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A Review of Atherosclerosis Disease Prediction Using Machine Learning Algorithms

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ABSTRACT: The medical discipline is divided into various sub-fields, each with its own diagnostic techniques. Nonetheless, in projecting the future of drugs and patient health, machine learning is becoming increasingly crucial. This is due to the trustworthiness of the various classification techniques. Because of the influence of numerous data retrieved from patients, reliable cardiac disease prediction is becoming increasingly difficult, and separating these components is a critical research issue. Higher performance can be achieved by introducing individual classification algorithms and ensemble learning approaches, which lead to accurate prediction of atherosclerosis disorders. For the purpose to increase the classification result accuracy rate of Atherosclerosis Diseases, heterogeneity of machine learning algorithms, also include their related problems and performance results; have been investigated in this work. Several symptoms that directly or indirectly suggest atherosclerosis (cardiovascular disease), as well as several modifiable and non-modifiable peril factors for athero disease and several forms of athero (heart) diseases with their causes of failures, have been examined in greater detail. The goal of all of these publications is to improve accuracy and make the system more efficient so that it can more accurately forecast attack probability. The results reveal improved performance in terms of performance measures and provide a better knowledge of the accuracy, dependability, and utility of the classifier models.

KEYWORDS: Atherosclerosis Diseases, Supervised Learning Algorithms, Machine Learning Algorithms, Performance measures.

1 INTRODUCTION

The cardiac muscle is a muscular organ which supplies blood to all parts of the body and one of the human anatomy's life-sustaining organs. The oxygen and nutrients required for healthy physiological function are delivered by the blood pumped by the heart. If it doesn't work properly, the brain and other organs will cease working, which is generally linked with greater chance of blood clotsand the accumulation of fat deposits within the arteries of heart. In some cases, it has been related to nerve damage in a variety of organs, including the brain, kidneys, heart, and eyes. The heart's function is affected by a change in living, task associated distress, and poor eating routine.As a result, the incidence of athero-related illnesses is on the rise. As a result of all of these factors, atherosclerosis has emerged as amongst the most common causes of death[1][2]. According to WHO report[3], atherosclerosis seems to be the leading cause of death, accounting for more than half of all deaths, is deaths each year than any other disease. Heart disease decrease the survival of 17.9 million people worldwide in 2016, contributing 31% all over deaths, with cardio attacks and strokes (brain) accounted for 85% of these fatal accidents.. Countries with a low and middle income accounted approximately 82 % of the 17 million annual deaths (that before age of 70) due by non-communicable diseases in 2015, with atherosclerosis disease (CVD) contributing for 37 percent. Many heart sicknesses can be reduced by following a healthy lifestyle and avoiding risk factors like cigarette use, poor diet and obesity, physical inactivity, and alcohol abuse[4]. Atherosclerosis disorders result in higher health-care costs and lower productivity.

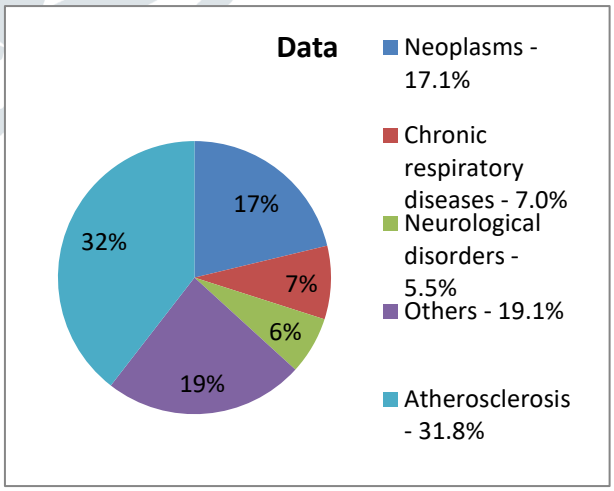

Figure 1: Percentage of atherosclerosis in 2017

From 2005 to 2015, India lost up to $237 billion owing to heart and atherosclerosis disorders[5]. The Pie-chart in **Error! Reference source not found.**above shows the top global causes of deaths in 2017 by Institute for health metrics and evaluation[6]. Men are more

likely than women to have CVDs everywhere over the world. People who have heart disease or are at high risk for heart disease due to one or more risk factors must be accurately detected and diagnosed so that doctors can intervene at an early stage prescribe the appropriate drugs and procedures to help them live longer[7][8]. Various people's lives could have been saved if they had been diagnosed on time. In line with these, diagnosing the disease is important and a daunting task. As a result, critical cardiac metrics for each type of heart illness must be recorded, and a system must be established to aid clinicians in establishing accurate and timely diagnosis. ECG, occultation, blood pressure, blood sugar, and cholesterol measurements are the standard methods for diagnosing athero (heart) disease. However, those methods are both costly and time-consuming. In truth, medical diagnosis is a categorization mission in which a doctor attempts to detect a deficiency by assessing the values of a number of criteria. This task is usually accomplished using a number of algorithms. Machine learning methods make atherosclerosis diagnosis a practical solution that drastically saves processing time and improves prediction accuracy.

1.1 Peril Factors of Atherosclerosis(Heart) Disease[9] [10]

As shown in **Error! Reference source not found.**, likelihood factors are unavoidable circumstances that have a major impact on an individual's chance of evolving athero disease. As previously said, peril classification is categorize into two factors: prime and contributor. Prime peril factors seemed to expand the possibility of atherosclerosis. Contributory risk factors, on the other hand, have been linked to an increased risk of atherosclerosis disease, but their importance and prevalence have yet to be confirmed.

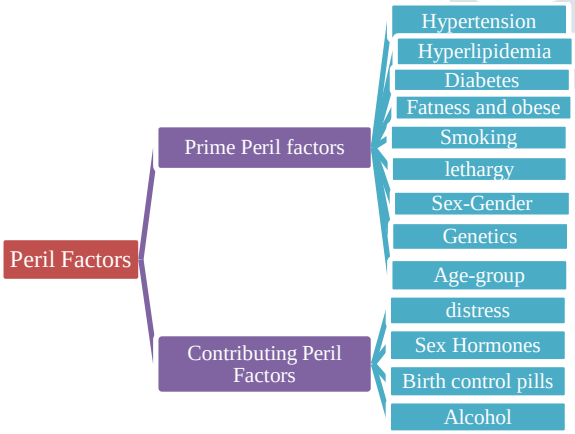

Figure 2: Categories of Peril Factors

a. Prime Peril Factors:

1. The risk of hypertension (high blood pressure) increases with age and physical activity, although a healthy adult's resting blood pressure should be 120/80.

2.Hyperlipidemia (high Blood Cholesterol) - Low-density lipoprotein (LDL) levels in the blood are high (LDL or "bad cholesterol") cause plaque to form on artery walls, leading to atherosclerosis and a higher risk of heart attack.

3. Diabetes - The leading cause of death among diabetics, particularly those with adult-onset or Type 2 diabetes, is heart disease (called as non-insulin-dependent diabetes).

4. Fatness and Obese - Being overweight or obese can lead to elevated cholesterol,diabetesandblood pressure which are all prime peril factors for atherosclerosis.

5. Smoking - This raises your heart rate, putting more strain on your heart, constricting key arteries, and causing abnormalities in your heartbeat.

6. Physical Inactivity - Exercise helps to maintain a healthy weight by burning calories, controlling cholesterol and diabetes, and maybe lowering blood pressure.

7 Gender - In generalmen are more likely than women to suffer from a heart attack. When all other risk factors are equal, Starting at the age of 65, male and female have the same peril of atherosclerosis disease.

8. Genetics - Heart disease is a disease that runs in families. Risk factors such as hypertension, diabetes, and fatness and obese can be proceed down from their lineage.

9. Period- As we get aged, our hearts have a tendency to workless efficiently, and the arteries and heart walls can contract, preventing the heart from flowing blood to the body's muscles.

b. Contributing Peril Factor:

1. Distress -distress elevates your heartbeat and blood pressure, increasing your heart's demand for oxygen. Ischemia (there isn't enough oxygen-rich blood entering the tissues) or angina pectoris (chest pain)could result from the increased need for oxygen.

2. Sex hormones- Heart disease is uncommon in women under the age of 40. Women's odds of having a heart attack grow between the ages of 40 and 65. Women account for nearly half of all people who have a heart attack after the age of 65.

3. Birth control pills - Birth control pills, especially if you are older than 35, You're more likely to develop heart disease and blood clots if you smoke or have other risk factors.

4. Alcohol Addiction - Drinking too much alcohol can lead to cardiac problems such hypertension, cerebrovascular disease, rapid heart rate, and myocardium (diseases of the heart muscle).

Some risk factors can be uncontrollable, but others can be.However, by removing the risk factors that we can control and minimising the ones that we can't, we can drastically reduce our chance of heart disease.The higher your peril of coronary athero disease, the more peril factors you have (plaque build-up in arteries of the heart that can lead to a heart attack). Atherosclerosis diseases have a slew of symptoms linked to a slew of risk factors, many of which are heavily influenced by one's lifestyle.

1.1.1 Prime Risk Factors of Atherosclerosis Diseases

Cardiovascular prime risk factors fall into 2 broad categories as given below in the **Error! Reference source not found.**:

A. Modifiable PerilFactors (MRF): MRF are the factors that can be decreased or controlled by human beings to subsidies risk by adopting certain changes to life style, Hypertension,

cholesterol, diabetes, fatness and obese, alcohol, stress, smoking, and nutrient-poor diet are just a few examples like eating high sugar or trans fat diets, lack of physical inactivity that can be avoided and cured by adopting healthier behaviours.

B. Non-modifiable PerilFactors (NMRF): NMRF are those factors with which we can't change. That include Person's age, ethnicity, being male & family Background (genetics cannot be changed) [16][30]as given below in **Error! Reference source not found.**.

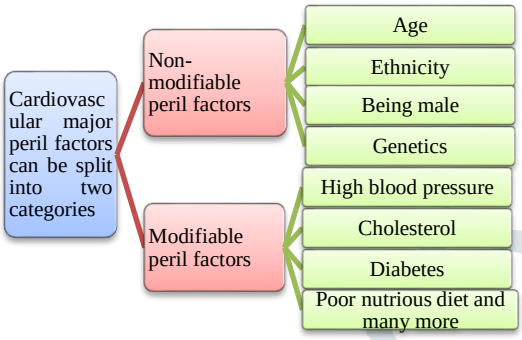

Figure 3: Categories of Prime Peril Factors

Hypertension and coronary athero disease, and a heart attack are the most common causes of heart failure.Heart failure can also be caused by disorders that weaken or destroy the heart valves or heart muscle.

1.2 Warning Signs of Atherosclerosis (Heart) attack[9][10]

A heart attack could be the first symptom of underlying health problems. The underlying illness of the blood vessels usually has no symptoms. The most common cause of a myocardial infarction is a blood clot blocking a coronary artery (heart attack).The artery has often narrowed by the deposition of fat on its walls. These deposits can break down or open up, reduce blood flow and release some substance that make the blood platelets sticky and have a greater chance of clotting. In some cases, blood clots form within the heart and then break down and become trapped in the arteries that supply the heart. A muscle spasm in one of these arteries can cause the blood flow to stop. Non-ST elevation myocardial infarction, or NSTEMI, is a key used to demonstrate a situation in which some patients have a "mild heart attack." Blood passage via one of the coronary arteries was partially obstructed in this sort of heart attack, reducing the availability of oxygenated blood to the heart muscle. This likely suggests that our heart was not severely damaged and continues to pump regularly.STEMI is a "severe" or "major" heart attack when a coronary artery gets fully obstructed and a substantial section of a muscle ceases to receive blood. It's a dangerous heart ailment that can lead to death. Squeezing can cause physical discomfort in one maybe both shoulders, spine, neck, jaw, or abdomen, as well as breathlessness, which might lead to number of issues and require prolonged rehabilitation.

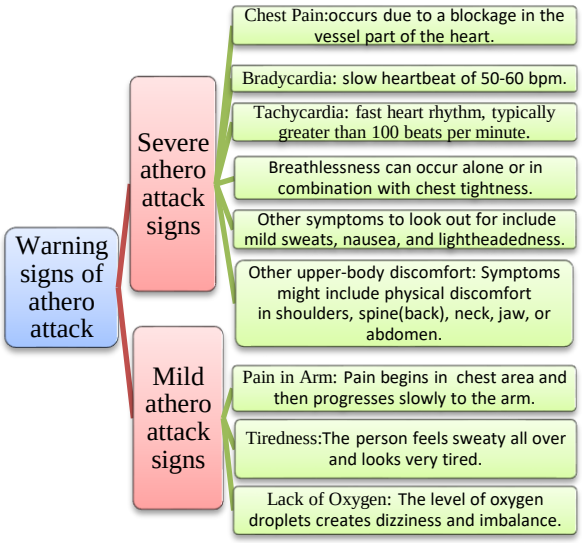

Figure 4: Warning signs of Atherosclerosis attack

Error! Reference source not found. depicts how persons with heart failure can develop these symptoms, as well as the reasons why they occur:

1.Blood "returns" to the pulmonary circulation (blood veins that connect the lungs to the heart) when the heart can't keep up with the demand, causing fluid to enter the lungs.

2. Fluid builds up in the lungs, causing a chronic cough or shortness of breath.

3. Edema is the accumulation of extra fluid in the bodily tissues as blood flows slowly from the heart and backs up in the veins, causing fluid to build up in the tissues. The kidneys are unable to eliminate salt and water, resulting in muscular fluid retention.

4. Exhaustion and fatigue are the heart's inability to pump enough blood to meet the needs of the body's tissue requirements causes this condition.

5. Nausea, lack of appetite - Nausea and a loss of appetite - The digestive tract receive less blood, causing digestion issues.

6. Changes in the quantity of certain molecules in the blood, such as salt, can induce confusion and impaired thinking.

7. Quicker heart rate – The heart beats faster to "avoid" the pumping loss.

8. Left Shoulder Pain - Nerves in the left arm and heart can communicate with the same pain regions in the brain. As a result, the brain can recognise heart abnormalities such as pain in the left arm or shoulder.

1.3 Different types of Atherosclerosis (Heart) diseases[9][10][11]

When the heart muscle is unable to efficiently pump blood, heart failure, also known as congestive heart failure, occurs. As a response, blood pressure drops and fluid accumulates in the lungs, resulting in breathlessness. Atherosclerosis-related diseases, such as cardiac disease or hypertension, cause the heart to weaken or grow too powerful to fill. As stated in Table 1heart disorders can be categorised into numerous categories

based on the symptoms linked with their aetiology and peril factors below:

Table 1: Different types of atherosclerosis disease

TYPES OF HEART DISEASES	SYMPTOMS OF DISEASES	AETIOLOGY	PERIL FACTORS
Sudden Cardiac arrest	a. No pulse. b. Loss of consciousness. c. chest discomfort. d. shortness of breath. e. weakness f. Fast-beating, fluttering or pounding heart(palpitations)	Sudden loss of cardiac function, awareness, and breathing problems can occur.	Being a man, Low potassium or magnesium levels, chronic renal illness, and other nutritional imbalances Cocaine or amphetamines are examples of illegal substances..
Congestive heart failure	a. Shortness of breath during physical exertion or during sleeping. b. Legs, ankles, and feet swelling. c. chronic cough as well as wheezing with bloody sputum that is white or pink in colour. c. fast weight gain due to fluid retention.	In heart failure, the primary heart muscles (ventricles) may well not fill properly among beats and become stiff. Some people's cardiac muscles may be weaker and damaged. The heart's ventricles can enlarge to the point where it can no longer pump enough blood into the body.	Heart valve disease, hypertension, diabetes, sleep apnea (Failure to breathe properly while sleeping causes Low blood oxygen levels and a higher risk of an irregular heartbeat).
Congenital heart disease	a. Heart beats that are abnormal (arrhythmias). b. Shortness of breath. c. A bluish tone to the lips, skin and fingernails(cyanosis). d. swelling of body tissue or organs(edema).	Heart abnormalities that develop before birth.	Genes, Medications, Alcohol, German measles(rubella), Diabetes, Smoking.
Coronary artery disease	a. Chest pain(angina) b. Heart attack. c. Shortness of breath.	Any condition that affects the blood vessels can be harmed by large coronary arteries.	Age, high blood pressure, family history, sexuality (men are at greater peril).
High Blood Pressure	a. Thyroid issues, for starters. b. Blood vessel problems that you are born with (congenital). c. Cocaine and amphetamines are examples of illegal substances.	Hypertension that is uncontrolled can cause the arteries to stiffen and thicken, restricting blood flow.	The term "obesity" refers to being overweight or obese, tobacco use, being physically lethargic, consuming too much sodium (salt) in your diet, deficiency in potassium
Peripheral artery disease (PAD)	a. Numbness or weakness in the legs. b. Legs that have changed colour. c. On your feet and legs, you may notice hair loss or decreased hair growth.	Reduced blood vessels that reduce blood flow to the feet, are a condition of blood circulation.	Stress, obesity, smoking, and High blood pressure (hypertension), Homocysteine is an amino acid that aids in production of protein as well as the formation and maintenance of tissue.
Stroke	a. High blood pressure that is uncontrollable. b. Excessive use of blood thinners (anticoagulants). c. A traumatic event (such as a car accident). d. In cerebral amyloid angiopathy, protein deposits in blood vessel walls cause weakness (vessel wall)	Disruption of the blood supply causes damage to the brain.	Hypertension, hyperlipidemia, and diabetes are all linked with the use of illegal narcotics like cocaine and methamphetamine.
Heart Arrhythmia	a. Coronary artery disease with blocked arteries (heart). b. Thyroid gland that is overactive (hyperthyroidism). c. Thyroid gland that is underactive (hypothyroidism).	The heartbeat is uncommon or may be abnormal, slow or very fast.	Caffeine, nicotin, or illegal drug use are all linked to high blood pressure, thyroid issues, and diabetes.

Heart failure symptoms and indicators can be improved with proper therapy, and some patients can live longer as a result. Exercising, losing weight, reducing the amount of sodium (salt) in the diets, and managing stress all of these things can help you live a healthier life.All of these things can help you live a healthier life. Cardiac arrest, on the extreme side, can result in serious symptoms that may require a heart surgery or the use of a ventricular assist machine (VAM) in some patients. Another way to avoid heart failure is to control and prevent dangerous conditions such cardiomyopathy, increased blood pressure, diabetes, and obese.

2 TECHNIQUES & THEIR ISSUES

Several research have utilised a variety of strategies to handle the challenge, with the highest classification precision achieved utilising a cardiovascular illness datasetof UCI's machine learning library. They used artificial neural networks, genetic algorithms, fuzzy logic, neuro-fuzzy, KN, nave Bayesian, as well as other machine learning techniques and other computer

models. According to experimental data, artificial intelligence and machine learning have made substantial advances in the medical profession[12]. Several studies and research on heart disease data sets have been undertaken utilising various methodologies and classifiers, as shown in **Error! Reference source not found.** below:

Table 2: Techniques and their issues

OBJECTIVE	METHODOLOGY	RESULTS (IN %)	ISSUES
"Decision support system for congenital heart disease diagnosis based on signs and symptoms using neural networks" by Vanisree K, JyothiSingaraju [13]	Neural Network with backward Model is implemented in MATLAB 7.3.	Accuracy achieved 90	The model's training time is extremely long.
"A hybrid data mining model to predict coronary artery disease cases using non-invasive clinical data" by Verma Luxmi., Sangeet Srivastava, and P.C. Negi.[14]	MLP, MLR, FURIA, and C4.5.	MLR has an accuracy of 88.4	The model's training time is extremely long.
"Hybrid system of tiered multivariate analysis and artificial neural network for coronary heart disease diagnosis" by Wiharto, Hari Kusnanto, and Herianto[15]	Perceptron neural network.	The accuracy value for system performance is 86.3.	The model's training time is extremely long.
"An ensemble based decision support framework for intelligent heart disease diagnosis" by Bashir, Saba, Usman Qamar, and M. Younus Javed[16]	Data mining, ,Decision trees, Naive Bayes Support vector machines, majority voting, and ensemble approaches.	Accuracy 82, sensitivity 74, and specificity 93.	The support vector machine is trapped by outliers, and the outputs are determined by the kernel..
"Prediction of Cardiovascular Disease using Machine Learning" by Balakrishnan, M., et al.[5]	Random forest algorithm	The accuracy achieved is 92.	By default, a python sklearn package creates 100 trees. This technique demands a substantial amount of computational power and resources to achieve.
"Prediction of Cardiovascular Disease Using Machine Learning Algorithms with SDNKL" by Kuppam Charitha Sri et al [10].	SVM, Decision Tree, KNN, Logistic Regression and Naive Bayes classifier.	Decision trees(Jaccard-score - 53 & F1-score - 50), SVM(Jaccard-score - 50 & F1-score - 33), Logistic Regression(Jaccard-score - 53 & F1-score - 43), KNN(Jaccard-score - 46 & F1-score - 34), Naive bayes (Jaccard-score - 60 & F1-score - 54).	It's challenging to find the ideal K value.
"Improving the accuracy of prediction of heart disease risk based on ensemble classification techniques" by Latha, C, Beulah et al[17]	Bayes Net, Naive Bayes, Random forest, C4.5, Multilayer perceptron, PART, and ensemble methods such as bagging, boosting, stacking, and majority voting.	Bagging accuracy - 6.92. Boosting accuracy 5.94. Stacking accuracy 6.93.	The training time for the model is extremely high.
"Heart Disease Diagnosis on Medical Data Using Ensemble Learning" by Boyang Dun et al[18].	Random forests, logistic regression, support vector machines, and neural networks.	Prediction accuracy 80	Significantly more healthy patients are erroneously diagnosed. As the performance of the model type declines, the skew increases.
"An improved ensemble learning approach for the prediction of heart disease risk" by Mienye, Ibomoiye et al [19]	Using the accuracy-based weighted ageing classifier ensemble(AB-WAE).	Cleveland dataset accuracy 93 and Framingham dataset accuracy 91.	The training time of the model is very high.
"Prediction of Heart diseases using Neural Networks" by Karayilan, Tulay et al [20]	Neural network using the backpropogation approach.	95% accuracy rate for prediction.	The model's training time is extremely long.
"Heart Disease prediction	Hidden Nave Bayes	100%	Overfitting is a

system based on hidden Naive Bayes" by Jabbar et al [21]			pitfall that the algorithm falls into.
Comparative Analysis ofApproaches for Heart Disease Prediction by M. Hasan et al [22]	KNN, Gaussian Naive Bayes, decision trees (ID3), random forest and logistic regression	Logistic regression accuracy 92.76.	KNN has been emphasised more since finding the ideal K value is tough.
"SSH - Structure risk minimization based support vector machine for heart disease prediction" by Selvakumar et al[23]	With an SSH method, SVM is employed with a Gaussian Kernel.	.	The Support Vector Machine is prone to outliers, and its outputs are dependent on the kernel.
"Prediction of Cardiac Disease Based on Patient's Symptoms" by Prabakaran et al[24]	SVM		The model's training time is extremely long.
"Diagnosis of Heart DiseaseUsing Data Mining Algorithm" by Chandna, Deepali [25]	KNN (K Nearest Neighbors) and Decision Trees	Accuracy achieved 98.24%.	It's challenging to find the ideal K value.
"Application of Multilayer Perceptron neural networks and support vector machines in classification of healthcare data" by Naraei, Parise et al[26]	The classification was done using Multi-Perceptron Neural Networks and Support Vector Machines.	SVM achieved accuracy of 84.48%.	The Support Vector Machine is prone to outliers, and its outputs are dependent on the kernel. The model's training time is extremely long.
"Accurate prediction of Coronary Heart Disease for Patients With Hypertension From Electronic Health Records With Big data and Machine Learning Methods: Model development and Performance Evaluation" Du, Zhenzhen, et al. [27]	An ensemble method, XGBoost , SVM, logistic regression, decision tree, , knn and random forest are used.	Logistic regression achieved accuracy of 80% decision tree, knn are having 82%,SVM is 85%, random forest is 86% and XGBoost is 87%.	The major limitation of our study is had a high missing rate, the higher level of noise in the data is seen as acceptable.
"Cardiovascular Disease Prediction Model using Machine Learning Algorithms" by Arunachalam, Siddhika[9].	Support Vector Machine, Logistic Regression,Extremely Randomized Trees Classifier, Gradient Boosting, Multi-Layer Perceptron (MLP) Classifiers,and Random Forest.	Results scored by random forest, gradient boosting , random forest& extra tree classifier are 86%, SVM & MLP gives 91% & logistic regression is 88%.	-------
"Cardiovascular Disease prediction using Machine Learning Algorithms" by R.M.Shaikh., et al[28]	Random Forest (RF), Support Vector Machine (SVM),Logistic Regression, and Nave Bayes are evaluated.	Random forest is having maximum acuuracy of 84%, linear regression 83%, SVM using kernel function is 74%, SVM with radial basis function 58% and naive bayes is 54%.	-------
"Prediction for cardiovascular diseases based on laboratory data: An analysis of random forest model" by Sy, Xi, et al [29]	Random Forest.	Random forest has accuracy rate OF 72.	-----
"Cardiovascular disease risk prediction based on random forest" by Li, Runchuan et al [30]	NB, SVM, DT, LR, RBF, and RF models	Baseline-NB has a sensitivity of 84.	--------
"Prediction of Cardiac Disease using Supervised Machine Learning Algorithms" by Princy, R.Jane Preetha, et al [31]	Naive bayes, decision tree,random forest, logistic regression, Knn and SVM.	Decision Tree gives the best results with accuracy rate of 73.	-------
"Analysis and prediction of cardio vascular disease using machine learning classifiers" by Kumar, N. Komal, et al [32]	Random Forest, Decision Tree, Logistic Regression, Support vector machine (SVM), and K-nearest neighbours (KNN).	Random forest had the highest accuracy of 85.	--------
"Prediction of cardiovascular diseases using machine learning algorithms by Dinesh, Kumar G., et	Support Vector Machine, Random Forest,logistic regression,Gradient Boosting,	Logistic regression has an overall accuracy of 86%	-------

al".[33]	and Naive Bayes classifier.		
"Effective disease prediction using hybrid machine learning " by Mohan, Senthilkumar et al [34]	Heart disease prediction using a hybrid random forest with a linear model (HRFLM).	performance level of 88.7%	--------
"Identification of heart disease using machine learning" by Louridi, Nabaouia et al[35]	The base classifiers employed are SVM-linear, SVM-RBF, KNN, and NB.	They check on different training and testing results.	--------

3 CONCLUSION

The vast majority of people suffer from cardio problems in India. There is a great need to provide affordable and best healthcare to the people. Access to information strategies can play a major role in the healthcare industry, especially in predicting diseases such as heart disease.In this paper, the researcher has reviewed research papers on machine learning methods used in health care systems. The machine learning classification algorithm used by the majority of researchers in their healthcare predictive research and are the best algorithm in case of accuracy. The effectiveness of these algorithms will be tested according to the conditions discussed in the text. Machine Learning have virtually endless applications in the healthcare and medical domain. This paper contributes to providing a system that is consistent with the analysis of different machine learning algorithms that provides a quick way for the user to apply machine learning techniques for diseases prediction. Machine learning helps to plan management processes, diagnostic tests, diagnostic diseases, treatment schedules and customize treatment in health care to map and treat diseases. The ability to predict heart disease in its earliest stages is crucial in the medical sector.The death rate can be significantly lowered if the sickness is recognised early and preventative actions are performed quickly.The death rate can be significantly lowered if the sickness is recognised early and preventative actions are performed quickly.

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