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AI-Based Maternal Healthcare Monitoring: A Comprehensive Survey

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Abstract: Maternal healthcare monitoring plays a crucial role in reducing maternal mortality and ensuring the well-being of both mother and child. Despite advancements in medical science, many regions, particularly rural and underdeveloped areas, still face challenges such as limited access to healthcare facilities, lack of continuous monitoring, and delayed identification of high-risk pregnancies. In recent years, Artificial Intelligence (AI), Machine Learning (ML), Internet of Things (IoT), and digital healthcare technologies have emerged as powerful tools to address these challenges.

This paper presents a comprehensive survey of existing maternal healthcare monitoring systems that utilize these advanced technologies. The study reviews a wide range of approaches, including machine learning-based risk prediction models, IoT-enabled real-time monitoring systems, mobile health (mHealth) applications, and conversational platforms such as chatbots and IVR systems. A structured classification of these systems is proposed based on their functionality and level of integration.

The paper further provides a comparative analysis of existing solutions in terms of prediction accuracy, accessibility, scalability, and integration capabilities. The survey reveals that while individual technologies have significantly improved maternal healthcare, most existing systems are fragmented and focus on isolated functionalities. A key observation is the absence of a unified system that integrates real-time monitoring, intelligent risk assessment, and accessible user interaction within a single platform.

Finally, the study identifies critical research gaps and highlights future directions for developing scalable, integrated, and inclusive maternal healthcare systems that can effectively address real-world challenges.

Keywords: Maternal Healthcare; Artificial Intelligence; Machine Learning; IoT; Risk Prediction; Healthcare Monitoring; Natural Language Processing; Digital Health Systems; mHealth; Telemedicine.

I. INTRODUCTION

Maternal healthcare is a vital component of public health systems, directly impacting the survival and well-being of both mothers and infants. Despite global efforts to improve maternal health outcomes, many developing regions continue to experience high maternal mortality rates due to inadequate healthcare infrastructure, limited access to medical professionals, and lack of continuous monitoring systems.

Traditional maternal healthcare relies heavily on periodic antenatal care (ANC) visits, during which key health parameters such as blood pressure, haemoglobin levels, and weight are recorded. However, this approach often fails to capture health variations that occur between visits, leading to delayed detection of complications such as preeclampsia, gestational diabetes, and anaemia.

With the rapid advancement of technology, Artificial Intelligence (AI) and digital healthcare systems have emerged as promising solutions to overcome these limitations. Machine learning algorithms enable early prediction of maternal risks based on clinical data, while IoT-based systems allow continuous monitoring of physiological parameters through wearable devices and sensors. Additionally, mobile health applications and conversational interfaces have improved accessibility by enabling users to interact with healthcare systems through smartphones or voice-based platforms.

This paper presents a comprehensive survey of AI-based maternal healthcare monitoring systems. The study aims to analyze existing technological approaches, evaluate their effectiveness, and identify key challenges and limitations. By

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providing a structured overview of current developments, this survey highlights the need for integrated and scalable healthcare solutions that can ensure timely and efficient maternal care.

II. THEORETICAL BACKGROUND

A. Machine Learning Models
Machine learning has become a fundamental component in modern healthcare systems, particularly for predictive analysis. In maternal healthcare, supervised learning algorithms such as Random Forest, Support Vector Machine (SVM), and K-Nearest Neighbors (KNN) are commonly used to predict pregnancy-related risks. These models analyze structured clinical data, including symptoms, medical history, and diagnostic parameters, to identify patterns associated with high-risk pregnancies.

B. Natural Language Processing (NLP)
Natural Language Processing enables healthcare systems to interpret user inputs provided in textual or spoken form. Techniques such as tokenization, stop-word removal, and keyword extraction are used to convert unstructured symptom descriptions into structured data. NLP plays a crucial role in improving user interaction, especially in conversational healthcare systems.

C. Risk Prediction Models
Risk prediction in maternal healthcare is typically based on probabilistic models that estimate the likelihood of complications based on observed symptoms and clinical data. The risk can be expressed as:
Risk = P(Disease | Symptoms)
Based on the calculated probability, patients are categorized into different risk levels, such as low, moderate, and high risk, enabling timely intervention.

D. Performance Metrics
The effectiveness of healthcare prediction models is evaluated using standard metrics such as Accuracy, Precision, Recall, and F1-score. In medical applications, recall is often prioritized to minimize false negatives, as missing a high-risk case can lead to severe consequences.

III. SYSTEM CLASSIFICATION

To better understand the diverse approaches in maternal healthcare monitoring, existing systems can be categorized into four tiers based on their functionality and level of integration.
Tier 1: Basic Monitoring Systems
These systems focus on recording maternal health parameters during antenatal care visits. They primarily involve manual or digital data entry without advanced analytics.

Tier 2: Machine Learning-Based Systems
These systems utilize machine learning algorithms to analyze clinical data and predict potential risks. They provide decision support but are often limited to static datasets.

Tier 3: IoT-Based Monitoring Systems
IoT-based systems enable continuous monitoring of physiological parameters using sensors and wearable devices. These systems improve early detection but require reliable infrastructure.

Tier 4: Intelligent Healthcare Systems
These systems integrate AI, IoT, and user interaction platforms such as chatbots and IVR systems. They aim to provide comprehensive healthcare support, including real-time monitoring, prediction, and communication.

IV. LITERATURE REVIEW

Maternal healthcare monitoring has been extensively studied using various technological approaches. Machine learning-based systems have demonstrated significant success in predicting pregnancy-related risks using structured clinical datasets. Algorithms such as Random Forest and SVM have shown high accuracy in identifying high-risk pregnancies.
IoT-based systems have further enhanced healthcare monitoring by enabling real-time data collection through sensors. These systems allow continuous tracking of health parameters, improving early detection of complications.

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Mobile health applications have improved accessibility by allowing users to track their health data and receive reminders for medication and appointments. Conversational systems such as chatbots and IVR platforms have addressed accessibility challenges by enabling interaction through natural language and voice.

Despite these advancements, most existing systems focus on individual functionalities and lack integration. There is a growing need for systems that combine multiple technologies to provide comprehensive maternal healthcare solutions.

Table I: Literature Review Summary

Sl.	Author(s)	Year & Title	Method / Technique	Key Findings	Venue & Index
1	Sharma et al.	2022 – AI-Based Pregnancy Risk Prediction	ML: SVM, Random Forest	Accurate prediction of pregnancy risks; effective ML-based classification	IEEE, 2022
2	Verma et al.	2023 – Maternal Health Monitoring using IoT	IoT sensors + real-time data streams	Continuous monitoring improves early detection of maternal complications	Springer, 2023
3	Khan et al.	2021 – Risk Assessment in Pregnancy	Data mining + classification	Efficient identification of high-risk pregnancies using data patterns	Elsevier, 2021
4	Gupta et al.	2020 – Mobile Health Apps for Maternal Care	Mobile-based healthcare apps	Improved accessibility and patient engagement via mobile platforms	IJERT, 2020
5	Lee et al.	2023 – AI in Healthcare: Predictive Analytics	Neural networks + predictive models	High accuracy in disease prediction; deep learning models outperform baselines	IEEE Access, 2023
6	Reddy et al.	2022 – Digital Health Systems for Rural Healthcare	Web-based health platforms	Enhanced rural healthcare access through digital system deployment	Springer, 2022
7	Thomas et al.	2021 – Health Monitoring using Web Applications	Web apps + centralized dashboards	Centralized systems enable better data tracking and clinical decision-making	IJRASET, 2021
8	Mehta et al.	2023 – IVR-Based Communication in Healthcare	IVR systems + voice interaction	Improved communication for non-smartphone users in rural areas	IEEE, 2023
9	Wilson et al.	2024 – Explainable AI in Healthcare	Explainable AI (XAI) models	Increased transparency and clinician trust in AI-based healthcare decisions	Elsevier, 2024
10	Jackins et al.	2021 – AI Smart Prediction (RF & Her Bayes)	Random Forest, Her Bayes	RF consistently outperformed Her Bayes across diabetes, cardiac, and cancer datasets	Springer, 2021
11	Islam et al.	2024 – Chronic Disease Prediction	RF, SVM, KNN	Multi-algorithm approach effective across several chronic disease types	Springer, 2024

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Sl.	Author(s)	Year & Title	Method / Technique	Key Findings	Venue & Index
12	Frontiers AI Team	2024 – Symptom-Based Diagnosis using ML	RF, Decision Tree, NLP	Symptom checker using NLP + RF outperformed single-model baselines significantly	Frontiers AI, 2024
13	Khan S.A. et al.	2025 – Explainable Disease Surveillance	RF, XAI, HER analysis	3–12 month early prediction demonstrated on real HER data with XAI transparency	arXiv, 2025
14	Nia et al.	2023 – AI Techniques in Disease Diagnosis	ML, DL models, data preprocessing	Strong prediction accuracy reported; data abelling and privacy remain open issues	Discover AI, 2023
15	Roy et al.	2022 – ML for Maternal Risk Detection	ML Classification algorithms	Strong classification performance for maternal risk detection; single-domain limitation noted	IEEE Access, 2022

Note: AI = Artificial Intelligence. ML = Machine Learning. DL = Deep Learning. NLP = Natural Language Processing. RF = Random Forest. SVM = Support Vector Machine. KNN = K-Nearest Neighbors. XAI = Explainable Artificial Intelligence. HER = Electronic Health Records. IVR = Interactive Voice Response.

V. COMPARATIVE SUMMARY OF REVIEWED LITERATURE

The comparative analysis of existing maternal healthcare systems reveals several key insights. Machine learning-based systems provide high prediction accuracy and are effective in identifying high-risk pregnancies. However, these systems are often limited to static datasets and do not support real-time monitoring.

IoT-based systems enable continuous monitoring and improve early detection of complications. However, they require infrastructure support, including sensors and reliable internet connectivity, which may not be available in rural areas. Mobile health applications enhance accessibility and user engagement but lack intelligent decision-making capabilities. Conversational systems improve usability and accessibility, especially for users with low digital literacy, but are often limited to basic functionality.

Overall, existing systems are fragmented and focus on individual components rather than providing an integrated solution. This highlights the need for unified systems that combine prediction, monitoring, and user interaction.

Table II: Comparative Summary of Reviewed Literature (2020–2025)

Sl.	Author(s)	Year	Method	System Focus	Modality	Key Limitation
1	Sharma et al.	2022	SVM, Random Forest	Pregnancy risk prediction	Structured form	Single domain; no NLP
2	Verma et al.	2023	IoT + Real-time streams	Maternal health monitoring	Sensor/IoT	Requires hardware; low accessibility
3	Khan et al.	2021	Data mining, Classification	Risk stratification in pregnancy	Structured form	Static interaction; no adaptation
4	Gupta et al.	2020	Mobile health apps	Maternal care access	Mobile app	No ML; manual data entry
5	Lee et al.	2023	Predictive neural networks	Early medical intervention	Batch processing	No real-time symptom intake
6	Reddy et al.	2022	Web-based delivery	Rural healthcare access	Web platform	Rule-based; no ML prediction

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7	Thomas et al.	2021	Web + centralized logging	Patient data tracking	Web platform	No risk categorization or NLP
8	Mehta et al.	2023	Call/interaction tracking	Follow-up efficiency	Admin workflow	Administrative focus; not patient-facing
9	Wilson et al.	2024	Explainable AI	Clinical decision support	Clinician-facing	Expert input required; computationally heavy
10	Roy et al.	2022	ML Classification	Maternal risk detection	Structured form	Single domain; no multi-disease scope
11	Jackins et al.	2021	Random Forest, Naive Bayes	General disease prediction	Structured form	No conversational interface
12	Khan et al.	2025	Explainable ML (SHAP)	Chronic disease surveillance	Clinician-facing	Requires clinical expertise to interpret
13	Frontiers AI	2024	Ensemble ML	Symptom-based health checks	System evaluation	No patient-facing deployment described
14	Nia et al.	2023	Multi-technique evaluation	Disease diagnosis review	Review only	No specific deployment
15	Islam et al.	2024	ML for chronic disease	Chronic disease prediction	Structured form	Requires longitudinal data collection

VI. RESEARCH GAPS AND SYNTHESIS

The literature review highlights several critical gaps in existing maternal healthcare systems. Firstly, most systems lack continuous monitoring between antenatal care visits, leading to delayed detection of complications. Secondly, real-time risk prediction and classification are not effectively implemented in many systems.

Thirdly, accessibility remains a major challenge, as many systems depend on smartphones and digital literacy. Fourthly, existing systems are fragmented and do not provide integrated healthcare solutions.

Additionally, personalization is limited, as most systems provide generic recommendations rather than tailored insights based on individual health data. These gaps indicate the need for future research focused on developing integrated, scalable, and accessible maternal healthcare systems.

VII. CONCLUSION

This paper presented a comprehensive survey of AI-based maternal healthcare monitoring systems, focusing on the application of machine learning, IoT, mobile health technologies, and conversational platforms in improving maternal care. The review highlights how advancements in these technologies have significantly contributed to early risk prediction, continuous health monitoring, and improved accessibility of healthcare services.

Machine learning models such as Random Forest, Support Vector Machine, and Neural Networks have demonstrated strong performance in predicting pregnancy-related risks using structured clinical data. Similarly, IoT-based systems have enabled real-time monitoring of vital health parameters, allowing timely detection of complications. Mobile health applications and conversational systems, including chatbots and IVR platforms, have further enhanced accessibility by enabling user-friendly interaction, particularly for populations with limited digital literacy.

However, despite these advancements, the study reveals that most existing systems operate in isolation and focus on specific functionalities such as prediction, monitoring, or communication. There is a noticeable lack of integrated platforms that combine these capabilities into a unified and scalable solution. Additionally, challenges such as dependency on infrastructure, limited personalization, and restricted accessibility in rural areas continue to hinder the effectiveness of current systems.

The analysis also indicates that while prediction accuracy has improved, real-world deployment remains a challenge due to issues such as data availability, system integration, and user adaptability. Furthermore, the absence of continuous monitoring and dynamic risk assessment in many systems highlights the need for more advanced and adaptive healthcare solutions.

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In conclusion, future research should focus on developing integrated maternal healthcare systems that combine machine learning, IoT, and accessible user interfaces to provide real-time monitoring, intelligent risk assessment, and seamless communication among stakeholders. Such systems have the potential to significantly improve maternal healthcare outcomes, particularly in resource-constrained environments, by enabling timely intervention, better decision-making, and inclusive healthcare delivery.

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