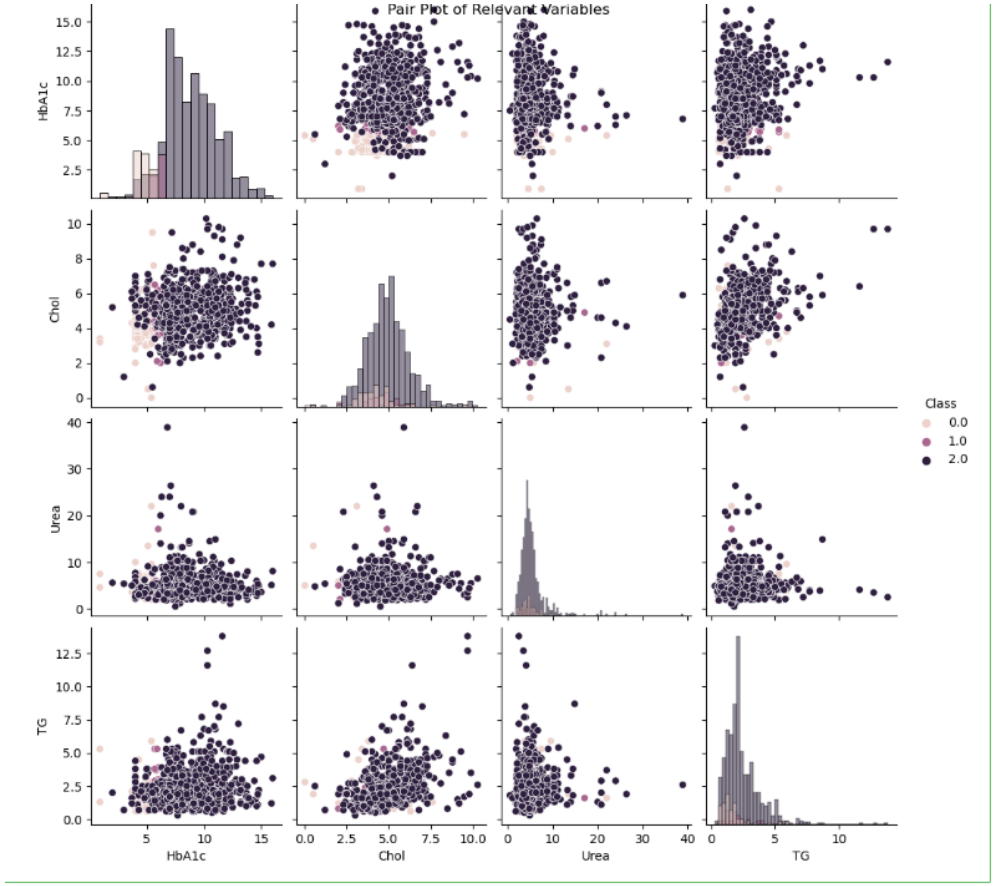
HbA1c Scatter Plot

The scatter plot of HbA1c visualizes the distribution of HbA1c values across the dataset. Each point on the plot represents an individual record, with the x-axis representing the index (row number) of the record and the y-axis representing the corresponding HbA1c value.



Data Visualization - Pair Plot

The pair plot visualizes the relationships between the selected variables ('HbA1c', 'AGE', 'Urea', 'Chol', 'TG') and the target variable 'Class'.

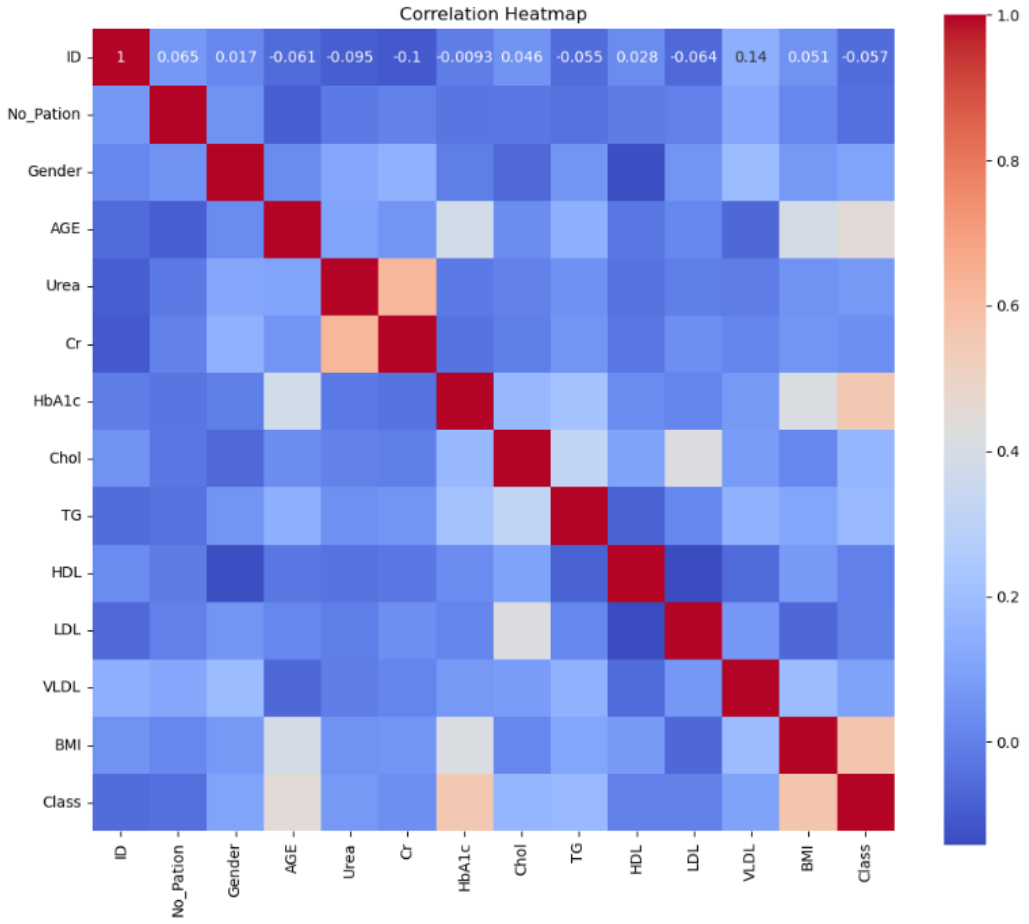


From the pair plot, we can observe the following: HbA1c vs Class: There is a clear separation between the different classes based on the HbA1c values. Higher HbA1c values are associated with the diabetic class (2.0), while lower values are more prevalent in the non-diabetic class (0.0). This confirms the strong positive correlation between HbA1c and the diabetes class. AGE vs Class: There is a slight trend indicating that older individuals are more likely to be in the diabetic class (2.0). However, the separation between classes based on age is not as distinct as with HbA1c. Urea vs Class: There is a slight tendency for higher Urea values in the diabetic class (2.0) compared to the non-diabetic class (0.0). However, the separation between classes based on Urea values is not very clear. Chol vs Class: The relationship between Chol and Class is not visually apparent in the pair plot. There is no clear separation between classes based on Chol values. TG vs Class: There is a slight trend indicating higher TG values in the diabetic class (2.0) compared to the non-diabetic class (0.0). However, the separation between classes based on TG values is not very distinct.

Overall, the pair plot confirms that HbA1c is the strongest predictor of the diabetes class among the selected variables. It shows a clear separation between the classes based on HbA1c values.

Data Visualization - Heat map

The correlation heatmap provides a visual representation of the pairwise correlations between the variables. It helps identify the strength and direction of the relationships among the variables. The color intensity and the values in each cell indicate the magnitude and direction of the correlation.



Section 4

Data Processing

Data Processing - Procedures, Model Development, Evaluation

Missing values

There were 5 missing values in the dataset in the "Class" column, with rows removed.

X and Y Variable

The target variable 'Class' and the input features were separated into 'X' (input variables) and 'y' (target variable) for model training and evaluation.

Training and Testing Datasets

The dataset was split into training and testing sets using the train_test_split function from scikit-learn, with 20% of the data reserved for testing.

3 Different Models were trained and evaluated

Logistic Regression - used to predict binary outcome

Decision Tree - combines multiple decision trees

Random Forest - combines the output of multiple decision trees to reach a single result.

We did not use Linear Regression as Linear Regression is typically used for regression tasks, where the target variable is continuous, In this case, the target variable 'Class" representes categories (Non_Diabetic, Predict-Diabetic, Diabetic), Linear Regression would not be a good choice.

Assessment and evaluation

The performance of each model was assessed using various evaluation metrics:

Accuracy: Measures the overall correctness of the model's predictions.

Precision: Indicates the proportion of true positive predictions among all positive predictions.

Recall: Represents the proportion of true positive predictions among all actual positive instances.

F1 Score: Provides a balanced measure of precision and recall

Features Importances

The feature importance analysis using Random Forest Classifier shows that 'HbA1c' is the most important feature for predicting the 'Class' variable, with an importance score of 0.636089. This aligns with the findings from the correlation matrix. Other variables that have relatively higher importance scores include 'AGE', 'Urea', 'Chol', 'TG', and 'Cr'. Based on the correlation analysis and feature importance, the variables that are most likely to predict diabetes ('Class') are: HbA1c AGE Urea Chol TG

Feature Importances:

	Feature	Importance
4	HbA1c	0.324747
10	BMI	0.301125
1	AGE	0.112784
5	Chol	0.070396
6	TG	0.042113
9	VLDL	0.041584
8	LDL	0.032798
3	Cr	0.025508
2	Urea	0.020963
7	HDL	0.019152
0	Gender	0.008830

These variables have higher correlations with the 'Class' variable and higher importance scores in the Random Forest Classifier.

Outcomes

Accuracy, Precision, Recall, and F1-Score on the test dataset - The evaluation results showed that the Random Forest model performed the best among the three models, achieving the highest accuracy, precision, recall, and F1 score. The best-performing model was selected based on the highest F1 score, which in this case was the Random Forest model.

Logistic Regression

Accuracy: 0.8593

Precision: 0.7384

Recall: 0.8593

F1 Score: 0.7943

Random Forest

Accuracy: 0.9849

Precision: 0.9854

Recall: 0.9849

F1 Score: 0.9851

Decision Tree

Accuracy: 0.9899

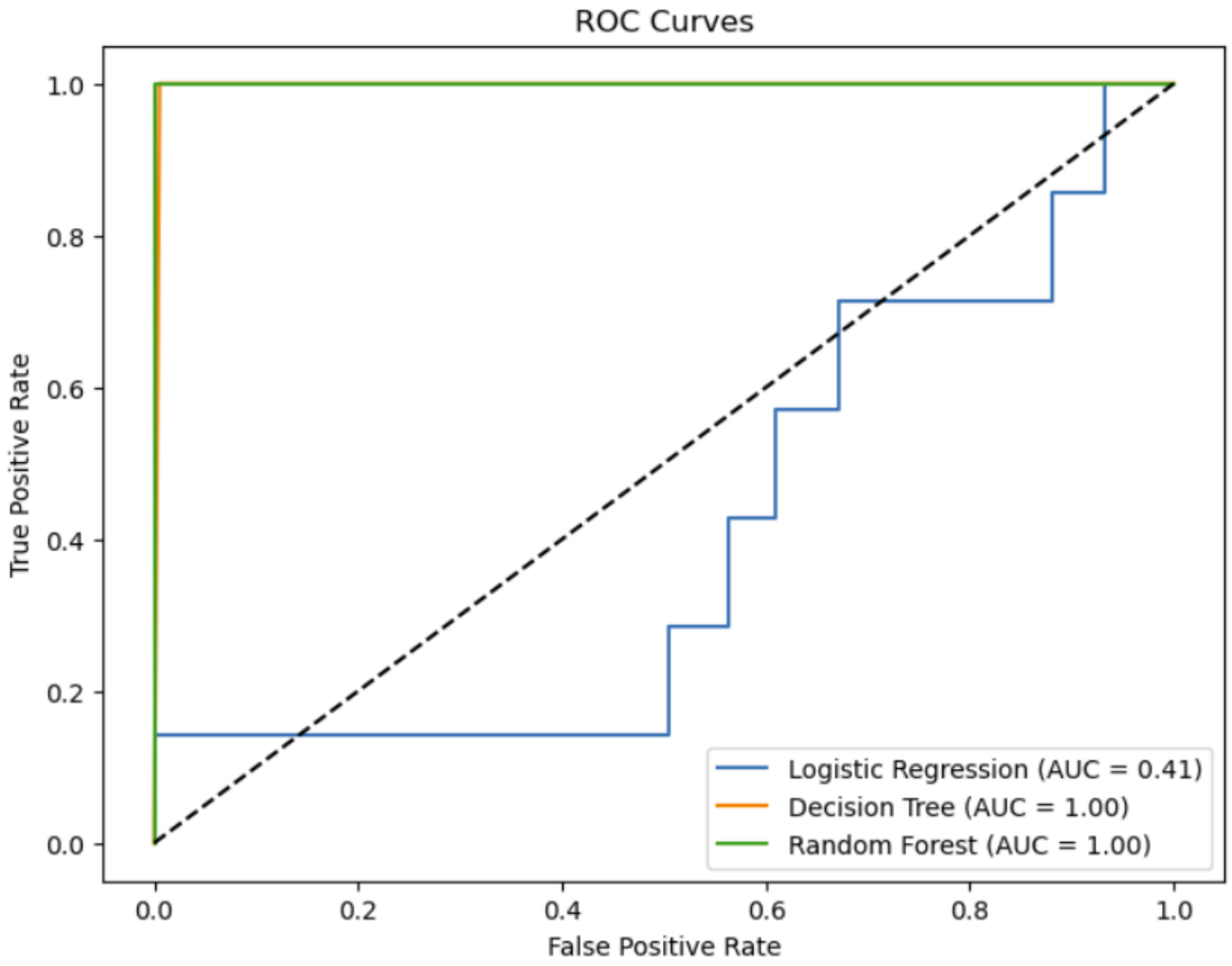
Precision: 0.9906

Recall: 0.9899

F1 Score: 0.9901

Model - Performance Visualization

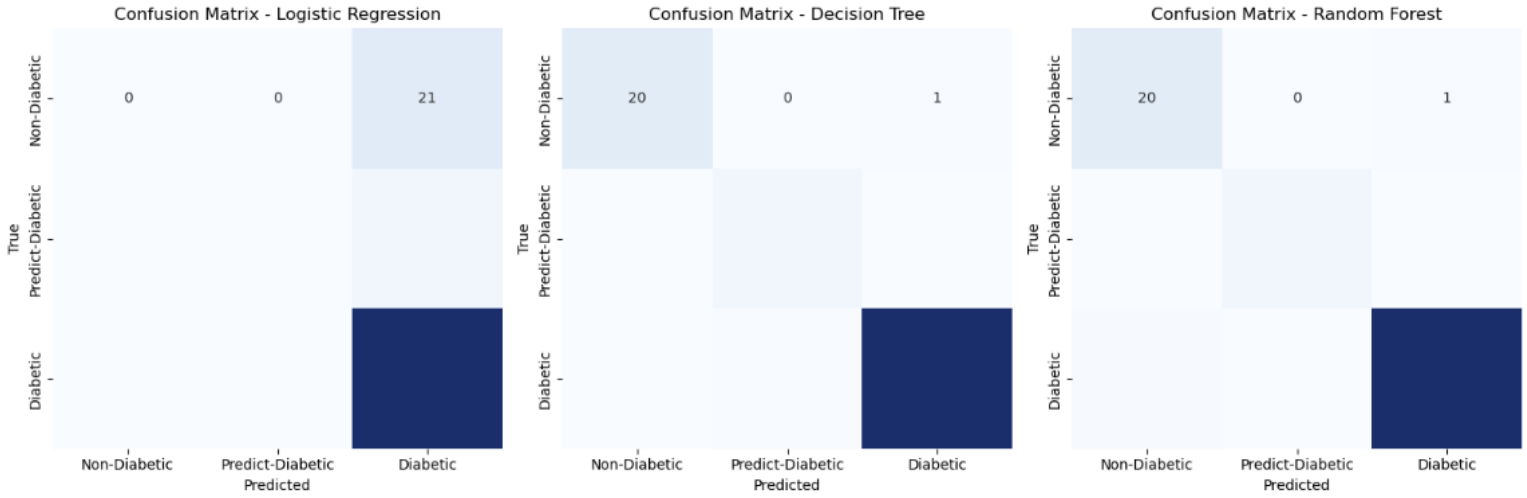
ROC curves



The ROC curves demonstrate the models' ability to discriminate between classes at different thresholds.

Model - Performance Visualization

Confusion matrices



The confusion matrices show the models' performance in correctly classifying instances of each class.

Section 5

Conclusion

Insights and Conclusion

Result

HbA1c is the best predictor for diagnosing the diabities, followed by BMI, with Random Forrest as the best model

Other Variables

To help identify the risk factor that causes higher levels HbA1c we need access to data that has variables that influence higher levels of glucose - such as stress, gestational diabites, family history, level of physical activity.

HbA1 and BMI

BMI and HbA1 are highly correlated.

Age and BMI

People's body mass index tends to go up with age.