

The Role of Artificial Intelligence in Predicting Pre-Term Birth: A Meta-Analysis

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BACKGROUND

- Defined as delivery before 37 weeks of gestation, **Preterm birth (PTB)** remains a leading cause of neonatal morbidity and mortality worldwide.
- Despite decades of research, the ability to accurately predict PTB remains limited, with current clinical tools offering modest sensitivity and specificity. The early identification of at-risk pregnancies is crucial. It's a matter of life and death for both mothers and infants, and it's a challenge we must urgently address.
- Artificial intelligence (AI)** and **machine learning (ML)** offer promising avenues for enhancing PTB prediction. Their ability to process complex, multidimensional datasets—including clinical history, genomics, and biomarkers—with greater precision than traditional statistical models is a testament to their power and potential healthcare.
- However, existing research varies considerably in the AI models employed, data sources used, and outcome definitions applied. This **data heterogeneity**—including clinical, methodological, and statistical differences across studies—poses a significant challenge to synthesising the evidence.
- This meta-analysis aims to fill this gap by systematically reviewing and evaluating the performance of various AI models in predicting PTB.

METHOD

- Design:** Systematic review and meta-analysis conducted according to PRISMA guidelines.
- Databases Searched:** PubMed, Scopus, EBSCO (2015 – 2025).
- Search Strategy:** Used Boolean operators to combine AI and ML terms with PTB and prediction-related keywords.
- Inclusion Criteria:**
 - Studies using AI/ML to predict PTB.
 - Reported performance metrics (e.g. accuracy, AUC)
 - Human subjects; English language
- Exclusion Criteria:** Non-AI models, insufficient methodology, or non-peer-reviewed literature.
- Screening:**
 - 724** records identified
 - 147** after filters applied
 - 75** full texts reviewed
 - 20** studies eligible
- Data Extraction:**
 - Model type, input features, sample size
 - Prediction outcomes and performance metrics
- Analysis:** Subgroup and sensitivity analyses to explore heterogeneity

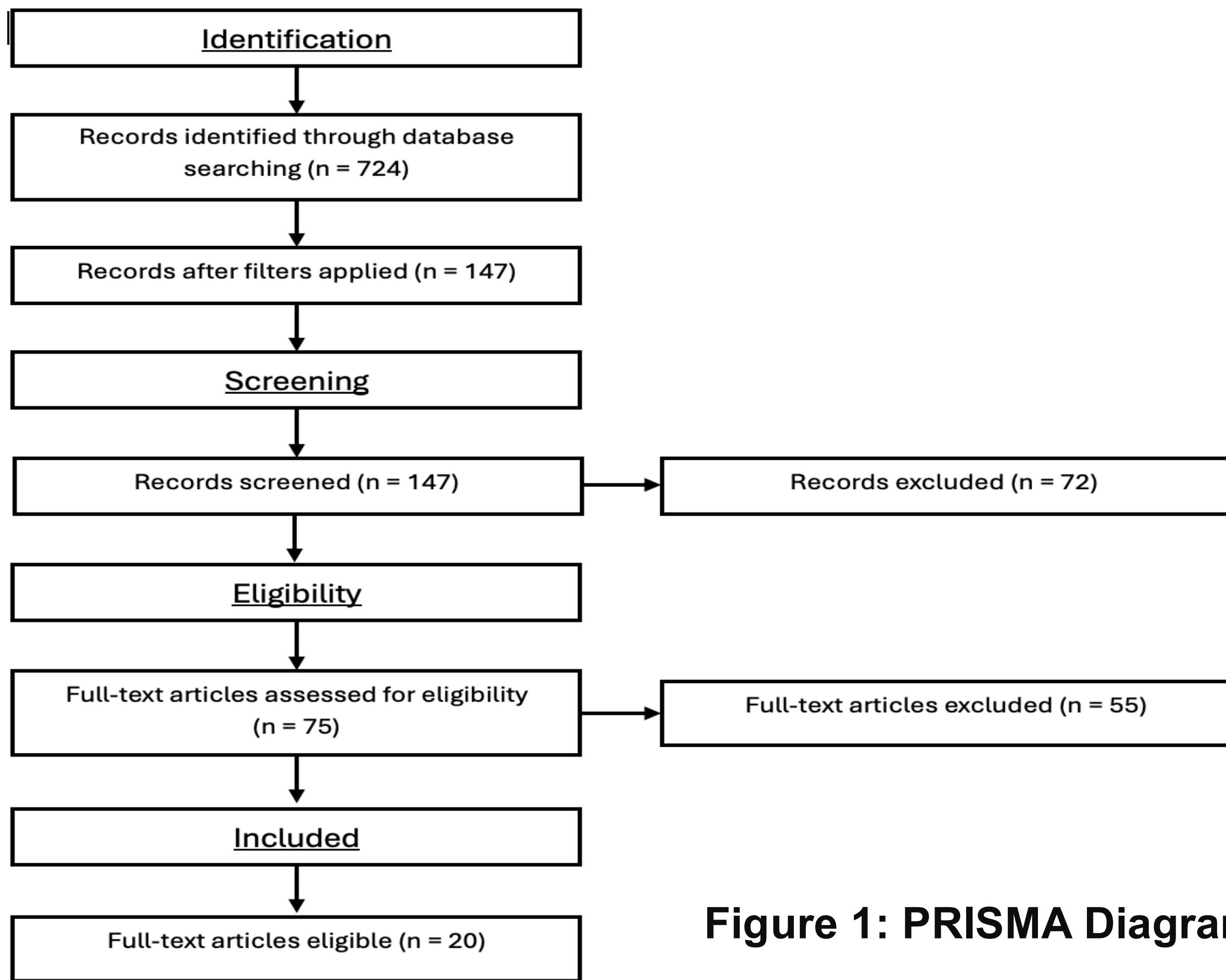


Figure 1: PRISMA Diagram

RESULTS

1. AI Models and Performance:

- Neural CDEs** (Controlled Differential Equations) achieved the highest performance (AUC: 0.82, Accuracy: 75%) by analysing vaginal microbiota dynamics in weeks 9–24 of gestation.
- LSTM** (Long Short-Term Memory) models using routine clinical data (e.g., blood pressure, metabolic markers) showed moderate accuracy (73.9%) but lower sensitivity (40.7%).
- XGBoost** consistently outperformed other models (AUC: 0.75–0.89) in studies leveraging biomarkers (e.g., ALP, AFP) and EHR data.
- RNNs** with word embedding predicted extreme preterm birth (birth at <28 weeks gestation) with high sensitivity (96.5%) but low PPV (3.3%).

2. Key Predictive Features

- Microbiome:** Low *Lactobacillus* and high *Gardnerella Prevotella* abundance has shown to be linked to PTB.
- Clinical/EHR Data:**
 - Early predictors: Short cervical length, hypertensive disorders, and twin pregnancy.
 - Metabolic markers: Triglycerides, glucose, uric acid.

REFERENCES:

- This work is based on the authors’ own meta-analysis of 20 studies conducted in 2025.
- References of all included studies are available on request.

- Biomarkers:**
 - Lipid mediators (e.g., resolvin D1, LTB4) and inflammatory markers (AUC: 0.78–0.84).
 - Routine blood tests (ALP, AFP, hemoglobin) in women under 35 (AUC: 0.89).
- Electrohysterography (EHG):** Phase synchronization in low-frequency bands (0.08–1.0 Hz) has shown to predict PTB (Accuracy: 90.5–97%).

3. Clinical Utility

- Early Prediction:** Neural CDEs and EHG-based models enabled risk assessment as early as 9–24 weeks.
- Non-Invasive Tools:** Vaginal swabs, EHG signals, and cfDNA analysis (e.g., **PTerm** classifier, AUC: 0.85) offered scalable alternatives to cervical length ultrasounds.
- Race-Specific Insights:** Chronic stressors (e.g., low education, violence) drove PTB risk in Black women; biomedical factors (e.g., BMI) were key for White women (AUC: 0.75–0.76).

4. Limitations & Future Directions

- Challenges:** Low PPV, overfitting in ML models, and lack of diverse validation cohorts.
- Opportunities:**
 - Integrate multi-omics data (microbiome, biomarkers, imaging).
 - Develop hybrid models (e.g., neural CDEs + XGBoost) for improved generalizability.

CONCLUSIONS

- Artificial intelligence demonstrates transformative potential for PTB prediction by integrating multi-source data.
- AI models (e.g. Neural CDEs, XGBoost) demonstrate **superior accuracy**. They achieve AUCs of 0.75–0.97, outperforming traditional methods (e.g. fetal fibronectin, cervical length).
- Reliable risk stratification as early as weeks 9–24 using vaginal microbiota, biomarkers (ALP/AFP), or EHG signals, allows for **early detection**.
- Equity & Scalability:**
 - Race-specific models uncover **disparities** (e.g. chronic stressors)
 - Non-invasive tools (e.g. vaginal swabs, cfDNA) enable **low-resource deployment**.
- Low PPV** in sensitive models (e.g., RNNs: PPV 3.3%) risks false alarms and is a **critical gap** to be addressed.
- There is an **urgent need** for:
 - Hybrid models** (e.g., Neural CDEs + XGBoost) integrating microbiome, biomarkers, and socio-demographics.
 - Clinical-AI partnerships** to translate predictions into interventions (e.g., targeted care pathways).

"AI is not a replacement—but rather a multiplier—for obstetric care. Prioritising diverse data and equitable implementation will unlock its potential to predict PTB and reduce global disparities"