Machine Learning Approaches For Predicting Heart Attacks

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Abstract*— Heart attacks are the leading cause of deaths worldwide. However, diagnosing them can be difficult as their symptoms can resemble those of other illnesses. There are several types of heart diseases, which makes identifying symptoms challenging. Mistaking these symptoms for something else can be very harmful to the patient. Heart disease is caused by various factors such as high bp, unhealthy diet, smoking, and lack of physical activity. New approaches are required to address heart problems since more young people are suffering from heart attacks, and current medical tools and diagnostic procedures are insufficient. This research aims to investigate the use of Machine Learning (ML) algorithms in heart attack prediction, emphasizing early detection and thereby increasing life expectancy and decreasing mortality rate. This research tries to determine the most successful models for heart attack prediction by analyzing KNN, Logistic Regression, XGBClassifier and ExtraTreeClassifier approaches. It also discusses the impact of these technologies in changing healthcare practices. The work synthesizes findings from 2016 to 2023, aiming to provide a comprehensive overview of the past works done in the field of heart attack detection and also proposes a methodology to predict heart disease using machine learning.

Keywords*— *Heart Attack Prediction, Heart Disease, Predictive Analytics, Machine Learning, Artificial Intelligence

I. INTRODUCTION

It's a concerning trend that the number of heart attacks among teenagers has climbed in recent years. Over the past five years, heart attack and stroke have become more common in India, where it remains a major cause of death [1]. The rise in cardiac arrests, along with its issues, is a result of our hectic lifestyle and evolving behaviours. It is now believed that every other adult between the ages of 30 and 40 suffers from a heart attack. The National Crime Records Bureau (NCRB) has revealed that in 2022 alone, the number of heart attack cases rose by an alarming 12.5% [2]. According to the NCRB's most recent data on "Accidental Deaths and Suicides in India," 32,457 people died from heart attacks in 2022—a sharp increase from the 28,449 deaths that were reported the year before [2].

Over 25,000 individuals have died in India from heart attacks annually for the past eight years, and the number has increased to over 28,000 during the last five years. This data is gathered by the NCRB and published in a report named "Accidental Deaths & Suicides in India" (ADSI) [3]. 32,457 persons died from heart attacks in 2022, according to the data in Table 1. Compared to the 28,449 deaths in 2021, this represents a significant increase. An easier way to assess how the number of heart attack deaths has increased over time is to look at the chart in Figure 1.

TABLE I. HEART ATTACK DEATHS IN INDIA [2]

Year	Heart Attack Deaths
2022	32,457
2021	28,449
2020	28,680
2019	28,005
2018	25,764
2017	23,246
2016	21,914

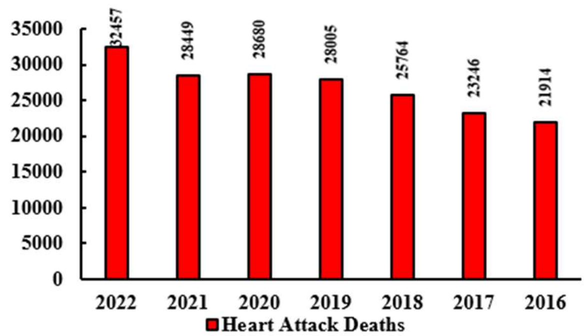

Figure 1. Heart Attack Deaths in India [2]

Given the high prevalence of heart disease, it is evident how urgently new predictive tools are needed to identify all individuals at risk. One of ML's greatest strengths is its broad consideration of various feature selections. Predictive models are constantly being improved because ML algorithms can adapt and get better with fresh data. Adaptability is especially important in the healthcare industry because new research and evolving patient data can significantly impact the accuracy of predictive analytics.

A. Research Questions

The fusion of technology and education in predicting heart attacks has become a major focus of research lately. This study aims to fill that gap by exploring some key questions.

R.Q. 1. What are the most effective ways to employ ML algorithms to increase the precision of prediction and early detection?

R.Q. 2. What characteristics and factors have a major role to identify individuals who are at risk of heart disease?

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R.Q. 3. Comparison of classification models for heart attack prediction using ML approaches.

B. Structure of the Paper

The manuscript is divided into five sections. In the first section, the authors presented an overview of Heart Attacks along with the stats associated with the number of deaths due to heart attack in India. Additionally, research questions were addressed. Section 2 of this study focuses on conducting a comprehensive literature review on Heart Attack Prediction. Section 3 provides valuable insights on the proposed methodology. Section 4 provides a presentation of the findings. The study is concluded in Section 5.

II. LITERATURE REVIEW

The investigation involved collecting approximately 75 scholarly articles spanning from 2016 to 2023. Google Scholar, arXiv, ResearchGate, and reputable journal sites were the primary sources for this research. These websites were chosen because they have a reputation for providing top-notch scholarly content.

TABLE II. SUMMARY OF ML TECHNIQUES USED IN HEART ATTACK PREDICTION

Year of Publication	Dataset Used	Methodology Used	Accuracy of the Model	Research Findings	Research Gaps
2020 [4]	Kaggle	Conditional Tabular Generative Adversarial Network (CTGAN)	RNN (Before Augmentation): - 80%. LSTM (Before Augmentation): - 65%	The study developed a method using the Conditional Tabular Generative Adversarial Network (CTGAN) model to enhance heart attack prediction accuracy.	Should have used other data augmentation methods and compare them to choose the best one in terms of accuracy.
2023 [5]	-	Hybrid SMLT	LR: - 83.78%. MLP: - 80.18%. CatBoost: - 98.19%	The study presents a ML model using a Hybrid SMLT technique.	The Data Source is not mentioned and further exploration on different machine learning techniques.
2023 [6]	Kaggle	Machine Learning Algorithms	LR: - 81.9%. SVM: - 62.2%. DT: - 81.4%. RF: - 77%	Logistic Regression was found to be the most effective among various ML models.	The technique used in this research should be more refined to obtain higher accuracy percentage.
2023 [7]	Kaggle	K-Means Clustering + Cosine Similarity	93.71%	Division of patient data into groups with distinct clinical profiles and comparison with predetermined risk group profiles.	Further exploration on different machine learning techniques.
2023 [8]	Patient Data (HDMS-DAPP)	(SCA-WKNN) Algorithm + Blockchain	SCA-WKNN: - 92.13%. KNN: - 81.49%. SVM: - 82.7%. RF: - 89.14%	Employed a ML algorithm (SCA-WKNN) and blockchain technology for secure data handling and high accuracy.	The need for further exploration of blockchain's role in healthcare data management and its impact on predictive accuracy.
2022 [9]	UCI Machine Learning Lab	Supervised Learning Techniques	XGBoost: - 95%. GNB: - 94.74%. RF: - 89.47%. SVM: - 89%. KNN: - 84.21%. LR: - 84%	Heart attack using Supervised ML techniques with several data preprocessing approaches.	Further validation on larger and diverse dataset should be explored.
2022 [10]	Myocardial Infarction Complications dataset	SVM+LR	95.15%	Utilized ML algorithms to predict based on 12 complications.	A need for real-world application and assessment of the model's predictive power.
2022 [11]	Kaggle	Machine Learning Algorithms	DT: - 86%. KNN: - 90%. LR: - 88%. RF: - 88%. xGB: - 86%. SVM: - 70%	Proposed a ML framework with an accuracy of 90.16% and recall of 87.09%.	-
2022 [12]	Kaggle	KNN+SVM	KNN: - 78.8%; SVM 76.9%	Focused on using classification algorithms like SVM and KNN for heart attack prediction.	Further exploration on different machine learning techniques.
2021 [13]	Framingham Dataset	Synthetic Minority Oversampling Technique (SMOTE)	LR: - 72.8%. RF: - 94.6%. KNN: - 88.6%	Comparative approach using ML algorithms, with a focus on logistic regression after data processing and feature selection.	Further validation on diverse dataset should be explored.
2021 [14]	Kaggle	Machine Learning Algorithms	KNN: - 84.2%. DT: - 70.33%. RF: - 79%. LR: - 85%. SVM: - 85.7%	Applied ML models to predict and displayed results through a website, focusing on attributes like cholesterol, blood pressure, and blood sugar.	The technique used in this research should be more refined to obtain higher accuracy percentage.
2022 [15]	-	Literature Review	-	Literature Review of 49 papers from the reputed journals.	-

Year of Publication	Dataset Used	Methodology Used	Accuracy of the Model	Research Findings	Research Gaps
2021 [16]	Kaggle	MLP Neural Network	MLP: - 91.1%; Radial Basis Function: - 79.7%	Compared MLP and RBF neural networks.	The integration of additional variables or the application of hybrid models to enhance prediction accuracy.
2020 [17]	Kaggle	ANN + TensorFlow	SVM: - 81.97%. KNN: - 67.2%. DT: - 81.97%. ANN: - 85.24%	Investigated the accuracy levels using ANN and TensorFlow.	Further validation on larger and diverse dataset should be explored.
2020 [18]	UCI Machine Learning Lab	ELM + Resampling	ELM: - 87.41%. SVM: - 85.9%. KNN: - 84.4%. Bagging Trees: - 82.2%. LR: - 84.8%	Proposed a new diagnostic system using extreme learning machines (ELM) integrated with the resampling strategy.	A need for real-world application and assessment of the model's predictive power.
2020 [19]	UCI Machine Learning Lab	Ensemble deep learning and feature fusion approaches.	98.5%	Suggests the use of ensemble DL and feature fusion techniques to create a smart healthcare system for the prediction of heart disease.	A need for real-world application and assessment of the model's predictive power.
2020 [20]	Kaggle	Machine Learning Algorithms	73%	Employed a ML algorithm for high accuracy in heart disease prediction.	The technique used in this research should be more refined to obtain higher accuracy percentage.
2019 [21]	Real World Clinical Data	Tree augmented Naïve Bayesian	LR: - 93%. NB: - 93.2%	Studied various prediction models for patients suffering from acute myocardial infarction (AMI) using actual patient data from hospitals in Syria and the Czech Republic.	Explore the application of these models in different geographical and healthcare settings.
2019 [22]	Hybrid Dataset	Machine Learning Algorithms	DT: - 84.91%. SVM: - 88.68%. NB: - 96.23%. KNN: - 58.49%	Emphasized on the early detection and prevention of heart diseases using various data mining classification methods.	The need for further exploration of data mining role in healthcare data management and its impact on predictive accuracy.
2018 [23]	UCI Machine Learning Lab	ANN	97.5%	Analyzed the performance of various heart disease prediction techniques using Cleveland Heart Disease dataset.	Further validation of methodology on diverse dataset should be explored.
2018 [24]	UCI Machine Learning Lab	Logistic Regression	89%	The study tested a system using seven well-known classifiers and three feature selection algorithms to select important features.	-
2017 [25]	Real World Clinical Data	Data Mining Techniques	96%	Developed a prototype for predicting heart attack chances using clinical data and data mining techniques.	The need for further exploration of data mining role in healthcare data management and its impact on predictive accuracy.
2017 [26]	Real World Clinical Data	Decision tree (c4.5)	86%	Proposed a smartphone-based system using statistical analysis and data mining approaches.	The absence of detailed methodology in the abstract implies a need for further information on the system's design and validation.
2017 [27]	University of California	Naïve Bayes algorithm	81.25%	Presented a prototype implementation of a heart attack prediction system with a web-based user interface using the Naïve Bayes algorithm.	Further exploration on different machine learning techniques.
2017 [28]	UCI Machine Learning Lab	ANN	95%	The proposed model utilizes an artificial neural network backpropagation algorithm.	Further exploration on different machine learning techniques.
2016 [29]	UCI Machine Learning Lab	Machine Learning Algorithms	LR: - 85.1%. SVM: - 85.1%. KNN: - 79.1%. ANN: - 83.3%. NB: - 80.7	Employed a ML algorithm for high accuracy in heart disease prediction.	Further validation of methodology on diverse dataset should be explored.

III. Proposed Methodology

The basic steps that are involved in machine learning models are shown in the block diagram (Fig 2). First of all, because raw data cannot be used directly, data cleaning is done to convert raw data into a format that can be handled. Relevant features are then found, and these processes are then applied to the predictions of the machine learning model.

A. About Dataset

The dataset utilized in this study was provided by Georgy Zubkov [30] and comprises a comprehensive collection of 320,000 entries. It encompasses 18 distinct variables relevant to health and lifestyle factors, including but not limited to heart disease, BMI, smoking, and alcohol drinking. Of these variables, nine are Boolean; five are categorical string values; and four are continuous numerical data. This diverse array of variables enables a multifaceted analysis of health-related outcomes.

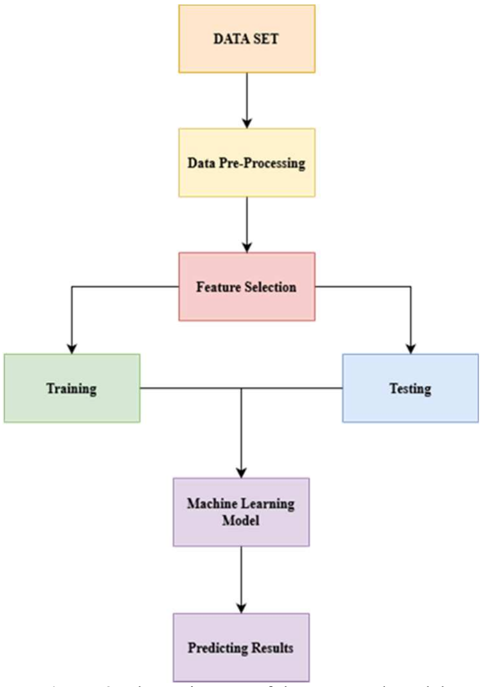

Figure 2. Flow Diagram of the proposed model

B. Data Pre-processing

In the preprocessing stage, Python was used within a Jupyter Notebook environment. First the unique values associated with each attribute were noted (Figure 3). This step was essential for any anomalies or outliers that might impact the predictive accuracy of our machine learning models. After assessing and cleaning the data, the author proceeded to train and test the machine learning models using these attributes.

```
Feature 'HeartDisease' has '2' unique values
Feature 'BMI' has '3604' unique values
Feature 'Smoking' has '2' unique values
Feature 'AlcoholDrinking' has '2' unique values
Feature 'Stroke' has '2' unique values
Feature 'PhysicalHealth' has '31' unique values
Feature 'MentalHealth' has '31' unique values
Feature 'DiffWalking' has '2' unique values
Feature 'Sex' has '2' unique values
Feature 'AgeCategory' has '13' unique values
Feature 'Race' has '6' unique values
Feature 'Diabetic' has '4' unique values
Feature 'PhysicalActivity' has '2' unique values
Feature 'GenHealth' has '5' unique values
Feature 'SleepTime' has '24' unique values
Feature 'Asthma' has '2' unique values
Feature 'KidneyDisease' has '2' unique values
Feature 'SkinCancer' has '2' unique values
```

Figure 3. Unique Values Associated with each Attributes

C. Feature Selection

The feature selection process played a critical role in enhancing the model's performance and interpretability. The initial dataset comprised eighteen attributes, each representing potential predictors of heart attack risk. However, to optimize and reduce the complexity of the model two attributes were excluded from the analysis. Consequently, the final model was constructed using a refined dataset of sixteen attributes.

D. ML Model

After refining the dataset through feature selection, key ML algorithms were implemented for prediction. These included KNN, Logistic Regression, XGBClassifier, and ExtraTreeClassifier. Each algorithm was chosen for its potential to effectively address classification tasks and model the data's intrinsic patterns, providing a robust framework for predicting heart attack risk. The performance of these models was then critically assessed to determine their efficacy in the predictive analysis.

IV. Results And Observations

The performance of ML algorithms, namely KNN, Logistic Regression, XGBClassifier and ExtraTreeClassifier, is evaluated. A table is presented, outlining the key metrics such as accuracy, precision, recall, and the F1-score obtained from each algorithm's predictions (Figure4). These metrics serve as essential indicators of the model's predictive capabilities across various classes or outcomes of interest.

TABLE III. Results

Models	Accuracy	Precision	Recall	F1 Score
KNN	90.37%	35.07%	8.64%	13.87%
Logistic Regression	91.16%	54.44%	8.96%	15.38%
XGB Classifier	91.12%	53.16%	9.06%	15.49%
Extra Trees Classifier	88.97%	27.99%	14.57%	19.16%

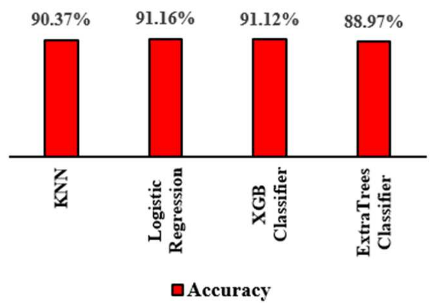

Figure 4. Model Prediction

To investigate Heart Attack Prediction Techniques, a comprehensive review of research articles encompassing the years 2016 to 2023 was conducted. Using a range of search phrases related to our subject, this search was conducted across several academic databases, including Google Scholar, Research Gate, Elsevier, Scopus, and Web of Science [31-42]. In the end, the author chose 30 papers to review.

In the study of 30 research papers, the authors found a mix of different data set sources used for prediction. Three of these papers used online articles as their source of information. One paper worked with the Framingham Dataset, a well-known set of data in health research. Another paper didn't specify which dataset it used, and one focused on reviewing other literature instead of using a dataset. One research paper used what's called a Hybrid Dataset (Kaggle + UCI Machine Learning Lab), and another examined data specifically about Myocardial Infarction Complications. Five papers used Real World Clinical Data, which means they looked at information gathered from actual patient care settings. Seven papers got their data from the UCI Machine Learning Lab, showing the lab's importance in providing high-quality data for research. Finally, one paper used a dataset from the University of California, pointing out the contribution of educational institutions to research resources. Table 4 provides a detailed breakdown of how these data sets were distributed across papers. Furthermore, Figure 5 offers a graphical depiction, more precisely a bar chart, showing the observed pattern.

TABLE IV. DATA SET DISTRIBUTION

Name of the Dataset	Count of Distribution
Online Articles	3
Literature Review [15]	1
Data Set Not Mentioned [5]	1
Framingham Dataset	1
Hybrid Dataset	1
Kaggle	9
Myocardial Infarction Complications Data	1
Real World Clinical Data	4
UCI Machine Learning Lab	7
University of California Dataset	1

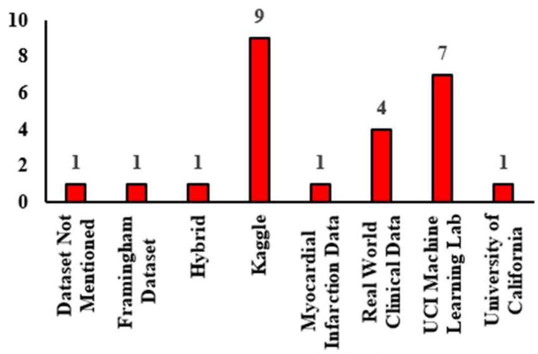

Figure 5. Data set Distribution

V. CONCLUSION

In conclusion, recent research underscores the pivotal role of ML in advancing the prediction and early detection of heart attacks, which is critical for improving healthcare outcomes. Studies highlight various ML techniques as effective tools in predicting heart disease with significant accuracy. These advancements offer promising pathways for incorporating ML into clinical settings, aiming to enhance the precision of cardiovascular disease diagnoses and treatment plans. Moreover, the emphasis on large and diverse datasets in these studies addresses previous limitations, potentially reducing the risk of overfitting and improving model generalizability. Future research should continue to explore and refine ML algorithms, focusing on integrating them into healthcare practices to ensure timely and accurate heart attack predictions, ultimately contributing to the reduction of cardiovascular disease mortality rates.

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