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RESEARCH ARTICLE

Enhancing Heart Health Prediction with Natural Remedies Through Integration of Hybrid Deep Learning Models

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Abstract

Background: Cardiovascular disease remains a leading cause of mortality worldwide, necessitating advanced predictive models to improve early detection and prevention. The integration of natural remedies with machine learning techniques offers a promising approach for enhancing heart disease prediction. **Aim:** This study aims to develop a hybrid learning model for predicting cardiac disease by combining machine learning algorithms with natural remedies to improve the model's accuracy and clinical applicability. **Methods**: A dataset titled "Indicators of Heart Disease (2022 UPDATE)" containing 246,023 patient records was sourced from Kaggle. The hybrid model combines Random Forest (RF) for interpretability and Long Short-Term Memory (LSTM) networks for time-series analysis. Features related to herbal medicines and their impact on heart health were incorporated to enhance predictive accuracy. **Results**: The hybrid model achieved an accuracy of 100%, demonstrating the potential of integrating traditional medical data with natural remedies to enhance cardiovascular disease forecasting. The inclusion of natural remedies provided a comprehensive tool for clinicians, enabling more precise decision-making. **Conclusion**: Integrating natural remedies into machine learning models is a promising direction for improving the prediction and early prevention of heart disease. This approach offers a sustainable and accessible solution to cardiovascular healthcare, with the potential to significantly improve patient outcomes.

Keywords: Artificial Intelligence, Cardiovascular Prediction, Deep Neural Networks, Healthcare Analytics, Herbal Treatments

1. Introduction

Heart disease is a significant contributor to mortality worldwide, posing a huge public health issue. Although medical technology and treatment choices have improved, prevention and early detection are still essential in reducing the effects of cardiovascular diseases. Conventional risk assessment models mostly depend on clinical and demographic data, which may not completely encompass the intricacies of individual health profiles. Lately, there has been increasing interest in utilising artificial intelligence specifically machine learning and deep learning, to improve predictive modelling in healthcare[1]. Despite technological developments, there is a renewed interest in natural therapies and lifestyle approaches for maintaining heart health. These comprise dietary adjustments, exercise, stress management strategies, and herbal supplements, among other methods[2,3]. Combining these comprehensive methods with advanced AI models offers a great opportunity to enhance heart disease prediction and prevention techniques. Cardiovascular disease (CVD) is the most common overall cause of death. Phytochemicals derived from medicinal plants have garnered attention for their potential in CVD treatment due to their reduced adverse effects and cost-effectiveness compared to synthetic drugs. Current research is

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dedicated to isolating bioactive compounds from various plant sources, such as phenols, flavonoids and terpenoids, among others, to counter CVD. These compounds exhibit cardio-protective properties by modulating factors like blood lipids, obesity, glucose levels, inflammation and oxidative stress.

Nevertheless, many of their mechanisms of action remain elusive. Although preclinical and clinical investigations highlight the promise of medicinal plants in mitigating cardiovascular risk factors, further studies are imperative to elucidate their comprehensive effects. Comprehensive clinical trials are necessary to evaluate the effectiveness, safety, and toxicity characteristics of phytochemicals found in medicinal plants[4].

The existing body of evidence indicates that herbal medicines exhibit considerable therapeutic potential in addressing the pathological manifestations associated with CVDs. Nevertheless, the precise clinical efficacy of these herbal treatments remains subject to uncertainty, precluding their unreserved recommendation as alternative therapeutic modalities for CVD management. Moreover, recent apprehensions have surfaced regarding the safety and potential toxicity of specific herbal remedies, notably exemplified by *Gingko Biloba*. In light of these uncertainties, there is a pressing need for meticulously designed studies and forthcoming clinical trials characterised by expanded sample sizes. These endeavours are essential for elucidating the diverse roles of medicinal plants and their underlying mechanistic pathways within the realm of CVDs. Notably, a paramount focus of future clinical investigations should be the thorough evaluation of the safety and toxicity profiles associated with the utilisation of herbal remedies in cardiovascular healthcare[5]. CVD poses a significant global health challenge, with limited therapeutic options due to side effects. *Ellagic acid* (EA) and its metabolite urolithin, abundantly found in pomegranates, berries and nuts, offer promising therapeutic potential. This study aims to analyse literature on EA and urolithins, highlighting their role in treating CVD. Findings indicate their preventive and curative effects with minimal side effects, including regulation of lipid metabolism and inhibition of pro-inflammatory factors. These chemicals have the potential to prevent and treat disorders like atherosclerosis, hypertension and myocardial infarction by affecting several molecular pathways. Both laboratory and live organism investigations provide evidence for their potential as early preventative and effective treatment medicines for cardiovascular disease[6].

2. Natural Remedies for Heart Health

Various interventions based on botanical, dietary and lifestyle strategies are considered natural cures for heart diseases. These cures may complement traditional treatment and improve cardiovascular health, which is attracting attention. Certain natural compounds possess cardio-protective qualities that could help prevent and treat cardiovascular disease, as suggested by research investigations. While natural remedies may have potential benefits for heart disease, they should not be used as a substitute for traditional medical therapy. People with cardiac issues should seek advice from their healthcare professional before adding any new vitamins or therapies to their routine. Table 1 below illustrates some of these natural remedies and their effect on heart health.

This research introduces a hybrid model that merges deep learning and machine learning techniques with knowledge from natural remedies and lifestyle therapies to enhance the precision and customisation of heart disease prediction. It seeks to create a complete predictive model for cardiovascular health by combining clinical data with lifestyle factors and natural therapies to account for its multidimensional nature. This hybrid method improves prediction accuracy and allows for more personalised interventions and patient-centred care.

Table 1. Natural remedies to heart health

S. No.	Natural Remedies	Effect on Heart Health	References
1	Hawthorn prepa rations	*Hawthorn* formulations have been used to treat heart failure, which occurs when a weak heart cannot supply peripheral tissues with oxygen and nutrients. *Hawthorn* flavonoids, procyanidins, organic acids and amines influence the heart. Notice that Commission E and the EMA gave leaf and bloom favourable monographs for traditional purposes. Dried hawthorn extracts have been tested for heart problems in many clinical trials. Commercial markets sell various galenic phytopreparations. *Hawthorn* preparations are recommended as heart failure supplements by current standards.	[7]

Table 1. Continued...

2	Ginse noside, Astrag aloside, and resveratrol in CHM	Oxidative Stress (OS) is an imbalance between oxidative and antioxidative mechanisms that increases oxidation. This imbalance can cause neutrophil infiltration, protease secretion and oxidative compound production. This phenomenon is fundamental to cardiovascular disease development. Bioactive substances from Chinese Herbal Medicines (CHMs) are frequently used to treat Cardiovascular Diseases (CVD), including hypertension and coronary heart disease. After Nobel winner, YouyouTu discovered artemisinin for malaria, the medical community has actively studied Chinese Complementary Medicine's (CCM's) medicinal potential for many illnesses. Ginsenoside, astragaloside, and resveratrol in CHM reduce oxidative stress and affect the circulatory system.	8
3	Resveratrol, berberine and curcumin	The greatest cause of death and disability worldwide is heart disease. Chronic proatherogenic inflammation causes heart disease and acute complications. Epidemiological study links hypercholesterolemia, hypertension, diabetes, inflammatory mediators, oxidative stress and heart disease. Herbal and nutraceutical heart disease treatments have been intensively investigated in recent decades. Much research has studied how medicinal plants' potent antioxidants affect serum cholesterol, atherosclerosis and ischemia. Resveratrol, berberine and curcumin may treat cardiac problems due to their antioxidant, anti-inflammatory and autophagy-modulating effects.	9
4	Herbal Plant	Cardiovascular diseases are major causes of global mortality and chronic illness. Chemical and natural therapies address cardiovascular disease. Herbal remedies include *Carumcarvi* L., *Echiumamoenum*Fisch. and C.A.Mey., *Citrus auranti-floria*, *Zataria multiflora* Boiss., *Teucrium polium* L., *Zingiber officinale* Roscoe, *Falcaria vulgaris*Bernh., *Cynodon dactylon* (L.) Pers., *Vitis vinifera* L., *Glycyrrhiza glabra* L., *Artemisia absinthium* L.	10
5	Nuts	Nuts are high in unsaturated fatty acids, protein, fibre, carbs and antioxidants. To reduce chronic heart disease risk, nuts are recommended in diets. The anti-inflammatory properties of nuts help manage weight and insulin sensitivity. Nutritional nuts contain vitamins, minerals and phenolic compounds. Phytosterols in nuts reduce cholesterol absorption. Omega-3 and omega-6 fatty acids in walnuts benefit the heart, brain and neurotransmitters. Linolenic and linoleic acids are in nuts. The body benefits from reducing low-density lipoproteins, increasing high-density lipoproteins and boosting vascular function. Pine and cashew nuts contain monounsaturated and polyunsaturated fats. People with metabolic issues benefit from cashew nuts' antioxidant properties. Iron-rich nuts can improve acute and chronic vascular reactivity. Cashews fight heart disease and diabetes with antioxidants.	11
6	Dark Chocolate	While chocolate is widely enjoyed, those with cardiovascular or neurovascular issues may be concerned about potential health hazards. The study utilises multivariate statistics to provide a health metric for heart disease patients who opt for healthy chocolate. Chocolate made from cocoa beans contains antioxidant flavonoids. Flavonoids are the predominant polyphenols in the diet. Polyphenols' antioxidant properties combat ageing and benefit individuals with heart disease and diabetes. Individuals with heart conditions should restrict their intake of saturated fat, trans fat, sodium and cholesterol and enhance their dietary fibre consumption. Cocoa flavanols enhance blood circulation throughout the body. Optimal circulation is essential for the heart, brain and muscles. The ingredient contents of 20+ chocolates from 60+ different varieties were analysed. A multivariate correlation analysis revealed significant negative associations between cocoa and sugar and positive correlations between diet fibre and iron. Dark chocolate contains a higher proportion of cocoa and less sugar. Higher cocoa content is associated with increased levels of dietary fibre and iron. Hierarchical clustering analysis can be used to differentiate between dark, milk and white chocolate, which can help clarify the mentioned relationships. These three chocolates are distinguished by their cocoa and calcium content. Consuming nutritious chocolate can aid in the prevention of heart disease. Cancer, diabetes and other illnesses can be improved using the same approach.	12
7	Purification techniques in Yoga	The study found that various yoga practices such as *Asanas*, *Pranayama*, *Shat Karmas*, *Mudras* and *Bandhas* were effective in preventing and treating cardiovascular diseases. Specific practices like *Shambhavi Mudra*, *Nasikagra Mudra* and *Bhramari Mudra* were identified as beneficial for cardiovascular health.	13
8	Four potent traditional botanicals viz	The paper examines the cardiovascular effects of four potent traditional botanicals: garlic (*Allium sativum*), guggul (*Commiphora wightii*), hawthorn (*Crataegus oxyacantha*) and *Arjuna* (*Terminalia arjuna*). Although traditionally utilised for heart disease treatment, a recent study suggests that these herbs can successfully treat cardiovascular disorders including ischemic heart disease, congestive heart failure, arrhythmias and hypertension.	14

3. Literature Review

This study proposes a novel hybrid model that integrates deep learning and machine learning methodologies with insights from natural remedies and lifestyle interventions to refine the accuracy and customisation of heart disease prediction. The aim is to develop a comprehensive predictive framework for cardiovascular health that integrates clinical data alongside lifestyle determinants and natural therapies, thus addressing its multifaceted nature. Through this hybrid approach, we enhance prediction precision and facilitate tailored interventions, thereby advancing patient-centred care in cardiovascular health management[15] .

The impact of lifestyle factors like physical exercise and sleep patterns on blood pressure varies from person to person. The goal of this research is to explore these correlations and offer personalised blood pressure recommendations, rather than broad lifestyle advice. Researchers analyse time-series data using automated data collection from home Blood Pressure (BP) monitors, wearable activity trackers and feature engineering techniques. Researchers advocate utilising RF with Shapley-Value-based Feature Selection to personalise blood pressure models and identify key lifestyle factors for appropriate recommendations. Individualised blood pressure models were created in a clinical investigation with 25 individuals, indicating significant differences in key parameters. Participants receiving customised advice experienced significant decreases in systolic and diastolic blood pressure compared to those not receiving suggestions. Wearables and machine learning can provide accurate models and lifestyle suggestions to improve blood pressure, as demonstrated in this study[16].

Drug discovery benefits from medicinal plants and their extracts, which contain natural substances such as phytochemicals, antioxidants, vitamins and minerals with health benefits and disease-preventive qualities. In vitro procedures can verify biological effects, but they can also save time and money. Proposed in silico approaches face challenges with different natural chemical data. Our deep learning technique analyses large pharmacological and natural component data to find therapeutic characteristics. Our 686-dimensional model for 4,507 natural chemicals and 2,882 pharmaceuticals efficiently utilises varied attributes, minimising incomplete data effects. The model, trained and validated with pharmaceutical indication data, effectively predicts efficacy with high sensitivity and specificity[17].

Traditional Chinese medicine is commonly used as a complementary therapy to address cardiovascular issues like diabetes and coronary heart disease. A three-year dataset of computerised medical records from the affiliated Hospital of Shandong University of Traditional Chinese Medicine was analysed in this study. Innovative networks and machine learning techniques were used to create a screening model that discovers paired plants for treating both diseases. The prescription network and symptom database were created by analysing 5688 electronic medical records. Hierarchical network extraction was used to discover key botanicals, whereas public databases provided plant biological attributes. Five machine-learning models were created using supervised techniques, exploiting the biological traits of mixed herbs. The K-nearest neighbour model had 91.0% AUROC. A total of 70 herbal combinations were discovered as prospective supplementary therapy for hypertensive individuals with CHD. These therapies primarily influence cytokines and inflammatory and metabolic processes. The study emphasises the model's ability to incorporate herb molecular biological features, assess herb combinations, and provide insights into their medicinal potential[18].

Cardiovascular disease is a global health issue, with Ayurveda highlighting the impact of behaviour and diet on its development. This study introduces 'Wedaduru,' an Ayurvedic-based web-based diagnosis tool for cardiac issues. Wedadu-ru uses AI to assess patients' physical attributes through image processing and a questionnaire-based model on symptoms. Through supervised learning and connection with the Google API, the system detects suitable medicines and treatments and provides herb data, including cultivation locations. Interestingly, the approach accurately predicts heart problems into Vataja, Pitaja, Kaphaja and Krimija kinds with 86% accuracy. 'Wedaduru' provides comprehensive studies on cardiac illnesses, including treatment options, nutrition suggestions, and useful information on medicinal plants and their locations. The launch of 'Wedaduru' aims to raise knowledge about Ayurvedic medications and their role in cardiovascular health management[19].

Machine learning techniques are crucial for artificial intelligence, enabling automated processing and analysis of enormous data sets, revealing hidden patterns and

providing new insights. This review dives into the scientific literature on using machine learning to detect and forecast coronary heart disease (CHD) progression. The study analyses using reference datasets like the European ST-T Database, Cleveland Heart Disease Database, and Multi-Ethnic Study of Atherosclerosis to build and evaluate models. The paper analyses the pros and cons of various machine learning methods, including logistic regression, support vector machines, decision trees, naïve Bayesian classifier, and k-nearest neighbours, for developing diagnostic and predictive algorithms. Deep learning is an advanced machine learning technique that makes use of multilayer artificial neural networks to improve diagnostic accuracy and prediction. Using machine learning models in clinical practice can enhance decision-making, enhance treatment outcomes and optimise healthcare costs[20].

This study aims to enhance healthcare efficiency using several methods. The initiative utilises Machine Learning (ML) algorithms to enhance healthcare resource allocation and help doctors select optimal treatment alternatives for patients. This method decreases medical practitioner burden and improves patient access to healthcare, saving resources and costs. The report presents research enabling transparent model building with fewer datasets. The article highlights the practicality of using a Naive Bayes classifier to predict heart disease, reducing sample size from exponential to linear. The report exhaustively studies the classification model, addressing its strengths and weaknesses and completely investigates the study materials and methodology[21].

3.1 Gaps in Literature Review

Currently, several gaps exist in the literature that affect the quality and reliability of findings. One major issue is the limited diversity of datasets, which hinders the generalisation of results to other populations. Additionally, models trained on imbalanced datasets often struggle to accurately predict the underrepresented class, reducing their overall predictive power. There is also a notable deficiency in robust cross-domain generalisation techniques, which leads to poor performance when models are applied to datasets different from those they were trained on. Furthermore, the absence of effective feature selection methods and the lack of model explainability undermine confidence in predictive models, particularly in the sensitive field of healthcare. Lastly, there is a significant shortage of comprehensive studies integrating natural remedies with artificial intelligence to enhance heart health, highlighting a critical area in need of further research.

3.2 Contributions Against Gaps in Research

Several important steps have been taken to address the limitations outlined in the paper. Including various targeted population groups and diverse data sources improves the generalisability of the results. Techniques such as oversampling and undersampling have been adopted to correct data imbalance, which previously led to biased models. Additionally, the application of effective strategies for cross-domain learning, such as transfer learning and domain adaptation, enhances model performance across different datasets. Mitigating issues with data selection through efficient feature selection techniques and ensuring the models have interpretability are crucial for building trust, especially in healthcare applications. Finally, improving heart health through the integration of natural medicine and ML technology is achievable when professionals from both fields collaborate effectively.

4. Materials and Methods

This research attempts to integrate natural remedies into the predictive modelling of CVD risk to bridge the gap between traditional risk assessment methods and holistic approaches to heart health. This study aims to analyse patient clinical data, lifestyle factors and natural remedies to gain a thorough understanding of how traditional risk factors and alternative strategies interact in preventing and managing cardiovascular disease. The study's results could guide tailored strategies for managing heart health by integrating evidence-based alternative remedies with traditional medical treatments. A hybrid deep learning model was created by integrating a Long Short-Term Memory (LSTM) network with an RF. This model was developed to predict CVD risk in healthcare settings. The main dataset utilised was the Kaggle dataset named "Indicators of Heart Disease (2022 UPDATE)." Models were trained and verified using relevant patient data and quantitative performance indicators were analysed to understand the process of predicting cardiovascular disease. Natural remedies were utilised to enhance heart health. The greatest herbs for heart disease are illustrated in Figure 1.

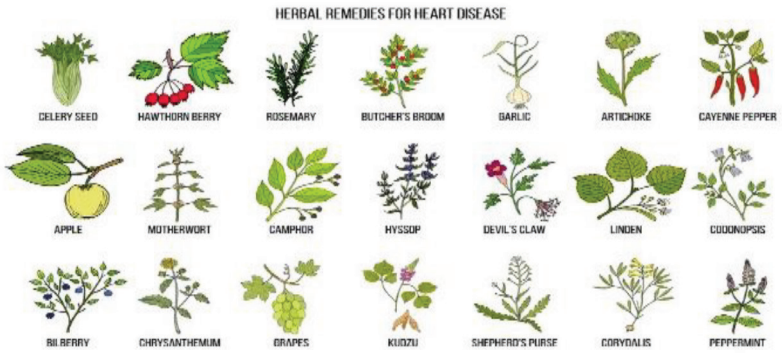


Figure 1. Collection of best herbs for heart disease vector image[22].

The technique of the suggested model is illustrated in Figure 2 below.

4.1 Model Development and Implementation

The outline below describes a step-by-step process to develop and implement a hybrid model with the enhancement of natural remedies to improve heart health outcomes.

4.1.1 Data Acquisition

Identify and gather pertinent data sources, ensuring data is structured appropriately with well-defined features.

4.1.2 Exploratory Data Analysis (EDA)

Examine the dataset's structure, variable distributions and interrelationships to unveil underlying patterns or trends.

4.1.3 Data Pre-processing

Address missing or incomplete data, handle outliers or anomalies, and standardize features through normalization or scaling.

4.1.4 Feature Selection

Assess and select relevant features, employing techniques like correlation analysis or feature importance scores.

4.1.5 Enhancement through Natural Remedies

Improving heart health through natural remedies, including dietary adjustments, physical activity, stress management, and herbal supplements, to reduce cardiovascular risk factors and enhance overall well-being.

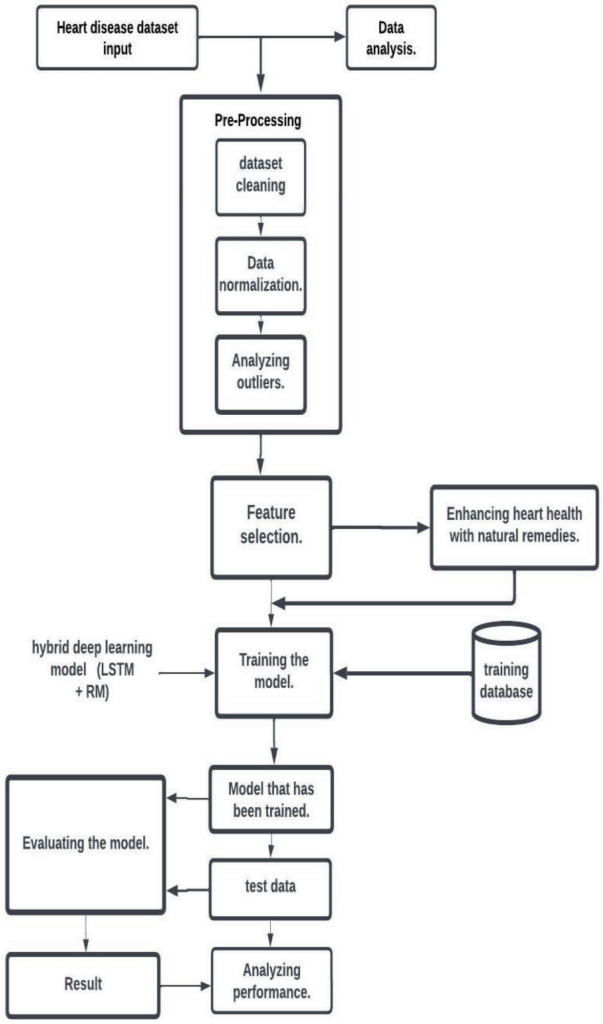


Figure 2. Proposed model methodology diagram.

4.1.6 Algorithm Selection

Determine suitable machine learning and deep learning algorithms based on the specific task requirements.

4.1.7 Ensemble Construction

Develop an ensemble model to enhance predictive performance by combining multiple models.

4.1.8 Model Training and Validation

Split the dataset into training and validation sets, utilise evaluation metrics (e.g., accuracy, precision) for model assessment, and fine-tune hyperparameters to optimise model performance.

4.2 Data Source

The dataset "Indicators of Heart Disease (2022 UPDATE)" sourced from the Kaggle website originates from the CDC and constitutes a fundamental component of the Behavioral Risk Factor Surveillance System (BRFSS). Established in 1984 with 15 states, the BRFSS conducts annual telephone surveys to collect health status information from individuals across the United States. Presently, the BRFSS encompasses all 50 states, the District of Columbia, and three U.S. territories, making it the world's largest health survey system, conducting over 400,000 adult interviews annually. The latest dataset, containing information from 2023, is titled "Indicators of Heart Disease (2022 UPDATE), 2023".

4.3 Data Description

The CDC reports that heart disease is a leading cause of death for several U.S. racial groups, including African Americans, American Indians, Alaska Natives and whites. Around 47% of Americans had one of three heart disease risk factors: high cholesterol, high blood pressure, or smoking. Other important factors include diabetes, obesity, inactivity and alcohol abuse. It is vital to identify and prevent factors that significantly impact heart disease in healthcare. Modern computer technology enables machine learning to discover patterns in data, enabling patient status prediction[23].

4.4 Dataset Features

A detailed summary of the dataset features is presented in Table 2.

Table 2. Summary of Dataset Features from the "Indicators of Heart Disease (2022 UPDATE)" Dataset

S. No.	Variable	Description
1	Sex	Sex of Respondent (0=female, 1=male)
2	General Health	How would you characterize your general state of health? (1=Excellent, 2=Very good, 3=Good, 4=Fair, 5=Poor)
3	Physical Health Days	How many days out of the last 30 days did you have problems with your physical health?
4	Last CheckupTime	Duration since your most recent medical appointment for a normal examination (1=Within past year, 2=Within past 2 years, 3=Within past 5 years, 4=5 or more years ago)
5	Physical Activities	Participation in physical activities or exercise sessions in the previous month (1=Yes, 0=No)
6	Sleep Hours	Typical daily sleep duration in 24 hours
7	Heart Attack	Have you ever had a heart attack? (1=Yes, 0=No)
8	Angina	Have you been diagnosed with angina or coronary heart disease? (1=Yes, 0=No)
9	Stroke	Have you had a heart stroke? (1=Yes, 0=No)
10	Diabetes	Have you had diabetes? (1=Yes, 2=Yes but only during pregnancy, 3=No, 4=No pre-diabetes or borderline diabetes)
11	Smoker Status	Smoker status (1=Current smoker (every day), 2=Current smoker (some days), 3=Former smoker, 4=Never smoked)
12	Age Category	Age category (1=18 to 24, 2=25 to 29, 3=30 to 34, 4=35 to 39, 5=40 to 44, 6=45 to 49, 7=50 to 54, 8=55 to 59, 9=60 to 64, 10=65 to 69, 11=70 to 74, 12=75 to 79, 13=80 or older)
13	Height in Meters	Height measured in meters
14	Weight in Kilograms	Weight reported in kilograms
15	BMI	Body Mass Index (BMI)
16	Alcohol Drinkers	Have you consumed alcohol in the last 30 days? (1=Yes, 0=No)
17	Covid	Have you tested positive for COVID-19? (1=Yes, 2=No, 3=Tested positive using home test)
18	Cardio Vascular Disease.	Target variable (Do you have cardiovascular disease? 1=Yes, 0=No)

4.5 Dataset Analysis

The dataset analysis reveals several notable trends and patterns regarding individuals with cardiovascular disease. It was observed that males with cardiovascular disease outnumber females with the condition. Additionally, a considerable number of individuals who reported being in good health were found to have cardiovascular disease, which was higher compared to other health categories. Another important finding was that individuals with cardiovascular disease were more likely to have had a routine medical checkup within the past year compared to those without the condition.

Furthermore, the data shows that individuals with cardiovascular disease were more likely to engage in physical activities or exercises within the past month, with the number of those participating in physical activities exceeding those who did not. Among this population, a significant proportion reported sleeping for eight hours per day. Interestingly, a notable number of individuals with cardiovascular disease had not experienced a heart attack, although there was a high incidence of angina in this group. On the other hand, among individuals without cardiovascular disease, there was a relatively higher occurrence of heart strokes.

Another key observation was the high prevalence of individuals with cardiovascular disease who do not have diabetes, as well as a large proportion of former smokers. In terms of age demographics, individuals aged 80 and older represented a significant percentage of the cardiovascular disease population. Furthermore, there was a high prevalence of individuals with cardiovascular disease who do not consume alcohol. Lastly, a considerable portion of the cardiovascular disease population had not contracted COVID-19. A histogram illustrating all the features is shown in Figure 3.

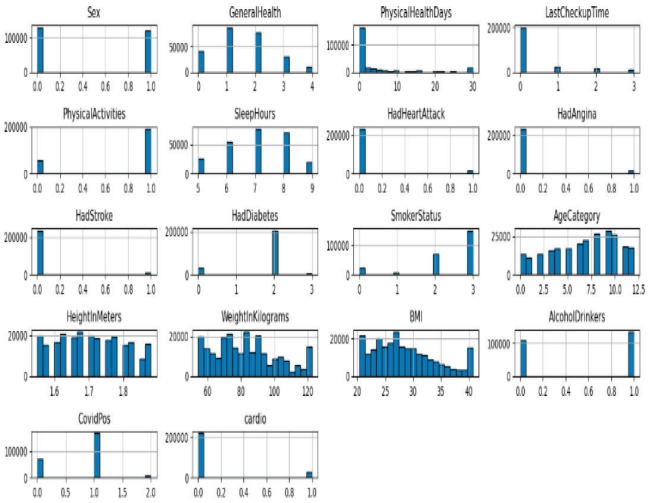


Figure 3. Histogram of all features of heart disease dataset 2022.

The correlation matrix indicates significant variations in 'General Health', ''Physical Activities', 'Heart Attack', 'Had Angina', 'Had Stroke 'Age Category' and target variable values that what is shown in Figure 4.

4.6 Pre-processing of Cardiovascular Disease Data

It is crucial to handle missing values in the cardiovascular disease dataset to maintain the data's integrity and precision for further analysis. Various methods are used, such as mean or median imputation for numerical values and mode imputation for categorical features. Advanced methods, such as predictive modelling, are used to predict missing values by analysing relationships in the dataset.

5. Normalisation

The "Standardisation" method, sometimes referred to as Z-Score normalization was utilised. The Z-Score of a value x for a random variable X with mean μ and standard deviation σ is calculated as follows:

$$X = \frac{x - \mu}{\sigma} \quad (1)$$

X represents a column value in a record, μ represents the dataset mean, and σ is the standard deviation of each column. Standardisation measures the divergence of a data point from the mean in standard deviation

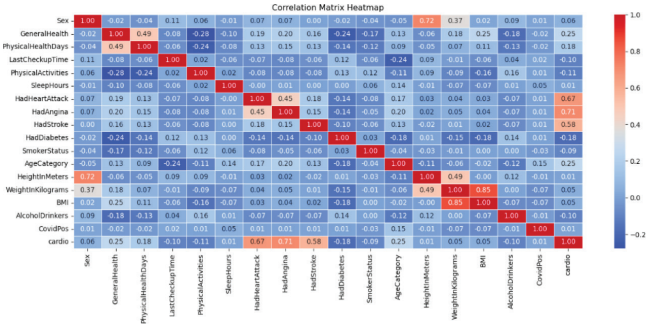


Figure 4. Correlation matrix between the cardiovascular disease features and target value [cardio].

units. Thus, the dataset is changed to have a mean of 0 and a standard deviation of 1. The approach preserves the shape features of the initial data, including skewness and kurtosis. Standardising data ensures uniformity before further analysis.

6. Result and Discussion

The study presents a hybrid learning approach (RF and LSTM) where a deep neural network is initially trained on a specific dataset. Following the training, unique characteristics are isolated from the deep network. The retrieved features are used to restructure the data, which is subsequently used as input for a non-deep learning approach. The traditional machine learning model is trained using a regimen customised for the final classification objective. This strategy emphasises the combination of deep learning with traditional techniques to improve the effectiveness of the classification process. Statisticians use a confusion matrix to evaluate classification models on test data. Accuracy is a frequently used metric that represents the proportion of right predictions. The accuracy formula is expressed as follows:

$$Accuracy \frac{TP + TN}{TP + FP + FN + TN} \quad (2)$$

Cm columns= ['Actual Positive: 1', 'Actual Negative: 0'],

Index= ['Predict Positive: 1', 'Predict Negative: 0'])

6.1 Random Forest Model

Random forests accuracy:1.0

Confusion Matrix:

[[436380]

[05567]]

Random forest model classification report:

In Table 3, the classification report for all metrics is presented.

6.2 Model of Long Short-Term Memory

Long-short-term memory model accuracy: 1.0

Confusion Matrix:

[[436380]

[0 5567]]

The classification report for all metrics is presented in Table 4.

The corresponding loss results are depicted in Figure 5

6.3 Hybrid Model of (LSTM+ RF)

The hybrid model, which combines LSTM and RF, achieved a perfect accuracy of 1.0. The confusion matrix further demonstrates the model's performance. It correctly classified all 43,638 instances of class 0 (no cardiovascular disease) and 5,567 instances of class 1 (presence of cardiovascular disease), without any misclassifications. The absence of false positives or false negatives underscores the robustness and reliability of the hybrid model in accurately predicting cardiovascular disease, making it a highly effective tool for classification in this domain.

In Table 5, the classification report for all metrics is presented.

The corresponding accuracy results of the hybrid model are depicted in Figure 6.

The corresponding model loss of the hybrid model are depicted in Figure 7.

Table 3. Classification report of random forest model

	Precision	Recall	F1-score	Support
0	1.00	1.00	1.00	43638
1	1.00	1.00	1.00	5567
Accuracy			1.00	49205
Macroavg	1.00	1.00	1.00	49205
Weighted Avg	1.00	1.00	1.00	49205

Table 4. LSTM model classification report

	Precision	Recall	F1-score	Support
0	1.0	1.0	1.0	43638
1	1.0	1.0	1.0	5567
Accuracy			1.0	49205
Macro Avg	1.0	1.0	1.0	49205
Weighted Avg	1.0	1.0	1.0	49205

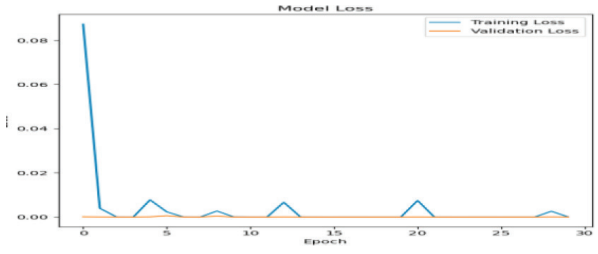


Figure 5. Loss level of LSTM model.

Table 5. Classification report of a hybrid model of (LSTM +RM)

	Precision	Recall	F1-score	Support
0	1.00	1.00	1.00	43638
1	1.00	1.00	1.00	5567
Accuracy			1.00	49205
Macro Avg	1.00	1.00	1.00	49205
Weighted`Avg	1.00	1.00	1.00	49205

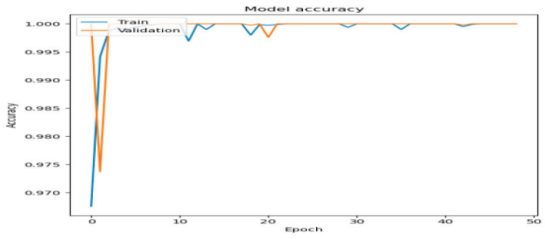


Figure 6. Model accuracy of hybrid model (LSTM and RF**).**

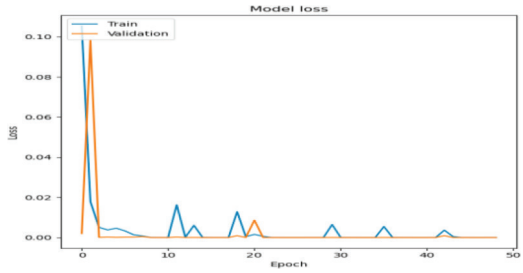


Figure 7. Model loss of hybrid model (LSTM and RF).

7. Conclusion

The work presents a hybrid learning approach (RF and LSTM) to forecast cardiac disease by combining natural therapies with sophisticated machine learning techniques. The models were trained using a dataset of patients with cardiovascular illness named "Indicators of Heart Disease (2022 UPDATE)," obtained from the Kaggle website. The dataset is derived from the CDC and is an essential part of the Behavioral Risk Factor Surveillance System (BRFSS). The hybrid model's accuracy of 100% is noteworthy, especially considering the dataset's size of 246,023 patient records, which is deemed substantial. Incorporating natural remedies into the hybrid model may improve its predictive powers by adding characteristics relating to herbal medicines and their impact on heart health. Utilising a hybrid strategy that combines LSTM and RF models for heart disease prediction has multiple advantages compared to utilising them alone. This hybrid model combines LSTM's capability to capture temporal dependencies with RF's effectiveness in managing complicated interactions among features, leading to improved predicted accuracy and generalisation of new data. Combining LSTM and RF predictions provides stability, interpretability and quick training, while also allowing for adaptive ensemble learning. The hybrid model, combined with natural remedies, offers a potent tool for enhancing clinical decision-making and patient outcomes in predicting heart disease by incorporating information on the therapeutic benefits of herbal treatments, thanks to its scalable architecture and practical deployment potential. Natural therapies are acknowledged for their potential benefits in managing many health disorders, such as cardiovascular diseases. Clinicians can enhance their decision-making on patient care and treatment methods by integrating data on the effectiveness and mechanisms of action of natural remedies into the hybrid model. This comprehensive method for predicting heart illness improves the model's accuracy and leads to better patient outcomes by taking into account a wider variety of parameters that affect heart health. The hybrid approach offers a sustainable and accessible alternative for enhancing cardiovascular healthcare by utilising natural therapies, which are cost-effective and have fewer bad effects than conventional pharmaceuticals. The incorporation of natural remedies into the hybrid model is a significant improvement in predicting heart disease, providing doctors with a comprehensive tool to enhance clinical decision-making and eventually enhance patient outcomes.

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