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Short Review: Maternal and Fetal Health with Artificial Intelligence

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Abstract

This paper explores the use of artificial intelligence (AI) and machine learning to predict risks in maternal and fetal health, including conditions like preeclampsia, gestational diabetes, preterm birth, and fetal growth abnormalities. By harnessing large datasets from health records, imaging, and real-time monitoring, AI models enhance risk assessment and facilitate early intervention. Although challenges in data privacy and model transparency persist, AI integration in maternal-fetal care hold promise for improved outcomes and healthier pregnancies.

Keywords*:* Maternal and Fetal Health; Risk Prediction; Preterm Birth; Artificial Intelligence.

Introduction

Maternal and fetal health encompasses the well-being of both the mother and her unborn child throughout pregnancy, childbirth, and the postpartum period. This critical field addresses a wide range of health considerations, from maternal nutrition and mental health to fetal development and the prevention of complications that could impact both mother and baby. Optimal maternal and fetal health [1,2] care includes routine monitoring to detect potential risks, such as preeclampsia, gestational diabetes, and intrauterine growth restrictions, allowing for timely interventions that improve outcomes. In recent years, advancements in technology and medical research have introduced predictive analytics and personalized care models that leverage data from electronic health records, imaging, and even wearable devices to enhance maternal and fetal care [3-8]. These tools offer valuable insights, enabling healthcare providers to make data-driven decisions that safeguard both maternal and fetal health, reduce the likelihood of adverse outcomes, and support healthier pregnancies.

The advent of artificial intelligence (AI) in healthcare has transformed how we approach complex medical challenges, offering promising solutions for prediction, diagnosis, and treatment across a variety of fields [9-12]. One particularly impactful area is Obstetrics and Gynecology, where AI-driven predictive analytics have shown immense potential in enhancing maternal and fetal health

outcomes. Pregnancy and childbirth involve significant physiological changes, which can sometimes result in unexpected complications. Early identification of risks allows healthcare providers to implement timely interventions, potentially preventing adverse outcomes for both mother and child. Predictive analytics—powered by AI and machine learning algorithms—leverages large datasets from electronic health records (EHRs), imaging, genetic data, and wearable devices to predict potential health risks. For maternal health, this includes the prediction of conditions like preeclampsia, gestational diabetes, and postpartum hemorrhage, which are leading causes of maternal morbidity and mortality. On the fetal side, predictive models can aid in detecting growth restrictions, congenital anomalies, and risks during labor, enabling clinicians to make data-driven decisions. The role of predictive analytics is particularly critical in Obstetrics and Gynecology due to the often-limited opportunities for clinical intervention and the high stakes involved in maternal and fetal health. For instance, predicting preterm birth allows for early interventions, such as corticosteroid administration, which can significantly improve neonatal outcomes. Similarly, real-time labor monitoring using AI tools helps in identifying fetal distress promptly, leading to timely interventions like emergency cesarean sections.

This review aims to provide a short overview of the current state of predictive analytics in maternal and fetal health. By examining recent advancements, applications, and challenges, we seek to illustrate how AI is being utilized to predict and mitigate pregnancy-related risks. This paper will cover predictive models in maternal health (including pregnancy complications and postpartum risks) and fetal health (covering growth and anomaly detection and labor complications).

AI in Maternal and Fetal Health

Predictive analytics represents a paradigm shift in maternal-fetal medicine, offering clinicians the ability to foresee complications and risks that may arise throughout pregnancy, delivery, and postpartum periods. This capability is especially critical in maternal and fetal health, where early detection of risks can significantly impact clinical outcomes. Pregnancy-related complications remain a major public health concern globally, contributing to substantial maternal and neonatal morbidity and mortality rates. According to the World Health Organization, maternal mortality remains unacceptably high in many regions, with approximately 295,000 women dying every year from pregnancy- and childbirth-related complications, most of which are preventable with timely intervention.

- *Risk Prediction for Maternal Complications*

Predictive analytics in maternal health aims to anticipate life-threatening complications such as preeclampsia, gestational diabetes, and postpartum hemorrhage, which are among the most common contributors to maternal morbidity. For example, preeclampsia—a condition marked by high blood pressure and potential organ damage—can lead to severe outcomes if not diagnosed early. Current models use a combination of clinical data, demographic information, and lab results (such as blood pressure, BMI, and proteinuria levels) to identify patients at risk. These predictive models allow healthcare providers to monitor high-risk patients closely, administer preventive medications, and prepare for emergency interventions, ultimately reducing the likelihood of severe outcomes. Gestational diabetes mellitus (GDM) is another condition with critical implications for maternal and fetal health. This form of diabetes, which typically develops during pregnancy, not only increases

the risk of birth complications but also predisposes both mother and child to future metabolic diseases. Machine learning models using maternal demographics, lifestyle factors, and initial lab results can predict the likelihood of GDM, enabling dietary and medical interventions to manage blood glucose levels effectively. This proactive approach mitigates complications such as macrosomia (large-for-gestational-age babies), which can lead to birth injuries and the need for cesarean delivery.

Research [13] proposed a risk prediction of maternal health by model analysis using artificial intelligence. The study highlighted that pregnant women with gestational diabetes mellitus (GDM) may increase the risk of health complications for their unborn children. GDM often leads to larger-than-average babies, which can complicate vaginal delivery. This chapter presents a case study analyzing various machine learning methods to propose a model for the early detection of GDM and its likelihood of progressing to type 2 diabetes. Furthermore, another study [14] utilized an extensive dataset to develop highly accurate and reliable models for predicting potential health issues. Thanks to innovative feature engineering techniques, including Featurewiz and chi-square tests, alongside meticulous data processing, these models offer both high predictive power and enhanced transparency. The models underwent rigorous validation, demonstrating superior evaluation metrics across three distinct categories, each achieving over 99% accuracy.

- *Predicting Preterm Birth and Its Complications*

Preterm birth, defined as delivery before 37 weeks of gestation, is a leading cause of neonatal mortality and can result in lifelong complications for the child. Predictive analytics models leverage clinical variables like cervical length, maternal history, and biochemical markers to assess the likelihood of preterm labor. Some advanced models incorporate real-time data from wearable devices that track uterine contractions and fetal movement. Early identification of preterm birth risk enables interventions, such as administering corticosteroids to promote fetal lung development, thus increasing the neonate's chances of survival and reducing complications like respiratory distress syndrome. In addition to improving neonatal outcomes, predictive models for preterm birth are valuable for resource allocation. High-risk pregnancies can require extensive monitoring, increased hospital visits, and specialized care. By identifying at-risk patients, healthcare facilities can allocate resources more effectively, providing closer surveillance and timely intervention for those in need, while reducing unnecessary interventions for low-risk pregnancies.

The aim of [15] was to showcase a range of machine learning algorithms applied to predict preterm birth. A key strength of this survey lies in the diverse datasets analyzed, including electrohysterogram signals, electronic health records, and transvaginal ultrasounds. While previous reviews on preterm birth predictions exist, this is the first to include studies based specifically on transvaginal ultrasound examinations. This work provides a critical appraisal of widely used methods that have implemented machine learning techniques for preterm birth prediction. In another study [16], a prototype expert system was developed to assess the risk of preterm birth in pregnant women. While a normal pregnancy term is around 40 weeks, 8–12% of babies in the United States are born before reaching 37 weeks, resulting in significant challenges associated with prematurity for families, individuals, and the healthcare system. The design of this system used a knowledge-based development methodology that combined machine learning, statistical analysis, and validation techniques to analyze three large datasets, comprising 18,890 subjects and 214 variables. The

primary outcome variable was the gestational age at delivery, categorized as preterm (before 37 weeks) or full-term (37 weeks or more). This approach provided a comprehensive foundation for creating a reliable tool to support early intervention and improve outcomes related to preterm birth.

- *Fetal Growth Monitoring and Anomaly Detection*

Fetal growth restriction (FGR) is a significant predictor of neonatal morbidity and can indicate underlying placental dysfunction or other complications. AI-driven models that analyze ultrasound measurements, Doppler imaging, and maternal health parameters help in early detection of FGR. These models facilitate regular monitoring of fetal growth patterns, enabling clinicians to intervene if abnormal growth trends are detected. For instance, timely induction of labor can be considered in cases of severe FGR, improving outcomes for infants who might otherwise suffer from hypoxia or developmental delays. Additionally, predictive analytics has revolutionized the detection of congenital anomalies, allowing for early diagnosis and planning. Anomalies like congenital heart defects, neural tube defects, and chromosomal abnormalities can be challenging to detect in standard ultrasounds, especially at earlier stages of pregnancy. Machine learning algorithms trained on large datasets of ultrasound images and genetic markers have shown promise in enhancing the accuracy of these detections, offering parents and clinicians the chance to prepare for specialized care if necessary.

Researchers in [17] proposed an integrated model combining deep learning and supervised machine learning for predictive fetal monitoring. This work aimed to develop a feature extraction and prediction algorithm capable of identifying key features from the SISPORTO software package, along with late and variable decelerations. These extracted features were then used to classify umbilical cord pH data. The developed algorithms enabled the prediction of cord pH levels, providing obstetricians with a more accurate assessment of fetal status compared to traditional categorical methods. Notably, only around 30% of patients in the pathological category experienced acidosis, while the majority of acidotic newborns were classified within the "suspect" category, which is traditionally considered lower risk. Another study [18] introduced a radial basis function support vector machine (RBF-SVM) classification model utilizing quantitative features extracted from fetal heart rate (FHR) signals obtained through routine cardiotocography (CTG). The model was applied to a dataset comprising 160 healthy fetuses and 102 fetuses diagnosed with late intrauterine growth restriction (IUGR).

Conclusion

This paper reviewed the applications of artificial intelligence (AI) and machine learning in maternal and fetal health, focusing on their role in predicting and mitigating risks associated with pregnancy complications. By examining recent advancements in predictive models for maternal health conditions such as preeclampsia, gestational diabetes, and preterm birth, as well as fetal growth monitoring and anomaly detection, this review highlights the potential of AI to enhance early detection and intervention. The study discussed the effectiveness of AI-driven models in improving clinical outcomes through the analysis of extensive health data, such as electronic health records, ultrasound images, and real-time monitoring.

Conflict of interest

The authors declared no conflict of interest.

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