Capstone Project – 3

Cardiovascular Risk Prediction

Submitted by
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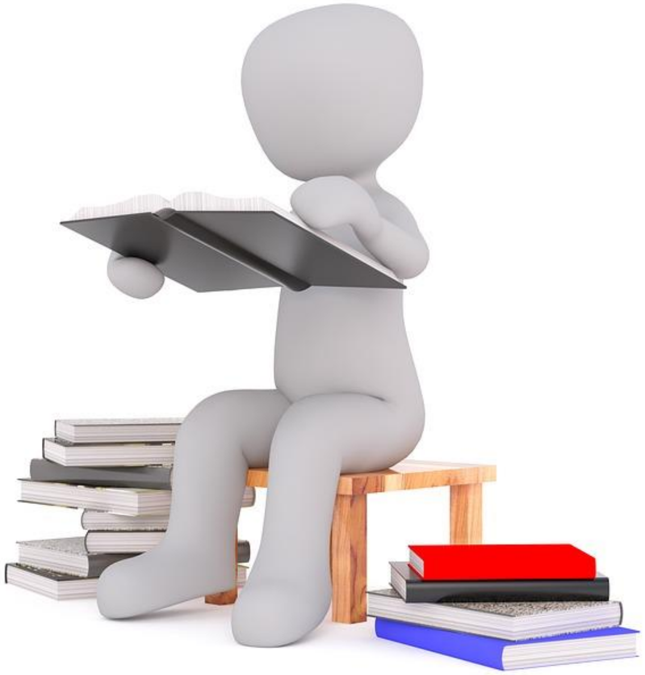
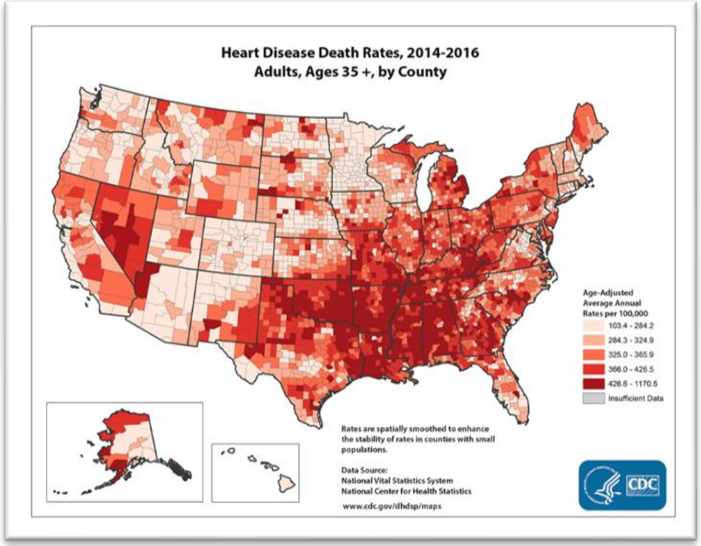


Abstract

- Cardiovascular diseases (CVDs) are the major cause of mortality worldwide.
- According to WHO, **17.9 million** people died from CVDs in 2019, accounting for **32%** of all global fatalities.
- Though CVDs cannot be treated, predicting the risk of the disease and taking the necessary precautions and medications can help to avoid severe symptoms and, in some cases, even death.



Problem Statement

- The goal of this project is to develop a classification model that can predict whether a patient is at risk of **coronary heart disease (CHD)** over the period of 10 years, based on demographic, lifestyle, and medical history.
- The data was gathered from **3390** adults participating in a cardiovascular study in Framingham, Massachusetts.

Data Summary

- **Demographic**
  - Sex
  - Age
  - Education

- **Behavioral**
  - Is smoking
  - Cigarettes per day

- **Current Medical Status**
  - Total cholesterol
  - Systolic BP
  - Diastolic BP
  - BMI
  - Heart rate
  - Glucose

- **Medical History**
  - BP medication
  - Prevalent stroke
  - Prevalent hypertension
  - Diabetes

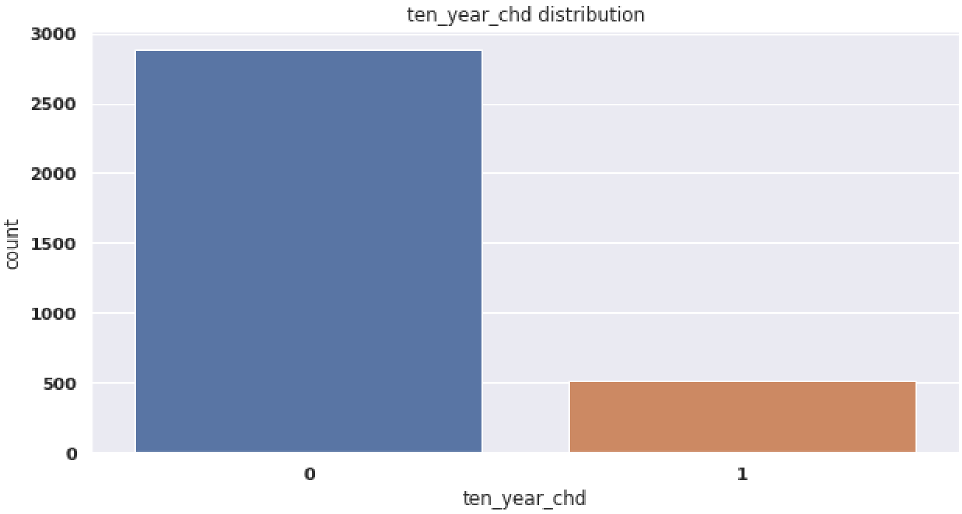
- Ten year risk of CHD ➔ DV

Handling Missing Values

- There were a total of **510** missing values in the dataset.
- Total missing values and how they were handled are as follows:
    - Education(87) , BP Medication(44) – **mode** imputation
    - Cigarettes per day(22) – imputed with **median** cigarettes per day for **smokers**
    - Total cholesterol(38), BMI(14), Heart rate(1) – **median** imputation
    - Glucose(304) – **KNN** imputation with k = 10

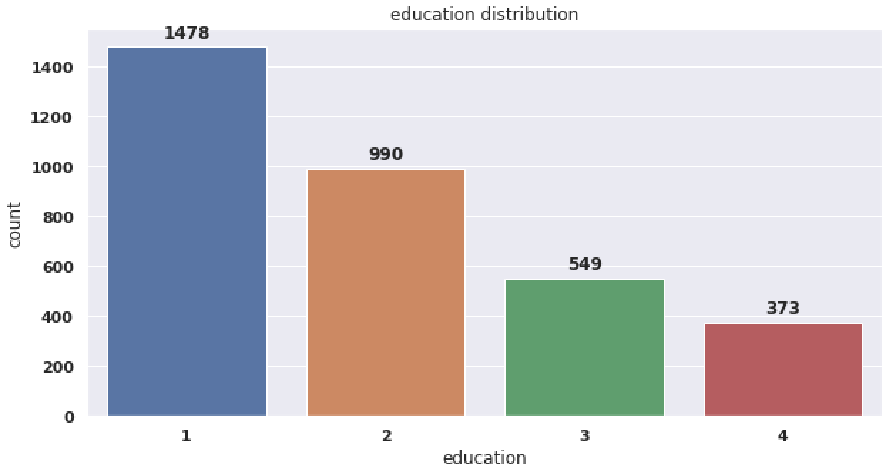
Exploratory Data Analysis (EDA)

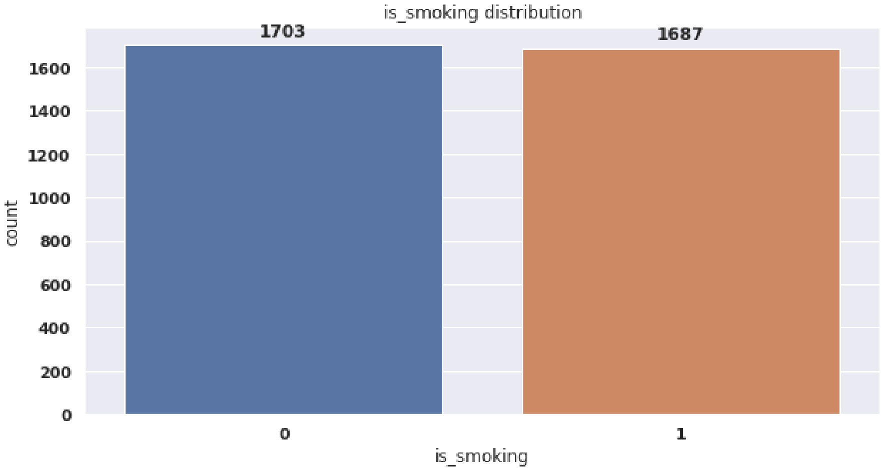
- The dependent variable is imbalanced, with just **~15%** of patients testing positive for CHD.
- All continuous independent variables are **positively skewed** except age, which is almost normally distributed.

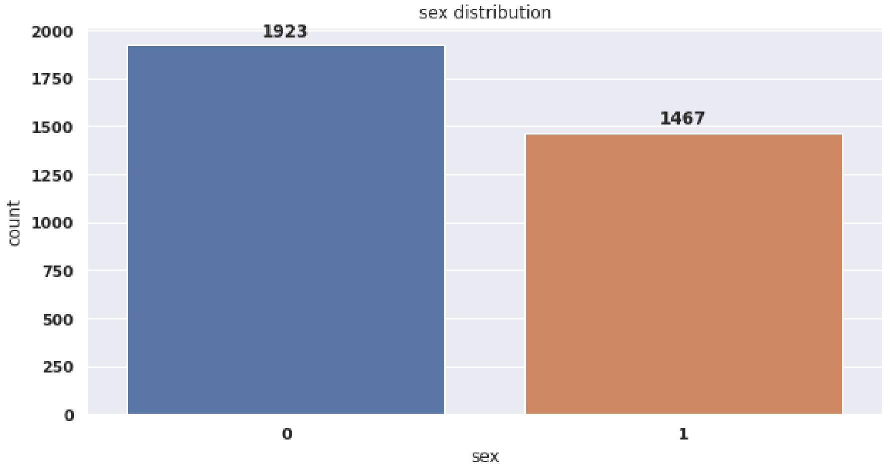


EDA (Contd.)

- **Half** the patients are smokers
- There are **more female** patients than male
- Most patients have education **level 1**

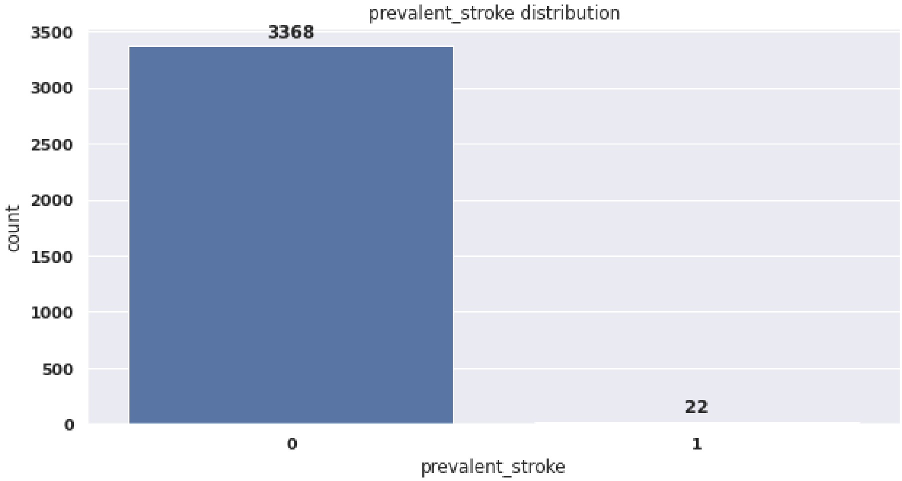


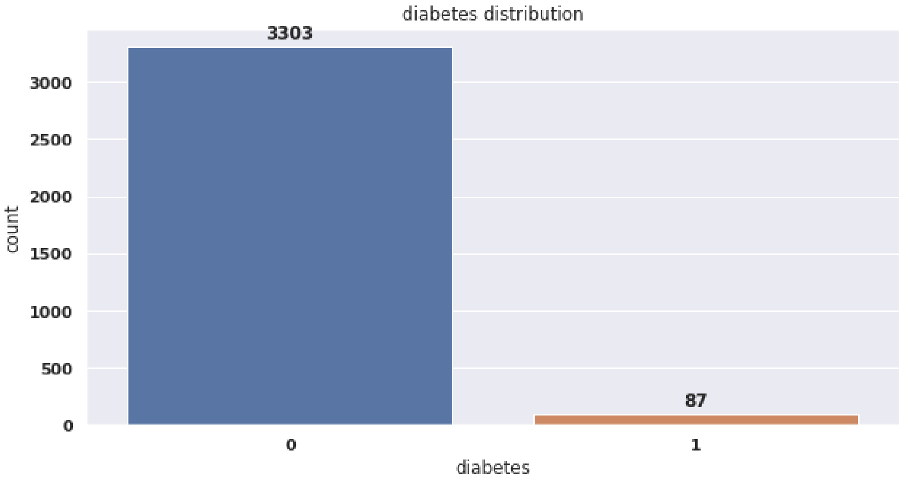


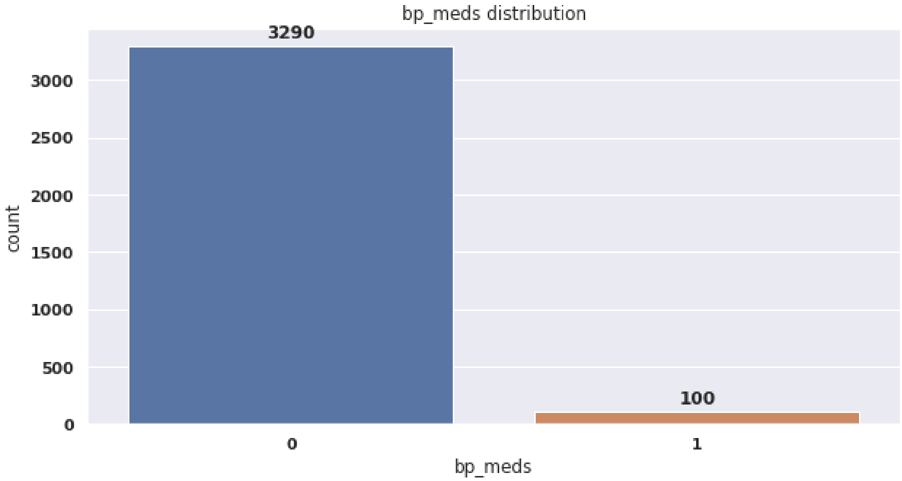


EDA (Contd.)

- There are relatively **few** individuals who have had a stroke, have diabetes, or are using blood pressure medicine.

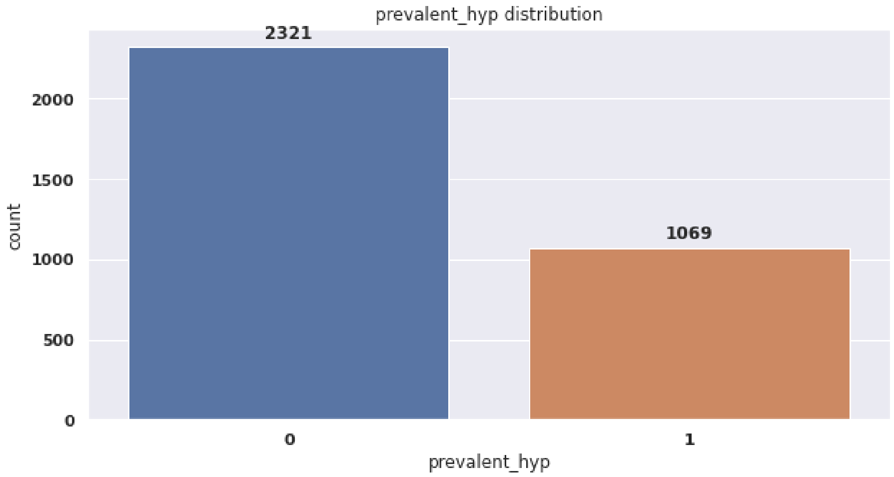


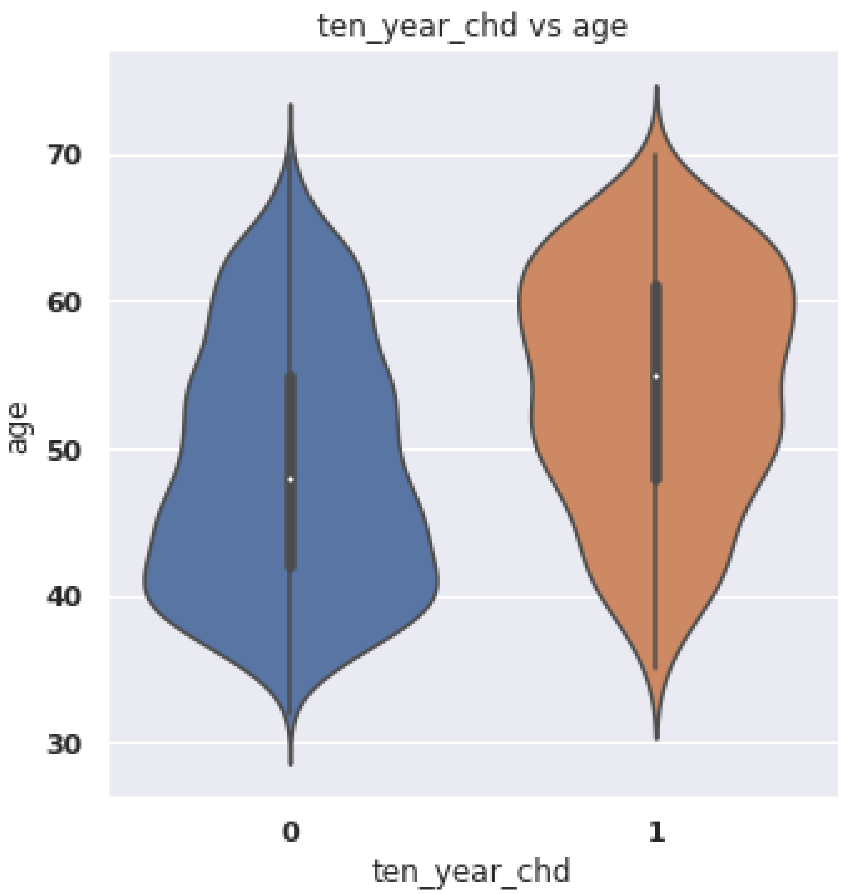




EDA (Contd.)

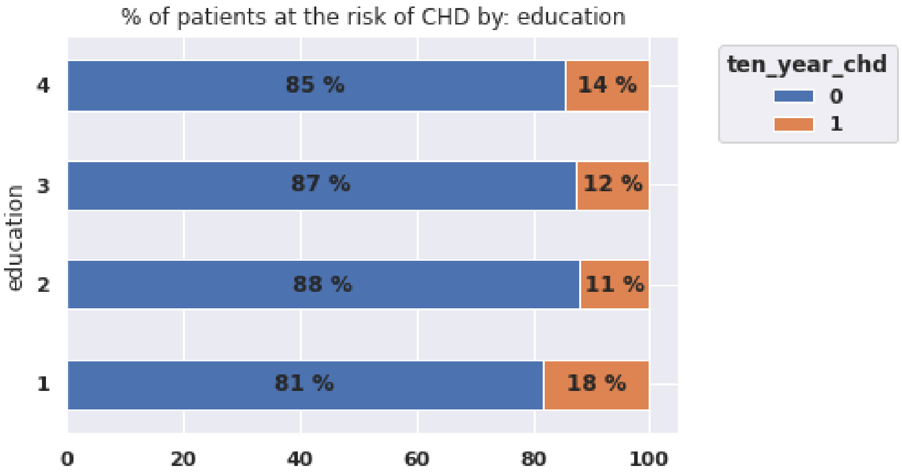
- 1069 patients have hypertension
- The risk of CHD increases with age

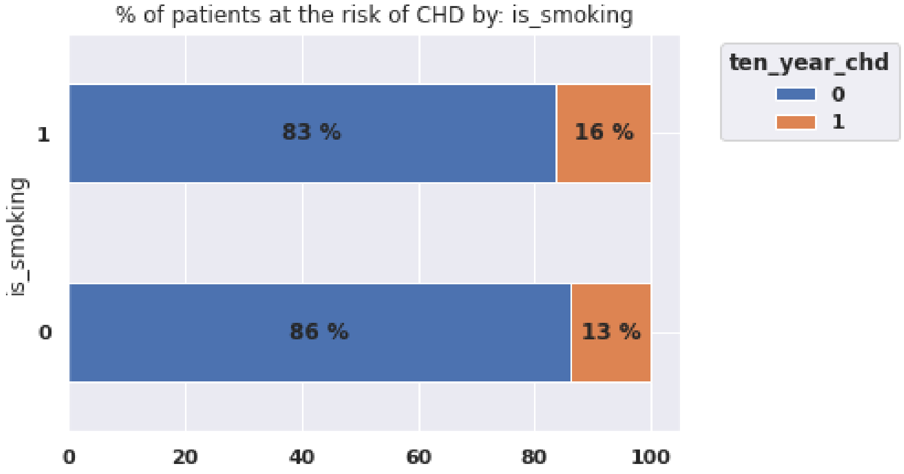


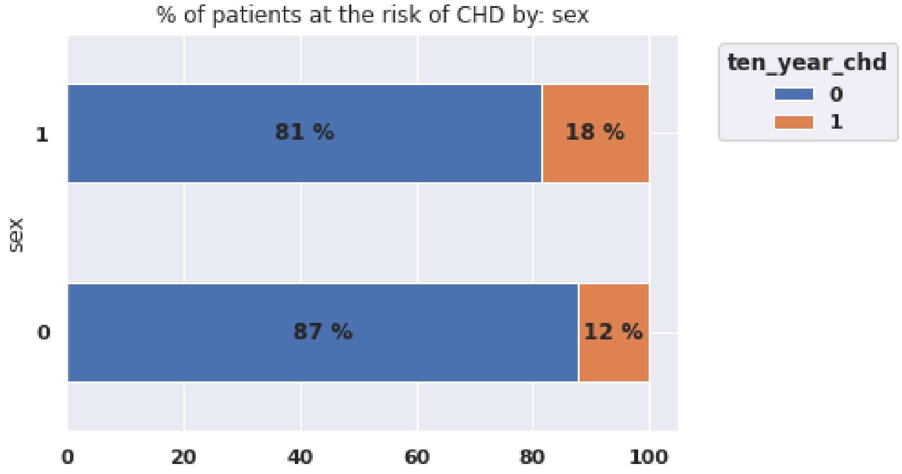


EDA (Contd.)

- The risk of CHD varies by educational level, gender, and whether or not the patient smokes.

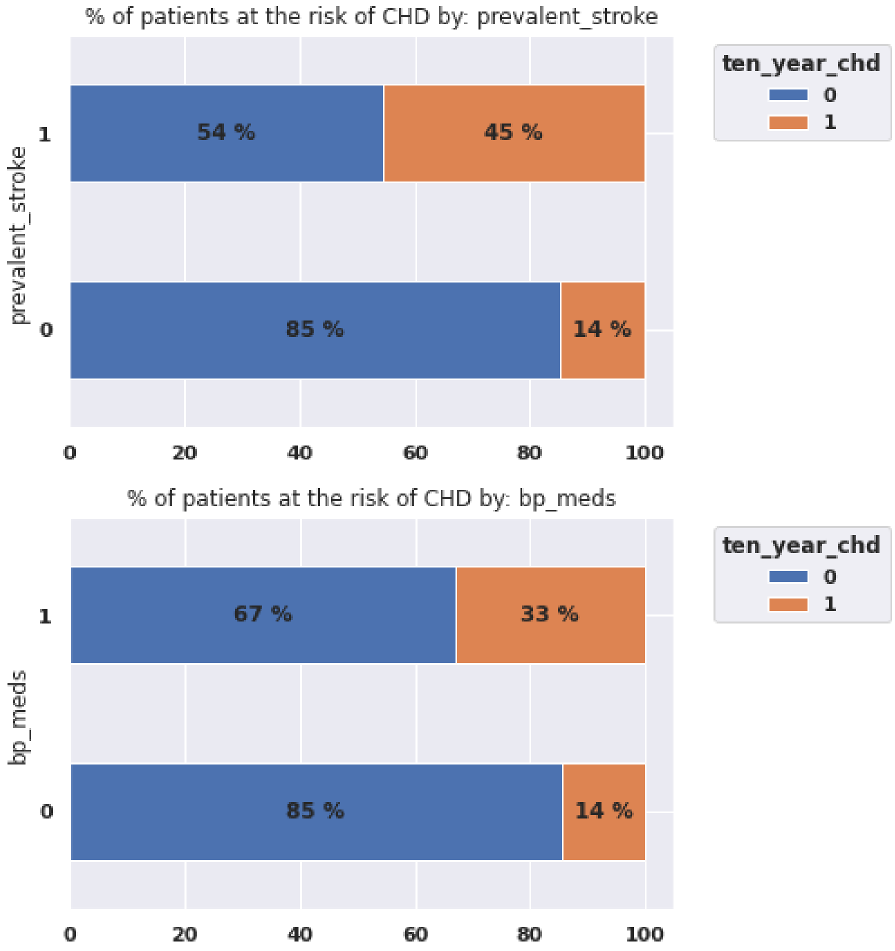






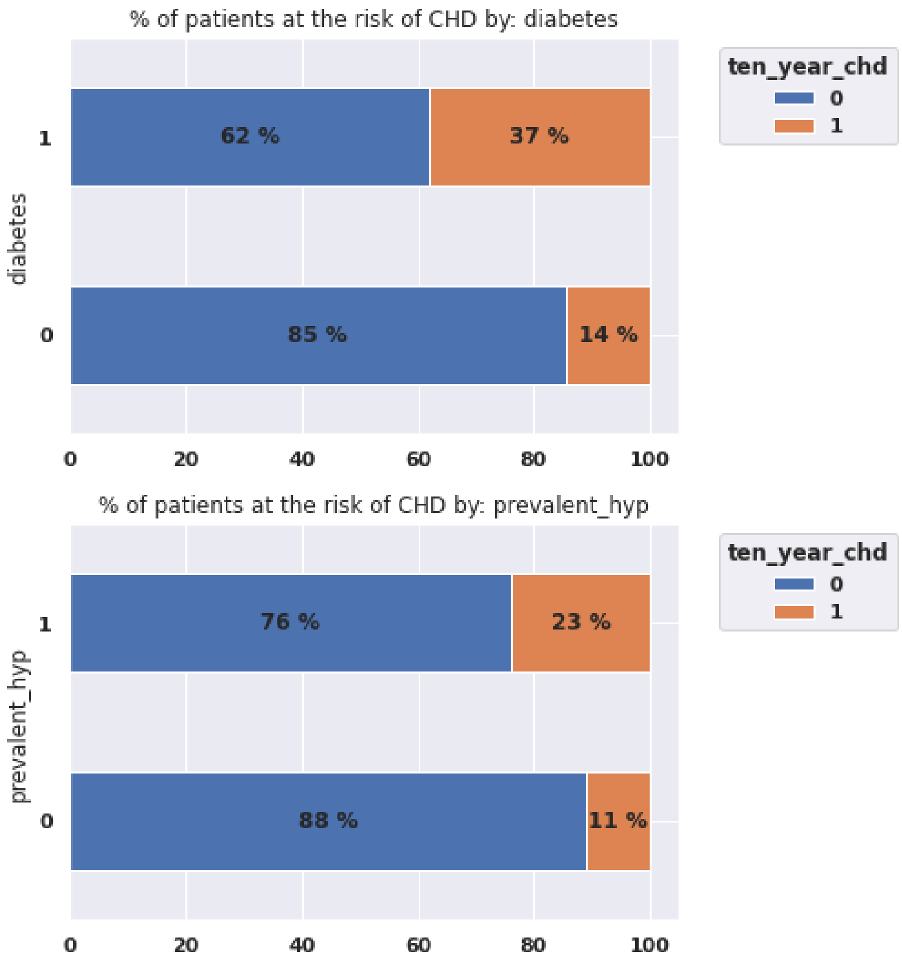
EDA (Contd.)

- Patients who have had a **stroke** or are presently on **blood pressure medication** are more likely to test positive for CHD.

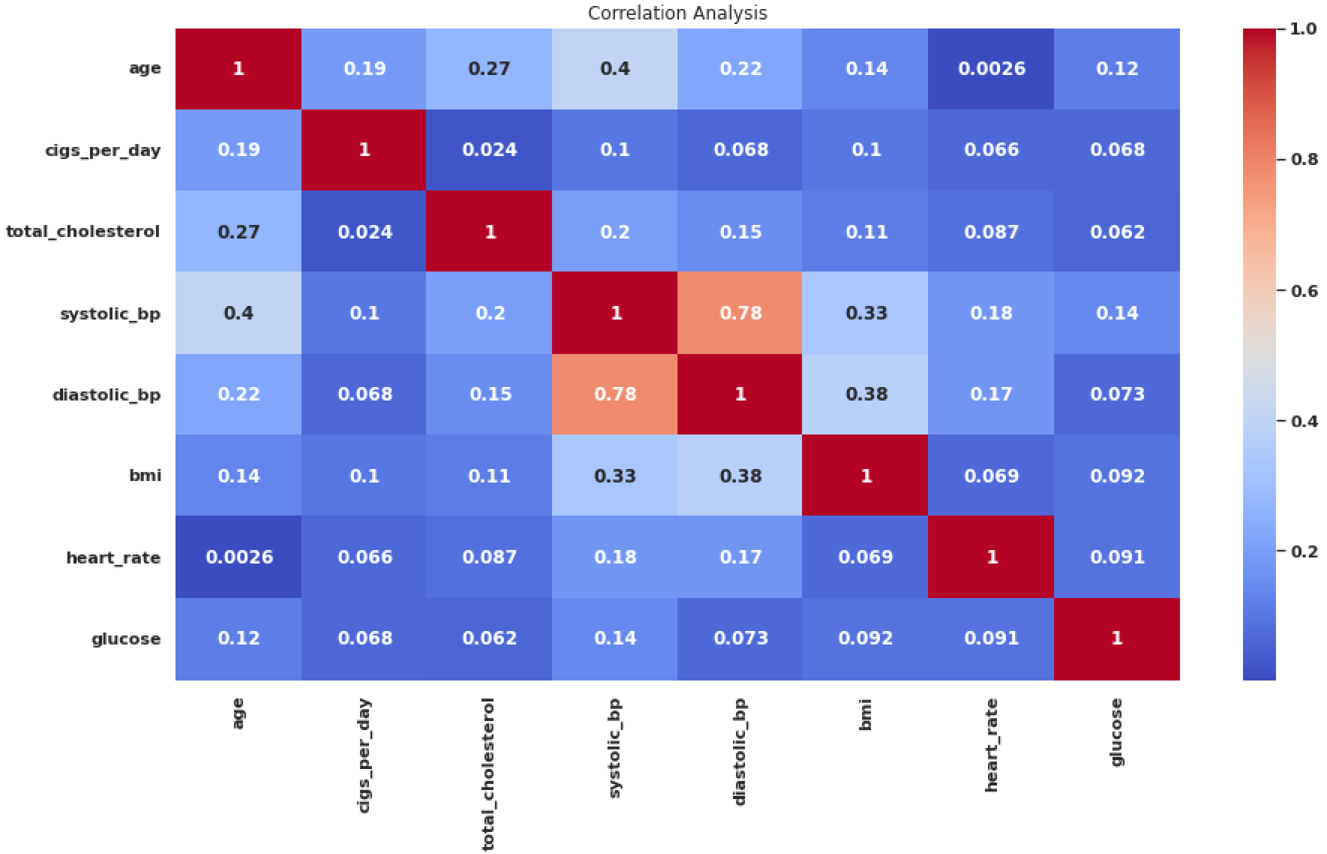


EDA (Contd.)

- Patients with **hypertension** or **diabetes** are more likely to be diagnosed with CHD.

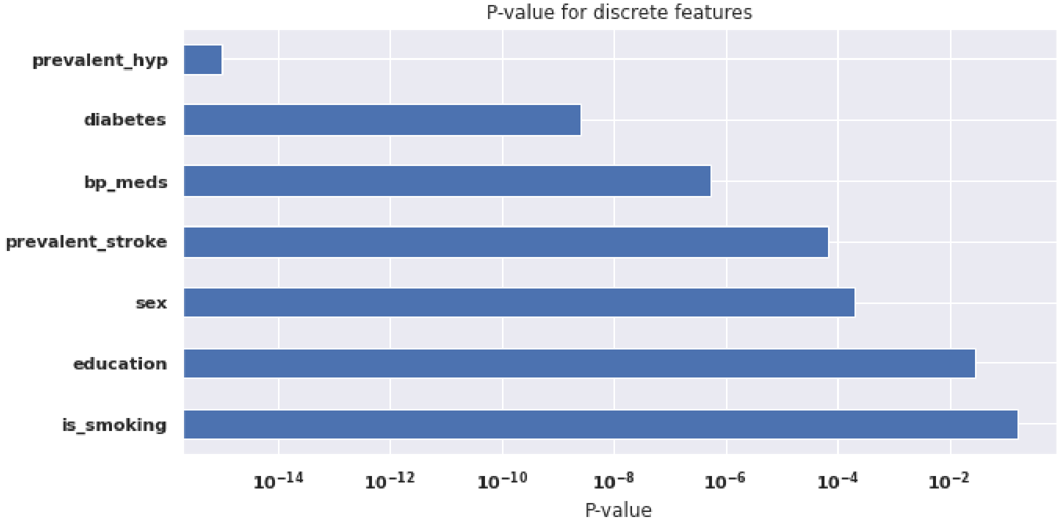


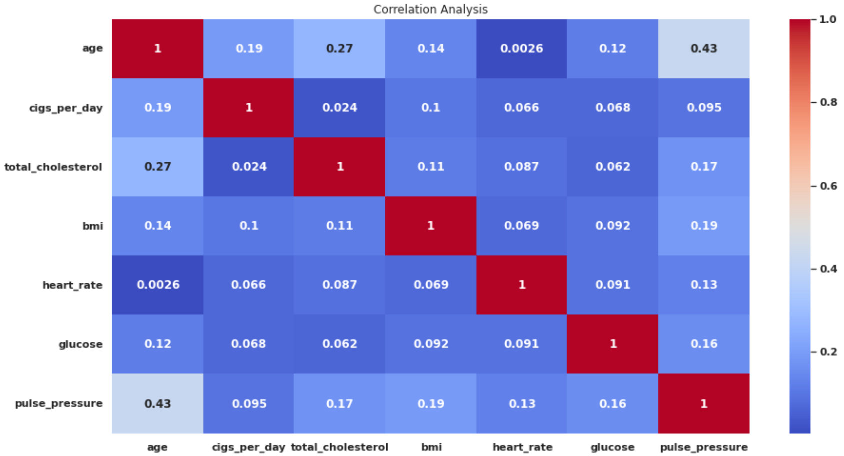
EDA (Contd.)


Correlation Analysis
age
cigs_per_day
total_cholesterol
systolic_bp
diastolic_bp
bmi
heart_rate
glucose
1 0.19 0.27 0.4 0.22 0.14 0.0026 0.12
0.19 1 0.024 0.1 0.068 0.1 0.066 0.068
0.27 0.024 1 0.2 0.15 0.11 0.087 0.062
0.4 0.1 0.2 1 0.78 0.33 0.18 0.14
0.22 0.068 0.15 0.78 1 0.38 0.17 0.073
0.14 0.1 0.11 0.33 0.38 1 0.069 0.092
0.0026 0.066 0.087 0.18 0.17 0.069 1 0.091
0.12 0.068 0.062 0.14 0.073 0.092 0.091 1
1.0
0.8
0.6
0.4
0.2

Feature Engineering

- Pulse Pressure = Systolic BP – Diastolic BP
- The Chi2 test on discrete features indicates that the 'is_smoking' column has the highest p-value and so is the least relevant feature. As a result, we drop it.





Handling Skew

- The skew in continuous variables is reduced by performing log10 / inverse transformations.

Attribute	Original skew	Transformation Used	Skew After Transformation
Age	0.225796	Log10	-0.015053
Cigarettes Per Day	1.204077	Log10	0.275072
Total Cholesterol	0.948170	Log10	0.011860
BMI	1.025551	Log10	0.370422
Heart Rate	0.676660	Log10	0.165898
Glucose	6.361911	Inverse	-0.297404
Pulse Pressure	1.412382	Log10	0.354174

Summary so far...

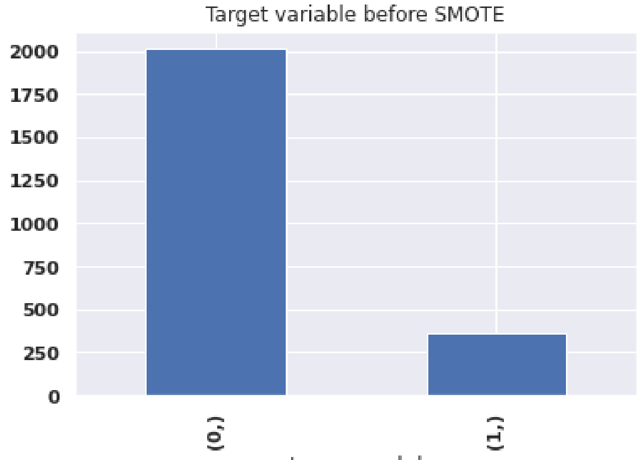
- We defined the problem statement
- Handled the missing values
- Created data visualizations
- Performed feature engineering and feature selection
- Transformed continuous independent variables to reduce skew.

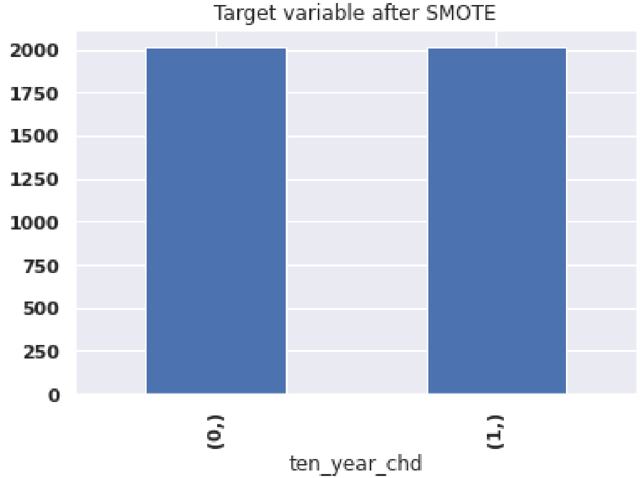
Modelling Approach

- Data points in test data set = 30%
- Choice of split: Repeated stratified K fold, k = 4
- Evaluation metric: Recall

$$\text{Recall} = \frac{\textit{True Positive}}{\textit{False Negative} + \textit{True Positive}}$$

- Hyperparameter tuning: Gridsearchcv
- Oversampling strategy: SMOTE
- Data points before SMOTE = 2373
- Data points after SMOTE = 4030
- Scaler used: Standard Scaler

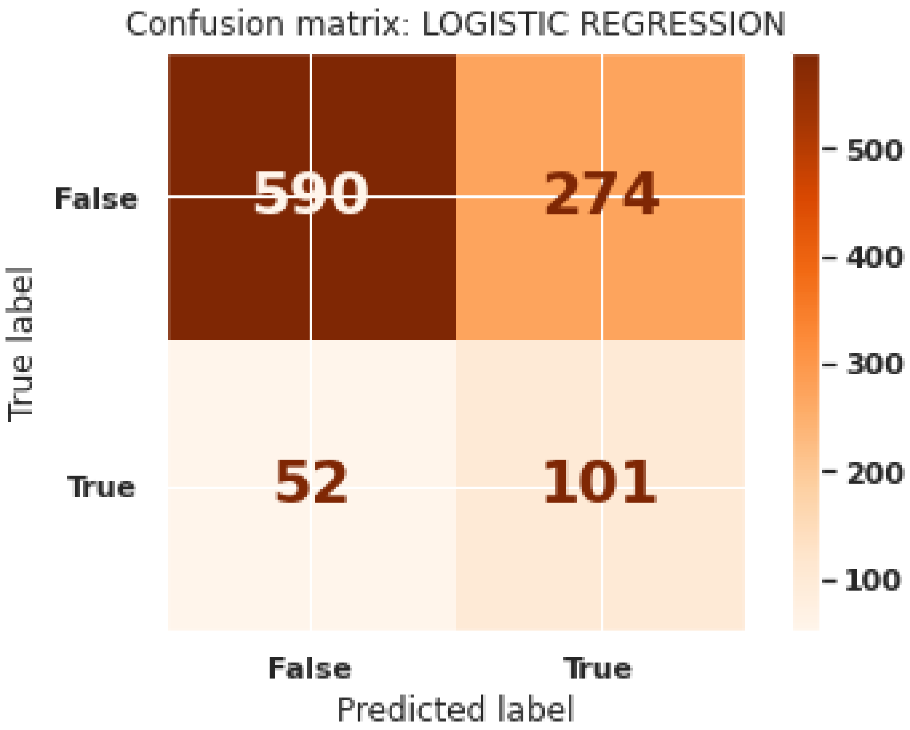




Logistic Regression

Evaluation metrics:

- Train Recall = 0.6923
- Test Recall = 0.6601
- Test Accuracy = 68%



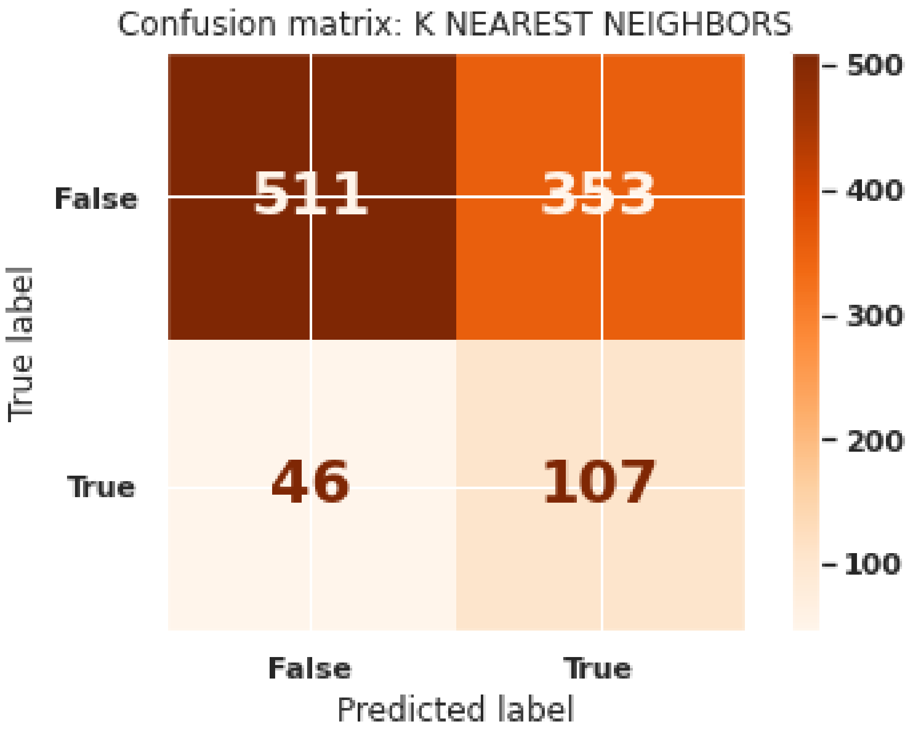
K-Nearest Neighbors

Parameters:

- K = 55

Evaluation metrics:

- Train Recall = 0.8312
- Test Recall = 0.6993
- Test Accuracy = 61%



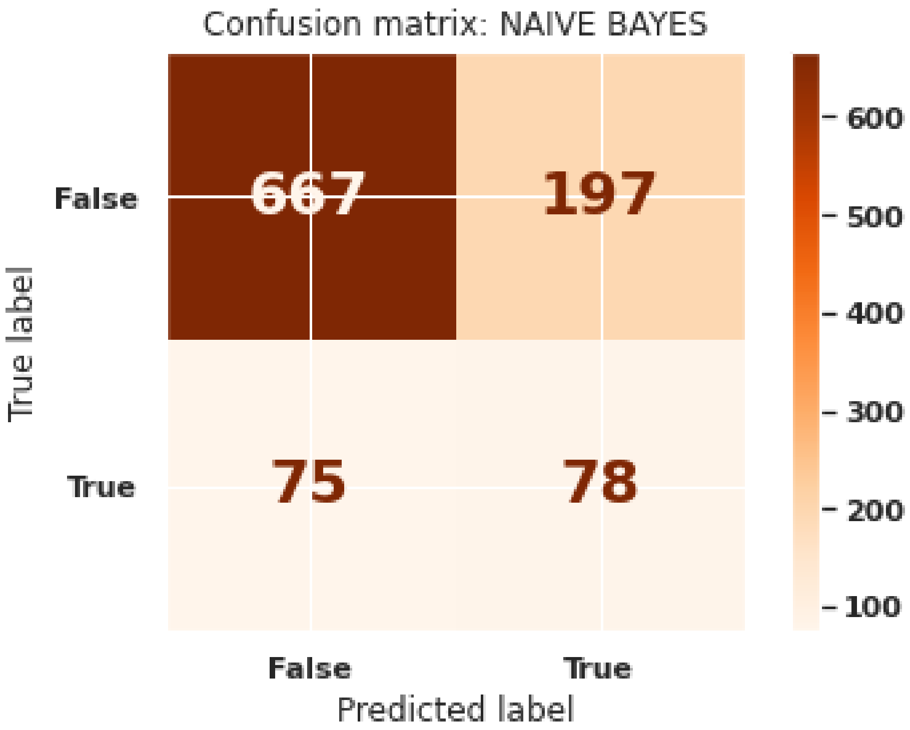
Naïve Bayes

Parameters:

- var_smoothing= 0.6579

Evaluation metrics:

- Train Recall = 0.533
- Test Recall = 0.5098
- Test Accuracy = 61%



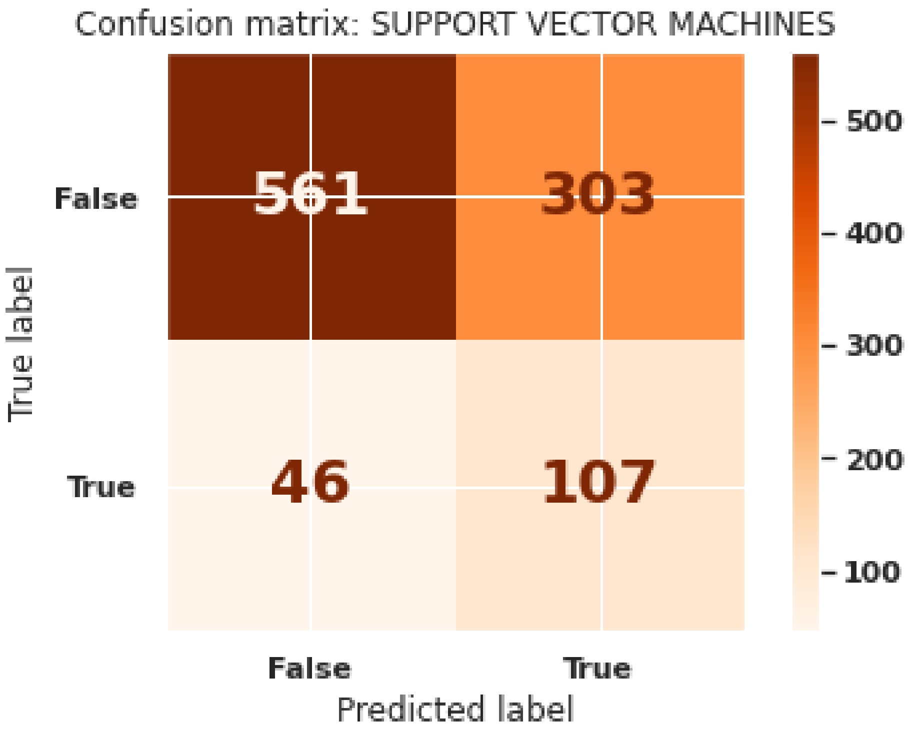
Support Vector Machines

Parameters:

- C = 1
- Gamma = 0.01
- Kernel = rbf

Evaluation metrics:

- Train Recall = 0.7478
- Test Recall = 0.6993
- Test Accuracy = 66%



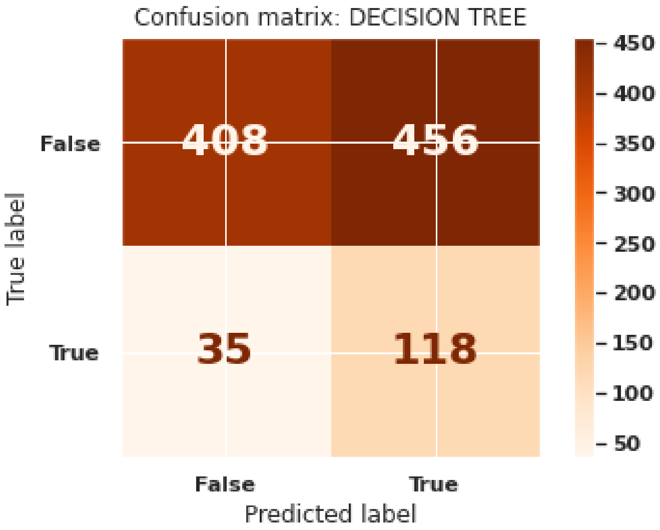
Decision Tree

Parameters:

- max_depth = 1
- min_samples_leaf = 0.1
- min_samples_split = 0.1

Evaluation metrics:

- Train Recall = 0.86
- Test Recall = 0.7712
- Test Accuracy = 52%



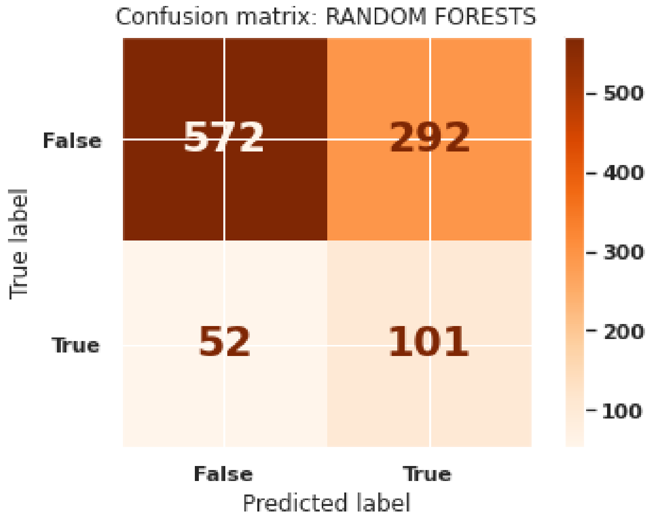
Random Forests

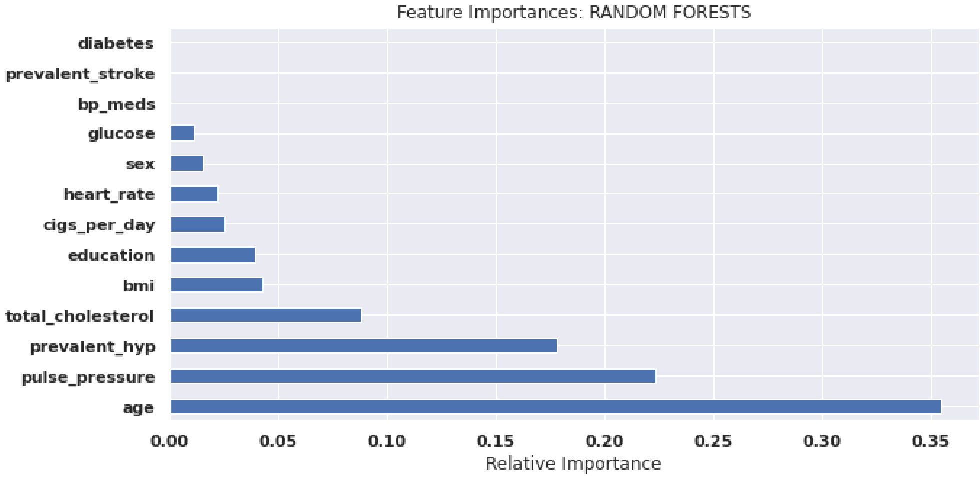
Parameters:

- max_depth = 2
- min_samples_leaf = 0.1
- min_samples_split = 0.1
- n_estimators = 500

Evaluation metrics:

- Train Recall = 0.7062
- Test Recall = 0.6601
- Test Accuracy = 66%





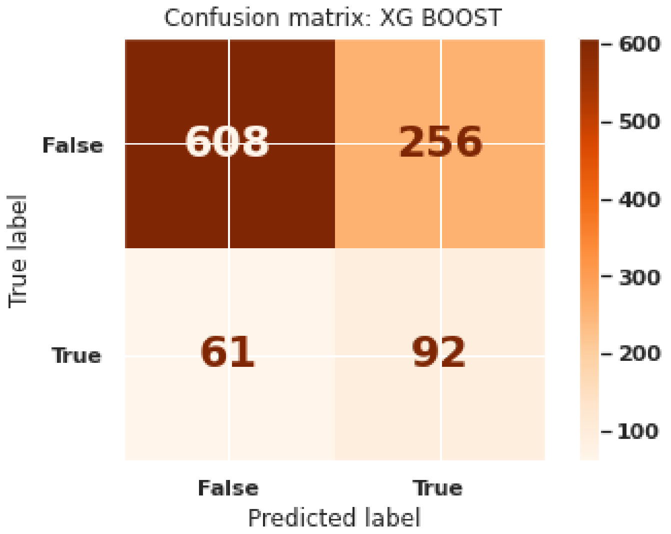
XG Boost

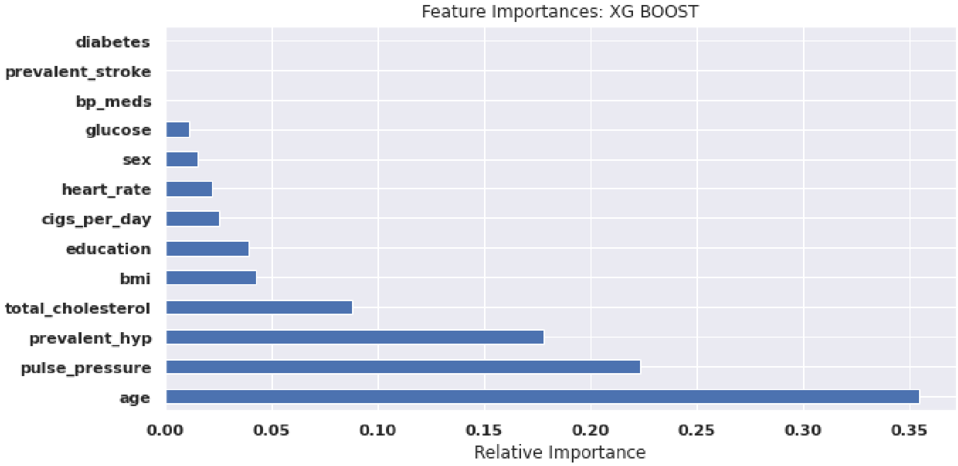
Parameters:

- max_depth = 1
- min_samples_leaf = 0.1
- min_samples_split = 0.1
- n_estimators = 500

Evaluation metrics:

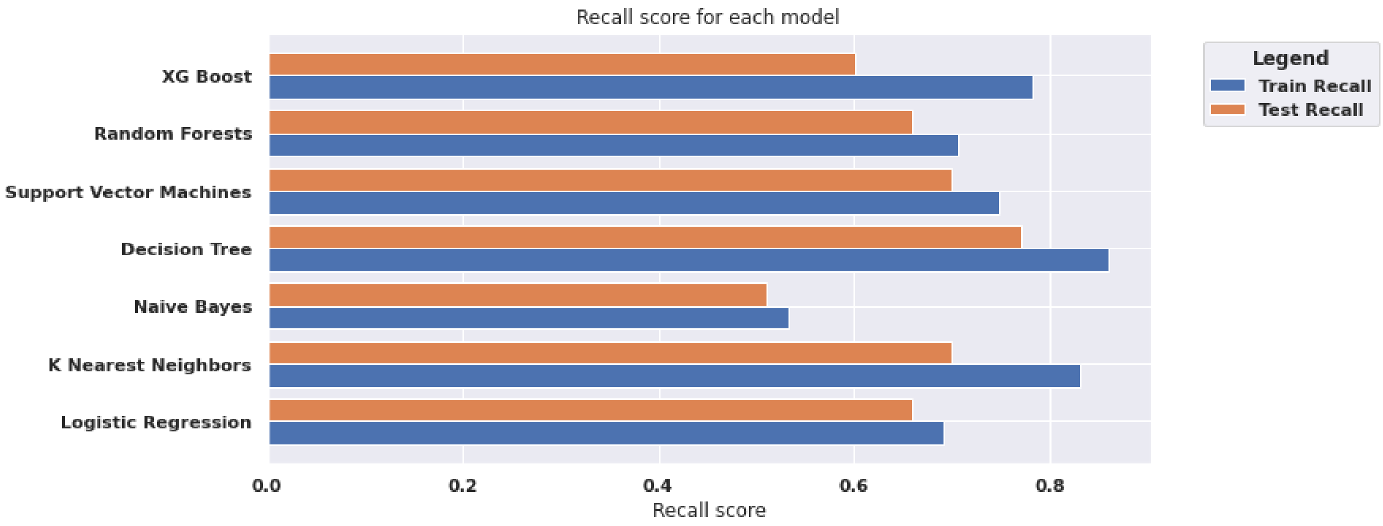
- Train Recall = 0.7831
- Test Recall = 0.6013
- Test Accuracy = 69%





Model Comparison

- The Decision Tree model has the highest test Recall compared to other models.



Challenges Faced

- Comprehending the problem statement, and understanding the business implications – understanding the importance of predicting the risk of this disease
- Handling missing values in the dataset, and working with limited availability of data
- Feature engineering – deciding on which features to be dropped / kept / transformed
- Choosing the best visualization to show the trends among different features clearly in the EDA phase
- Choosing the best hyperparameters, which prevents overfitting

Conclusion

- We have successfully built predictive models that can predict a patients risk for CHD based on their demography, lifestyle, and medical history.
- The predictive models built were evaluated using Recall, and it was found that decision tree (0.77) has the highest test recall compared to other models.
- Efforts must be put into gathering more data, and also include people who have undergone different medical conditions.
- Future developments must include a strategy to improve the model recall score, enabling us to save even more lives from this disease.

Thank You!