SCRIPTA SCORE Scientific Medical Journal
Journal homepage: https://talenta.usu.ac.id/scripta

Can Algorithms Improve Birth? A Meta-Analysis of AI-Enhanced Digital Care on Obstetric care and Fetal Wellness

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ARTICLE INFO

Article history:
Received 19 May 2026
Revised 1 August 2026
Accepted 11 August 2026
Available online 28 August 2026

E-ISSN: 2686-0864
P-ISSN: 2088-8686

How to cite:
Irawan MA, Samosir FAHH Ikhwan M, Sabhrina F, Samosir KA. Can Algorithms Improve Birth? A Meta-Analysis of AI-Enhanced Digital Care on Obstetric care and Fetal Wellness. SCRIPTA SCORE Sci Med J. 2026 Aug 28;8(1):042–047

ABSTRACT

Background: Traditional digital antenatal care (ANC) fails to sufficiently lower global maternal and neonatal mortality. Artificial Intelligence (AI) shifts this paradigm by enabling proactive prevention through predictive analytics and real-time, personalized risk assessments. **Objectives**: To systematically review and meta-analyze the impact of AI-enhanced digital monitoring and predictive alert systems on antenatal fetal wellness. **Methods**: Following PRISMA guidelines, a systematic search of PubMed, Scopus, and Web of Science was conducted. Studies evaluating AI-enhanced digital monitoring or predictive algorithms in antenatal and intrapartum care were included to assess fetal growth restriction (FGR)-mortality, spontaneous delivery, and congenital defects. **Discussion**: Ten studies were analyzed. AI-enhanced ANC demonstrated high diagnostic accuracy for FGR (AUC: 0.831–0.918) and outperformed standard cervical length assessment in predicting spontaneous preterm delivery (AUC 0.75 vs. 0.67; $p < 0.001$). AI-driven echocardiography boosted congenital heart defect detection sensitivity to 85% (vs. 34% clinically). Furthermore, graphical models revealed a 10-fold increased risk of perinatal morbidity when FGR combined with maternal diabetes (RR 9.8). AI also successfully identified delayed fetal brain maturation and predicted emergency Cesarean rates using heart rate variability. Overall, the models showed strong discriminative performance, yielding a pooled AUC of 0.858 (95% CI: 0.766–0.951). **Conclusion**: AI-enhanced digital ANC significantly improves the early detection of critical fetal complications, substantially strengthening antenatal surveillance and intrauterine intervention management.

Keyword: Artificial intelligence, digital antenatal care, fetal growth restriction, fetal wellness, predictive analytics

ABSTRAK

Latar Belakang: Perawatan antenatal (Antenatal Care/ANC) digital tradisional belum cukup mampu menurunkan angka kematian maternal dan neonatal global. Kecerdasan Buatan (AI) mengubah paradigma ini dengan mengaktifkan pencegahan proaktif melalui analitik prediktif dan penilaian risiko yang dipersonalisasi secara real-time. **Tujuan**: Meninjau secara sistematis dan melakukan meta-analisis terhadap dampak pemantauan digital berbasis AI dan sistem peringatan prediktif pada kesejahteraan janin selama masa antenatal. **Metode**: Berdasarkan pedoman PRISMA, pencarian sistematis dilakukan pada database PubMed, Scopus, dan Web of Science. Studi yang dievaluasi mencakup pemantauan digital berbasis AI atau algoritma prediktif dalam perawatan antenatal dan intrapartum untuk menilai hambatan pertumbuhan janin (Fetal Growth Restriction/FGR)-mortalitas, persalinan spontan, dan cacat bawaan. **Pembahasan**: Sepuluh studi dianalisis. ANC berbasis AI menunjukkan akurasi diagnostik yang tinggi untuk FGR (AUC: 0,831–0,918) dan mengungguli penilaian panjang serviks standar dalam memprediksi persalinan prematur

https://doi.org/10.32734/scripta.v8i1.25652

spontan (AUC 0,75 vs. 0,67; $p < 0,001$). Ekokardiografi berbasis AI meningkatkan sensitivitas deteksi cacat jantung bawaan hingga 85% (dibandingkan standar klinis yang hanya 34%). Selain itu, model grafis menunjukkan peningkatan risiko morbiditas perinatal sebesar 10 kali lipat ketika FGR disertai dengan diabetes maternal (RR 9,8). AI juga berhasil mengidentifikasi keterlambatan pematangan otak janin dan memprediksi tingkat operasi sesar darurat menggunakan analisis variabilitas denyut jantung. Secara keseluruhan, model-model ini menunjukkan performa diskriminatif yang kuat, dengan nilai gabungan AUC sebesar 0,858 (95% CI: 0,766–0,951). **Kesimpulan**: ANC digital berbasis AI secara signifikan meningkatkan deteksi dini komplikasi janin yang kritis, serta memperkuat pengawasan antenatal dan manajemen intervensi dalam rahim.

Kata kunci: Analitik prediktif, kecerdasan buatan, kesejahteraan janin, pelayanan antenatal digital, pertumbuhan janin terhambat

1. Introduction

Maternal and neonatal health and well-being remain major challenges in modern medicine, particularly in the field of obstetrics. Despite substantial advances in contemporary medical practice, which have reduced maternal mortality by approximately 40% over the past two decades, data from 2023 indicate that significant challenges persist. With a frequency of nearly one maternal death every two minutes—or more than 700 cases per day—most of these deaths are attributable to largely preventable causes, including postpartum hemorrhage, hypertensive disorders of pregnancy, infections, and other obstetric complications.[1] Notably, World Health Organization (WHO) statistics indicate that approximately 90% of maternal deaths occur in low- and middle-income countries.[2] This situation reflects profound systemic inequities, underscoring the urgent need for advanced technological solutions to bridge gaps in the quality of antenatal care.

Based on the above considerations, maternal and fetal health remain critical issues in the global health landscape, largely driven by disparities in access and standards of care that contribute to high maternal morbidity and mortality.[3] The emergence of artificial intelligence (AI) technologies offers promising potential as both a practical and strategic solution to enhance diagnostic precision, improve the efficiency of patient monitoring, and expand access to high-quality healthcare services. Such advancements are particularly beneficial for populations with limited access to professional healthcare providers.[4,5]

Despite the growing body of research demonstrating the benefits of AI-based interventions, significant heterogeneity exists among study findings. Some studies report a substantial reduction in neonatal complications, whereas others show no statistically significant differences compared to standard antenatal care.[6] This inconsistency in the scientific evidence may generate uncertainty among clinicians regarding the widespread integration of AI technologies into obstetric care protocols.[7]

Given the variability and inconsistency of findings across previous studies, a systematic and comprehensive synthesis of evidence is required to generate the highest level of scientific evidence (Level I Evidence) regarding the effectiveness of such technologies in modern obstetric practice. Therefore, this meta-analysis was conducted to evaluate the impact of AI-based Digital Antenatal Care on maternal and neonatal outcomes through the integration of data from multiple published clinical studies. By pooling available evidence, this approach is expected to enhance statistical power and provide more precise effect estimates. For the purpose of this study, AI-enhanced Digital Antenatal Care refers to the integration of artificial intelligence technologies into existing antenatal care services to support clinical decision-making, rather than to replace healthcare professionals.

2. Methods

A systematic and comprehensive literature search was conducted in accordance with the protocol outlined by the PRISMA guidelines for systematic reviews and meta-analyses. The study protocol adhered to PRISMA recommendations to ensure transparency, reproducibility, and methodological rigor throughout the data extraction and study selection processes. We systematically searched for eligible studies, including retrospective cohort studies, prospective cohort studies, and randomized controlled trials, that evaluated the implementation of artificial intelligence (AI)-enhanced digital monitoring systems or predictive algorithms in antenatal and intrapartum care

A comprehensive search of electronic databases, including PUBMED/Medline (U.S. National Library of Medicine), Scopus, and Web of Science was performed for peer-reviewed original research articles published up to 30th April 2026. The search strategy incorporated both controlled vocabulary (Medical Subject Headings [MeSH]) and free-text terms to maximize sensitivity and specificity. The primary search terms included: ("Artificial Intelligence" [Mesh] OR "predictive analytics" OR "machine learning") AND ("antenatal care" OR "prenatal care") AND ("fetal growth restriction" OR "preterm delivery" OR "congenital heart disease" OR "fetal brain development" OR "perinatal morbidity"). Boolean operators "AND" and "OR" were applied to appropriately combine related concepts and broaden the search scope. In addition, manual screening of reference lists from relevant studies was conducted to identify potentially eligible articles not captured through database searches.

A total of 1,227 records were identified through database searching and manual reference screening. After removing 427 duplicates, 800 records underwent title and abstract screening, resulting in the exclusion of 730 studies. Of the 70 full-text articles assessed for eligibility, 60 were excluded because of missing AUC or confidence interval data, inappropriate study design, or outcome mismatch. Ultimately, 10 studies met the inclusion criteria for the systematic review, with 5 providing sufficient quantitative data for meta-analysis. The included studies enrolled pregnant women across a wide range of gestational ages, trimesters, parity, maternal ages, and geographic regions, with no restrictions on publication year, language, or participant characteristics, thereby maximizing the comprehensiveness and generalizability of the findings.

Our primary outcome was fetal wellness, assessed through the incidence and early detection of major antenatal complications, including fetal growth restriction (FGR), spontaneous preterm delivery, and congenital anomalies. Secondary outcomes comprised the diagnostic performance of AI-based predictive models (accuracy, sensitivity, specificity, and area under the curve [AUC]) and their association with adverse perinatal outcomes such as perinatal morbidity, delayed fetal brain maturation, and emergency cesarean delivery. All outcomes were quantitatively synthesized using appropriate effect measures, including odds ratios (ORs), relative risks (RRs), and pooled diagnostic metrics with corresponding 95% confidence intervals. Statistical analyses were performed using JASP, with heterogeneity assessed using the I^2 statistic and random-effects models applied where appropriate to account for between-study variability.

3. Results

A total of ten studies met the eligibility criteria and were included in the systematic review. Following duplicate removal and title, abstract, and full-text screening, studies evaluating the use of artificial intelligence (AI) in digital antenatal care for the prediction or detection of maternal-fetal complications were selected. Of these, five studies provided sufficient quantitative data, including area under the curve (AUC) values with corresponding confidence intervals, and were therefore eligible for meta-analysis. The remaining five studies were included in the qualitative synthesis due to incomplete reporting of pooled statistical measures, non-comparable outcomes, or protocol-based designs. Five studies were entered into the quantitative synthesis using a random-effects model. These studies evaluated AI-based prediction or detection of FGR, PE with FGR, spontaneous preterm birth, FGR-related morbidity, and late IUGR. Five additional studies were not eligible for quantitative pooling but provided relevant findings in the qualitative synthesis.

Table 1. Meta-Analytic Estimates

			95% CI		95% PI	
	Estimate	Standard Error	Lower	Upper	Lower	Upper
Pooled effect	0.858	0.033	0.766	0.951	0.633	1.084
I^2	97.50		92.79	99.68		

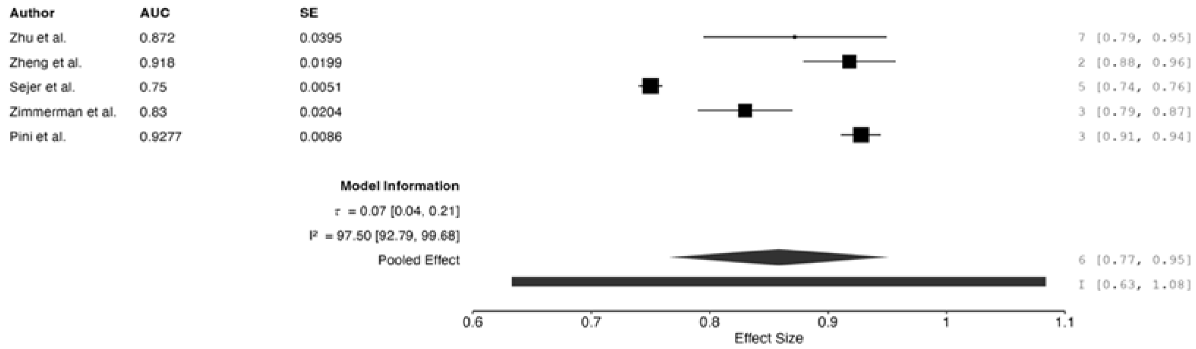

Figure 1. Forest Plot

These studies focused on AI-based identification or prediction of FGR, PE complicated by FGR, spontaneous preterm birth, FGR-associated morbidity, and late IUGR.

4. Discussion

The pooled analysis demonstrated an overall AUC of 0.858 (95% CI 0.766–0.951), indicating good to excellent discriminative capability of AI models for adverse obstetric outcomes. Reported AUC values among individual studies ranged from 0.750 to 0.928, with the highest performance observed in the cardiotocography-based late IUGR model and the lowest in the spontaneous preterm birth prediction model.

Marked heterogeneity was identified across studies (I^2 = 97.5%; Q = 356.41, $p < 0.001$), reflecting substantial between-study variability. This finding was likely influenced by differences in patient populations, clinical outcomes, AI architectures, imaging modalities, validation methods, and study designs.

The highest AUC in the pooled analysis was reported by Pini et al. (2021), whose machine learning model analyzed cardiotocography data to identify late IUGR, achieving an AUC of 0.928. This is clinically relevant because late IUGR is frequently missed before delivery. The strong performance of this cardiotocography-based model suggests that affordable and widely available fetal monitoring tools could be significantly enhanced through AI integration.[8]

Zhu et al. (2025) developed a machine learning model using fetal cardiac remodeling parameters to predict fetal growth restriction. The model showed strong diagnostic accuracy with an AUC of 0.872, indicating that subtle alterations in fetal cardiac function may serve as earlier indicators of placental insufficiency compared with conventional biometric measurements. These results support the potential usefulness of physiological fetal markers for improving FGR detection.[9]

Zheng et al. (2025) reported one of the best performances among the included studies, with an AUC of 0.918 for detecting preeclampsia associated with fetal growth restriction using deep learning radiomics based on placental magnetic resonance imaging. This finding highlights the value of combining advanced imaging techniques with AI to identify placental abnormalities, particularly in high-risk pregnancies involving both maternal and fetal complications.[10]

Sejer et al. (2026) evaluated deep learning analysis of cervical ultrasound images for predicting spontaneous preterm birth. Although this study had the lowest pooled estimate (AUC 0.750), the model still demonstrated acceptable predictive performance and exceeded the accuracy of conventional cervical length assessment. This suggests that AI may identify cervical patterns not captured by routine linear measurements.[11]

Zimmerman et al. (2025) used explainable AI to estimate combined risks related to fetal growth restriction and adverse perinatal outcomes. The reported AUC of 0.830 reflected good predictive performance. Notably, the study focused on individualized risk assessment rather than simple binary outcomes, indicating that AI may contribute to precision obstetrics by integrating multiple maternal and fetal risk factors.[12]

Five studies were not eligible for quantitative pooling but provided relevant evidence in the qualitative synthesis. Stringer et al. (2024) showed that an AI-assisted blind ultrasound sweep model estimated gestational age with accuracy comparable to standard ultrasonography, supporting its use in low-resource settings. Patey et al. (2025) presented a large multicenter protocol study aimed at developing deep learning models for prenatal detection of congenital heart defects using fetal echocardiography images and videos.[13,14] Vasilache et al. (2024) reported that a Random Forest model achieved high accuracy for first-trimester prediction of preeclampsia and intrauterine growth restriction using maternal biomarkers and clinical variables.[15] Teng et al. (2022) identified second-trimester nuchal fold thickness as a potential novel predictor of fetal growth restriction through machine learning analysis.[16] Meijerink et al. (2026) demonstrated delayed fetal brain maturation in early-onset fetal growth restriction using deep learning analysis of three-dimensional ultrasound. Collectively, these findings further support the broad applicability of AI in digital antenatal care beyond the outcomes included in the pooled analysis.[17]

5. Conclusion

This systematic review and meta-analysis demonstrates that artificial intelligence has promising clinical utility in digital antenatal care for the prediction and detection of adverse maternal-fetal outcomes. Across five studies included in the quantitative synthesis, AI models showed good to excellent overall discriminative performance, with a pooled AUC of 0.858 (95% CI 0.766–0.951). These findings indicate that AI can effectively support the identification of conditions such as fetal growth restriction, preeclampsia with fetal growth restriction, spontaneous preterm birth, and late intrauterine growth restriction.

The qualitative synthesis further expanded these findings by demonstrating potential applications of AI in gestational age estimation, congenital heart defect screening, biomarker-based first-trimester risk prediction, and fetal neurodevelopmental assessment. Collectively, the evidence suggests that AI may enhance prenatal screening accuracy, improve risk stratification, and broaden access to specialized antenatal services, particularly in resource-limited settings.

However, the high between-study heterogeneity highlights the need for standardized reporting, external validation, and large prospective multicenter studies before routine clinical implementation. Future research should focus on integrating AI into real-world obstetric workflows while ensuring interpretability, safety, and equitable access.

References

[1] Wei Y, Luo H, Liu X, Sun G, Liu J, Wei X, et al. Global, regional, and national levels of maternal mortality, 1990-2021: a systematic analysis for the Global Burden of Disease Study 2021. BMC Pregnancy Childbirth. 2025 Dec 1;25(1). doi:10.1186/S12884-025-08456-5 PubMed PMID: 41469576.

[2] Cresswell JA, Alexander M, Chong MYC, Link HM, Pejchinovska M, Gazeley U, et al. Global and regional causes of maternal deaths 2009–20: a WHO systematic analysis. Lancet Glob Health. 2025 Apr 1;13(4):e626–34. doi:10.1016/S2214-109X(24)00560-6 PubMed PMID: 40064189.

[3] Mapari SA, Shrivastava D, Dave A, Bedi GN, Gupta A, Sachani P, et al. Revolutionizing Maternal Health: The Role of Artificial Intelligence in Enhancing Care and Accessibility. Cureus. 2024 Sep 17;16(9):e69555. doi:10.7759/CUREUS.69555 PubMed PMID: 39421118.

[4] Saleh S, El Arnaout N, Sabra N, El Dakdouki A, El Iskandarani K, Chamseddine Z, et al. Evaluating the impact of engaging healthcare providers in an AI-based gamified mHealth intervention for improving maternal health outcomes among disadvantaged pregnant women in Lebanon. Front Digit Health. 2025;7:1574946. doi:10.3389/FDGTH.2025.1574946 PubMed PMID: 40873765

[5] Correia V, Mascarenhas T, Mascarenhas M. Smart Pregnancy: AI-Driven Approaches to Personalised Maternal and Foetal Health-A Scoping Review. J Clin Med. 2025 Oct 1;14(19). doi:10.3390/JCM14196974 PubMed PMID: 41096056.

[6] Patel DJ, Chaudhari K, Acharya N, Shrivastava D, Muneeba S. Artificial Intelligence in Obstetrics and Gynecology: Transforming Care and Outcomes. Cureus. 2024 Jul 17;16(7):e64725. doi:10.7759/CUREUS.64725 PubMed PMID: 39156405.

[7] Adusei-Mensah F, Muthelo L, Ngwenya MW, Mphasha MH, Kauhanen J. Digital health interventions for pregnant women and mothers with under 5-year-olds in low- and middle-income countries: a scoping review. Global Health Journal. 2025 Jun 1;9(2):113–23. doi:10.1016/J.GLOHJ.2025.06.008.

[8] Pini N, Lucchini M, Esposito G, Tagliaferri S, Campanile M, Magenes G, et al. A Machine Learning Approach to Monitor the Emergence of Late Intrauterine Growth Restriction. Front Artif Intell. 2021 Mar 8;4. doi:10.3389/frai.2021.622616.

[9] Zhu C, Li J, Ren M, Chen Y, Chen Y, Li M, et al. Machine learning-enhanced prediction of fetal growth restriction using fetal cardiac remodeling parameters. BMC Med. 2025 Dec 1;23(1). doi:10.1186/s12916-025-04468-2 PubMed PMID: 41250095.

[10] Zheng W, Jiang Y, Jiang Z, Li J, Bian W, Hou H, et al. Association between deep learning radiomics based on placental MRI and preeclampsia with fetal growth restriction: A multicenter study. Eur J Radiol. 2025 Mar 1;184. doi:10.1016/j.ejrad.2025.111985 PubMed PMID: 39946812.

[11] Sejer EPF, Pegios P, Lin M, Bashir Z, Wulff CB, Christensen AN, et al. The combined use of cervical ultrasound and deep learning improves the detection of patients at risk for spontaneous preterm delivery. Am J Obstet Gynecol. 2026 Jan 1;234(1):172–94. doi:10.1016/j.ajog.2025.09.012 PubMed PMID: 40945809.

[12] Zimmerman RM, Hernandez EJ, Yandell M, Tristani-Firouzi M, Silver RM, Grobman W, et al. AI-based analysis of fetal growth restriction in a prospective obstetric cohort quantifies compound risks for perinatal morbidity and mortality and identifies previously unrecognized high risk clinical scenarios. BMC Pregnancy Childbirth. 2025 Dec 1;25(1). doi:10.1186/s12884-024-07095-6 PubMed PMID: 39881241.

[13] Stringer JSA, Pokaprakarn T, Prieto JC, Vwalika B, Chari S V., Sindano N, et al. Diagnostic Accuracy of an Integrated AI Tool to Estimate Gestational Age from Blind Ultrasound Sweeps. JAMA. 2024 Aug 27;332(8):649–57. doi:10.1001/jama.2024.10770 PubMed PMID: 39088200.

[14] Patey O, Hernandez-Cruz N, D'Alberti E, Salovic B, Noble JA, Papageorghiou AT. Prenatal detection of congenital heart defects using the deep learning-based image and video analysis: Protocol for Clinical Artificial Intelligence in Fetal Echocardiography (CAIFE), an international multicentre multidisciplinary study. BMJ Open. 2025 Jun 5;15(6). doi:10.1136/bmjopen-2025-101263 PubMed PMID: 40473283.

[15] Vasilache IA, Scripcariu IS, Doroftei B, Bernad RL, Cărăuleanu A, Socolov D, et al. Prediction of Intrauterine Growth Restriction and Preeclampsia Using Machine Learning-Based Algorithms: A Prospective Study. Diagnostics. 2024 Feb 1;14(4). doi:10.3390/diagnostics14040453.

[16] Teng LY, Mattar CNZ, Biswas A, Hoo WL, Saw SN. Interpreting the role of nuchal fold for fetal growth restriction prediction using machine learning. Sci Rep. 2022 Dec 1;12(1). doi:10.1038/s41598-022-07883-0 PubMed PMID: 35273269.

[17] Meijerink L, Wyburd M, Namburete AIL, Alderliesten T, Groenendaal F, Benders M, et al. Deep learning assessment of fetal brain maturation on 3D ultrasound volumes in early-onset fetal growth restriction. Ultrasound in Obstetrics and Gynecology. 2026 Mar 1. doi:10.1002/uog.70168.