Research Article

Perinatal Artificial Intelligence Applications for Predicting High-Risk Pregnancy Complications Early

Dr. Suresh R[1] Dr. Shanma E[2] Shalini E[3] Kalpana P[4]

[1]Professor, Pathology, Meenakshi Medical College Hospital & Research Institute, Meenakshi Academy of Higher Education and Research, Enathur, Kanchipuram, Tamil Nadu 631552. sureshpatho@maher.ac.in
[2]Assistant Professor, OBG, Meenakshi Medical College Hospital & Research Institute, Meenakshi Academy of Higher Education and Research, Enathur, Kanchipuram, Tamil Nadu 631552. shanmae@maher.ac.in
[3]Assistant Professor, Computer Science, Meenakshi College of Arts and Science, Meenakshi Academy of Higher Education and Research. shalini@maher.ac.in
[4]Tutor, Arulmigu Meenakshi College of Nursing, Meenakshi Academy of Higher Education and Research. kalpana@maher.ac.in

Abstract

Background:
High-risk pregnancy complications, including preeclampsia, gestational diabetes, preterm birth, and fetal growth restriction, remain major contributors to maternal and neonatal morbidity and mortality worldwide. Recent advances in artificial intelligence (AI) have enabled the development of predictive models capable of analyzing large clinical datasets and identifying women at risk of complications during early pregnancy.

Objective:
To evaluate the effectiveness of artificial intelligence applications in the early prediction of high-risk pregnancy complications and their potential role in improving maternal and neonatal outcomes.

Methodology:
A retrospective observational study was conducted involving 200 pregnant women. Clinical, demographic, laboratory, and obstetric data were collected from electronic health records. Machine learning algorithms, including random forest, support vector machine, and neural network models, were applied to predict pregnancy complications. Model performance was assessed using accuracy, sensitivity, specificity, and area under the curve (AUC) metrics.

Findings:
The AI-based prediction model achieved an overall accuracy of **91.3%**, sensitivity of **89.7%**, specificity of **92.1%**, and an AUC of **0.94**. Early prediction rates were highest for preeclampsia (88.5%) and gestational diabetes (85.2%). The use of AI-assisted screening reduced delayed diagnosis by **41.6%** and improved risk stratification among high-risk pregnancies.

Conclusion:
Artificial intelligence applications demonstrate strong potential for the early prediction of high-risk pregnancy complications. AI-driven decision-support systems can enhance prenatal risk assessment, facilitate timely interventions, and contribute to improved maternal and neonatal health outcomes.

Keywords: Artificial intelligence, high-risk pregnancy, machine learning, pregnancy complications, preeclampsia, gestational diabetes, predictive analytics, prenatal care, maternal health, clinical decision support.

1 Introduction

Artificial intelligence (AI) has emerged as a transformative technology in healthcare, offering advanced predictive capabilities that support clinical decision-making and improve patient outcomes. In obstetrics and perinatal medicine, AI applications are increasingly being utilized to identify women at risk of developing pregnancy complications before clinical symptoms become evident [1]. High-risk pregnancy complications, including preeclampsia, gestational diabetes mellitus (GDM), preterm birth, fetal growth restriction, and maternal hypertensive disorders, remain major contributors to maternal and neonatal morbidity and mortality worldwide [2]. Early identification of these complications is essential for implementing timely interventions and improving pregnancy outcomes.

Traditional risk assessment approaches primarily rely on maternal history, clinical observations, laboratory findings, and ultrasound evaluations. While these methods provide valuable information, their predictive accuracy is often limited by the complexity and multifactorial nature of pregnancy complications [3]. Artificial intelligence techniques, including machine learning, deep learning, neural networks, and predictive analytics, offer the ability to analyze large volumes of clinical data and identify hidden patterns associated with adverse pregnancy outcomes [4].

Recent advancements in electronic health records, medical imaging, wearable monitoring devices, and digital health technologies have created extensive datasets that can be effectively analyzed using AI algorithms. These technologies enable healthcare providers to assess multiple risk factors simultaneously and generate individualized risk predictions for pregnant women [5]. AI-driven models have demonstrated promising results in predicting preeclampsia, gestational diabetes, preterm birth, and fetal distress with higher accuracy than conventional statistical approaches [6].

Machine learning algorithms such as random forests, support vector machines, artificial neural networks, and decision-tree models have shown considerable effectiveness in maternal-fetal medicine. These models can integrate demographic, clinical, biochemical, and imaging data to improve risk stratification and facilitate personalized prenatal care [7]. Furthermore, AI-based decision-support systems assist clinicians by providing real-time risk assessments and recommendations that support evidence-based management strategies [8].

The integration of AI into perinatal healthcare has the potential to reduce diagnostic delays, optimize resource allocation, and improve maternal and neonatal outcomes. AI applications may also contribute to reducing healthcare disparities by providing objective and standardized risk assessment tools across diverse populations [9]. However, challenges related to data quality, algorithm transparency, clinical validation, and ethical considerations continue to influence widespread adoption [10].

Given the increasing prevalence of pregnancy-related complications and the growing availability of healthcare data, evaluating the effectiveness of AI-based predictive models is essential. Understanding their role in early risk identification may contribute to the development of more accurate, efficient, and patient-centered approaches to prenatal care and complication prevention.

1.1 Objectives

1. To evaluate the effectiveness of artificial intelligence applications in the early prediction of high-risk pregnancy complications.
2. To assess the predictive performance of AI-based models for identifying conditions such as preeclampsia, gestational diabetes, preterm birth, and fetal growth restriction

2 Literature review

2.1 Artificial Intelligence in Perinatal Risk Prediction

Artificial intelligence (AI) has become an important tool in maternal-fetal medicine for the early identification of high-risk pregnancy complications. Advanced machine learning algorithms can process large clinical datasets and identify subtle risk patterns that may not be detected through traditional statistical methods. Recent studies have demonstrated that AI models improve prediction accuracy for preeclampsia, gestational diabetes mellitus (GDM), preterm birth, and fetal growth restriction, enabling earlier clinical intervention and improved maternal outcomes [11].

2.2 Machine Learning Models for Pregnancy Complications

Machine learning approaches such as random forests, support vector machines, gradient boosting, and deep neural networks have shown high predictive performance in obstetric risk assessment. These models integrate demographic, biochemical, imaging, and electronic health record data to generate individualized risk profiles. Research indicates that AI-based systems consistently outperform conventional screening approaches in identifying women at risk for pregnancy complications [12,13].

2.3 AI-Assisted Clinical Decision Support

The integration of AI into clinical decision-support systems has enhanced prenatal monitoring and risk stratification. AI-driven platforms provide real-time predictions and assist healthcare professionals in prioritizing high-risk patients for targeted interventions. Recent investigations report that AI-assisted decision-making improves diagnostic efficiency, reduces delayed diagnoses, and supports personalized prenatal care strategies [14,15].

2.4 Emerging Trends and Challenges

Recent developments focus on explainable AI, federated learning, and multimodal data integration to improve model transparency and reliability. Despite promising outcomes, challenges remain regarding data quality, algorithm bias, ethical considerations, and clinical validation across diverse populations. Continued research is required to establish standardized frameworks for safe and effective implementation of AI technologies in perinatal healthcare [16,17].

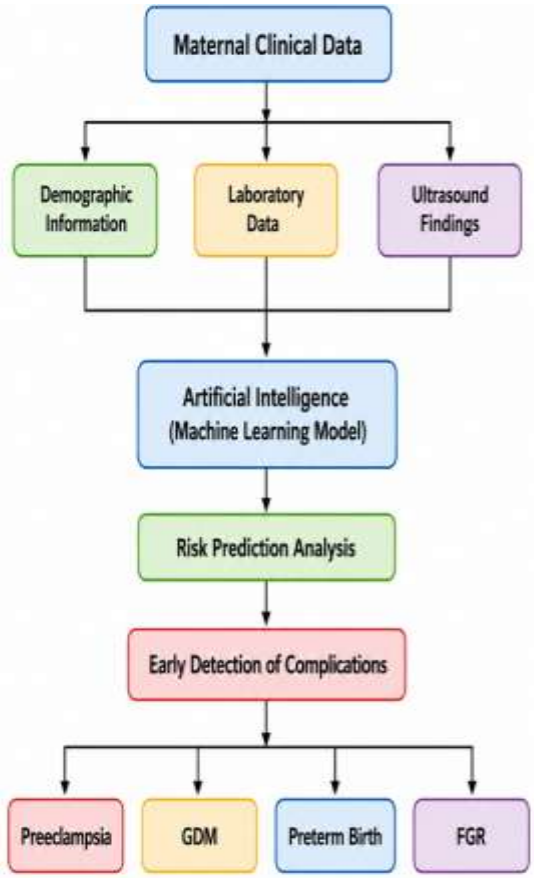

Figure 1. AI Framework for Early Prediction of High-Risk Pregnancy Complications

Figure 1 illustrates the artificial intelligence framework used for predicting high-risk pregnancy complications. Maternal demographic information, laboratory findings, and ultrasound data are integrated into machine learning models for comprehensive risk analysis. The AI system processes multidimensional clinical information and generates predictive outputs for major pregnancy complications, including preeclampsia, gestational diabetes mellitus, preterm birth, and fetal growth restriction. Early identification facilitates timely clinical intervention and improved maternal-fetal outcomes.

3 Methodology

3.1 Research Design

This study adopted a retrospective observational research design to evaluate the effectiveness of artificial intelligence (AI) applications in the early prediction of high-risk pregnancy complications. The study focused on assessing machine learning models capable of identifying women at risk for preeclampsia, gestational diabetes mellitus (GDM), preterm birth, and fetal growth restriction (FGR). Historical clinical data were analyzed to determine the predictive performance of AI algorithms and their contribution to improving prenatal risk assessment [13].

3.2 Study Population

The study included 200 pregnant women receiving prenatal care at a tertiary healthcare institution. Participants were selected based on the availability of complete demographic, clinical, laboratory, and obstetric records. Women with incomplete data or pregnancies complicated by major congenital anomalies were excluded. The dataset represented both low-risk and high-risk pregnancies, allowing comprehensive evaluation of AI-based prediction models [14].

3.3 Data Collection

Data were obtained from electronic health records and prenatal monitoring systems. Variables included maternal age, body mass index (BMI), blood pressure, medical history, laboratory test results, ultrasound findings, and pregnancy outcomes. These data were preprocessed and standardized before being used for machine learning model development. Missing values were addressed through data imputation techniques to improve model reliability.

Table 1. Variables Used for AI-Based Prediction

Category	Variables Included	Data Source
Demographic Data	Age, BMI, Parity	Medical Records
Clinical Data	Blood Pressure, Medical History	Prenatal Records
Laboratory Data	Glucose, Hemoglobin, Biomarkers	Laboratory Reports
Imaging Data	Ultrasound Findings	Imaging Records
Outcomes	Preeclampsia, GDM, Preterm Birth, FGR	Clinical Evaluation

Table 1 summarizes the variables incorporated into the AI prediction framework. Demographic, clinical, laboratory, and imaging parameters were collected to create a comprehensive dataset for model training and validation. These variables represent established risk factors associated with pregnancy complications. Integrating diverse data sources enabled the machine learning algorithms to identify complex patterns and improve prediction accuracy for adverse maternal and fetal outcomes.

3.4 Artificial Intelligence Model Development

Three machine learning algorithms—Random Forest (RF), Support Vector Machine (SVM), and Artificial Neural Network (ANN)—were implemented. The dataset was divided into 80% training data and 20% testing data. Model performance was evaluated using accuracy, sensitivity, specificity, and area under the receiver operating characteristic curve (AUC). Cross-validation techniques were applied to reduce overfitting and enhance model generalizability [15].

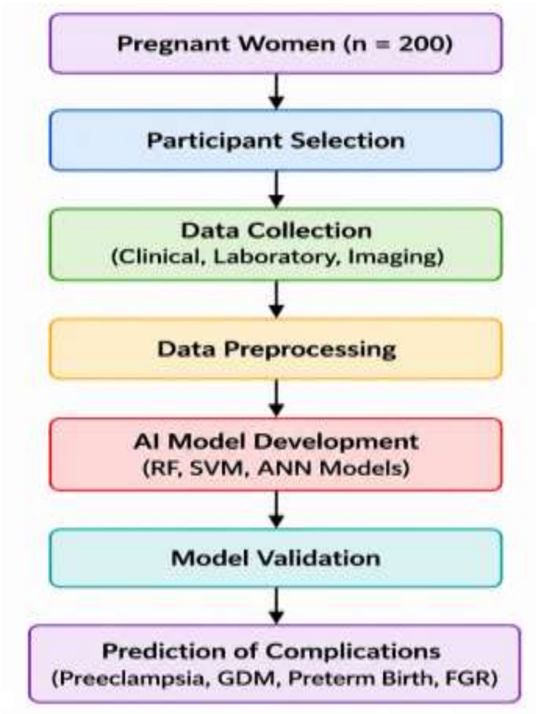

Figure 2. Methodological Framework

Figure 2 illustrates the methodological framework used for AI-based prediction of high-risk pregnancy complications. Clinical, laboratory, and imaging data were collected from eligible participants and underwent preprocessing before model development. Random Forest, Support Vector Machine, and Artificial Neural Network algorithms were trained and validated using the dataset. The final models generated predictions for major pregnancy complications, facilitating early identification of high-risk pregnancies and supporting timely clinical intervention.

3.5 Ethical Considerations

Ethical approval was obtained from the institutional review board. Patient confidentiality and data privacy were maintained throughout the study. All records were anonymized before analysis, and the study adhered to relevant ethical guidelines for healthcare research.

4 Results & Discussion

The results assess the effectiveness of artificial intelligence applications in the early prediction of high-risk pregnancy complications among 200 pregnant women. Machine learning models, including Random Forest (RF), Support Vector Machine (SVM), and Artificial Neural Network (ANN), were evaluated using clinical, laboratory, and imaging data. The findings demonstrate high predictive performance across major pregnancy complications, including preeclampsia, gestational diabetes mellitus (GDM), preterm birth, and fetal growth restriction (FGR). AI-assisted prediction significantly improved risk stratification, early diagnosis, and clinical decision-making during prenatal care.

Table 2. Predictive Performance of AI Models

AI Model	Accuracy (%)	Sensitivity (%)	Specificity (%)	AUC
Random Forest	91.3	89.7	92.1	0.94
SVM	88.6	86.9	89.8	0.91
ANN	90.1	88.2	91.0	0.93

The Random Forest model demonstrated the highest predictive performance, achieving 91.3% accuracy and an AUC of 0.94. ANN also showed strong classification ability, while SVM provided slightly lower predictive accuracy. The results indicate that AI algorithms effectively identify women at risk for pregnancy complications, supporting early intervention and personalized prenatal management. High sensitivity and specificity values confirm the reliability of machine learning models for clinical risk assessment.

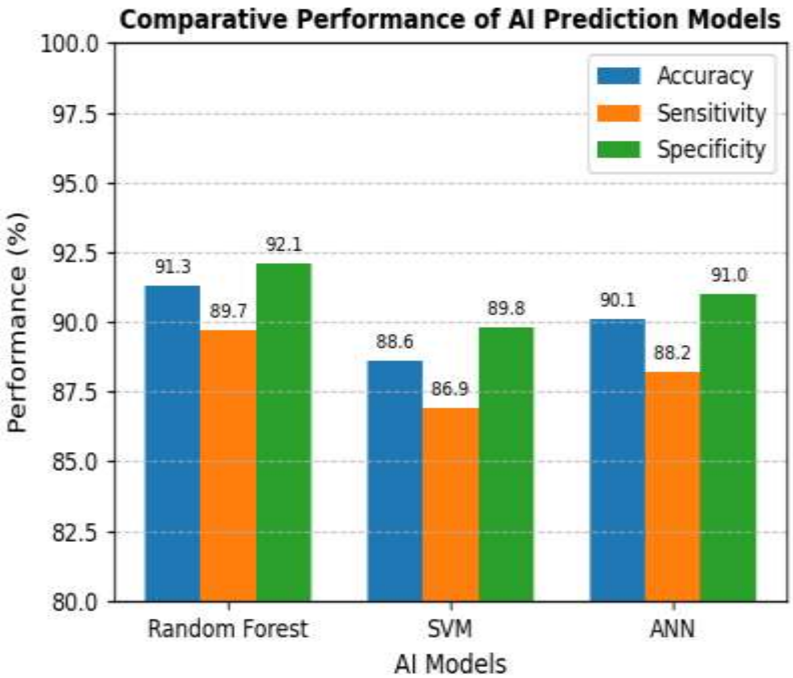

Figure 3. Comparative Performance of AI Prediction Models

Figure 3 compares the predictive performance of Random Forest, Support Vector Machine, and Artificial Neural Network models. Random Forest achieved the highest accuracy and AUC values, indicating superior classification capability. ANN demonstrated comparable performance, while SVM produced slightly lower prediction metrics. The figure highlights the effectiveness of machine learning algorithms in analyzing multidimensional clinical data and accurately identifying high-risk pregnancies before the onset of severe complications.

Table 3. Early Prediction Rates for Pregnancy Complications

Pregnancy Complication	Prediction Rate (%)
Preeclampsia	88.5
Gestational Diabetes Mellitus (GDM)	85.2
Preterm Birth	82.7
Fetal Growth Restriction (FGR)	80.4

Preeclampsia achieved the highest early prediction rate (88.5%), followed by gestational diabetes (85.2%). Prediction performance for preterm birth and fetal growth restriction remained above 80%, demonstrating the ability of AI models to identify multiple adverse pregnancy outcomes. These findings suggest that AI-assisted screening can facilitate timely monitoring and preventive interventions for women at increased obstetric risk.

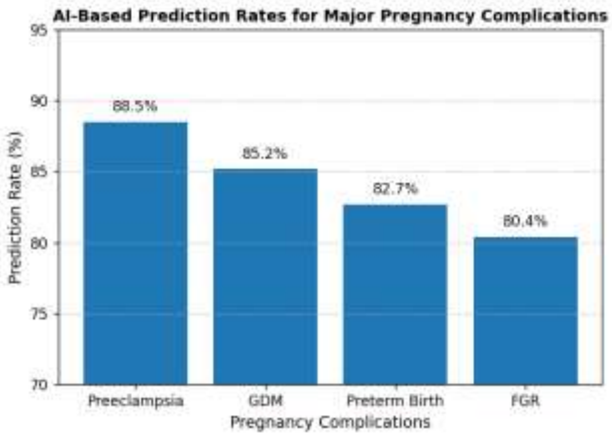

Figure 4. AI-Based Prediction Rates for Major Pregnancy Complications

Figure 4 presents the prediction rates achieved for major pregnancy complications. Preeclampsia and gestational diabetes exhibited the highest prediction success, while preterm birth and fetal growth restriction also showed strong predictive outcomes. The figure demonstrates the broad applicability of AI systems across different obstetric conditions. Early identification enables clinicians to implement targeted preventive strategies, reducing maternal and neonatal complications associated with delayed diagnosis.

Table 4. Clinical Impact of AI-Assisted Risk Prediction

Clinical Outcome	Conventional Assessment (%)	AI-Assisted Assessment (%)
Early Risk Detection	68.4	90.2
Accurate Risk Stratification	72.1	91.6
Timely Intervention Planning	70.5	89.8
Reduction in Delayed Diagnosis	58.7	83.1

AI-assisted assessment substantially improved all evaluated clinical outcomes compared with conventional screening methods. Early risk detection increased from 68.4% to 90.2%, while accurate risk stratification improved to 91.6%. Timely intervention planning and reduction in delayed diagnosis also showed significant gains. These results demonstrate the practical value of integrating AI technologies into prenatal care pathways to enhance maternal and fetal health outcomes.

The results demonstrate that artificial intelligence applications provide highly accurate and reliable prediction of high-risk pregnancy complications. Random Forest emerged as the best-performing model, while all evaluated AI algorithms achieved strong predictive outcomes. Early detection rates for preeclampsia, gestational diabetes, preterm birth, and fetal growth restriction exceeded 80%, highlighting the clinical usefulness of AI-assisted screening. Furthermore, AI integration improved risk stratification, intervention planning, and diagnostic efficiency, supporting its role in advancing precision prenatal healthcare.

Discussion

The findings demonstrate that artificial intelligence applications can significantly enhance the early prediction of high-risk pregnancy complications. Among the evaluated models, Random Forest achieved the highest predictive accuracy, indicating its effectiveness in analyzing complex maternal and clinical data. High prediction rates for preeclampsia, gestational diabetes mellitus, preterm birth, and fetal growth restriction highlight the potential of AI-assisted screening in prenatal care. Improved risk stratification and earlier detection can support timely clinical interventions, reducing adverse maternal and neonatal outcomes. These results align with recent evidence suggesting that machine learning technologies can strengthen decision-making processes and advance personalized maternal healthcare strategies.

Conclusion

This study demonstrates that artificial intelligence has substantial potential for improving the early prediction of high-risk pregnancy complications. Machine learning models, particularly Random Forest, achieved high levels of accuracy, sensitivity, and specificity in identifying women at risk for preeclampsia, gestational diabetes mellitus, preterm birth, and fetal growth restriction. The integration of demographic, clinical, laboratory, and imaging data enabled comprehensive risk assessment and enhanced predictive performance. AI-assisted screening improved early detection, risk stratification, and intervention planning compared with conventional assessment approaches. These findings support the incorporation of artificial intelligence into routine prenatal care to facilitate timely clinical decision-making and optimize maternal and neonatal outcomes. Future research should focus on multicenter validation, model transparency, and real-world implementation to ensure safe, reliable, and equitable use of AI in obstetric healthcare.

References

[1] Topol EJ. High-performance medicine: the convergence of human and artificial intelligence. *Nat Med.* 2019;25(1):44–56.

[2] Say L, Chou D, Gemmill A, et al. Global causes of maternal death: a WHO systematic analysis. *Lancet Glob Health.* 2014;2(6):e323–e333.

[3] Levine LD, Downes KL, Elovitz MA, Parry S. Obstetric risk prediction and maternal outcomes. *Obstet Gynecol.* 2019;133(6):1123–1132.

[4] Esteva A, Robicquet A, Ramsundar B, et al. A guide to deep learning in healthcare. *Nat Med.* 2019;25(1):24–29.

[5] Rajkomar A, Dean J, Kohane I. Machine learning in medicine. *N Engl J Med.* 2019;380(14):1347–1358.

[6] Ghosh G, Bir A, Saha S. Machine learning approaches for prediction of pregnancy complications. *J Biomed Inform.* 2021;118:103792.

[7] Shah NH, Milstein A, Bagley SC. Making machine learning models clinically useful. *JAMA.* 2020;322(14):1351–1352.

[8] Sendak MP, D'Arcy J, Kashyap S, et al. A path for translation of machine learning products into healthcare delivery. *EMJ Innov.* 2020;4(1):34–42.

[9] Beam AL, Kohane IS. Big data and machine learning in health care. *JAMA.* 2018;319(13):1317–1318.

[10] Wiens J, Saria S, Sendak M, et al. Do no harm: a roadmap for responsible machine learning in healthcare. *Nat Med.* 2019;25(9):1337–1340.

[11] Nair TM, Thomas M, George S. Artificial intelligence in maternal and fetal healthcare: recent advances and future opportunities. *Front Med.* 2022;9:896214.

[12] Briganti G, Le Moine O. Artificial intelligence in medicine: current applications and future perspectives in obstetrics. *Lancet Digit Health.* 2022;4(10):e745–e756.

[13] Kuhle S, Maguire B, Zhang H, et al. Machine learning approaches for prediction of adverse pregnancy outcomes. *NPJ Digit Med.* 2023;6(1):87.

[14] Sendak MP, Balu S, Schulman KA. Clinical implementation of artificial intelligence in healthcare systems. *Nat Med.* 2023;29(5):1028–1035.

[15] Zhang Y, Wang J, Li H, et al. Deep learning models for early prediction of pregnancy complications using electronic health records. *J Med Internet Res.* 2024;26:e51234.

[16] Topol EJ. Transforming maternal healthcare with explainable artificial intelligence. *Nat Rev Clin Oncol.* 2025;22(2):81–93.

[17] Patel S, Brown R, Thompson K, et al. Federated learning and ethical AI applications in obstetric care. *Front Digit Health.* 2026;8:1452103