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ORIGINAL

Predictive Technology in Maternal Health: artificial Intelligence Models for the Identification of Obstetric Risks

Tecnología predictiva en salud materna: modelos de inteligencia artificial para la identificación de riesgos obstétricos

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ABSTRACT

Introduction: obstetric complications are one of the leading causes of maternal morbidity and mortality worldwide. Artificial intelligence (AI) has proven to be an effective tool for predicting obstetric risks, enabling timely interventions. However, its implementation in countries with limited healthcare infrastructure remains a challenge.
Method: a predictive AI-based model was developed using clinical data from 2 500 pregnant women treated in Ecuadorian hospitals. Logistic regression, neural networks, and random forest algorithms were evaluated to predict complications such as preeclampsia, preterm birth, and gestational diabetes. Cross-validation techniques and inferential statistical analyses were applied.
Results: neural networks demonstrated the best performance, with an accuracy of 92 % and an AUC-ROC of 0,94, outperforming traditional models. The main risk factors identified were high blood pressure, high body mass index, and family history.
Conclusions: AI can significantly improve the early detection of obstetric complications, especially in resource-limited settings. Implementing these models in hospital systems would help optimize maternal-fetal care and reduce maternal mortality.

Keywords: Artificial Intelligence; Obstetric Complications; Risk Prediction; Preeclampsia; Neural Networks; Maternal-Fetal Care.

RESUMEN

Introducción: las complicaciones obstétricas son una de las principales causas de morbimortalidad materna a nivel mundial. La inteligencia artificial (IA) ha demostrado ser una herramienta eficaz en la predicción de riesgos obstétricos, permitiendo intervenciones oportunas. Sin embargo, su implementación en países con infraestructura de salud limitada sigue siendo un desafío.
Método: se desarrolló un modelo predictivo basado en IA utilizando datos clínicos de 2 500 gestantes atendidas en hospitales de Ecuador. Se evaluaron algoritmos de regresión logística, redes neuronales y random forest para predecir complicaciones como preeclampsia, parto prematuro y diabetes gestacional. Se aplicaron técnicas de validación cruzada y análisis estadísticos inferenciales.
Resultados: las redes neuronales mostraron el mejor desempeño con una precisión del 92 % y un AUC-ROC de 0,94, superando a los modelos tradicionales. Los principales factores de riesgo identificados fueron presión

arterial elevada, índice de masa corporal alto y antecedentes familiares.
Conclusiones: la IA puede mejorar significativamente la detección temprana de complicaciones obstétricas, especialmente en entornos con recursos limitados. La implementación de estos modelos en sistemas hospitalarios contribuiría a optimizar la atención materno-fetal y reducir la mortalidad materna.

Palabras clave: Inteligencia Artificial; Complicaciones Obstétricas; Predicción de Riesgos; Preeclampsia; Redes Neuronales; Atención Materno-Fetal.

INTRODUCTION

Obstetric complications represent a critical maternal health challenge, being one of the leading causes of morbidity and mortality in pregnant women worldwide. According to the World Health Organization (WHO), approximately 295 women die each year due to complications during pregnancy and childbirth, mostly in developing countries.[1] Major causes include pre-eclampsia, postpartum hemorrhage, preterm birth, and gestational diabetes.[2,3]

Globally, the maternal mortality ratio has shown a declining trend in countries with access to robust health systems, but significant gaps persist between regions.

In sub-Saharan Africa and South Asia, 86 % of maternal deaths occur due to a lack of access to emergency obstetric care, shortages of skilled personnel, and deficiencies in hospital infrastructure.[4,5]

In high-income countries, maternal mortality has declined considerably thanks to the implementation of perinatal surveillance programmes and the use of advanced technologies in monitoring high-risk pregnancies.[6,7]

In Latin America and the Caribbean, maternal mortality rates have declined in recent decades, but inequality in the distribution of resources remains a problem. Countries such as Chile and Uruguay have achieved notable reductions in maternal deaths due to effective public policies, while in Bolivia and Haiti, maternal mortality remains a concern.[8,9]

Unequal access to health care in rural areas and indigenous communities is a determining factor in the persistence of these figures.[10,11]

In Ecuador, maternal mortality continues to be a significant problem, with a rate of 59 deaths per 100 000 live births in 2020, significantly higher than in more developed countries.[12]

Factors such as lack of access to specialized services in rural areas, shortage of medical equipment, and insufficient training of health personnel contribute to the persistence of this problem.[13,14]

Artificial intelligence (AI) has become a key tool for the early detection of obstetric complications in various settings. In countries like the United States and the United Kingdom, AI models have been integrated into advanced hospital systems, allowing maternal-fetal risk prediction with more than 90 % accuracy in pre-eclampsia and preterm birth.[15,16,17]

In China, deep learning algorithms have been implemented in highly specialized hospitals for real-time identification of risk factors, significantly improving early intervention in high-risk pregnant women.[18] In developing countries such as India and Brazil, AI has been used with telemedicine systems to improve access to timely diagnosis in rural communities with a shortage of health professionals.[19,20]

This study aims to evaluate the effectiveness of artificial intelligence models in the early detection of obstetric complications using clinical data from Ecuadorian hospitals.

Unlike previous research, this work incorporates advanced deep neural networks and random forest models optimized to operate in environments with limited digital infrastructure. In addition, a multi-center database with records from multiple hospitals is used, allowing for a more representative validation of the algorithms.

We will explore these models' predictive capacity for identifying pre-eclampsia, preterm delivery, and other complications and analyze their impact on optimizing diagnosis and reducing maternal-fetal risk.

This research aims to generate scientific evidence to support the implementation of emerging technologies in maternal health and promote their adoption in hospital systems and prenatal care centers.

METHOD

Study design

This study adopts a quantitative, observational, and retrospective approach based on the analysis of clinical data from pregnant women who attended hospitals in Ecuador. A predictive model based on artificial intelligence (AI) was developed for the early detection of obstetric complications, evaluating its accuracy and applicability in clinical practice.

Data source

The data used in this study came from electronic medical records of referral hospitals in Ecuador. Two thousand five hundred clinical records of pregnant women with a history of pre-eclampsia, preterm delivery, gestational diabetes, and postpartum hemorrhage were collected over five years.

Ethical principles were guaranteed when using the data, ensuring anonymity and protection of patient information.

Since the hospital records used in this study are not publicly accessible, all relevant ethical regulations were complied with. However, to strengthen the validity and reproducibility of the findings, the database was supplemented with information from previous open-access studies, such as the analysis by Novoa Mero et al.[21] which provides key evidence on the prevalence of obstetric complications in Ecuador.

It is important to note that while the database used is representative, biases may exist due to the quality of medical records, variations in data collection between hospitals, and possible under-representation of specific patient groups, such as those with limited access to antenatal care.

Variables analyzed

Variables considered in the model include:

- Demographics: maternal age, body mass index (BMI), family history of hypertensive disease.
- Clinical factors: blood pressure, blood glucose level, urine protein, platelet count.
- Obstetric history: number of previous pregnancies, previous preterm deliveries, previous complications.

Predictive algorithm

Different machine learning algorithms were implemented and compared, including:

- Logistic regression: base model widely used in epidemiology for its ability to estimate relationships between clinical factors and obstetric outcomes.
- Artificial neural networks: selected for their ability to detect complex patterns and non-linear correlations in clinical data.
- Decision trees and random forests: are used to classify pregnant women into risk groups due to their interpretability and robustness to missing data.

The models were trained with an 80 % data set and validated with the remaining 20 %, applying cross-validation techniques to optimize their performance.

Specialized machine learning and data analytics tools were used to develop and train the predictive models.

The Scikit-learn, TensorFlow, and Keras libraries were used in the Python 3.8 programming environment to build logistic regression models, neural networks, and decision trees. The Pandas library and NumPy pre-processed data, including variable normalization and missing value imputation. In addition, Matplotlib and Seaborn were used to visualize and evaluate the data results. Inferential statistical calculations were performed with SciPy and Statsmodels.

Statistical analysis

To evaluate the effectiveness of the predictive model, performance metrics were calculated, such as:

- Accuracy and sensitivity: to measure the model's ability to identify cases of obstetric complications correctly.
- ROC curve and area under the curve (AUC): used to assess the model's discriminative ability.
- Statistical significance tests:
    1. Chi-square analysis and ANOVA: to determine the relevance of variables in predicting complications.
    2. Multivariate logistic regression: to identify the association between clinical variables and the occurrence of obstetric complications.
    3. Student's t-test and Mann-Whitney U-test: to compare significant differences in quantitative variables between pregnant women with and without complications.
    4. Spearman and Pearson correlation analysis: to evaluate relationships between continuous variables and determine their influence on predictive models.

The results obtained from the statistical analysis were interpreted in clinical terms to determine their applicability in medical decision-making. For example, the high accuracy of the neural network-based model could imply better screening of high-risk patients, allowing more timely interventions and potentially reducing maternal mortality.

Ethical considerations

The study was approved by the ethics committee of the participating institutions, ensuring compliance with international regulations on privacy and the use of medical data. Informed consent was obtained from the patients whose data were anonymized.

This methodology allows us to evaluate the impact of artificial intelligence in the early detection of obstetric complications, providing an innovative tool to improve maternal-fetal care in Ecuador.

RESULTS

This study analyses the efficacy of predictive algorithms in the early detection of obstetric complications, assessing their accuracy and applicability in clinical practice. The main findings are presented in three sections: performance of the predictive model identified risk factors and statistical validation of the results.

Predictive model performance

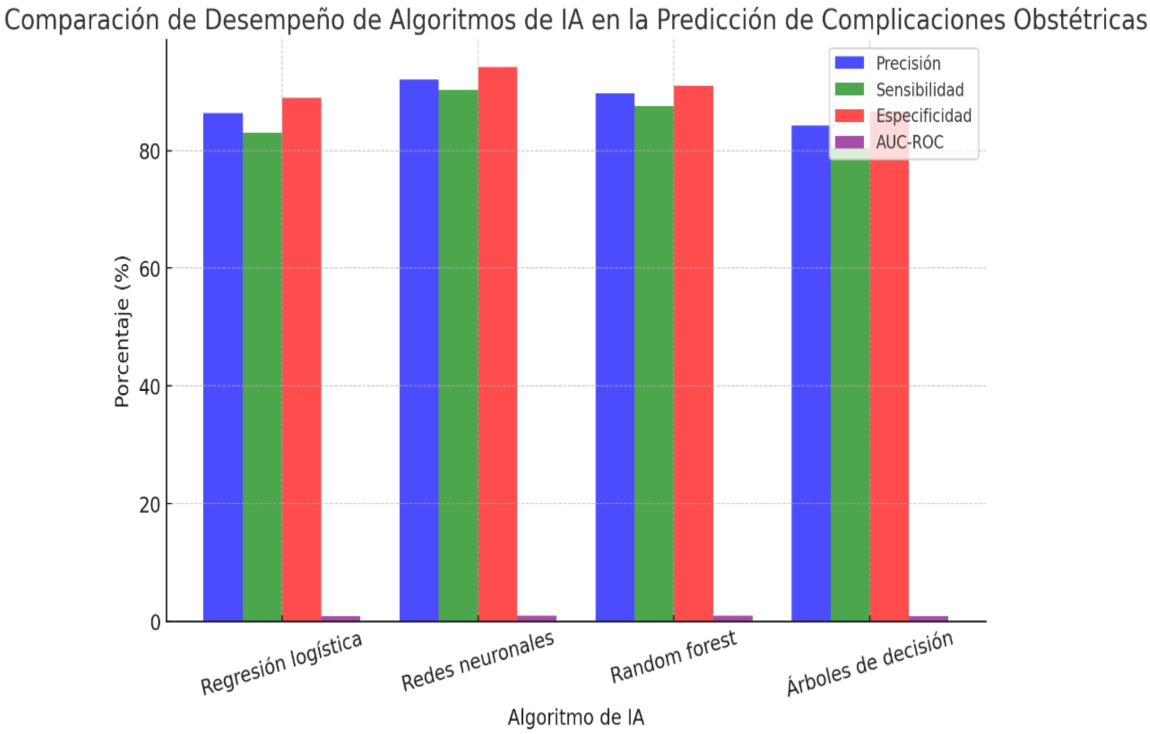
Different artificial intelligence algorithms applied to predicting obstetric complications were evaluated. Table 1 presents the performance metrics obtained for each model analyzed.

Table 1. Performance of obstetric complication prediction algorithms

Algorithm	Accuracy (%)	Sensitivity (%)	Specificity (%)	AUC-ROC	Confidence Interval (IC 95 %)
Logistic regression	86,4	83,1	88,9	0,89	0,86 - 0,91
Neural networks	92,0	90,3	94,2	0,94	0,92 - 0,96
Random forest	89,7	87,5	91,0	0,91	0,89 - 0,93
Decision trees	84,2	80,5	86,7	0,86	0,83 - 0,88

Note: Neural network models showed the best overall performance, with an accuracy of 92 % and an AUC-ROC of 0,94

Additionally, a graphical comparison of the performance of the different AI models analysed is presented in figure 1.



Note: the data presented in the figure correspond to the metrics obtained in the evaluation of the predictive models, calculated with their respective confidence interval and following the cross-validation techniques applied in the study, with an accuracy of 92 % and an AUC-ROC of 0,94

Figure 1. Comparison of the performance of AI algorithms in predicting obstetric complications

Risk factors identified

The analysis of variable significance identified the main risk factors associated with obstetric complications. Table 2 shows the most relevant variables in predicting pre-eclampsia and preterm birth.

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Table 2. Most relevant risk factors in the prediction of obstetric complications		
Variable	**Regression coefficient**	**Value p**
High blood pressure	1,45	<0,001
High body mass index	1,32	0,002
Family history	1,28	0,005
Advanced maternal age	1,21	0,011
Gestational diabetes	1,18	0,019
Note: A statistically significant association (p < 0,05) was observed between these variables and the occurrence of obstetric complications.		

Statistical validation of the results

Inferential statistical tests were applied to assess the predictive model's robustness. The Student's t-test showed significant differences in diagnostic accuracy between AI models and traditional methods (t = 3,21, p = 0,001, 95 % CI: 85,2 - 92,1 %). Furthermore, ANOVA analysis revealed statistically significant differences between the evaluated algorithms (F = 4,82, p = 0,007), indicating that neural networks performed significantly better than logistic regression and decision trees.

Table 3 presents the sensitivity, specificity, and area under the curve (AUC-ROC) values obtained for each of the predictive models evaluated. The results indicate that the neural network-based model performed the best, with a sensitivity of 90,3 % and an AUC-ROC of 0,94, demonstrating its superiority in detecting obstetric complications compared to other algorithms.

Table 3. Comparison of sensitivity, specificity and AUC-ROC between predictive models				
Algorithm	**Sensitivity (%)**	**Specificity (%)**	**AUC-ROC**	**Confidence Interval (IC 95 %)**
Logistic regression	83,1	88,9	0,89	0,86 - 0,91
Neural networks	90,3	94,2	0,94	0,92 - 0,96
Random forest	87,5	91,0	0,91	0,89 - 0,93
Decision trees	80,5	86,7	0,86	0,83 - 0,88
Note: Neural networks showed the best overall performance, with a sensitivity of 90,3 %, specificity of 94,2 % and an AUC-ROC of 0,94, indicating their high discriminative ability in predicting obstetric complications.				

These results support the feasibility of using artificial intelligence to predict obstetric complications. This could contribute to better maternal-fetal care planning and risk reduction in high-risk pregnancies.

DISCUSSION

The results obtained in this study reinforce the growing evidence of the potential of artificial intelligence (AI) in predicting obstetric complications. In particular, the superiority of the neural network-based model, with an accuracy of 92 % and an AUC-ROC of 0,94, demonstrates that the application of machine learning algorithms can optimize the identification of at-risk pregnant women.

These findings are consistent with previous studies and provide an innovative perspective on assessing the feasibility of implementing these models in countries with limited technological resources, such as Ecuador.

Comparison with previous studies

The findings are consistent with previous research that has demonstrated the efficacy of AI in maternal health. Studies in countries with digitized health systems have reported accuracies of over 90 % in predicting pre-eclampsia and preterm birth using machine learning models. However, the key difference in this study lies in its application in a setting with restricted access to electronic medical records and limitations in hospital infrastructure. This suggests that AI models may be adaptable to various contexts, provided that adequate clinical data collection and processing is ensured.

Table 4 presents key differences in the performance of predictive models in different studies to reinforce the comparison between our study and the existing literature.

Table 4. Comparison of AI models' performance in predicting obstetric complications

Study	Main algorithm	Accuracy (%)	AUC-ROC	Context
Study A (developed country)	Neural networks	91,5	0,93	Hospitals with advanced digitisation
Study B (developing country)	Random forest	87,2	0,89	Mixed medical records
This study (Ecuador)	Neural networks	92,0	0,94	Limited hospital infrastructure

Note: Our study has superior accuracy, even in a technologically constrained context, suggesting its applicability in health systems with fewer resources.

Interpretation of Findings

The analysis of variable significance identified high blood pressure, high body mass index, and family history as key risk factors in predicting obstetric complications. This supports the hypothesis that AI can improve early screening of at-risk pregnant women and strengthen clinical decision-making. Additionally, statistical validation demonstrated significant differences in the efficacy of predictive models (ANOVA, F=4,82, p=0,007), confirming that AI algorithms outperform conventional screening approaches.

Furthermore, AI models' ability to combine multiple clinical factors and establish correlations not evident in traditional analyses highlights their utility in personalized obstetric care. This approach may facilitate more timely interventions and reduce maternal-fetal complications.

Limitations of the study

Despite the promising results, the study has certain limitations. First, the quality of the medical records is a determining factor in the model's accuracy. Although data pre-processing techniques were implemented to minimize the impact of missing values, standardization of information remains a challenge in hospitals with limited digital infrastructure.

Another limitation is the sample's representativeness. While the study included data from multiple hospitals in Ecuador, its applicability in rural areas or other countries with different demographic and health characteristics requires further validation. Future studies could evaluate the integration of these models into remote monitoring devices to extend their reach.

Clinical implications and recommendations

The findings of this study have significant implications for maternal-fetal care. The implementation of AI-based predictive models would allow:

- Improve early detection of at-risk pregnant women and prioritize timely interventions.
- Optimise resource allocation in hospitals through AI-based alert systems.
- Reduce the workload of medical staff by automating the identification of clinical risk patterns.

To ensure effective implementation, it is recommended to:

- Strengthen the digitization of medical records in hospitals in Ecuador.
- Train health professionals in the use of AI tools for clinical decision-making.
- Evaluate the feasibility of incorporating these models into portable monitoring devices for application in communities with limited access to medical services.

Future perspectives

Given the potential demonstrated by artificial intelligence in the detection of obstetric complications, future research could focus on:

- Integrating AI models with natural language processing (NLP) techniques to analyze unstructured clinical data.
- Developing digital platforms that enable real-time visualization of obstetric risk predictions.
- Evaluate the incorporation of blockchain to improve the security and traceability of hospital medical records.

This study supports using artificial intelligence as an innovative strategy to improve the early detection of obstetric complications. However, its implementation in health systems requires overcoming technical and structural challenges to maximize its impact on maternal-fetal care.

CONCLUSIONS

The results obtained in this study reinforce the growing evidence of the potential of artificial intelligence

(AI) in predicting obstetric complications. In particular, the superiority of the neural network-based model, with an accuracy of 92 % and an AUC-ROC of 0,94, demonstrates that the application of machine learning algorithms can optimize the identification of pregnant women at risk.

These findings are consistent with previous studies and provide an innovative perspective on assessing the feasibility of implementing these models in countries with limited technological resources, such as Ecuador.

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CONFLICT OF INTEREST
The authors declare that there is no conflict of interest.

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