Data Analytics and Machine Learning STAT555

Department of Analytics in the Digital Era (UAEU)

FACTORS PREDICTING HEART DISEASE

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Subject:

Contents

ABSTRACT

Heart disease is a leading cause of death worldwide, and risk factors include high blood pressure, high cholesterol, smoking, diabetes, obesity, and a sedentary lifestyle. The prediction of Heart disease can be described through various factors that affect the heart and blood vessels. These conditions can include coronary artery disease, heart rhythm disorders, heart failure, and many others. The purpose of the paper is to aim to identify the various factors predicting heart disease. The comprehensive study analyses the effect of lifestyle factors on the development of heart disease. As well as explores the impact of environmental factors on cardiovascular health.

Additionally, the study addresses the role of genetics and family history in predisposing individuals to heart disease. This study concludes the significance of the various factors that predict heart disease and provides useful strategies and conclusions to decrease and prevent heart disease.

1- Literature review

Heart disease is one of the leading causes of death around the world. It entirely depends on multiple factors and several risk factors have been identified, including age, sex, smoking, hypertension, diabetes, and obesity. While some risk factors are modifiable, others, such as age and sex, are not. Several studies have investigated the relationship between sex and heart disease and have shown that there are differences in the prevalence, presentation, and outcomes of heart disease between males and females.

One of the earliest studies to explore the differences between males and females with heart disease was the Framingham Heart Study, which found that men had a higher incidence of coronary heart disease than women until age 75, after which the incidence rates were similar. However, women tended to have a higher mortality rate than men after a heart attack.

Other studies have also shown differences in the prevalence of risk factors between males and females. For example, men tend to have a higher prevalence of smoking, hypertension, and dyslipidemia, while women tend to have a higher prevalence of diabetes, obesity, and metabolic syndrome. These differences in risk factor profiles may contribute to the differences in the incidence and outcomes of heart disease between males and females.

In addition to differences in risk factors, there are also differences in the presentation of heart disease between males and females. Women tend to present with atypical symptoms, such as fatigue, shortness of breath, and nausea, which may lead to delays in diagnosis and treatment. Men, on the other hand, tend to present with the classic symptoms of chest pain and discomfort.

Several studies have also investigated the differences in treatment and outcomes between males and females with heart disease. While there have been improvements in the management of heart disease in recent years, disparities still exist between males and females. For example, women are less likely to receive guideline-recommended treatments such as aspirin, beta-blockers, and statins after a heart attack or other cardiac event. This may contribute to the higher mortality rates observed in women with heart disease.

This Report suggests that there are differences in the prevalence, presentation, and outcomes of heart disease between males and females. These differences may be due to variations in risk factor profiles, symptom presentation, and treatment patterns. Further research is needed to better understand the underlying mechanisms and to develop targeted interventions to reduce the disparities in heart disease outcomes between males and females.

In this report, we used different techniques and methodologies to identify the best predicting factor and their proportion. furthermore, it also provides, which gender has tending to have heart disease more.

2- Introduction

This Report involves the Model prediction using regression algorithms including logistic regression through the logit approach. We use Logistic regression to do an analysis of the relationship between a binary dependent variable and other independent variables. As well as estimates the probability of a binary outcome based on the values of the independent variables. The output of the model is a logistic function, which transforms the linear combination of the independent variables into a probability value between 0 and 1.

Heart disease is a leading cause of the death globally. There is a range of factors affecting the heart and blood vessels, including coronary artery disease, heart failure, and arrhythmias. We analyse factors that cause the development of heart disease. Furthermore understanding of the risk factors, lifestyle influences, demographic considerations, comorbidities, and the latest advancements in the field. This report analyses a dataset using the R programming language to identify factors predicting heart disease. These factors can include coronary artery disease, heart rhythm disorders, and heart failure The study examines modifiable and non-modifiable risk factors, including lifestyle choices, environmental factors, genetics, and biomarkers. The data is the Statlog Heart Disease dataset taken from the UCI repository and prepared for analysis using statistical methods including data cleaning, data transforming and data encoding. The report discusses the various conditions for the prevention of heart disease.

Heart disease is a complex condition that affects millions of people worldwide, and identifying the risk factors that contribute to its development is crucial for prevention and treatment.

2.1- Research Question

Our research question is to analyze the factors predicting heart disease. Our main goal is to study the various factors that predict heart disease. This report is centred on understanding the key predictors of heart disease, including age, gender, high blood pressure, high cholesterol, smoking, diabetes, and obesity. Further, We explore the relationship between these factors and how they lead to the development of heart disease, as well as their interactions with one another. This research will predict the various factors causing heart disease

2.2- Objective

The main purpose of conducting this research is to provide valuable about the predicting factors of heart disease and identification of the key risk factors that can be implemented for the prevention and treatment of the h. Our findings will be of great significance to healthcare professionals, policymakers, and individuals at risk of developing heart disease, as this can be done by using significant statistical models that give the best analysis of the data. Furthermore, this report also highlights the essential techniques and methodology which can be adopted throughout the research report, in order to get the required results.

2.3- Structure of the paper

The first chapter briefly explains the purpose of this study, a detailed introduction to the data and the collection of the data. We briefly introduced the methods, techniques and statistical algorithms used in this research report. The second Chapter is about the description of the data, and elaboration of all the attributes in the heart disease data set. The Third Chapter is About the Discussion and results, it contains a comprehensive analysis of all the factors and their impact in causing heart disease

3- Data

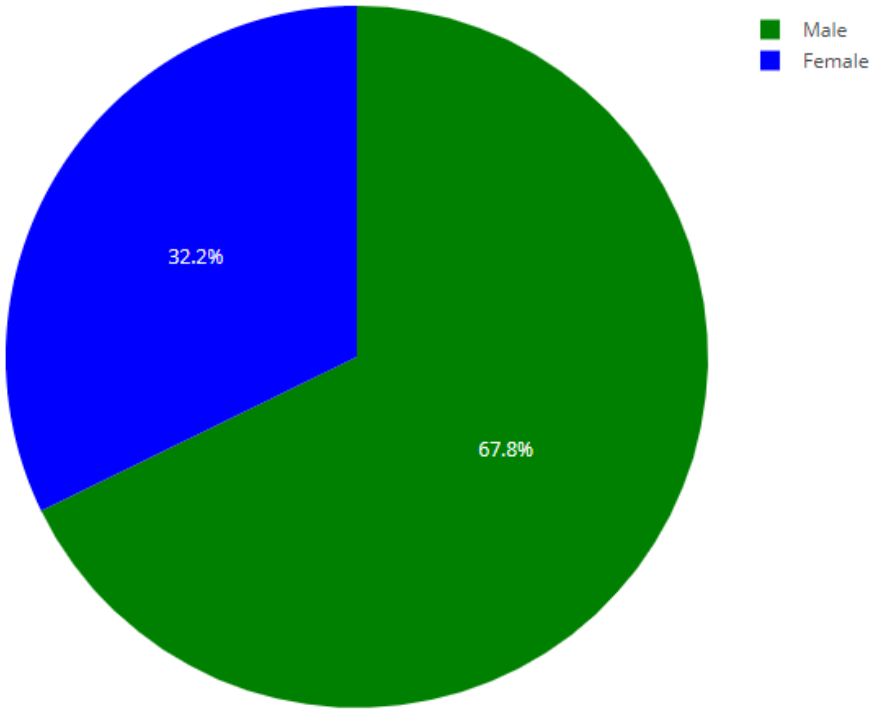
The dataset is taken from the UCI repository, it belongs to the Statlog Heart Disease dataset. The Heart disease dataset contains the data of 270 individuals. The data set consists of 14 columns which have been extracted from a larger set of 75. The data set has Not any null values or missing values. The aim of this report is to predict whether an individual is suffering from heart disease or not. For this we choose 0 and 1 to identify whether the individual is suffering from heart disease or not, 0 indicates the absence of heart disease whereas 1 indicates the presence of heart disease

This database contains 13 attributes and a target variable. It has 8 nominal values and 5 numeric values. A detailed description of all these features is as follows:

1. Age: Patients Age in years (Numeric)
2. Sex: Gender (Male: 1; Female : 0) (Nominal)
3. cp: Type of chest pain experienced by the patient. This term is categorized into 4 categories. 0 typical angina, 1 atypical angina, 2 non-anginal pain, 3 asymptomatic (Nominal)
4. treetops: patient's level of blood pressure at resting mode in mm/HG (Numerical)
5. chol: Serum cholesterol in mg/dl (Numeric)
6. FBS: Blood sugar levels on fasting > 120 mg/dl represent 1 in case of true and 0 as false (Nominal)
7. restecg: The result of an electrocardiogram while at rest is represented in 3 distinct values 0: Normal 1: having ST-T wave abnormality (T wave inversions and/or ST elevation or depression of > 0.05 mV) 2: showing probable or definite left ventricular hypertrophy by Estes' criteria (Nominal)
8. thalacha: Maximum heart rate achieved (Numeric)
9. exang: Angina induced by exercise 0 depicting NO 1 depicting Yes (Nominal)
10. old peak: Exercise-induced ST depression relative to the state of rest (Numeric)
11. slope: ST segment measured in terms of the slope during peak exercise 0: up sloping; 1: flat; 2: down sloping(Nominal)
12. ca: The number of major vessels (0–3)(nominal)
13. thal: A blood disorder called thalassemia 0: NULL 1: normal blood flow 2: fixed defect (no blood flow in some part of the heart) 3: reversible defect (a blood flow is observed but it is not normal(nominal)
14. target: It is the target variable which we have to predict 1 means the patient is suffering from heart disease and 0 means the patient is normal. Variable to be predicted Absence (1) or presence (2) of heart disease.

3.1- Exploratory Data Analysis

Firstly, we implement the Exploratory data analysis technique on a data set, including Data Wrangling, Cleaning and Transformation. After these techniques, the dimensions of our data set are 14 columns and 270 Rows.



Our dataset Heart disease has more proportion of males rather than females. It consists of 67.8% male and 32.2% of female population.

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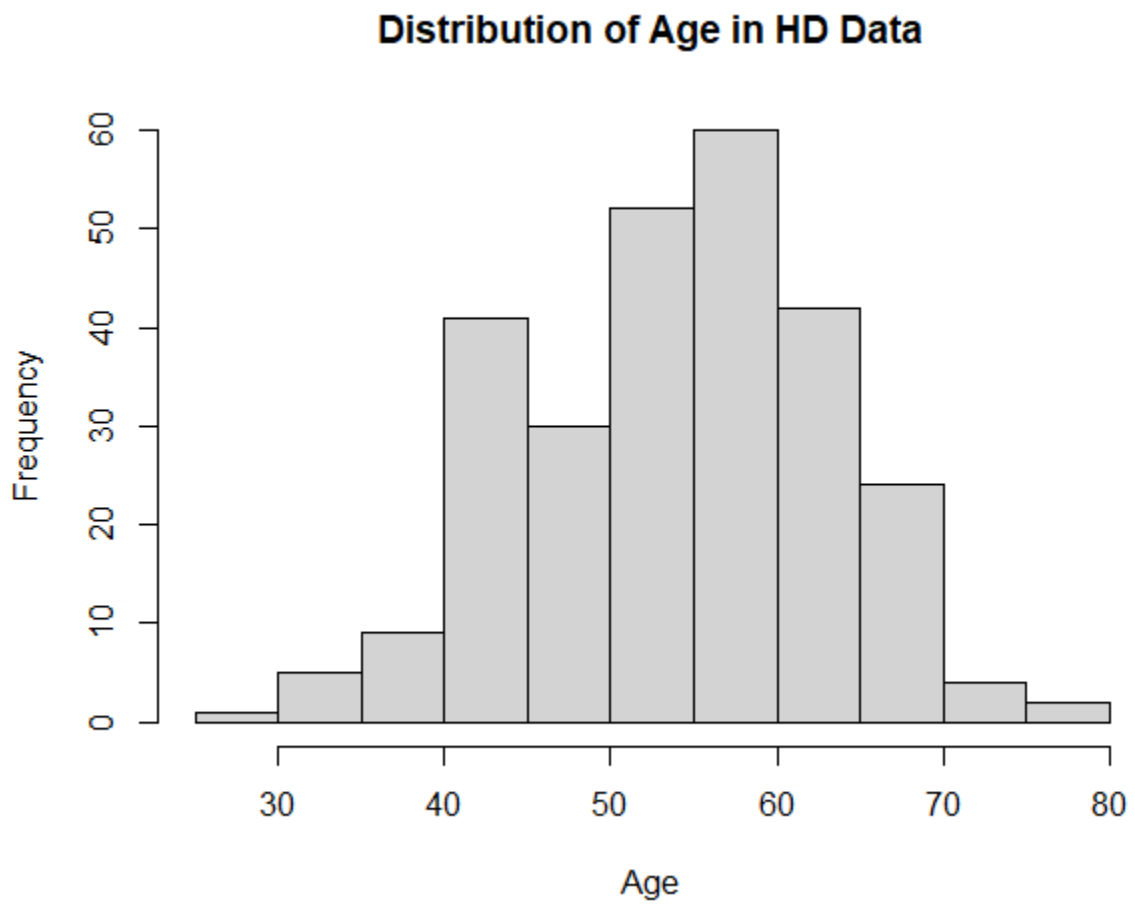
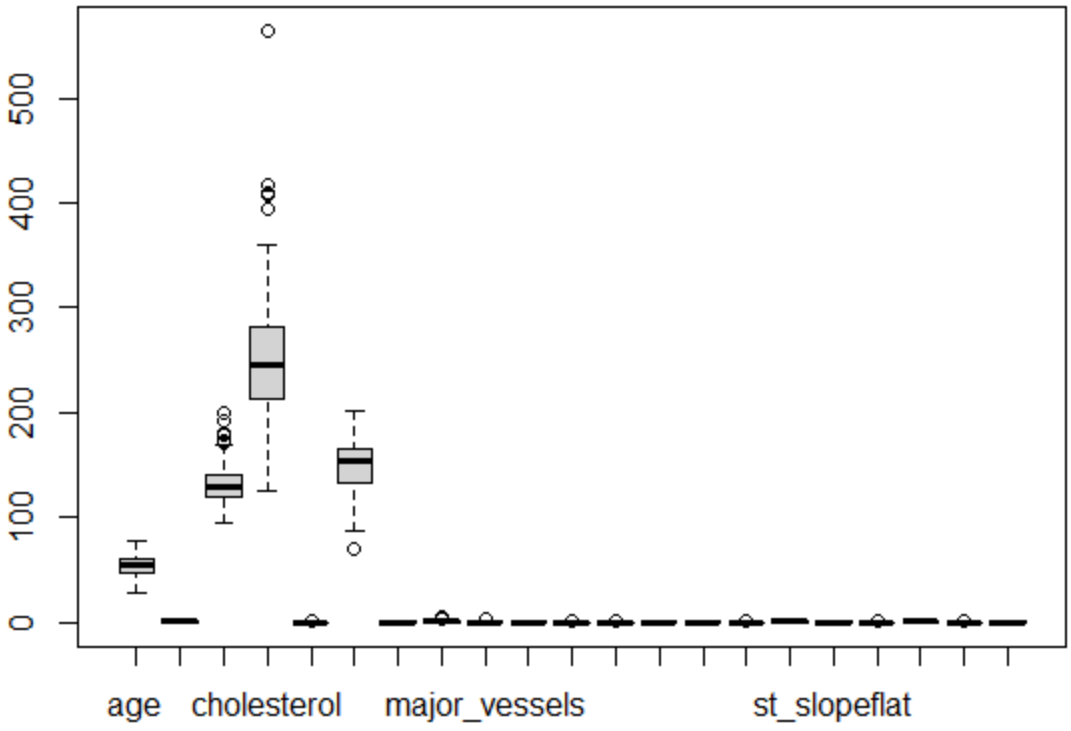


This project of heart disease has the Age predicting Factor lies between 29 to 77 years old. It shows our data set has individuals of age between 29 to 77 years old.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age
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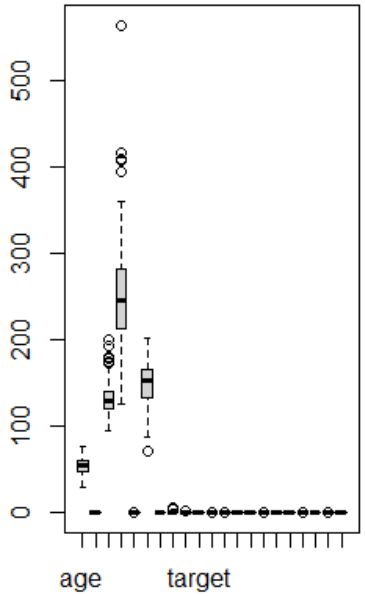
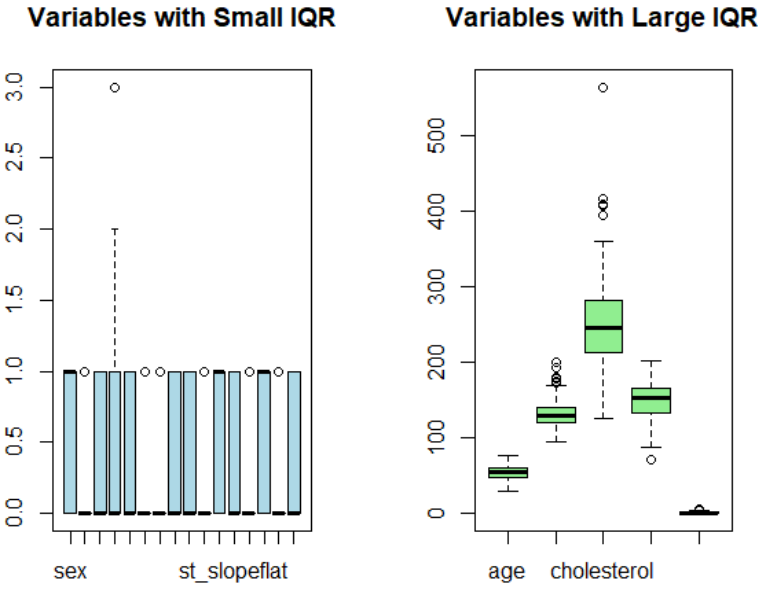


To check the quality and accuracy of the dataset examine the proportion of the outliers and null values. The result of the Boxplot shows there are outliers in the dataset, they are surely going to put a negative impact on the analysis of data. Therefore, removing the null values and outliers from the data set is compulsory in order to analyze the best results.



Interquartile Range is used to describe the spread of a dataset, as it is the range that lies between the first and third quartiles. Small IQR shows that predicting variables are clustered around the median. While the Larger IQR shows the spread of various predicting variables.

3.2- Summary of Data

The Descriptive statistics include the summary of the data set including mean Median Sum, Min, max and Summary of the data, Our data Set has an age variable ranging from 29 to 77, with a mean of 54.43 and a standard deviation of 9.11.

The sex variable is binary, with 0 representing female and 1 representing male, 68% of the observations are male and 32% of observations are female. The cp variable represents chest pain type and takes four values (0, 1, 2, 3). The mean is 2.17, indicating that most observations have type 2 or 3 chest pain. The treetops variable (resting blood pressure) ranges from 94 to 200, with a mean of 131.34 and a standard deviation of 17.86. The chol variable (serum cholesterol level) ranges from 126 to 564, with a mean of 249.66 and a standard deviation of 51.69. The FBS variable (fasting blood sugar > 120 mg/dl) is binary, with 0 indicating false and 1 indicating true. About 15% of the observations have a fasting blood sugar level above 120 mg/dl. The thalach variable (maximum heart rate achieved) ranges from 71 to 202, with a mean of 149.68 and a standard deviation of 23.17. The exang variable (exercise-induced angina) is binary, with 0 indicating false and 1 indicating true. About 33% of the observations have exercise-induced angina. The old peak variable (ST depression induced by exercise relative to rest) ranges from 0 to 6.2, with a mean of 1.05 and a standard deviation of 1.15. The ca variable (number of major vessels (0-3) coloured by fluoroscopy) ranges from 0 to 3, with a mean of 0.67 and a standard deviation of 0.99. The thal variable (3 = normal; 6 = fixed defect; 7 = reversible defect) takes three values. Most observations have a value of 2. The target variable is binary, with 0 indicating the absence of heart disease and 1 indicating the presence of heart disease. About 54% of the observations have heart disease

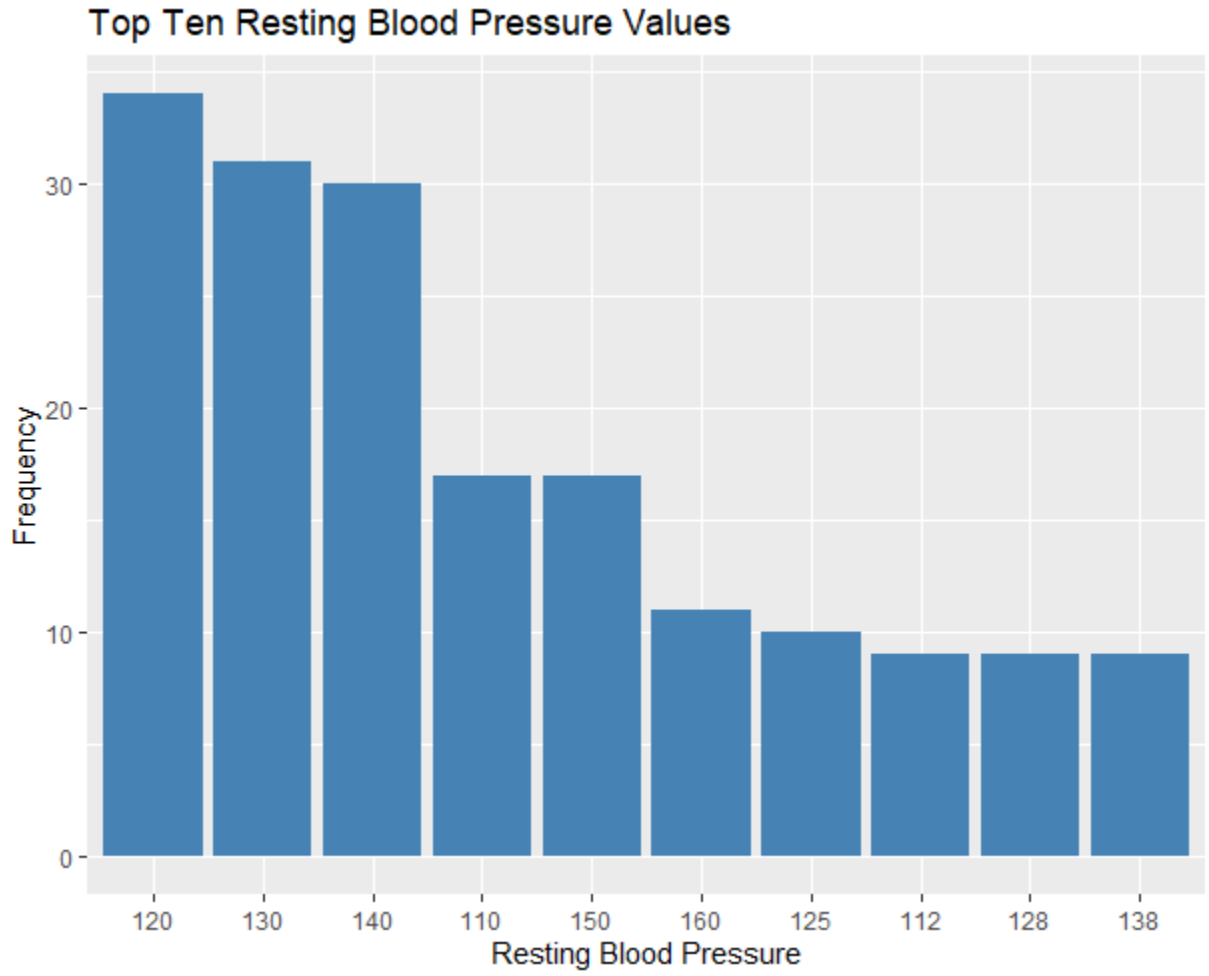
This research report concluded that Males have more heart diseases than females. The proportion of males with heart disease is 0.5634 and higher than the proportion of females with heart disease is 0.4375.

Table 3.1: Summary Statistics For the Predicting Variables

Variables	Min	Ist Quartile	Median	Mean	3rd Quartile	Max
Age	29.00	48.00	55.00	54.43	61.00	77.00
Sex	0.0000	0.0000	1.0000	0.6778	1.0000	1.0000
Chest pain type	0.0000	2.0000	2.0000	2.174	3.0000	3.0000
Resting BP	94.0	120.0	130.0	131.0	140.0	200.0
Cholesterol	126.0	213.0	245.0	249.0	280.0	564.0
Blood Sugar	0.0000	0.0000	0.0000	0.1481	0.0000	1.0000
Rest ecg	0.0000	0.0000	2.0000	1.022	2.0000	2.0000
Max heart rate	71.0	133.0	153.5	149.7	166.0	202.0
exercise-induced	0.0000	0.0000	0.0000	0.3296	1.0000	1.0000
St depression	0.00	0.00	0.80	1.05	1.60	6.20
St slope	0.0000	0.0000	1.0000	0.5852	1.0000	2.0000
Major vessels	0.0000	0.0000	0.0000	0.6704	1.0000	3.0000
Thalassemia	1.0000	1.0000	1.0000	1.822	3.0000	3.0000
Target	0.0000	0.0000	0.0000	0.4444	1.0000	1.0000

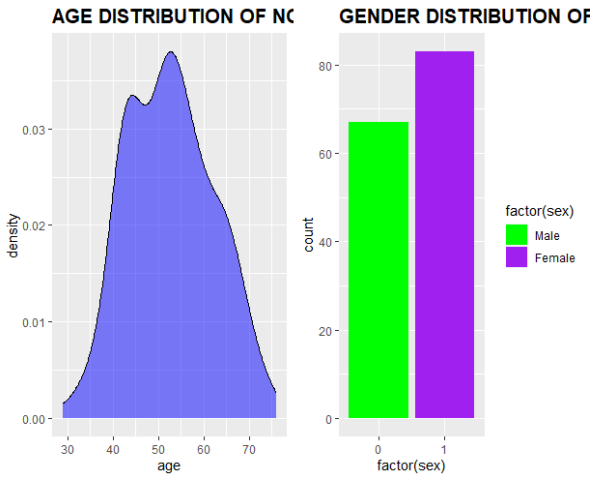
4- Analysis

The purpose is to predict the occurrence of heart disease in individuals. In this project, I used various different methodologies, techniques and models to Analyze which predicting factors have more role in causing Heart disease.



Top Ten Resting Blood Pressure Values.

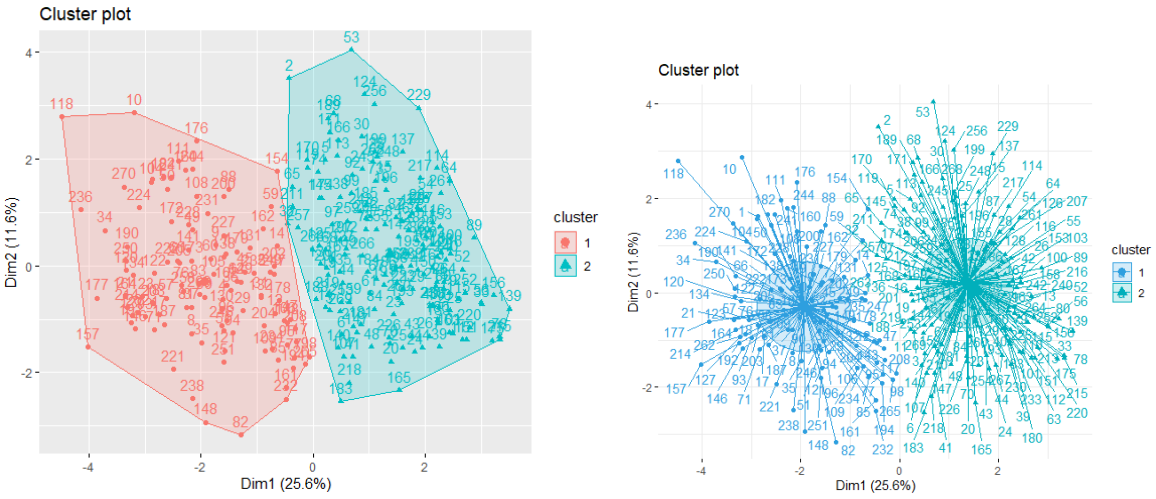
I used supervised and unsupervised statistical methods. I used parametric techniques such s logistic regression which I used for supervised methodology. As well As Non-parametric techniques such as regression trees. Furthermore, I constructed multiple models and compared their performance to predict the accurate predicting factor of heart disease. For unsupervised methodology, I constructed clustering models. I computed Cross-validation for each Model.



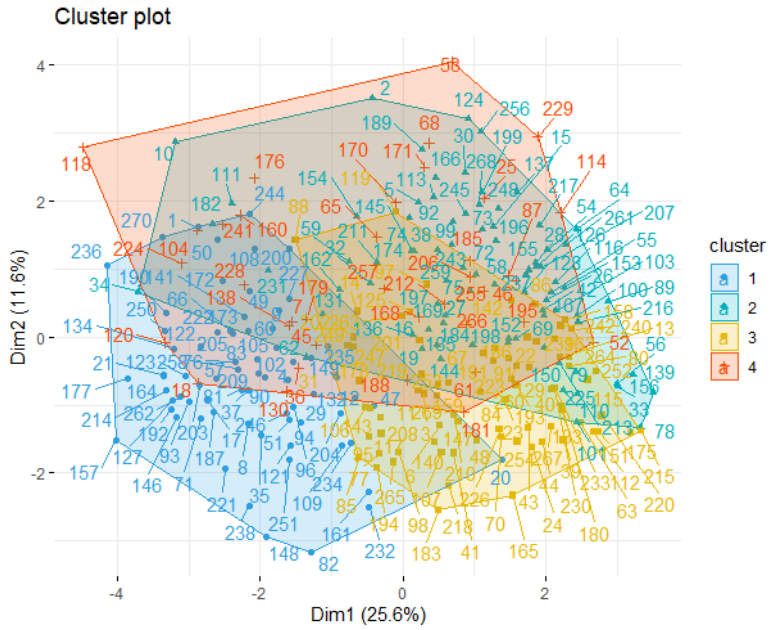
Age and gender Distribution with the ratio of heart disease.

4.1- Clustering Technique

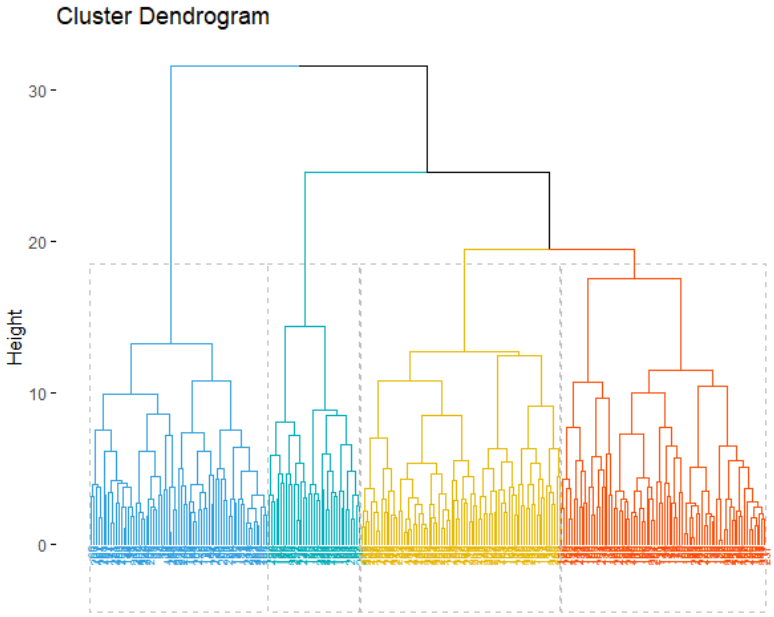
Implementation of clustering techniques on the data set, we analyze how factors including age, Gender, Chest pain, cholesterol level, blood sugar, blood pressure, Heart rate, depression, thalassemia and exercise-induced play their role in predicting heart Disease.
Similar factors are clustered into Distinct groups to predict their role in heart disease.



The dataset is divided into two clusters consisting of similar observations within. Cluster plot on the left has two clusters having dimensions of 11.6% and 25.6%, as does the plot on the right.

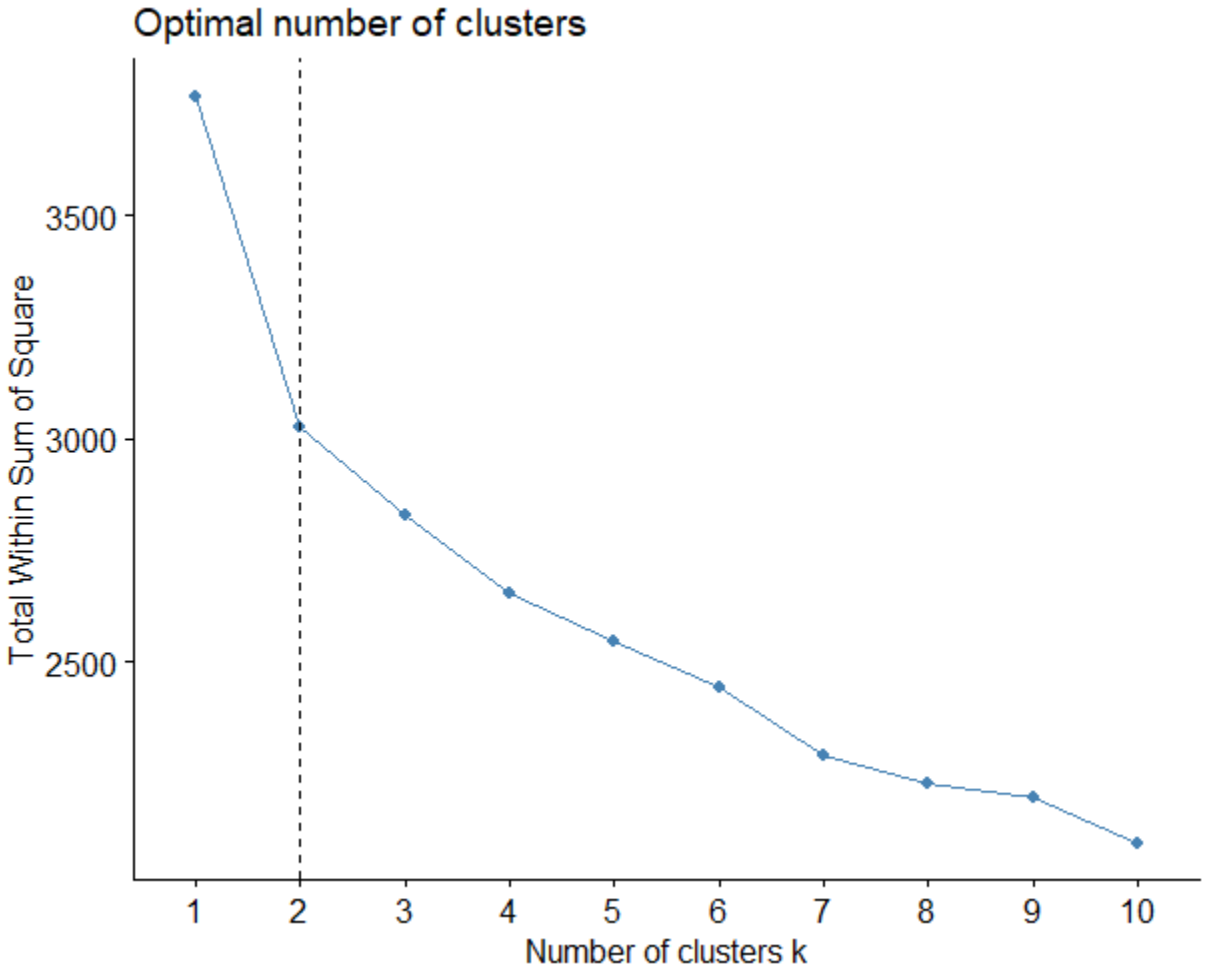


The figure shows five clusters with a dimension of 11.6% and 25,6%.

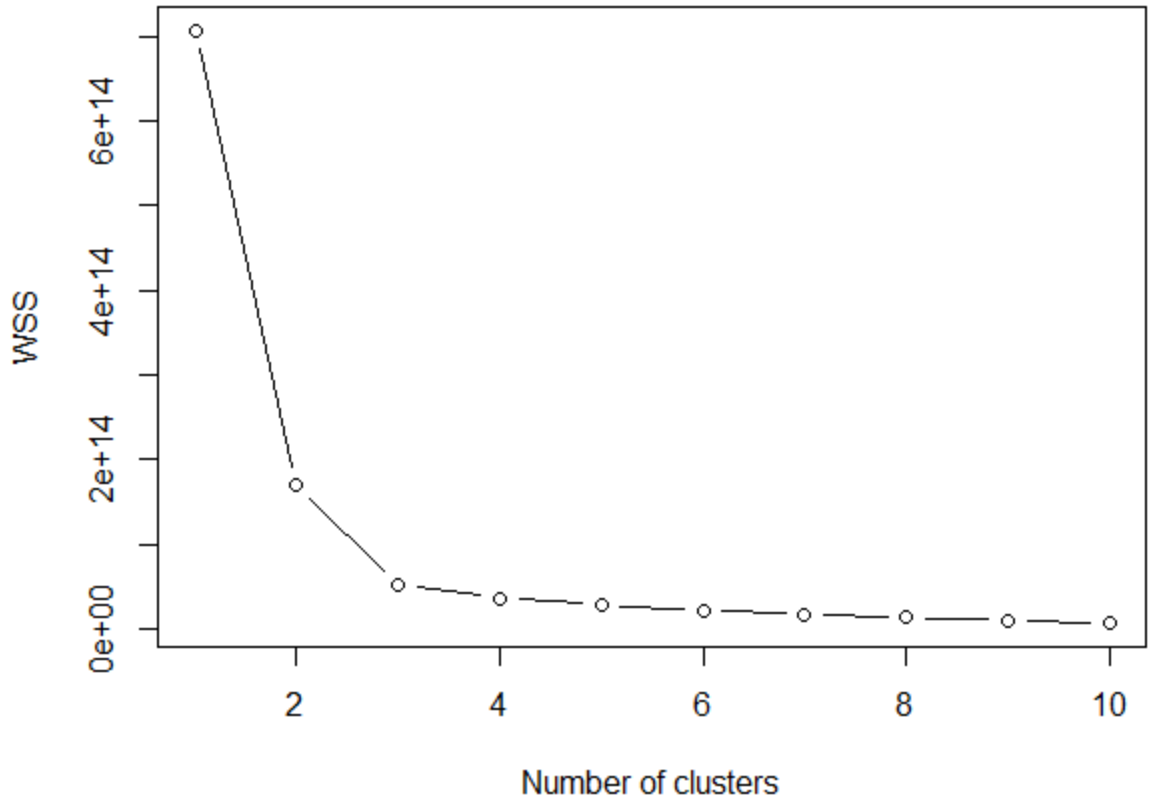


Cluster dendrogram indicates the order in which predicting heart factors are merged. The minimum height of the third cluster represents the minimum distance between the clusters and the cluster with maximum height represents the maximum distance between the clusters.

4.1.2- K Mean clustering technique



I apply the K means clustering technique, with 2 clusters consisting of Sizes 112 and 158. The average age of Clusters is 0.2876517 and 0.3449584.



We computed WSS 19.7% which indicates the observations within each cluster are more tightly around the clustered centroid.
That predicts Factors within the clusters have equal effects on Heart disease.

4.2- Logistic regression

The purpose of logistic regression is to analyze whether our Predicted factors are playing a role in causing Heart disease or not. The Intercept has an estimated value of 0.356 with a p-value of 0.248, indicating that it is not statistically significant at the 5% significance level. Age, resting blood pressure, and cholesterol are not the predicting factors of heart disease, as their coefficients have p-values greater than 0.05. However, Thalassemia and Blood vessels have a strong impact on the Prediction of heart disease.

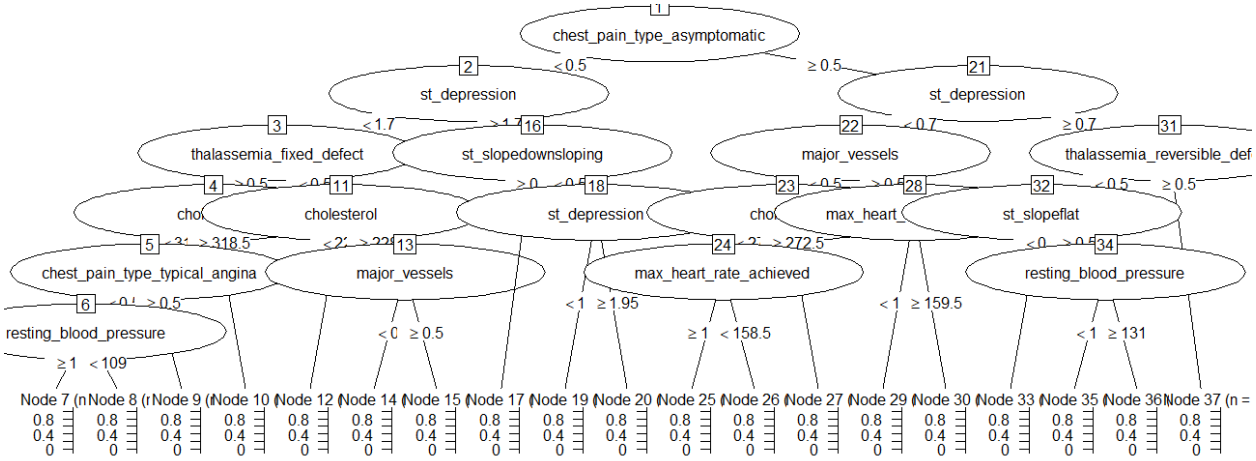
4.3- Regression Tree

A regression tree is a non-parametric supervised learning methodology used to predict a continuous outcome. In this report, we initialize the Target Variable consisting of all the hd datasets.

	ME	**RMSE**	**MAE**	**MPE**	**MAPE**
Test set	-0.120341	0.4342757	0.2872281	-Inf	Inf

	ME	**RMSE**	**MAE**	**MPE**	**MAPE**
Test set	-0.1663716	0.4453206	0.2967639	-Inf	Inf

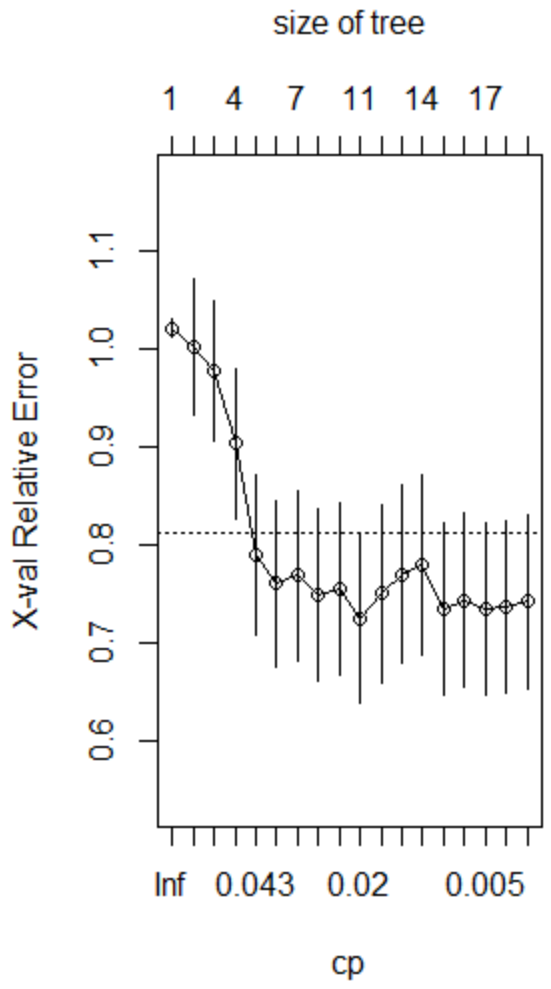
The complexity parameter (cp) used for each split, was set to 0, which means that the tree was grown. The tree starts with the root node, which has an error rate of 0.24923. The complexity parameter was 0.0200686, which resulted in a model with 9 splits.



The final tree included 11 predictor variables: chest_pain_type_asymptomatic, chest_pain_type_typical_angina, cholesterol, major_vessels, max_heart_rate_achieved, resting_blood_pressure, st_depression, st_slopedownsloping, st_slopeflat, thalassemia_fixed_defect, and thalassemia_reversible_defect.

4.3.1- Cross Validation

It is used to interpret the accuracy of the regression tree, here it is accurate with multiple nodes. The size of the tree is 17.



4.4- Stepwise regression

The initial model includes predicting variables, the model is updated by removing or adding predictors until the AIC value is minimized. The resulting model is chosen as the best-fit model. AIC is a measure of the model's goodness of fit, AIC=205.09 at Initial Step.
The second step shows AIC=201.09 and it's decreasing to AIC=197.16. As the Value of AIC is lower, it is a good fit.

	Df	Deviance	AIC
age		29.360	197.16
cholesterol	1	29.239	198.04
rest_ecgleft_ventricular_hypertrophy	1	29.699	198.26
resting_blood_pressure	1	29.714	198.39
exercise_induced_angina	1	29.715	198.40
fasting_blood_sugar	1	29.307	198.67
thalassemia_normal_blood_flow	1	29.747	198.69
rest_ecg_Abnormality_in_ST_T_wave	1	29.339	198.96
age	1	29.347	199.03
max_heart_rate_achieved	1	29.785	199.04
st_slopedownsloping	1	29.360	199.15
st_slopeflat	1	29.946	200.49
st_depression	1	29.988	200.87
chest_pain_type_atypical_angina	1	30.130	202.14
sex	1	30.469	205.16
chest_pain_type_typical_angina	1	30.846	208.48
chest_pain_type_non_angina_pain	1	31.321	212.61
thalassemia_fixed_defect	1	31.522	214.34
major_vessels	1	32.302	220.94

5- Results

At the initial step, the AIC value is 205.09, and as the model is updated, the AIC value decreases to 197.16, indicating a better fit. Therefore, the resulting model with the lowest AIC value is considered the best-fit model.

The tree was grown using a complexity parameter of 0, resulting in a model with 9 splits. The final tree included 11 predictor variables, such as chest pain type, cholesterol, major vessels, and thalassemia type. The root node of the tree had an error rate of 0.24923, and the model's complexity parameter was 0.0200686.

The Intercept has an estimated value of 0.356 and a p-value of 0.248, which implies that it is not statistically significant at a significance level of 5%. The coefficients of age, resting blood pressure, and cholesterol are not significant predictors of heart disease, as their p-values are greater than 0.05. However, Thalassemia and Blood vessels are important predictors of heart disease as they have a significant impact on the prediction of heart disease.

The findings of this research suggest that males are more likely to develop heart disease than females. Specifically, the proportion of males with heart disease is higher than that of females. Three key factors were identified as major causes of heart disease: chest_pain_type_asymptomatic, thalassemia_reversible_defect, and major blood vessels. The first two splits in the regression tree were based on these two predictor variables, indicating their strong influence on the diagnosis of heart disease. While other predictor variables also played a role, their impact was relatively smaller.
Additionally, age was found to be a significant predictor of heart disease, with the likelihood of developing heart disease increasing as age increases. In fact, each unit increase in age was associated with a higher probability of heart disease.

Conclusions

This research report concluded that Males have more heart diseases than females. The proportion of males with heart disease is higher than the proportion of females with heart disease.
There are Three predicting factors in our data set that are major causes of heart disease. These are chest_pain_type_asymptomatic, thalassemia_reversible_defect and the major blood vessels. However, chest_pain_type_asymptomatic and thalassemia_reversible_defect are the two predictor variables that were used as the first two splits in the regression tree, indicating that they have a strong influence on whether or not a person is diagnosed with heart disease. The other predictor variables that appear in the tree are also important but to a lesser extent than these two.

This report analyzed that, age is a significant predicting factor of heart disease, the more the age, high the chances of having heart disease. With every increasing unit in age lead to more probability of having heart disease.

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