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REVIEW ARTICLE

The role of Artificial Intelligence in Improving Maternal Fetal Health Outcomes: A Mini Review

Tarjani Vaidya [a,*], Akash Narayan Patil [b], Kathan Mankad [a], Apurva Ashok Aghade [b], Vedant Rambhau Tambade [b]

[a] Department of Public Health, Alumni at University of Texas Health science center at Tyler, TX, USA

[b] Department of Medicine, Alte University, Tbilisi 0177, Georgia

***Corresponding Author:** Tarjani Vaidya
Department of Public Health, Alumni at University of Texas Health science center at Tyler, TX, USA
Email: vaidyatarjani@gmail.com

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Abstract

Maternal-fetal health is a vital area of healthcare that significantly impacts the long-term wellbeing of mothers and their children. Despite advancements in medical technology, maternal and neonatal morbidity and mortality remain critical global health challenges. Complications such as preterm birth, preeclampsia, gestational diabetes, and fetal growth restrictions contribute to adverse outcomes and highlight the need for innovative solutions. Artificial Intelligence (AI) offers promising opportunities to address these challenges by enhancing diagnostic accuracy, predictive analytics, and personalized treatment plans. AI technologies, including machine learning, deep learning, natural language processing, and computer vision, can analyze vast datasets from electronic health records, wearable devices, genetic information, and imaging studies. These technologies enable early detection of complications, more precise diagnostic imaging, and real-time fetal monitoring. Predictive models powered by AI can identify high-risk pregnancies and provide healthcare providers with valuable insights for early intervention. AI also facilitates the creation of personalized care plans, optimizing management of conditions like gestational diabetes through customized dietary and exercise recommendations, glucose monitoring, and medication management. Despite the potential benefits, several challenges and ethical considerations must be addressed, including data privacy, algorithmic bias, and the need for robust regulatory frameworks. By navigating these challenges and leveraging AI's capabilities, maternal-fetal health can be transformed, improving outcomes and reducing disparities in care. This review explores the current applications and future prospects of AI in maternal-fetal health, emphasizing the importance of ethical and equitable implementation to fully realize AI's potential in this critical field.

1. Introduction

Maternal-fetal health is a cornerstone of public health, with significant implications for long-term health outcomes for both mother and child (Heuser et al., 2023). Despite advancements in medical technology, maternal and neonatal morbidity and mortality remain critical issues worldwide, particularly in low-resource settings. The advent of artificial intelligence (AI) in healthcare offers a promising avenue to address these challenges (Georgieva et al., 2022). AI, with its capabilities in data analysis, pattern recognition, and predictive analytics, has the potential to revolutionize maternal-fetal medicine by enhancing diagnostic accuracy, optimizing treatment plans, and improving overall healthcare delivery. This review delves into the current applications of AI in maternal-fetal health, examines the potential future impact of AI-driven technologies, and discusses the associated challenges and ethical considerations.

2. Current Applications of AI in Maternal-Fetal Health

2.1. Predictive Analytics and Risk Assessment

AI algorithms, particularly those employing machine learning (ML) techniques, have shown immense potential in predicting and assessing risks associated with pregnancy (Bertini et al., 2022; Islam et al., 2022) These tools analyze vast amounts of data from electronic health records (EHRs), wearable devices, and genetic information to identify patterns and predict complications such as preterm birth, preeclampsia, gestational diabetes, and fetal growth restriction.

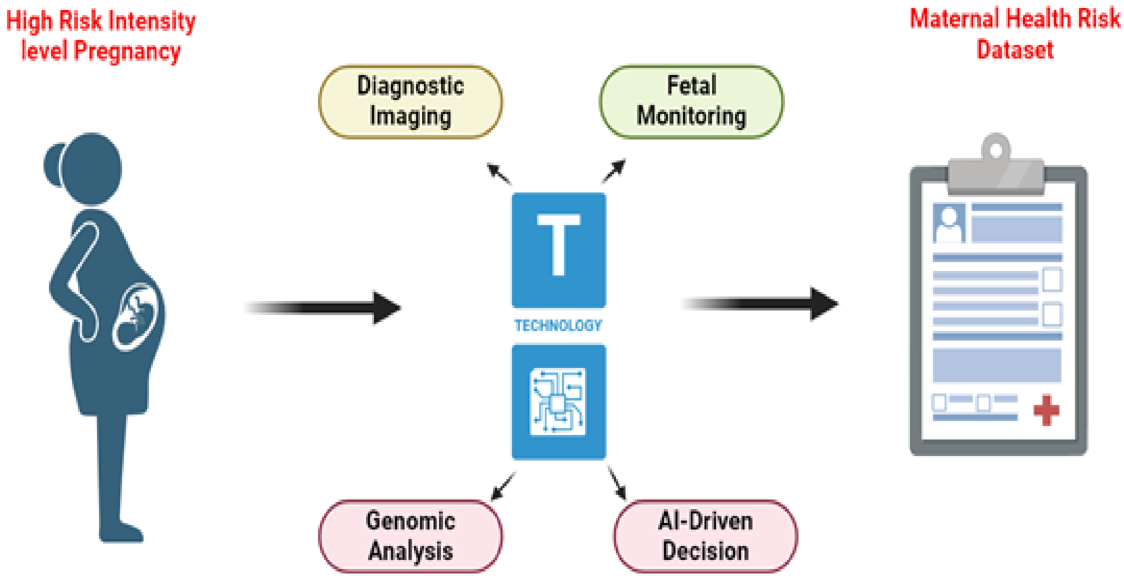

Figure 1: AI method to predict maternal health during pregnancy and health risk prediction

2.1.1. Preterm Birth Prediction

Preterm birth is a leading cause of neonatal morbidity and mortality (Meertens et al., 2018). Traditional methods of predicting preterm birth rely on clinical risk factors and history, which may not always be accurate. AI models, such as those developed using neural networks and random forest algorithms, have demonstrated superior accuracy in predicting preterm birth by analyzing data from EHRs, including maternal demographics, medical history, and prenatal test results (Gao et al., 2019). These models can identify subtle patterns and interactions between variables that are often missed by conventional methods (Figure 1).

2.1.2. Preeclampsia Detection

Preeclampsia is a serious condition characterized by high blood pressure and damage to organs, typically the liver and kidneys, which can be life-threatening for both mother and baby (Armaly et al., 2018). AI-driven predictive models have been developed to assess the risk of preeclampsia by analyzing a combination of clinical data, biomarkers, and imaging results (Alkhodari et al., 2023). These models can help in early identification and timely intervention, potentially reducing the incidence and severity of preeclampsia.

2.1.3. Gestational Diabetes Management

Gestational diabetes mellitus (GDM) is a common complication that can have adverse effects on both maternal and fetal health (Murray and Reynolds, 2020). AI systems can enhance the management of GDM by predicting which women are at higher risk based on factors like age, body mass index (BMI), family history, and glucose levels. Additionally, AI-driven applications can assist in personalized dietary and exercise recommendations, glucose monitoring, and insulin management, thereby improving outcomes for both mother and baby (Ahmad and Mohamed, 2024).

3. Diagnostic Imaging and Fetal Monitoring

AI has made significant strides in the field of diagnostic imaging and fetal monitoring (Drukker et al., 2020), providing enhanced accuracy and efficiency in the interpretation of ultrasound and MRI images.

3.1. Ultrasound Imaging

Ultrasound is a critical tool in prenatal care, used for monitoring fetal development, detecting anomalies, and assessing placental health (Salomon et al., 2019). AI algorithms, particularly those based on deep learning, have been developed to assist radiologists in interpreting ultrasound images with greater accuracy. These algorithms can automatically identify and measure anatomical structures, detect anomalies, and even predict gestational age more accurately than traditional methods (Rawat et al., 2018). This reduces the likelihood of human error and enhances the overall quality of prenatal care.

3.2. MRI Analysis

Magnetic Resonance Imaging (MRI) is used in high-risk pregnancies to provide detailed images of the fetus and placenta (De Oliveira Carniello et al., 2022). AI-based tools can analyze MRI scans to detect abnormalities in fetal brain development, congenital heart defects, and other structural anomalies. These tools improve diagnostic accuracy and allow for earlier and more precise intervention planning.

3.3. Fetal Monitoring

Continuous monitoring of fetal heart rate and uterine contractions is essential during labor to ensure the well-being of the fetus (Urdal et al., 2021). AI-enhanced fetal monitoring systems can analyze cardiotocography (CTG) data in real-time, identifying patterns indicative of fetal distress. These systems can alert healthcare providers to potential issues, enabling timely interventions and reducing the risk of adverse outcomes (Table 1).

4. Conclusion

The integration of artificial intelligence into maternal-fetal health holds immense promise for improving outcomes

Table 1: The various applications of AI in maternal-fetal health

Features	AI Application	Impact	Examples
Predictive Analytics	Machine learning algorithms to predict complications	Early identification of high-risk pregnancies	Predicting preterm birth, preeclampsia, gestational diabetes
Diagnostic Imaging	Deep learning models for image analysis	Enhanced accuracy in detecting fetal anomalies and assessing development	Analyzing ultrasound and MRI images
Fetal Monitoring	AI-enhanced analysis of cardiotocography (CTG) data	Real-time detection of fetal distress during labor	Identifying abnormal heart rate patterns
Personalized Treatment Plans	Integration of genomic and lifestyle data	Tailored care strategies for individual patients	Personalized dietary recommendations, medication management
Remote Health Monitoring	Wearable devices and AI algorithms for continuous monitoring	Improved access to prenatal care in low-resource settings	Wearable devices tracking maternal vital signs
Genomic Data Analysis	AI algorithms to analyze non-invasive prenatal testing (NIPT) data	Early detection of genetic abnormalities	Identifying chromosomal abnormalities
Natural Language Processing (NLP)	AI tools for processing and analyzing patient records and clinical notes	Enhanced decision-making through comprehensive data analysis	Extracting relevant patient history from unstructured data
AI-Driven Decision Support Systems	Clinical decision support tools integrating AI-driven insights	Improved clinical outcomes through evidence-based decision-making	Recommending interventions based on patient-specific data
Resource Optimization	AI models for optimizing resource allocation in healthcare settings	Enhanced efficiency and reduced costs in maternal-fetal healthcare delivery	Scheduling prenatal visits based on risk assessments
Ethical and Regulatory Considerations	Development of ethical frameworks and regulatory standards for AI implementation	Ensuring fair, safe, and effective use of AI technologies	Addressing bias in AI models, ensuring patient data privacy

and reducing disparities in care. AI has the potential to enhance predictive analytics, diagnostic accuracy, and personalized treatment plans, ultimately leading to better health outcomes for both mothers and babies. However, realizing this potential requires addressing several challenges, including ensuring interoperability, training healthcare providers, addressing ethical and privacy concerns, and advancing research and innovation. By carefully navigating these challenges and leveraging the power of AI, we can transform maternal-fetal health and pave the way for a healthier future for all.

Declarations

Ethics approval statement

No ethical approval was required for the current study as it did not deal with any human or animal samples.

Consent to participate

Not applicable

Consent to publish

Not applicable

Data Availability Statement

The data are available from the corresponding author upon reasonable request

Competing Interests

The authors declare that they have no conflict of interest

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Author contribution

T.V: Supervision, Methodology, Resources. A.N.P: Conceptualization and Project administration. K.M: writing and reviewing original draft. A.A.A: Formal analysis. V.R.T: Investigation

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