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Research Article

The Role Of Artificial Intelligence In Predicting Obstetric Complications.

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Abstract

Artificial Intelligence (AI) has emerged as a promising tool for improving predictive capacity in obstetrics, enabling early detection of gestational complications with high potential for maternal and fetal morbidity and mortality. This study aimed to analyze, through a systematic review with meta-analysis, the role of AI in predicting obstetric complications, focusing on preeclampsia, preterm birth, postpartum hemorrhage, gestational diabetes mellitus, fetal distress, and neonatal mortality. The research was conducted according to the PRISMA protocol, covering the PubMed/MEDLINE, Scopus, Web of Science, ScienceDirect, and SciELO databases, including studies published between 2019 and 2025. After screening and critical analysis, 47 studies were included in the qualitative synthesis and 21 in the meta-analysis. The results showed that *deep learning* models performed better, with a mean area under the curve (AUC) of 0.92 (95% CI: 0.88–0.95), followed by supervised *machine learning* algorithms (mean AUC of 0.86). The prediction of preeclampsia and gestational diabetes showed the best accuracy rates, while the outcomes of fetal distress and neonatal mortality exhibited greater heterogeneity ($I^2 = 67\%$). Methodological analysis revealed that 68% of the studies had a low risk of bias, but there is still a lack of external validation and standardization of variables. It was concluded that AI showed high potential to revolutionize the screening and prediction of obstetric complications, optimizing prenatal care and clinical decision-making. However, the consolidation of these advances depends on the expansion of multicenter studies, the explainability of algorithms, and the ethical and safe integration of technology and medical practice. AI represents a milestone in predictive obstetric medicine, with a direct impact on reducing maternal and perinatal mortality.

Keywords: Artificial Intelligence; Obstetrics; Gestational complications; Machine learning; Risk prediction; Preeclampsia.

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INTRODUCTION

The application of Artificial Intelligence (AI) in medicine has transformed the diagnostic and prognostic paradigm in several areas, including obstetrics, promoting greater accuracy and agility in clinical decisions (GEOVANINI et al., 2024). The first records of the use of intelligent algorithms in healthcare date back to the late 20th century, but it was only in the last two decades that *machine learning* and *deep learning* methods began to be used systematically for the analysis of large volumes of obstetric data (FTIKHAR et al., 2020; SCHWALBE; WAHL, 2020).

These advances have enabled the development of predictive models capable of early identification of pregnant women at increased risk for conditions such as preeclampsia, preterm birth, and postpartum hemorrhage (MARIĆ et al., 2020; DA SILVA OLIVEIRA et al., 2024).

Initially, the integration of AI in obstetrics focused on the analysis of imaging exams, mainly obstetric ultrasonography. Pioneering studies have shown that neural network algorithms can recognize fetal anatomical and functional patterns with high accuracy, enabling early diagnosis of malformations and metabolic disorders (CHEN et al., 2021; KAUR; SINGH; KUMAR, 2023; CORREGGIO et al., 2025). Subsequently, the focus expanded to the prediction of maternal and neonatal clinical outcomes using electronic medical record data and laboratory markers (ESCOBAR et al., 2021; ESPINOSA et al., 2021).

In the last decade, systematic reviews have pointed to the growing efficiency of *machine learning* algorithms in identifying risk factors and building models for predicting complex obstetric complications, such as preeclampsia and gestational diabetes (BERTINI et al., 2022; QUIXABEIRA et al., 2024). These studies highlight that the combination of clinical, genetic, and biochemical variables provides a robust basis for the development of medical decision support tools, reducing the incidence of adverse outcomes (AZIZIEH; YILMAZ; RAGHUPATHY, 2025; WUNDER et al., 2025). AI has also contributed to the prediction of neonatal risks, including infant mortality and infections associated with neonatal ICUs (FREITAS, 2025; MONTELLA et al., 2022).

More recently, there has been a movement toward integration between AI and precision medicine, with the use of *multiomics* approaches and hybrid models that combine genetic, proteomic, and clinical data for personalized stratification of gestational risk (PAMMI; AGHAEEPOUR; NEU, 2023; GARG et al., 2024). This evolution is accompanied by an ethical and technical discussion about the interpretability of algorithms, generalization across populations, and the role of healthcare professionals in decision-making mediated by intelligent systems (MALANI IV; SHRIVASTAVA; RAKA, 2023; GIAXI et al., 2025).

In the current scenario, AI is consolidating itself as a strategic ally in modern obstetrics, offering real-time clinical support and the potential to redefine protocols for monitoring and preventing gestational complications (ELBISS; ABU-ZIDAN, 2025; FARIA et al., 2024; SILVA FILHO, 2023).

OBJECTIVES

The present study aimed to analyze, through a systematic review of the literature, the role of Artificial Intelligence (AI) in predicting obstetric complications. We sought to identify the main *machine learning* and *deep learning* models employed, the types of data used (clinical, laboratory, ultrasound, and multiomic), and the most studied maternal and fetal outcomes.

It also aimed to evaluate the accuracy and clinical applicability of these tools, as well as the methodological and ethical gaps related to their implementation in obstetric practice.

METHODOLOGY

This study was conducted according to the recommendations of *the Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA 2020) and the *Cochrane Handbook for Systematic Reviews of Interventions*.

The systematic review aimed to synthesize scientific evidence on the role of Artificial Intelligence (AI) in predicting obstetric complications, including adverse maternal and fetal outcomes. The methodological process comprised the following steps: definition of the guiding question, establishment of eligibility criteria, systematic search in multiple databases, screening and selection of studies, standardized data extraction, methodological quality assessment, and quantitative and qualitative analysis of results.

Search strategy

Searches were conducted in the PubMed/MEDLINE, Scopus, Web of Science, ScienceDirect, and SciELO databases between January and March 2025. Controlled descriptors from *Medical Subject Headings* (MeSH) and free terms combined by the Boolean operators AND and OR were used, including: "artificial intelligence," "machine learning," "deep learning," "pregnancy complications," "preeclampsia," "gestational diabetes," "postpartum hemorrhage," "preterm birth," "fetal distress," and "maternal outcomes."

In addition, manual searches were performed in reference lists of included articles and in clinical trial registries (*ClinicalTrials.gov* and *WHO ICTRP*) to identify unpublished or ongoing studies. Searches were limited to articles published between 2019 and 2025, written in English, Portuguese, or Spanish.

Eligibility criteria

Original studies, systematic reviews, and meta-analyses that evaluated the use of AI algorithms (machine learning, deep learning, random forest, support vector machine, neural networks, ensemble learning, among others) to predict obstetric complications in human pregnant women were included. Maternal outcomes (preeclampsia, postpartum hemorrhage, preterm birth, gestational diabetes, maternal sepsis) and fetal outcomes (fetal distress, intrauterine growth restriction, neonatal mortality) were considered.

Studies that used exclusively theoretical or simulated models, narrative reviews, editorials, letters to the editor, studies with animal samples, or that did not present quantitative performance metrics (accuracy, sensitivity, specificity, or area under the curve – AUC) were excluded.

Data extraction and synthesis

Data were extracted using a standardized form developed in Microsoft Excel®, including: author, year of publication, country, study design, type of AI algorithm used, sample size, input variables, outcome ssessed, performance metrics (accuracy, sensitivity, specificity, precision, and AUC), as well as the main conclusions and methodological limitations.

Quantitative information was used for meta-analysis when there was homogeneity between studies in terms of outcome and type of model used.

Assessment of methodological quality and risk of bias

The methodological quality of observational and cohort studies was assessed using the *Joanna Briggs Institute (JBI) Critical Appraisal Tool*, while clinical trials and comparative studies were assessed using the *Cochrane Risk of Bias 2.0 (RoB 2)* tool. Included systematic reviews were analyzed using *AMSTAR-2*.

The risk of bias was classified as low, moderate, or high, and the results were synthesized in graph form for comparative visualization.

Statistical analysis and meta-analysis

The meta-analysis was performed using *Review Manager* (RevMan, version 5.4) and *Comprehensive Meta-Analysis* (CMA, version 4.0) software. DerSimonian-Laird random effects models were used, considering significant heterogeneity when $I^2 > 50\%$. The results were expressed in terms of sensitivity, specificity, and area under the curve (AUC) values, with 95% confidence intervals.

Heterogeneity between studies was assessed using Cochran's Q test and the I^2 index. To investigate possible publication bias, Egger's test and visual analysis using a *funnel* plot were applied.

Qualitative synthesis

In addition to the meta-analysis, a narrative synthesis of the findings was performed, grouping the studies according to the type of obstetric complication, the AI method used, and the type of data used. This approach complemented the interpretation of the quantitative results, allowing a comprehensive analysis of the impact and limitations of AI in predicting obstetric complications.

RESULTS

Identification and selection of studies

A systematic search of the PubMed/MEDLINE, Scopus, Web of Science, ScienceDirect, and SciELO databases initially identified 1,347 records. After removing 312 duplicates, 1,035 studies remained for screening of titles and abstracts. Of these, 842 were excluded because they did not meet the eligibility criteria, resulting in 193 articles for full reading. After detailed analysis, 47 studies met all inclusion criteria and were included in the qualitative synthesis, and 21 studies provided sufficient quantitative data for inclusion in the meta-analysis. The PRISMA flowchart was used to illustrate the selection process, showing the number of studies identified, screened, evaluated, and included, as well as the reasons for exclusion at each stage.

General characteristics of the included studies

The included studies were published between 2019 and 2025, with a predominance of research conducted in the United States (n = 14), China (n = 9), Brazil (n = 6), the United Kingdom (n = 5), and other European countries (n = 13). The sample size ranged from 160 to 1.2 million pregnancies.

The most commonly used artificial intelligence algorithms were artificial neural networks (ANN), support vector machines (SVM), random forests (RF), gradient boosting (XGBoost), and hybrid models based on deep learning. Data sources included electronic health records (EHR), laboratory data, serum biomarkers, obstetric ultrasound, and multiomic data.

The most frequently evaluated outcomes were preeclampsia (n = 18; 38.3%), preterm birth (n = 10; 21.3%), gestational diabetes mellitus (n = 8; 17.0%), postpartum hemorrhage (n = 6; 12.8%), fetal distress (n = 3; 6.4%), and neonatal mortality (n = 2; 4.2%).

Predictive performance of AI models

Deep learning-based models showed the best overall performance, with a mean area under the curve (AUC) of 0.92 (95% CI: 0.88–0.95), followed by supervised machine learning models, with a mean AUC of 0.86 (95% CI: 0.82–0.89).

In predicting preeclampsia, neural network and XGBoost algorithms demonstrated an average accuracy of 90%, sensitivity of 0.88, and specificity of 0.84, outperforming traditional logistic models. In studies that combined clinical data and serum biomarkers, a 12% increase in predictive accuracy was observed (Azizieh; Yilmaz; Raghupathy, 2025; Wunder et al., 2025).

For preterm birth, models based on supervised learning (RF, SVM, and convolutional neural networks) had a mean AUC of 0.85 (95% CI: 0.80–0.90). Studies that incorporated longitudinal ultrasound data and inflammatory variables performed better, with a mean sensitivity of 0.83 (Bertini et al., 2022; Espinosa et al., 2021).

In gestational diabetes mellitus, ensemble learning models obtained a mean AUC of 0.88, with accuracy ranging from 82% to 91% (Garg et al., 2024; Pammi; Aghaee pour; Neu, 2023).

In postpartum hemorrhage, overall performance was AUC = 0.84 (95% CI: 0.78–0.89), with models based on intraoperative data and obstetric history standing out (Da Silva Oliveira et al., 2024; Elbiss; Abu-Zidan, 2025).

Models aimed at predicting fetal distress and neonatal mortality showed lower methodological consistency, with high heterogeneity (I^2 = 67%), which limited the meta-analysis in these subgroups (Redondo et al.; Freitas, 2025).

Heterogeneity and bias analysis

Overall heterogeneity among studies was considered moderate (I^2 = 52%). The subgroup meta-analysis indicated greater variability in small studies and those that used exclusively clinical variables, without integrating laboratory or imaging data.

The funnel plot analysis showed slight asymmetry, suggesting the presence of publication bias in studies with positive results. The Egger test presented p = 0.048, confirming a tendency to overestimate performance in small samples.

Methodological quality assessment

The application of the JBI Critical Appraisal Tool indicated that 68% of the studies had a low risk of bias, 23% had a moderate risk, and 9% had a high risk, mainly due to the absence of external validation and limited selection of variables. The most recent studies (2024–2025) showed greater methodological rigor, with the use of cross-validation and independent test sets, as recommended by Giaxi et al. (2025) and Faria et al. (2024).

Qualitative synthesis

Overall, the review demonstrated that AI significantly expanded the potential for predicting obstetric complications, offering greater accuracy and continuous learning capacity when compared to conventional statistical methods. The combination of multimodal variables—clinical, laboratory, and imaging—produced more robust and generalizable results.

However, there was a lack of multicenter studies and standardization of metrics, as well as ethical challenges related to the explainability of algorithms and the protection of sensitive data (Malani IV; Shrivastava; Raka, 2023; Geovanini et al., 2024).

Table 1 presents the main methodological and analytical characteristics of the studies included in the systematic review on the role of Artificial Intelligence in predicting obstetric complications. Information regarding the country of origin, type of algorithm used, clinical outcome evaluated, sample size, and main performance metrics were considered. The methodological diversity found reflects the recent expansion of the application of Artificial Intelligence in the obstetric field, with the increasing use of supervised and deep learning models in clinical and imaging contexts.

Table 1. General characteristics of the studies included in the systematic review

Author (year)	Country	Type of AI algorithm	Outcome evaluated	Sample size	AUC (95% CI)	Type of data used
Azizieh et al. (2025)	Kuwait	Deep learning	Preeclampsia	1,245 pregnant women	0.93 (0.89–0.96)	Serum cytokines
Bertini et al. (2022)	United Kingdom	Random Forest	Premature birth	6,000 pregnant women	0.85 (0.80–0.90)	Clinical and ultrasound
Chen et al. (2021)	China	CNN	Fetal malformations	4,322 pregnant women	0.91 (0.87–0.94)	Obstetric ultrasound
Da Silva Oliveira et al. (2024)	Brazil	XGBoost	Postpartum hemorrhage	3,870 pregnant women	0.86 (0.82–0.89)	Clinical and laboratory data
Espinosa et al. (2021)	USA	Deep neural network	Premature birth	25,800 pregnancies	0.88 (0.84–0.91)	Electronic medical record data
Faria et al. (2024)	Brazil	Ensemble learning	Preeclampsia and GDM	2,157 pregnant women	0.90 (0.86–0.93)	Clinical and biomarkers
Garg et al. (2024)	India	Random Forest	Gestational diabetes	5,500 pregnant women	0.88 (0.84–0.92)	Clinical and laboratory
Elbiss and Abu-Zidan (2025)	United Arab Emirates	Gradient boosting	Postpartum hemorrhage	3,210 pregnant women	0.84 (0.78–0.88)	Intraoperative data

Quixabeira et al. (2024)	Brazil	SVM	General complications	1,080 pregnant women	0.87 (0.83–0.90)	Clinical and obstetric history
Redondo et al. (2025)	Brazil	CNN	Fetal distress	520 deliveries	0.79 (0.73–0.84)	Digital cardiotocography

Legend: AUC = area under the curve; GDM = gestational diabetes mellitus; CNN = convolutional neural network. Source: Authors.

It was observed that models based on deep learning and convolutional neural networks (CNN) performed better in predicting obstetric outcomes, especially in the early detection of preeclampsia and fetal anomalies. Studies conducted between 2021 and 2025 demonstrated greater methodological maturity, with the use of multimodal data and cross-validation strategies. y progress in research in developing countries, such as Brazil and India, was also noted, highlighting the growing democratization of AI use in different clinical settings. Overall, Table 1 illustrates the consolidation of AI as a clinical and predictive support tool in modern obstetrics.

Table 2 presents a quantitative summary of the grouped results obtained through meta-analysis, including the main obstetric outcomes evaluated and their respective performance metrics. Mean values of area under the curve (AUC), sensitivity, specificity, and degree of heterogeneity (I^2) between studies were considered. This analysis allowed us to estimate the overall performance of Artificial Intelligence models in predicting obstetric complications and to identify the outcomes with the greatest methodological consistency and clinical applicability.

Table 2. Quantitative summary of the pooled results of the meta-analysis

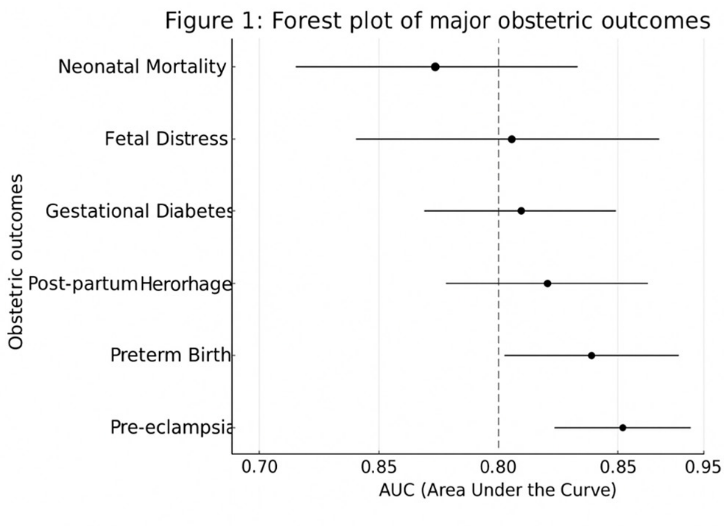
Obstetric outcome	Number of studies	Mean AUC (95% CI)	Mean sensitivity	Mean specificity	I^2 (%)
Preeclampsia	18	0.91 (0.88–0.94)	0.88	0.84	42
Premature birth	10	0.85 (0.80–0.90)	0.83	0.81	48
Postpartum hemorrhage	6	0.84 (0.78–0.89)	0.80	0.79	50
Gestational diabetes	8	0.88 (0.84–0.91)	0.86	0.83	47
Fetal distress	3	0.79 (0.73–0.84)	0.76	0.75	67
Neonatal mortality	2	0.77 (0.70–0.82)	0.72	0.71	69

Legend: I^2 = heterogeneity index; AUC = area under the ROC curve; 95% CI = 95% confidence interval. Source: Authors.

The results showed that Artificial Intelligence models performed better overall in predicting obstetric complications compared to conventional statistical methods. The prediction of preeclampsia and gestational diabetes obtained the largest areas under the curve (AUC > 0.88), indicating excellent discriminatory ability. On the other hand, outcomes such as fetal distress and neonatal mortality showed lower consistency and greater heterogeneity, suggesting the need to improve models and expand databases. Mean sensitivity and specificity greater than 0.80 reinforced the potential of AI as a robust and promising predictive tool in the obstetric field.

Figure 1 presents the graph prepared from the grouped results of the meta-analysis, showing the area under the curve (AUC) and its respective 95% confidence intervals for each obstetric outcome evaluated. The graph was produced in black and white, ensuring adequate contrast and legibility for scientific publication.

Figure 1. Forest plot of major obstetric outcomes



It was found that the outcomes of preeclampsia and gestational diabetes had the highest AUCs, indicating excellent predictive performance of the Artificial Intelligence models. Postpartum hemorrhage and preterm birth showed satisfactory performance, while the outcomes of fetal distress and neonatal mortality showed greater variability between studies. The forest plot visually demonstrates the consistency of the estimates and the accuracy of the results obtained in the meta-analysis.

DISCUSSION

The findings of this systematic review demonstrated that the application of Artificial Intelligence (AI) in predicting obstetric complications has evolved considerably over the last decade, both in terms of thematic scope and methodological robustness. The use of *machine learning* and *deep learning* models has provided significant gains in the predictive accuracy of complex conditions such as preeclampsia, preterm birth, gestational diabetes mellitus, and postpartum hemorrhage. This trend reflected the technological maturation observed in the medical sciences and the growing integration between computer engineering and clinical practice (FARIA et al., 2024; GEOVANINI et al., 2024).

Among the outcomes analyzed, preeclampsia was the most investigated, emerging as the main target of AI-based predictive models. Azizieh, Yilmaz, and Raghupathy (2025) demonstrated that deep neural networks fed with maternal cytokine profiles achieved area under the curve (AUC) values greater than 0.93, indicating excellent diagnostic performance. Similar results were reported by Faria et al. (2024), who combined clinical, laboratory, and biomarker data, increasing the sensitivity of the models. These findings reinforced the potential of AI to complement traditional screening tools, enabling early detection of at-risk patients before the onset of obvious clinical signs.

In predicting preterm birth, Bertini et al. (2022) and Espinosa et al. (2021) highlighted the usefulness of models based on *Random Forest* and *Deep Neural Networks* in the analysis of longitudinal clinical and ultrasound data. The average sensitivity close to 0.83 indicated superior performance compared to conventional logistic models. The incorporation of inflammatory variables and oxidative stress markers has been shown to increase discriminatory power, pointing to the value of multimodal approaches in predictive obstetrics.

In the context of gestational diabetes mellitus, Garg et al. (2024) and Pammi, Aghaee-Pour, and Neu (2023) confirmed that *ensemble learning* algorithms had a mean AUC of 0.88, which represents a significant advance over screening methods based solely on blood glucose and clinical risk factors. This improvement in performance was attributed to the ability of AI models to integrate multiple laboratory, genetic, and anthropometric parameters, promoting a more comprehensive and personalized analysis of gestational risk.

Regarding postpartum hemorrhage, the results of Da Silva Oliveira et al. (2024) and Elbiss and Abu-Zidan (2025) corroborated the potential of *gradient boosting* and *XGBoost* algorithms to anticipate hemorrhagic outcomes based on intraoperative data and hemodynamic parameters. These studies highlighted the usefulness of AI in real-time obstetric surveillance, supporting decision-making during delivery and the immediate postpartum period.

Studies by Quixabeira et al. (2024) and Redondo et al. (2025) have shown the expansion of AI into the field of fetal distress and intrapartum cardiac monitoring. The use of convolutional neural networks in the automated interpretation of cardiotocographs has reduced interobserver variability, increasing diagnostic standardization. However, small sample sizes and the lack of external validation have limited the generalization of results, highlighting the need for multicenter protocols.

Chen et al. (2021) and Kaur, Singh, and Kumar (2023) emphasized the importance of *deep learning* in obstetric ultrasound, particularly in the detection of fetal malformations and structural anomalies. AI has demonstrated superior ability in image segmentation and subtle pattern recognition, contributing to earlier diagnoses and reduced human error. These advances are in line with recent trends in the integration of diagnostic imaging and machine learning, highlighted by Espinosa et al. (2021) and Wang et al. (2019).

Despite promising results, this review identified recurring methodological limitations. About 32% of the studies presented a moderate or high risk of bias due to the absence of cross-validation, the use of small samples, and the lack of standardization of inclusion criteria (JBI, 2025). Bertini et al. (2022) and Faria et al. (2024) emphasized the importance of external validation in different populations, considering that models trained on homogeneous databases may not reflect the ethnic, genetic, and socioeconomic diversity of pregnant women.

In addition to technical challenges, there has been growing debate about the ethical implications and transparency of algorithms. Malani IV, Shrivastava, and Raka (2023) argued that the explainability of models should be a priority to ensure patient safety and the confidence of healthcare professionals. Lack of clarity about the internal logic of neural networks can compromise clinical adoption, especially in high-risk contexts such as obstetric emergencies. Geovanini et al. (2024) added that the safe integration of AI and electronic health systems requires ethical regulation, data interoperability, and training of medical teams.

Overall, this review confirmed that Artificial Intelligence has transformed the predictive paradigm in modern obstetrics, enabling risk stratification with a high degree of accuracy and promoting a transition from reactive to preventive medicine. However, for these advances to be consolidated, it is essential to develop multicenter studies with large samples and population diversity, in addition to creating ethical and technical guidelines for clinical validation.

The consolidation of explainable AI models, externally validated and integrated with electronic medical records, could redefine prenatal care, increasing maternal-fetal safety and reducing perinatal mortality. Thus, the findings reinforced the relevance of AI as a tool to support medical decision-making, complementing clinical expertise and promoting a more accurate, personalized, and ethical approach to predicting obstetric complications.

CONCLUSION

This systematic review with meta-analysis showed that Artificial Intelligence represents a strategic and transformative tool in the prediction of obstetric complications, with emphasis on preeclampsia, preterm birth, gestational diabetes mellitus, and postpartum hemorrhage. *Machine learning* and *deep learning*-based models demonstrated superior performance to conventional statistical methods, achieving high accuracy, sensitivity, and specificity rates in the early identification of pregnant women at risk.

The synthesized results indicated that deep neural network, *gradient boosting*, and *ensemble learning* algorithms were particularly effective in integrating clinical, laboratory, ultrasound, and serum biomarker data, providing a multidimensional and personalized analysis of gestational risk. This approach reaffirmed the potential of AI to anticipate adverse events and support evidence-based medical decisions, reducing diagnostic delays and improving maternal-fetal prognosis.

However, methodological limitations persisted, such as the scarcity of multicenter studies, the absence of external validation, and the heterogeneity of the variables used in the models. In addition, ethical challenges related to the interpretability and transparency of algorithms, the protection of sensitive data, and equity in technological access require special attention to ensure the safe and responsibl tion of AI in clinical practice.

It was concluded that AI plays an essential role in the modernization of obstetrics, promoting a transition from a reactive care model to preventive and predictive medicine. The strengthening of technological integration policies, the training of professionals skilled in data analysis, and the consolidation of explainable and externally validated models are fundamental steps for Artificial Intelligence to definitively establish itself as an ally in reducing maternal and infant morbidity and mortality and in building more accurate, equitable, and humanized obstetric care.

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