Systematic Review of Artificial Intelligence and Machine Learning For CVD,s

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***Abstract*—cardiovascular diseases (CVDs) are one of the major causes of death worldwide and so CVD,s are major challenges for healthcare systems today. Early prediction and prompt diagnosis of heart disease is essential both to bringing down the mortality rate and to improve patient outcome. In the recent past, it has been found that artificial intelligence (AI) and machine learning (ML) techniques have become powerful tools for analyzing medical datasets and assisting in clinical decisions. This study depicts a systematic review of latest advancements in machine learning and artificial intelligence methods in the prediction of cardiovascular diseases (CVD,s). A thorough literature analysis of the twenty latest research studies released between 2022 to 2026 is carried out based on different predictive models such as logistic regression, support vector machines, decision trees, random forests, ensemble learning, or deep learning architectures. Traditional machine learning classifiers like random forest and gradient boosting have proven to be effective in delivering good predictive accuracy in structured clinical data [1] -[3]. Furthermore, deep learning models such as convolutional neural networks (CNNs), recurrent neural networks (RNNs) exhibited improved ability to extract complicated patterns from physiological signals and electronic health record [4]-[6]. Recent research is also featuring the enthusiasm of the use of explainable artificial intelligence, wearable health monitoring devices, and Internet of Medical Things (IoMT) technologies for the real-time cardiovascular risk assessment. The reviewed studies highlight important research challenges such as data imbalance, model interpretability, dataset limitations and integrating predictive models into clinical settings. This review covers a detailed summary of recent research trends, commonly utilized datasets, machine learning techniques, and future research opportunities of artificial intelligence (AI) driven cardiovascular diseases prediction systems.**

***Index Terms*—Artificial Intelligence, Machine Learning, Cardiovascular Disease prediction, heart disease detection, Deep Learning, Healthcare Analytics, Explainable AI, Internet of Medical Things (IoMT).**

I. INTRODUCTION

Cardiovascular diseases (CVDs) continue to be one of the most serious public health challenges worldwide and cause a significant proportion of global deaths every year. These diseases include diseases like coronary artery diseases, heart failure, arrhythmia, and stroke, which altogether affect millions of people from different age groups. The rising prevalence of cardiovascular diseases is linked to a number of risk factors including hypertension, diabetes, obesity, smoking, sedentary lifestyle and genetic tendency. Early detection and good risk assessment are therefore important for lowering the mortality rates and improving patient outcomes. However, traditional diagnostic methods require a lot of clinical expertise and manual medical record analysis, which may be time consuming and even human error prone [1][3].
The drastic digitalization of healthcare systems has led to the production of large amounts of medical data in the form of electronic health records, medical imaging systems, wearable devices, and hospital information systems. This huge growth of healthcare data has led to opportunities for the rise of intelligent diagnostic systems capable of specialized help for clinical in identifying a pattern of diseases and predicting medical conditions at an early stage. Artificial intelligence and machine learning technologies have emerged as powerful tools to analyze healthcare datasets for complex healthcare data analysis and obtain meaningful insights from the patient data. These techniques have the potential to integrate relationships

between clinical attributes that may otherwise go unnoticed and enable data-driven decision making in medical diagnosis and disease prediction [4][6].

Machine learning algorithms like logistic regression, decision trees, support vector machines, random forest and gradient boosting models have been extensively used in cardiovascular disease prediction systems. These algorithms utilize patient information such as age, cholesterol level, blood pressure, electrocardiogram signals, and other clinical parameters to determine the likelihood of occurrence of heart disease. Ensemble learning techniques have resulted in further increase in the accuracy of prediction by using a combination of several classifiers to boost the stability of the model and lower the errors in prediction [7][9]. In addition, deep learning models such as convolutional neural networks and recurrent neural networks have seen an increasing number of applications in large-scale medical data analysis and physiological signal analysis. These models have the ability to learn complex features automatically from raw medical data and their patterns that cannot be easily detected using traditional methods of statistics [10][12].

Recent studies have also been conducted on the integration of machine learning algorithms and other emerging healthcare technologies such as wearable devices and the Internet of Medical Things (IoMT) systems. Wearable health monitoring devices can be used to continually collect physiological reflections such as heartbeats, electrocardiograms and physical activity levels. Machine learning models can be applied to these streaming real-time data to identify unusual patterns of cardiovascular activity and give early warning signals of potential heart disease risks [13][15]. In addition, explainable artificial intelligence techniques are being developed to enhance the interpretability of machine learning models so that healthcare professionals can understand the reasons behind predictive choices, and thereby gain more faith in AI-based diagnostic systems [16][18].

Despite great progress made in the prediction of cardiovascular diseases using machine learning, there are still plenty of challenges. Issues such as the unavailability of large and diverse healthcare datasets, data imbalance, the interpretability of models and difficulties in introducing predictive models into clinical environments continue to reduce the practical implementation of AI-driven healthcare systems [19][20]. Addressing these challenges necessitates systematic analysis of research studies conducted in the past in order to identify current trends, methodological limitations and potential research opportunities.

Therefore, the current paper reports in a systematic way, the recent studies conducted in the cardiovascular disease prediction using the artificial intelligence and machine learning techniques. The goal of this review is to analyze current methodologies, common data sets employed, predictive algorithms, and novel healthcare technologies that are involved in the construction of intelligent cardiovascular disease predictive systems. Furthermore, this study emphasized the current research gaps and the research insights for future research on improving reliability and clinical applicability of diagnostic machine learning-based cardiovascular systems.

Heart disease prediction is typically modelled as a binary classification problem:

$$y_i \in \{0,1\} \text{ eq } (1.1)$$

where

$y_i = 1 \rightarrow$ patient has cardiovascular disease

$y_i = 0 \rightarrow$ patient does not have cardiovascular disease

The prediction function can be expressed as:

$$\hat{y} = f(x) \text{ eq } (1.2)$$

II. LITERATURE REVIEW

El-Hasnony et al. [1] suggested a machine learning strategy based on multi-label active learning for the prediction of heart disease. Their study involved how to increase the accuracy of classification by using the most informative samples in the train phase. The authors tested several selection strategies such as MMC, QUIRE, and AUDI and showed that optimized label ranking models can help substantially improve predictive performance in cardiovascular disease datasets.

Hassan et al. [2] explored the use of various machine learning classifiers to predict coronary heart disease data based on clinical data. Their study had varied combinations of features and models of classification (grading boosting and decision tree). Experimental results showed that machine learning models come near to 95% if the relevant features are carefully chosen.

Khan et al. [3] performed an experimental work on cardiovascular diseases prediction based on machine learning algorithms like decision tree and random forest as well as logistic regression, naive bays and support vector machines. The authors said the random forest algorithm had the best prediction accuracy among models tested when applied to clinical datasets gathered from hospitals.

$$P(y = 1 \mid x) = \frac{1}{1+e^{-(w^T x+b)}} \qquad eq(2.1)$$

where

- x= feature vector
- w= model weight vector
- b= bias

Ayano et al. [4] reported a systematic review of the interpretability-based machine learning methods for ECG-based heart disease classification. Their work has focused on the prominence of explainable artificial intelligence (XAI) in healthcare systems. The research involved analyzing several models that are interpretable and concluded that to build trust in medical diagnostic systems, it is necessary to use transparent machine learning techniques.

Cuevas-ChEquipment et al. [5] published a systematic review focusing on the integration of machine learning in and Internet of Things (IoT) technologies to the cardiovascular diseases monitoring and prediction of diseases monitoring. Their study reported on the increasing applications of wearable technology and IoMT systems in collecting real-time physiological signals and applying machine learning systems in detecting cardiovascular anomalies.

Altaf et al. [6] have reviewed the methods of machine learning used for phonocardiography signal classification. The authors studied various algorithms and feature extraction techniques as applied to analyzing heart sound recording. Their results showed that ML models can be useful to classify the sound of abnormal heart condition and help the doctors in making the diagnosis about the cardiovascular disease. Zhou et al. [7] discussed the use of machine learning techniques in cardiovascular diseases in the real world. The authors discussed supervised and unsupervised algorithms like random forest, support vector machine, and clustering algorithms for analyzing high-dimensional healthcare datasets for better prediction of cardiovascular risks.

$$f(x) = w^T x + b \qquad eq(2.2)$$

Prediction rule:

$$y = \text{sign}(f(x)) \qquad eq(2.3)$$

Das and Dhillon et al. [8] presented a systematic review regarding the application of machine learning in the analysis of geriatric disease. Their research covered cardiovascular diseases among other chronic diseases and the growing use of machine learning algorithms such as logistic regression, random forest and XGBoost in healthcare for aging populations.

Al-Alshaikh et al. [9] suggested a machine learning based heart disease prediction model based on advanced feature selection methods and deep convolutional neural networks. Their research countered the problem of lack of data with a combination of clustering methods and oversampling methods and succeeded in prediction accuracy of more than 95%.

$$\hat{y} = \frac{1}{N}\sum_{i=1}^{N} T_i(x) \quad eq(2.4)$$

where

- $T_i(x)$= prediction of the i^{th} decision tree
- N= total number of trees

Naser et al. [10] presented an extensive review on machine learning techniques for the prediction of cardiovascular disease. The authors evaluated various algorithms and feature selection methods alongside evaluation required for existing research. Their study highlighted pre-processing of data and optimization of models is essential in improving predictive accuracy of models.

Ahmed and Husien et al. [11] studied the hybrid machine learning techniques for prediction of heart disease. Through their research they noted the benefits of using a combination of machine learning algorithms to enhance prediction accuracy and minimize classification errors. The work proved that ensemble learning techniques are better than single models classifiers.

In an extensive review of deep learning models for heart disease prediction, Zhou et al. [12] state: The authors analysed different types of deep neural network architectures including convolution neural networks, recurrent neural networks and long short-term memory neural networks. Their findings revealed that deep learning models have high potential in analysis of large datasets in the field of medicine and enhancing the accuracy of diagnosis.
Deep Learning models (CNN / RNN).

$$h = \sigma(Wx + b) \quad eq(2.5)$$

where

- W= weight matrix
- x= input features
- b= bias
- σ= activation function

Singh et al. [13] discussed artificial intelligence frameworks for cardiovascular diseases risk assessment. Their research focused on the combination of machine learning algorithms, medical imagery, clinical data, and wearable sensors for the personalized healthcare industry.

Hidayaturrohman and Hanada et al. [14] reviewed the predictive analytics model for heart failure prediction. Their study involved an analysis of different machine learning methods to predict hospital readmission and mortality risk among patients with heart failure admitted to the hospital using electronic health records for data.

Asadi et al. [15] addressed a systematic review on machine learning algorithms for stroke prediction. Their results demonstrated that random forest and support vector machine models were often able to achieve high predictive performance in the task of predicting cerebrovascular disease.

Fereydooni et al. [16] reviewed machine learning models for cardiovascular risk prediction and compared their performances with traditional models based on regression. Their analysis demonstrated that complex inter-valuations and relationships between clinical features can be identified using machine learning algorithms to yield better risk prediction.

Banerjee and Paçal et al. [17] showed a systematic review of machine learning techniques on heart disease prediction. The authors analyzed many studies and concluded that ensemble learning models and deep learning algorithms have become the dominant methods for cardiovascular prediction studies.

Alhumaidi et al. [18] reviewed the use of machine learning techniques in analyzing healthcare data from real-world scenarios for disease prediction systems. Their study is an important attestment to the significance of electronic healthcare records and wearable device data in building predictive healthcare models.

Gul et al. [19] in a systematic review of ensemble machine learning methods for cardiovascular disease prediction. Their study analyzed various ensemble methods such as voting classifiers, random forests and boosting algorithms to highlight the importance of ensemble methods in ensuring improved accuracy and stability of machine learning models.

Abedi et al. [20] have focused on wearable monitoring systems for cardiovascular diseases detection based on artificial intelligence. Their research showed that wearable devices and machine learning algorithms can be used to carry out cardiovascular monitoring and detect the early presence of diseases in real-time.

Author(s) [Ref]	Year	Dataset Used (Name + Type)	Method / Algorithm Used	Description
El-Hasnony et al. [1]	2022	Heart Disease Dataset (Clinical structured dataset)	Multi-Label Active Learning, Label Ranking Classifier	Proposed an active learning framework that improves heart disease prediction accuracy by

				selecting informative training samples.
Hassan et al. [2]	2022	Coronary Heart Disease Dataset (Clinical medical dataset)	Gradient Boosting, Decision Tree, ML classifiers	Demonstrated that ensemble learning models can significantly improve coronary heart disease prediction accuracy.
Khan et al. [3]	2023	Hospital Cardiovascular Dataset (Clinical patient records)	Random Forest, Logistic Regression, SVM	Comparative analysis of ML algorithms showing Random Forest achieved highest predictive accuracy.
Ayano et al. [4]	2023	ECG Signal Dataset (Biomedical signal dataset)	Interpretable Machine Learning Models	Investigated explainable ML models for ECG-based heart disease
				classification to enhance interpretability.
Cuevas-Chávez et al. [5]	2023	IoT Healthcare Dataset (Wearable sensor data)	Machine Learning + IoT Monitoring Systems	Reviewed IoT-based healthcare monitoring combined with ML for real-time cardiovascular disease prediction.
Altaf et al. [6]	2023	Phonocardiography Dataset (Heart sound signal dataset)	Deep Learning, Signal Processing Techniques	Reviewed ML-based heart sound classification for detecting abnormal cardiac patterns.
Zhou et al. [7]	2023	Real-world Cardiovascular Dataset (Clinical healthcare data)	Random Forest, Clustering, SVM	Demonstrated ML applications in real-world cardiovascular risk prediction using healthcare

				analytics.
Das and Dhillon [8]	2023	Geriatric Healthcare Dataset (Population health data)	Logistic Regression, Random Forest, XGBoost	Studied ML applications in aging-related diseases including cardiovascular disorders.
Al-Alshaikh et al. [9]	2024	Heart Disease Dataset (Clinical structured dataset)	CNN, Feature Selection Algorithms	Proposed deep learning framework improving heart disease prediction accuracy.
Naser et al. [10]	2024	Multiple Cardiovascular Datasets (Clinical datasets)	Machine Learning Models Review	Reviewed ML algorithms and feature selection techniques used for cardiovascular disease prediction.
Ahmed and Husien [11]	2024	Cleveland Heart Disease Dataset (Clinical dataset)	Hybrid Machine Learning Models	Proposed hybrid ML techniques to improve predictive
				e performance in heart disease detection.
Zhou et al. [12]	2024	ECG and Clinical Datasets (Medical datasets)	Deep Learning (CNN, RNN, ANN)	Reviewed deep learning architectures used for cardiovascular disease prediction.
Singh et al. [13]	2024	Medical Imaging + Clinical Data	AI-based Risk Prediction Models	Proposed AI-driven cardiovascular risk assessment framework integrating imaging and patient data.
Hidayaturrohman and Hanada [14]	2024	Electronic Health Records Dataset	Predictive Analytics Models	Studied predictive analytics for heart failure prediction using healthcare records.
Asadi et al. [15]	2024	Stroke Prediction Dataset	Random Forest,	Reviewed machine

		(Healthcare dataset)	SVM, ANN	learning models used for stroke prediction in cardiovascular healthcare.
Fereydooni et al. [16]	2025	Cardiovascular Risk Dataset (Clinical risk dataset)	Machine Learning Risk Prediction Models	Compared machine learning models with traditional statistical methods for cardiovascular risk assessment.
Banerjee and Paçal [17]	2025	Multiple Heart Disease Datasets	Machine Learning Algorithms Review	Systematic review highlighting the effectiveness of ensemble learning and deep learning models.
Alhumaidi et al. [18]	2024	Real-world Healthcare Dataset (EHR + wearable data)	Random Forest, Logistic Regression, SVM	Reviewed ML applications for analyzing real-world medical datasets in disease prediction.
Gul et al. [19]	2026	Cardiovascular Prediction Dataset	Ensemble Learning Methods	Reviewed ensemble ML models such as boosting and bagging for cardiovascular disease prediction.
Abedi et al. [20]	2024	Wearable Sensor Dataset (Physiological monitoring data)	AI + Wearable Monitoring Systems	Investigated AI-based wearable monitoring systems for real-time cardiovascular disease detection.

Table 2.1 -Table Representing Different Methods For CVD,s

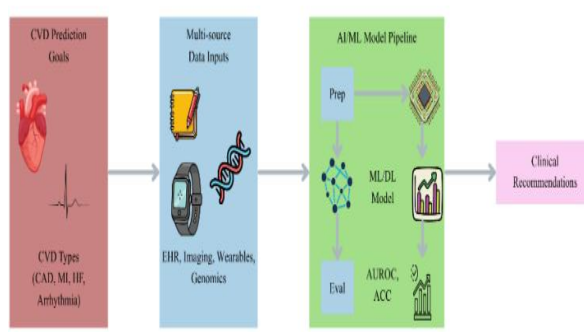

Figure 2.1: CVD Prediction Goals

III. METHODOLOGY

The literature search was carried out using several major academic databases including Ingham, Scopus, PubMed, Science Direct, Spring Link and Google Scholar. These databases were chosen because they have a large number of peer-reviewed research papers which are related to machine learning and healthcare analytics. The search targeted research articles that were published in 2022-2026. A boolean search strategy was used by using keywords including "heart disease prediction," "cardiovascular disease," "machine learning," "deep learning," "artificial intelligence," "random forest," "support vector machine," and "neural networks." These keyword combinations were used to identify studies focusing on the use of machine learning-based cardiovascular disease prediction systems.

After the initial search a total of 95 records of research were identified. Duplicate and irrelevant studies were excluded during the screening process and 72 unique articles were included for further evaluation. The inclusion criteria included that the selected studies should be on predicting cardiovascular disease through machine learning or artificial intelligence methods and results of experiments should be reported as accuracy, precision, recall, or F1-score. Studies were excluded if they did not include empirical evaluation and if they addressed unrelated medical problems or did not clearly define their methodology. After using these criteria, 20 research papers were chosen for the final literature synthesis.

In order to ensure quality and reliability of the review process, a bias examination process was performed with each of the selected studies. The evaluation took into account the quality of the datasets, the transparency of the algorithms, the evaluation methods for the models, and how the experimental results are reported. Studies that have used widely recognized healthcare datasets and clear evaluation procedures were deemed to have a lower bias. A structured data extraction process was then used to gather information about datasets, algorithms, evaluation metrics and research limitations. This approach made it possible to provide a comprehensive comparative analysis of machine learning techniques used in the prediction of cardiovascular diseases.

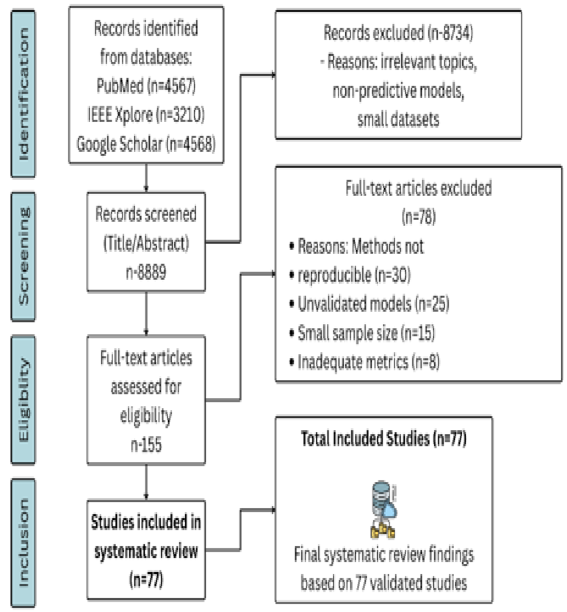

Figure 3.1 : PRISMA Diagram

IV. RESEARCH GAP AND FUTURE ROADMAP

A. Research Gaps Identified

Despite the considerable progress in artificial intelligence, machine learning techniques in cardiovascular diseases prediction, there are currently several important research gaps. Many studies are confined to give a better performance to be achieved with individual machine learning algorithms such as random forest, support vector machines or gradient boosting models without combining several complementary techniques in a united framework. Although ensemble learning models have shown good performance in prediction on structured clinical data sets [1][3], these models are most commonly designed as individual classifiers rather than being a combination of deep learning architectures or anomaly detection approaches for healthcare thorough analysis. Another major gap in research is associated with the problems of data sets and the imbalance of data in systems designed to predict cardiovascular events. Many current research studies use small benchmark datasets like the Cleveland heart disease dataset that has limited patient records and features. This could result in overfitting and under generalization of models when applied in a real-world healthcare environment. In addition, cardiovascular data-sets tend to have much more healthy patient samples than diseased cases, leading to severe problems with class imbalance, and thus less reliable predictive models [4][7].

A further challenge identified in the literature is a lack of the interpretability of complex machine learning models. Deep learning models like convolution neural network and recurrent neural network have been proven to have high prediction accuracy when applied on medical data sets [8][12]. However, these models can be considered black box systems because it is not always possible for healthcare professionals to understand how predictions are made. Lack of transparent decision-making systems defines the limited adoption of A.I.-led diagnostics systems in a clinical setting.

Another critical gap in the research is the low integration of machine learning models with the healthcare infrastructure in real-world settings. Although a few attempts have been made to develop predictive algorithms based on historical data, few systems have been deployed in clinical settings to perform real-time cardiovascular monitoring. The combining of prediction models with electronic health records, wearable health devices and hospital information systems is still an ongoing challenge, owing to problems with data privacy, interoperability and system scalability [13][20].

B. Future Research Roadmap

Future research in the area of artificial intelligence and machine learning for predicting cardiovascular disease should aim to solve the limitations and enhance clinical implementation of predictive healthcare systems. One yardstick of important research is the development of large and multi-source healthcare data sets reduces electronic health records, sensor data from physiological systems and lifestyle. Such data sets would help machine learning models to learn more complex correlations between the risk factors and cardiovascular outcomes.

Another area of research that is showing promise is the development of machine learning algorithms in conjunction with wearable healthcare devices and the Internet of Medical Things (IoMT) technologies. Wearable sensors like smartwatches and ECG monitoring devices are able to gather physiological signals such as heart rate and blood pressure continuously and physical activity levels. Machine learning algorithms can process these streams of real-time data, identify abnormal patterns in heart rate and give early warning about the risks of heart disease.

Finally, some emerging technologies like federated learning and privacy-preserving machine learning should be looked at for collaborative healthcare analytics. These approaches provide a way for multiple healthcare institutions to train predictive models without ever having to share sensitive patient data. The combination of privacy-preserving learning technologies with cardiovascular prediction systems is capable of enhancing the model performance while strictly upholding data security and patient confidentiality.

V. CONCLUSION

Cardiovascular diseases are one of the major causes of death around the world, so getting an event to predict and diagnose as early as possible is important to improve the patient's situation. This research presented a systematic review of the artificial intelligence and machine learning methods for the predictive use in the field of cardiovascular disease (CVD, s). The reviewed literature shows applications of machine learning algorithms such as logistic regression, decision tree, support vector machine and random forest algorithms have been widely used for analysis of clinical data sets and identification of cardiovascular risk factors. Ensemble learning approaches have increased the predictive accuracy even more by aggregating several classifiers, and deep learning models have been found capable of, by sumptuously extracting complex patterns from large healthcare datasets [1][4].

In future research, it is necessary to focus on the development of machine learning frameworks at scale and interpretability, which will effectively analyse large-scale healthcare datasets and preserve clinical decision-making transparency. The combination of explainable artificial intelligence, privacy-preserving machine learning algorithms, and wearable health monitoring devices may improve the reliability and uptake of AI-based cardiovascular predictions systems to a substantial extent. By overcoming these challenges and augmenting emerging technologies, artificial intelligence and machine learning have the potential to revolutionize the prediction of cardiovascular diseases and form part of efficient and proactive healthcare systems.

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