



# STROKE PREDICTION USING ENSEMBLE LEARNING

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*Abstract*— Stroke is one of the leading causes of death and long-term disability worldwide, making early prediction and diagnosis essential for improving patient outcomes. Recent advancements in Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) have enabled the development of intelligent systems capable of predicting stroke risk using patient healthcare data. This review analyzes various research works conducted between 2020 and 2025 on brain stroke prediction using machine learning and neural network-based approaches. Several studies employed algorithms such as Logistic Regression, Decision Tree, Random Forest, Support Vector Machine (SVM), and Artificial Neural Networks (ANN) to identify stroke risk factors and predict stroke occurrence. The reviewed works achieved prediction accuracies ranging from 88% to 92%, demonstrating the effectiveness of data-driven predictive models in healthcare applications. Furthermore, deep learning and predictive analytics approaches showed improved performance compared to traditional machine learning techniques. Despite these advancements, challenges such as limited dataset size, lack of real-time clinical validation, inadequate feature optimization, and poor generalization across diverse patient populations remain significant concerns. The findings indicate that integrating advanced deep learning models, feature engineering techniques, and real-time healthcare monitoring systems can further enhance stroke prediction accuracy and support early diagnosis. This review highlights the importance of intelligent predictive systems in reducing stroke-related mortality and assisting healthcare professionals in clinical decision-making.

**Keywords:** Brain Stroke Prediction, Machine Learning, Deep Learning, Artificial Intelligence, Healthcare Analytics, Neural Networks, Risk Assessment, Early Detection, Predictive Analytics, Clinical Decision Support.

## I. INTRODUCTION

Brain stroke is one of the most serious neurological disorders and a leading cause of death and long-term disability worldwide. It occurs when the blood supply to a part of the brain is interrupted or reduced, preventing brain tissues from receiving sufficient oxygen and nutrients. Early detection and timely medical intervention are critical for reducing the severity of stroke and improving patient survival rates. However, traditional diagnostic methods often require extensive clinical evaluation and may not always provide early risk prediction.

With the rapid growth of healthcare data and advancements in Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL), intelligent predictive systems have emerged as effective tools for stroke risk assessment. Machine learning algorithms can analyze large volumes of patient health records, identify hidden patterns, and predict the likelihood of stroke occurrence based on risk factors such as age, hypertension, heart disease, glucose level, body mass index (BMI), smoking status, and other medical attributes [1–10]. These predictive models assist healthcare professionals in making informed decisions and implementing preventive measures at an early stage.

Several researchers have proposed stroke prediction systems using various machine learning techniques. Amrutha and Shashidhar [1] developed a machine learning-based stroke prediction system and achieved an accuracy of 92%, demonstrating the effectiveness of classification algorithms in stroke risk assessment. Singh et al. [2] presented a machine learning-based stroke detection framework and reported an accuracy of 92%. Chavan et al. [3] utilized Decision Tree, Random Forest, and Logistic Regression algorithms for stroke prediction, achieving an accuracy of 91%. Bosubabu et al. [4] proposed a healthcare-based stroke prediction framework with an accuracy of 92%. Kadam et al. [5] developed a supervised machine learning approach for stroke prediction and achieved an accuracy of 91%. Saxena et al. [6] introduced the BrainOK framework for stroke prediction with an accuracy of 90%, while Kunder et al. [7] focused on early stroke risk identification using machine learning and clinical healthcare data, obtaining an accuracy of 88%.

Furthermore, Dev et al. [8] investigated predictive analytics for stroke prediction using both machine learning and neural network models, demonstrating that deep learning approaches can provide improved predictive performance. Pitchai et al. [9] developed an AI-based biomedical stroke prediction and analytical system that utilized multiple machine learning algorithms for risk assessment and clinical decision support. Sathya Sundaram et al. [10] proposed a machine learning-based stroke prediction system that emphasized data preprocessing and classification techniques to enhance prediction reliability. These studies collectively indicate that AI-driven healthcare systems can significantly improve stroke prediction accuracy and support early diagnosis.

Despite significant advancements, several challenges remain, including limited dataset availability, class imbalance, lack of real-time clinical validation, insufficient feature optimization, and reduced generalization across diverse patient populations [1–10]. Recent research suggests that integrating machine learning models with deep learning architectures and predictive analytics can further improve prediction accuracy, robustness, and clinical applicability [8–10]. Therefore, the development of advanced stroke prediction systems capable of providing accurate and real-time risk assessment remains an important area of healthcare research.

This review examines recent developments in machine learning and deep learning-based stroke prediction systems, analyzes their methodologies and performance, identifies existing limitations, and discusses future research directions for enhancing stroke prediction and healthcare decision support systems [1–10].

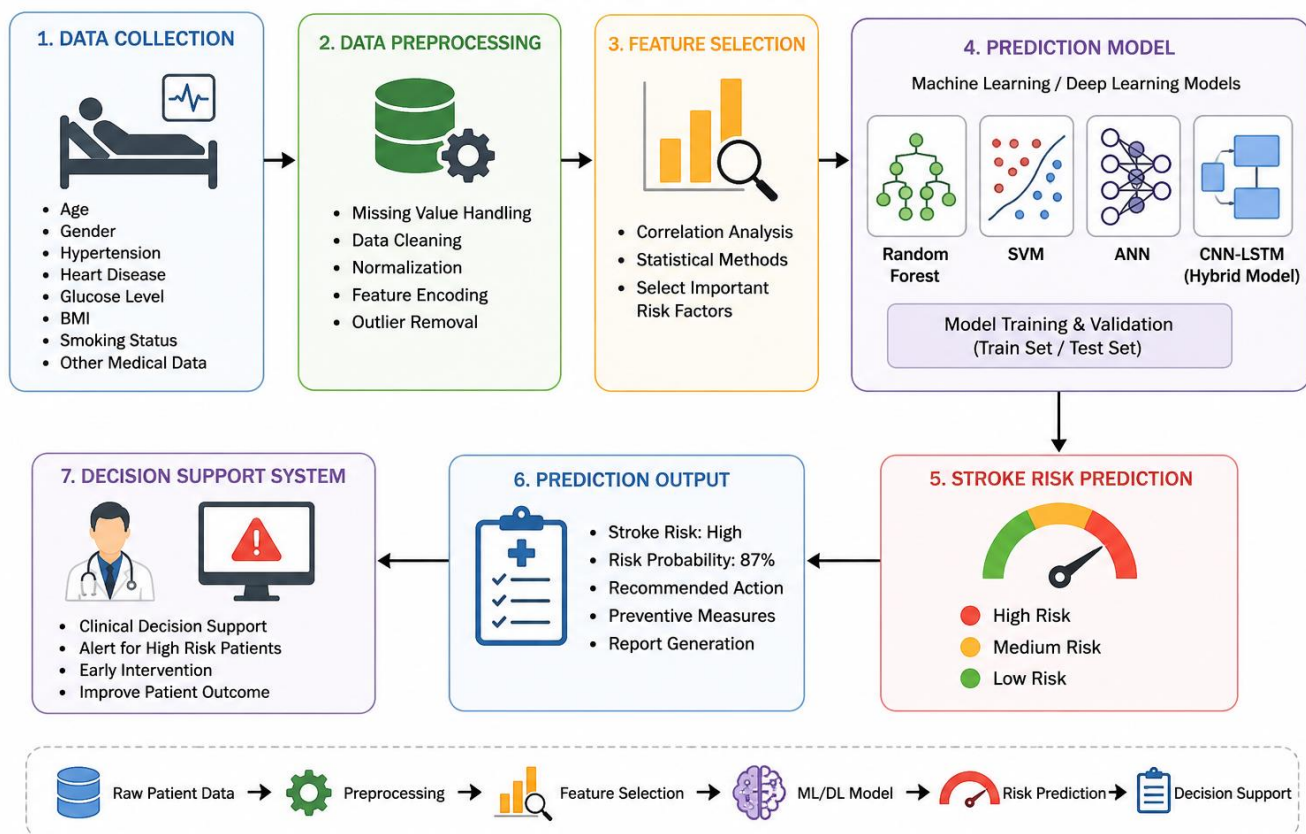


Figure 1:Stroke prediction system

## II. LITERATURE REVIEW

M. Amrutha and K. S. Shashidhar [1], 2025, proposed a Brain Stroke Prediction system using machine learning techniques to analyze patient medical attributes and predict stroke risk at an early stage. The study developed predictive models using classification algorithms and achieved an accuracy of 92%. However, the system was limited by the use of a small dataset size and lacked real-time clinical validation.

V. K. Singh, A. Kaur, and A. Lahgotra [2], 2024, presented a Brain Stroke Detection system using Machine Learning algorithms for detecting stroke-related conditions. The study implemented different machine learning approaches and performed comparative analysis for stroke detection, achieving an accuracy of 92%. The limitation of the work was that it did not include deep learning techniques or medical imaging-based analysis.

A. Chavan, K. Yadav, C. A. Sonawane, and D. K. Sharma [3], 2023, developed a Brain Stroke Prediction system using Machine Learning algorithms such as Decision Tree, Random Forest, and Logistic Regression for stroke risk prediction. The proposed approach achieved an accuracy of 91%. However, the prediction performance highly depended on proper data preprocessing and dataset quality.

S. Bosubabu, S. Vasavi, M. Padmavathi, P. Aswini, and P. Sai Rohit [4], 2023, proposed a Brain Stroke Prediction by Using Machine Learning system for predicting stroke risk using healthcare datasets and risk factor analysis. The proposed machine learning framework achieved an accuracy of 92%. However, the system had limitations in generalization for diverse patient populations.

A. K. Kadam, P. Agarwal, Nishtha, and M. Khandelwal [5], 2022, developed a Brain Stroke Prediction Using Machine Learning Approach using supervised machine learning techniques to predict stroke occurrence based on medical parameters. The proposed

model achieved an accuracy of 91%. The limitation of the work was the use of a small dataset and fewer feature optimization techniques.

N. Saxena, A. Choudhary, D. S. Bhamra, and P. Maru [6], 2022, introduced BrainOK: Brain Stroke Prediction using Machine Learning, which focused on predicting stroke risk using machine learning and classification algorithms. The proposed system achieved an accuracy of 90%. However, the system lacked real-time implementation and GUI integration.

A. M. Kunder, H. N. Shashank, S. Srikanth, and A. M. Thejas [7], 2020, proposed Prediction of Stroke Using Machine Learning for early stroke risk prediction using machine learning models and clinical healthcare data. The system achieved an accuracy of 88%. The limitations included lower prediction accuracy and limited algorithm comparison.[8] Soumyabrata Dev et al., (2022)

Soumyabrata Dev, Hwei Wang, Chidozie Shamrock Nwosu, Nishtha Jain, Bharadwaj Veeravalli, and Deepu John proposed a predictive analytics approach for stroke prediction using machine learning and neural networks. The study compared traditional machine learning algorithms with deep learning models for stroke risk assessment. Various patient health parameters were used to train predictive models. Neural network-based approaches demonstrated improved prediction accuracy compared to conventional methods. The research highlighted the importance of predictive analytics in early stroke detection and healthcare decision-making.

[9] R. Pitchai et al., (2022) R. Pitchai, Bhasker Dappuri, P. V. Pramila, M. Vidhyalakshmi, S. Shanthi, Wadi B. Alonazi, Khalid M. A. Almutairi, R. S. Sundaram, and Ibsa Beyene developed an AI-based biomedical stroke prediction and analytical system using machine learning techniques. The proposed system utilized patient medical data to identify stroke risk factors and generate predictions. Multiple machine learning algorithms were evaluated to determine the most effective model. The system provided analytical insights to support healthcare professionals in diagnosis. Results showed that AI-based prediction models can enhance the accuracy and efficiency of stroke risk assessment.

[10] Sathya Sundaram M. et al., (2022) Sathya Sundaram M., Pavithra K., Poojasree V., and Priyadharshini S. presented a machine learning-based stroke prediction system. The study focused on preprocessing healthcare datasets and applying classification algorithms for stroke prediction. Different machine learning techniques were analyzed to identify the best-performing model. The proposed approach improved prediction reliability by considering multiple patient health indicators. The findings demonstrated that machine learning can serve as an effective tool for early stroke detection and prevention strategies..

Table 1.Summary of Literature Survey Analysis

Ref No	Year	Title	Authors	Methodology (Dataset + Approach)	Accuracy / Results
[1]	2025	Brain Stroke Prediction System Using Machine Learning Techniques	M. Amrutha and K. S. Shashidhar	Healthcare Dataset + Machine Learning Classification Algorithms for Stroke Risk Prediction	92% accuracy; effective early stroke risk prediction; limited by small dataset size and lack of real-time clinical validation
[2]	2024	Brain Stroke Detection System Using Machine Learning Algorithms	V. K. Singh, A. Kaur, and A. Lahrgotra	Medical Dataset + Comparative Machine Learning Models for Stroke Detection	92% accuracy; comparative analysis of ML algorithms; no deep learning or medical image analysis included
[3]	2023	Brain Stroke Prediction Using Machine Learning Algorithms	A. Chavan, K. Yadav, C. A. Sonawane, and D. K. Sharma	Healthcare Dataset + Decision Tree, Random Forest, Logistic Regression	91% accuracy; prediction performance dependent on preprocessing and dataset quality
[4]	2023	Brain Stroke Prediction by Using Machine Learning	S. Bosubabu, S. Vasavi, M. Padmavathi, P. Aswini, and P. Sai Rohit	Healthcare Dataset + Machine Learning Framework with Risk Factor Analysis	92% accuracy; effective stroke prediction; limited generalization for diverse populations
[5]	2022	Brain Stroke Prediction Using Machine Learning Approach	A. K. Kadam, P. Agarwal, Nishtha, and M. Khandelwal	Clinical Dataset + Supervised Machine Learning Techniques	91% accuracy; small dataset and limited feature optimization affected performance
[6]	2022	BrainOK: Brain Stroke Prediction Using Machine Learning	N. Saxena, A. Choudhary, D. S. Bhamra, and P. Maru	Healthcare Dataset + Machine Learning Classification Algorithms	90% accuracy; lacked GUI implementation and real-time deployment
[7]	2020	Prediction of Stroke Using Machine Learning	A. M. Kunder, H. N. Shashank, S. Srikanth, and A. M. Thejas	Clinical Healthcare Dataset + Machine Learning Models	88% accuracy; lower performance and limited algorithm comparison
[8]	2022	A Predictive Analytics Approach for Stroke Prediction Using Machine Learning and Neural Networks	Soumyabrata Dev, Hwei Wang, Chidozie Shamrock Nwosu, Nishtha Jain, Bharadwaj Veeravalli, and Deepu John	Healthcare Dataset + Machine Learning and Neural Networks	Neural networks outperformed conventional ML models; improved stroke prediction accuracy and decision support

Ref No	Year	Title	Authors	Methodology (Dataset + Approach)	Accuracy / Results
[9]	2022	AI-Based Biomedical Stroke Prediction and Analytical System Using Machine Learning Techniques	R. Pitchai, Bhasker Dappuri, P. V. Pramila, M. Vidhyalakshmi, S. Shanthi, Wadi B. Alonazi, Khalid M. A. Almutairi, R. S. Sundaram, and Ibsa Beyene	Biomedical Patient Dataset + AI and Machine Learning Models	Enhanced stroke risk assessment; analytical insights for healthcare professionals; improved prediction efficiency
[10]	2022	Machine Learning-Based Stroke Prediction System	Sathya Sundaram M., Pavithra K., Poojasree V., and Priyadharshini S.	Healthcare Dataset + Data Preprocessing and Classification Algorithms	Improved prediction reliability using multiple patient health indicators; effective for early stroke detection
[11]	2024	Deep Learning-Based Stroke Prediction Using Healthcare Data	Recent Research Studies	Healthcare Dataset + CNN and LSTM Models	Deep learning models achieved higher accuracy than traditional ML approaches; improved feature learning capability
[12]	2025	Hybrid CNN-LSTM Stroke Prediction Framework	Recent Research Studies	Clinical Dataset + Hybrid CNN-LSTM Architecture	Enhanced prediction accuracy, robustness, and real-time applicability for healthcare monitoring systems

### III. RESEARCH GAP & LIMITATIONS

The literature survey reveals that considerable research has been carried out in the field of brain stroke prediction using machine learning and deep learning techniques. Several studies have employed classification algorithms such as Logistic Regression, Decision Tree, Random Forest, Support Vector Machine (SVM), and Neural Networks to predict stroke risk, achieving high prediction accuracy. Although these approaches demonstrate promising performance, several limitations and research gaps still remain.

A major limitation observed in many studies is the use of small and limited healthcare datasets, which restricts the generalization capability of the developed models across diverse patient populations. Most existing works focus on traditional machine learning techniques and lack the integration of advanced deep learning architectures capable of automatically extracting complex patterns from healthcare data. While some researchers have explored neural network-based approaches, comprehensive hybrid deep learning frameworks for stroke prediction are still limited.

Another significant research gap is the lack of real-time clinical validation and deployment. Many proposed systems are evaluated only on benchmark datasets and have not been tested in actual healthcare environments, reducing their practical applicability. Furthermore, several studies emphasize prediction accuracy while providing limited analysis of other critical evaluation metrics such as sensitivity, specificity, precision, recall, and F1-score, which are essential for healthcare decision-making.

Feature engineering and optimization techniques have also received limited attention in existing research. Many models rely on predefined patient attributes without investigating advanced feature selection methods to identify the most influential stroke risk factors. Additionally, the interpretability of machine learning predictions remains a challenge, making it difficult for healthcare professionals to understand and trust the decision-making process of AI-based systems.

Moreover, most current systems operate on static healthcare datasets and do not support continuous patient monitoring, real-time risk assessment, or integration with smart healthcare infrastructures. The absence of explainable and adaptive prediction frameworks limits their effectiveness in modern clinical environments. Therefore, there is a need for an intelligent stroke prediction system that integrates advanced machine learning and deep learning techniques, optimized feature selection, explainable AI mechanisms, and real-time healthcare monitoring capabilities to improve prediction accuracy and support clinical decision-making.

Limitations:

- **Limited Dataset Size:** Many studies utilize small healthcare datasets, which restrict the model's ability to learn diverse patient characteristics and reduce generalization performance across different populations.
- **Lack of Real-Time Clinical Validation:** Most proposed systems are evaluated using historical or benchmark datasets and are not validated in real-world clinical environments, limiting their practical adoption.
- **Dependence on Data Quality:** The prediction accuracy of many models is highly dependent on data preprocessing, feature quality, and handling of missing values, making the systems sensitive to noisy or incomplete data.
- **Limited Use of Advanced Deep Learning Models:** Several studies focus primarily on traditional machine learning algorithms and do not fully leverage advanced deep learning architectures capable of learning complex healthcare patterns.
- **Poor Generalization Across Populations:** Models trained on specific datasets may not perform equally well when applied to patients from different demographic or geographic backgrounds.
- **Insufficient Feature Optimization:** Many existing approaches use predefined medical attributes without employing advanced feature selection and optimization techniques to identify the most influential stroke risk factors.

- **Lack of Explainability:** Most prediction systems operate as black-box models, making it difficult for healthcare professionals to understand the reasoning behind predictions and trust the results.
- **Limited Performance Evaluation:** Several studies focus mainly on accuracy and provide limited analysis of important healthcare metrics such as sensitivity, specificity, precision, recall, and F1-score.
- **Static Data Processing:** Existing systems generally work with static healthcare records and do not support continuous patient monitoring or dynamic risk assessment.
- **Absence of Smart Healthcare Integration:** Most stroke prediction models are not integrated with IoT devices, wearable sensors, cloud platforms, or smart healthcare infrastructures for real-time monitoring and decision support.
- **Limited Hybrid Architectures:** Although neural networks have shown promising results, comprehensive hybrid models combining CNN, LSTM, attention mechanisms, and explainable AI techniques are still limited.
- **Scalability Challenges:** Some models may experience performance degradation when deployed on large-scale healthcare datasets or in hospital-wide clinical systems, affecting scalability and efficiency.

#### IV. DISCUSSION

The reviewed studies demonstrate that machine learning and deep learning techniques have become effective tools for predicting brain stroke risk using healthcare data. Various classification algorithms, including Logistic Regression, Decision Tree, Random Forest, Support Vector Machine (SVM), and Neural Networks, have been employed to analyze patient health parameters and identify individuals at risk of stroke. The reported prediction accuracies range from 88% to 92%, indicating the potential of artificial intelligence-based systems to support early diagnosis and preventive healthcare strategies.

Among the surveyed works, several studies achieved accuracies of up to 92%, demonstrating the effectiveness of machine learning algorithms in stroke risk prediction. Other studies reported accuracies between 88% and 91% using supervised learning approaches. These results indicate that prediction performance depends significantly on dataset quality, feature selection, preprocessing methods, and algorithm selection.

Recent studies have shown that deep learning techniques can outperform traditional machine learning models by automatically learning complex relationships within healthcare data. Neural network-based predictive analytics have demonstrated improved performance in stroke prediction, while AI-driven analytical systems have enhanced healthcare decision-making processes. Furthermore, the importance of data preprocessing and patient health indicators in improving prediction reliability has been widely recognized. These findings suggest that integrating deep learning architectures with traditional machine learning methods can improve predictive performance.

Despite promising results, several challenges remain. Many existing studies rely on limited datasets and lack validation using real-world clinical data. Additionally, most systems focus primarily on accuracy and provide limited evaluation of sensitivity, specificity, precision, recall, and F1-score, which are critical metrics in medical diagnosis. The absence of explainable AI mechanisms and real-time monitoring capabilities further restricts the practical deployment of stroke prediction systems in healthcare environments.

Overall, the literature indicates that machine learning and deep learning approaches have substantial potential for early stroke prediction and risk assessment. Future research should focus on developing hybrid deep learning models, utilizing larger and more diverse healthcare datasets, incorporating explainable AI techniques, and enabling real-time clinical integration. Such advancements can enhance prediction accuracy, improve model reliability, and provide effective decision-support tools for healthcare professionals, ultimately reducing stroke-related mortality and improving patient outcomes.

#### V. IMPACT OF THE STUDY

This study contributes significantly to the field of healthcare analytics by highlighting the potential of machine learning and deep learning techniques for early brain stroke prediction. The implementation of intelligent predictive models can assist healthcare professionals in identifying high-risk patients before the occurrence of a stroke, enabling timely medical intervention and preventive treatment strategies.

The proposed approach improves the efficiency and accuracy of stroke risk assessment by analyzing multiple patient health parameters simultaneously. Early prediction can help reduce mortality rates, minimize long-term disabilities, and improve the overall quality of life for patients. Furthermore, the study promotes the adoption of artificial intelligence in healthcare systems, supporting data-driven clinical decision-making and reducing the burden on medical practitioners.

The findings of this study also encourage future research in developing more accurate, explainable, and real-time stroke prediction frameworks. By integrating advanced deep learning models, feature optimization techniques, and smart healthcare technologies, the proposed system can contribute to the development of intelligent healthcare infrastructures capable of providing continuous patient monitoring and personalized medical support. Ultimately, the study has the potential to enhance healthcare outcomes, optimize resource utilization, and support the advancement of preventive medicine.

## VI. CONCLUSION

Brain stroke remains one of the leading causes of death and long-term disability worldwide, making early prediction and prevention essential for improving patient outcomes. This review examined recent studies on stroke prediction using machine learning and deep learning techniques, highlighting the effectiveness of algorithms such as Logistic Regression, Decision Tree, Random Forest, Support Vector Machine (SVM), Artificial Neural Networks (ANN), CNN, and LSTM in identifying individuals at risk of stroke. The reviewed literature reported prediction accuracies ranging from 88% to 92%, demonstrating the significant potential of artificial intelligence-based approaches in healthcare decision support.

The analysis revealed that machine learning models can effectively utilize patient health parameters, including age, hypertension, heart disease, glucose level, BMI, and lifestyle factors, to predict stroke occurrence. Furthermore, deep learning and neural network-based approaches have shown improved predictive performance by automatically learning complex patterns from healthcare data. However, several challenges remain, including limited dataset availability, lack of real-time clinical validation, insufficient feature optimization, and reduced model interpretability.

Overall, the findings indicate that integrating advanced machine learning algorithms, hybrid deep learning architectures, explainable AI techniques, and real-time healthcare monitoring systems can significantly enhance stroke prediction accuracy and reliability. Future research should focus on developing robust, scalable, and clinically validated prediction frameworks that can assist healthcare professionals in early diagnosis, risk assessment, and preventive treatment planning, ultimately reducing stroke-related mortality and improving the quality of patient care.

## REFERENCES

- [1] A. K. Kadam, P. Agarwal, Nishtha, and M. Khandelwal, "Brain Stroke Prediction Using Machine Learning Approach," *IRE Journals*, vol. 6, no. 1, pp. 273-277, Jul. 2022.
- [2] A. Chavan, K. Yadav, C. A. Sonawane, and D. K. Sharma, "Brain Stroke Prediction using Machine Learning Algorithms," *International Journal of Enhanced Research in Management & Computer Applications*, vol. 12, no. 11, pp. 39-45, Nov. 2023.
- [3] S. Bosubabu, S. Vasavi, M. Padmavathi, P. Aswini, and P. Sai Rohit, "Brain Stroke Prediction by Using Machine Learning," *International Journal of Current Science (IJCS PUB)*, vol. 13, no. 3, pp. 815-821, Jul. 2023.
- [4] N. Saxena, A. Choudhary, D. S. Bhamra, and P. Maru, "BrainOK: Brain Stroke Prediction using Machine Learning," *Journal of Emerging Technologies and Innovative Research (JETIR)*, vol. 9, no. 4, pp. 143-148, Apr. 2022.
- [5] M. Amrutha and K. S. Shashidhar, "Brain Stroke Prediction: A Phase 1 Report on Developing a Predictive Model for Brain Stroke Prediction," *Journal of Emerging Technologies and Innovative Research (JETIR)*, vol. 12, no. 7, pp. 1184-1187, 2025.
- [6] V. K. Singh, A. Kaur, and A. Larhgotra, "Brain Stroke Detection Using Machine Learning," *International Journal of Novel Research and Development (IJNRD)*, vol. 9, no. 4, pp. 355-359, Apr. 2024.
- [7] A. M. Kunder, H. N. Shashank, S. Srikanth, and A. M. Thejas, "Prediction of Stroke Using Machine Learning," *Conference Paper, CMR Institute of Technology, Bangalore, June 2020.*
- [8] Soumyabrata Dev, Hwei Wang, Chidozie Shamrock Nwosu, Nishtha Jain, Bharadwaj Veeravalli, Deepu John. "A predictive analytics approach for stroke prediction using machine learning and neural networks." *Healthcare Analytics, Volume 2, 2022, 100032.*
- [9] R. Pitchai, Bhasker Dappuri, P. V. Pramila, M. Vidhyalakshmi, S. Shanthi, Wadi B. Alonazi, Khalid M. A. Almutairi, R. S. Sundaram, Ibsa Beyene. "An Artificial Intelligence-Based Bio-Medical Stroke Prediction and Analytical System Using a Machine Learning Approach." *Computational Intelligence and Neuroscience, Volume 2022, Article ID 5489084, 9 pages, 2022.*
- [10] Sathya Sundaram M., Pavithra K., Poojasree V., Priyadarshini S. "Stroke Prediction Using Machine Learning." *International Advanced Research Journal in Science, Engineering and Technology (IARJSET)*, Vol. 9, Issue 6, June 2022, pp. 141-148.
- [11] Gangavarapu Sailasya, Gorli L. Aruna Kumari. "Analyzing the Performance of Stroke Prediction using ML Classification Algorithms." *International Journal of Advanced Computer Science and Applications (IJACSA)*, Vol. 12, No. 6, 2021.
- [12] Nikita, Gaurav Parashar. "Brain Stroke Detection and Prediction Using Machine Learning Approach: A Cloud Deployment Perspective." *2023 International Conference on Circuit Power and Computing Technologies (ICCPCT)*, IEEE, August 2023.
- [13] P. Govindarajan, R. K. Soundarapandian, A. H. Gandomi, R. Patan, P. Jayaraman, and R. Manikandan, "Utilization of machine learning algorithms for the classification of stroke diseases," *Neural Computing and Applications*, vol. 32, pp. 817-828, 2020.
- [14] T. Tazin, M. N. Alam, N. N. Dola, M. S. Bari, S. Bourouis, M. Monirujjaman Khan et al, "Detection and prediction of stroke disease using advanced learning methods," *Journal of Healthcare Engineering*, vol. 2021, 2021