

Foetal Health Status Prediction: Systematic Literature Review

**Faith Kabanda, Melissa Tubili, Caroline Mhlanga
Frederick Mlungisi Dandure, Angeline Rutendo Coffee
and Sibusisiwe Dube**

Department of Informatics and Analytics
National University of Science and Technology
Bulawayo, Zimbabwe

n02425179w@students.nust.ac.zw, n02427116j@students.nust.ac.zw
n02426891w@students.nust.ac.zw, n02423750@students.nust.ac.zw
n02424460c@students.nust.ac.zw, sibusisiwe.dube@nust.ac.zw

Sinokubekezela P. Dube

School of Engineering
The University of Zambia
Lusaka, Zambia

2023008623@student.unza.zm

Abstract

Foetal health monitoring is a vital component of prenatal care, ensuring the well-being of both mother and child. Traditional techniques such as cardiotocography (CTG) are widely used, however, they are often limited by subjective interpretation and time inefficiencies. There is also limited literature that presents guidelines on the application of machine learning in Foetal health status prediction, particularly addressing challenges such as data variability, model generalizability, and algorithmic bias. This paper presents findings from a Systematic Literature Review (SLR) that followed the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model. The SLR examined 42 peer-reviewed studies published between 2021 and 2024 from Google Scholar and IEEE Xplore databases. The findings indicate that while machine learning models like random forests and neural networks achieve high predictive accuracy, their performance is often limited by data variability, lack of generalizability across diverse populations, and algorithmic bias. By addressing these challenges, Machine Learning can improve foetal health outcomes, ensuring timely and accurate interventions. These findings inform healthcare policymakers on how to intervene and manage foetal health hence reducing the mortality and morbidity of mother and/or child. Researchers interested in maternal and foetal health will also benefit from the findings of this paper through adhering to the guidelines provided in the resultant framework to improve the health management of the foetus.

Keywords

Foetal Health Status, Prediction, Machine Learning, Foetus Health Monitoring, Foetal Well-being.

1. Introduction

Foetal health monitoring is the cornerstone of prenatal care, aimed at identifying potential risks to safeguard maternal and foetal well-being. Traditional approaches, such as cardiotocography (CTG), are commonly employed to monitor foetal heart rate and uterine contractions, providing valuable insights into foetal health status. However, these methods

are not without limitations. The manual interpretation of CTG data is inherently subjective and time-intensive, often leading to variability in diagnostic accuracy (Sunge et al. 2023). Machine Learning (ML) has emerged as a powerful tool in addressing these limitations by offering data-driven solutions that enhance predictive accuracy and decision-making efficiency. By analyzing complex datasets, ML algorithms can identify patterns and relationships that are not easily discernible through conventional methods. Recent studies have demonstrated the potential of ML techniques such as random forests, neural networks, and support vector machines in predicting pregnancy-related complications, including preeclampsia, gestational diabetes, and foetal distress (Jiang et al. 2023; Mistry 2022).

Maternal health plays a critical role in determining foetal outcomes, with factors such as gestational age, maternal Body Mass Index (BMI), and blood pressure serving as key predictors of foetal health status. Addressing complications early is essential to mitigating risks for both mother and child. Despite promising advancements, the application of ML in this domain faces challenges, including data variability, limited dataset diversity, and ethical concerns like fairness and bias in predictive models (Albakoor et al. 2024; Nwokoro et al. 2023). Moreover, the generalisability of ML models across diverse populations remains a significant hurdle, emphasising the need for standardized methodologies and robust datasets (Moutaib et al. 2024). Currently there is limited literature that presents a systematic literature reviews of foetal health status. Nevertheless, there is a need for a systematic literature review that provides insight into the current techniques used for monitoring foetal health status, technologies for predicting foetal health status, challenges currently faced in the prediction of foetal health status and methods for improving the prediction of the foetal health status. For instance, Moutaib et al. (2024) highlight the need for standardised methodologies for such practices as predicting future events as well as the need for larger datasets to validate the reliability of ML applications across diverse populations. In addition, while ML holds potential in prenatal care, there is a pressing need to address data quality and population-specific model variations (Albakoor et al. 2024).

Research Questions

How is the foetal health status currently predicted?

What models are mostly applied in the prediction of foetal health status?

2. Methodology

This systematic literature review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model, ensuring rigor, transparency, and reproducibility. PRISMA's structured approach enabled the comprehensive synthesis of existing research on foetal health prediction. Each step, from study selection to data analysis was meticulously documented to maintain reliability and replicability.

2.1 Search Strategy

To create a search strategy, we developed a specific search string to capture the relevant studies within the specified time frame and research area. The search string used was:

(("Prediction" OR "Forecasting") AND ("Foetal health status") OR ("embryo health status" OR "Foetus wellbeing") AND ("Artificial Intelligence" OR "AI" OR "machine learning" OR "ML"))

The search strategy also included criteria based on the frequency of keywords, author reputation, citation count, and publication source to ensure relevance and quality (Lee and Koo 2022). The search filters included the prominence of keywords in titles, abstracts, or main text, ranking studies by frequency of keyword use (Page et al. 2021). Papers authored by prominent researchers with high citation counts in foetal health prediction or machine learning were prioritised, as were studies published in high-impact, peer-reviewed journals (Arya et al. 2021).

2.2 Selection Criteria

Table 1. Search Protocol for Studies on Foetal Health Prediction

Protocol Element	Description
Digital Library	Google Scholar, IEEE Xplore
Search Period	2021–2024 (initial search), 2022–2024 (refined search)
Number of Results	Google Scholar (381 initial, 322 refined), IEEE Xplore (6)
Inclusion Criteria	Peer-reviewed articles, English language, relevance to foetal health prediction using machine learning
Exclusion Criteria	Non-English articles, non-peer-reviewed studies, conference abstracts, unpublished manuscripts

2.3 Reporting

The results were reported in accordance with PRISMA guidelines, including a flow diagram in Figure 1 below, to illustrate the study selection process. Summary tables were created to present key characteristics and findings of the included studies clearly.

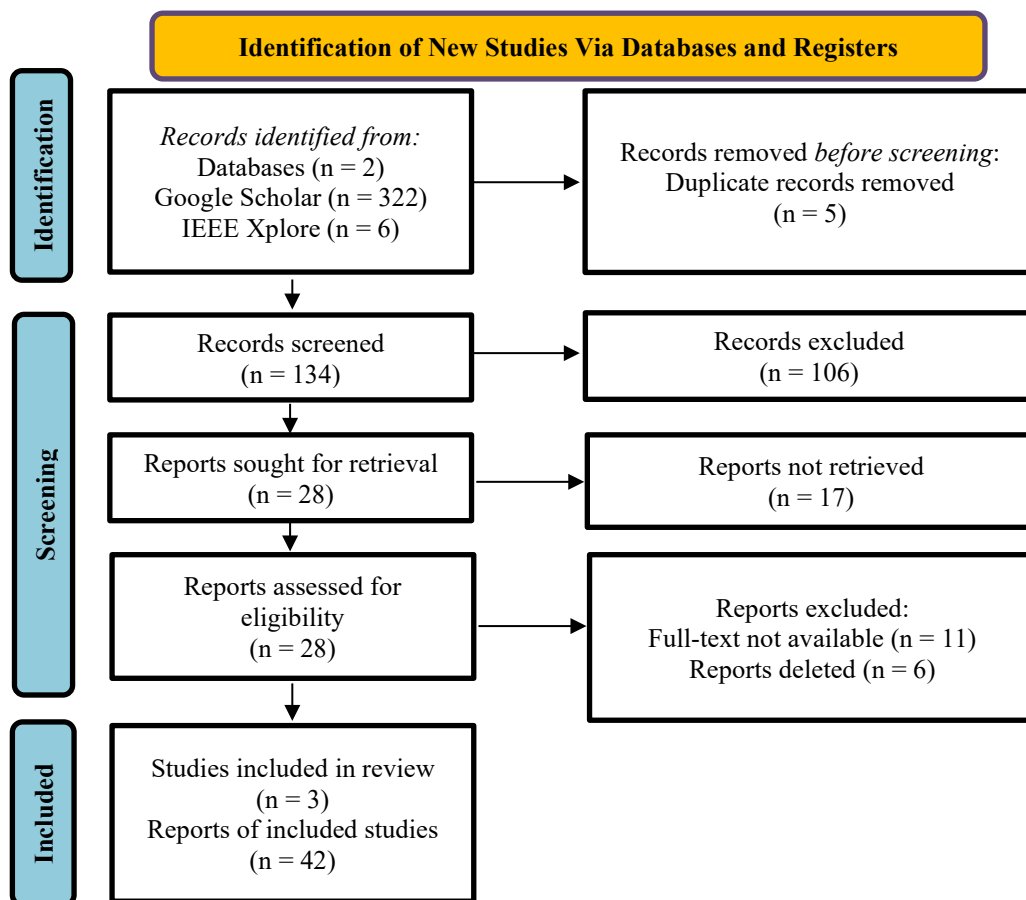


Figure 1. Prisma Flow Diagram

The table 2 below categorizes existing research on foetal health prediction based on key research questions. By grouping the studies, we can better understand the current methods used, technological advancements, efforts to improve prediction accuracy, and challenges faced in the field. This classification helps highlight gaps in research and areas for further exploration.

Table 2. Categories of Existing Research on Foetal Health Prediction

No.	Author(s)	Foetal Health Status Prediction Techniques	Challenges of Foetal Health Status Prediction	Models Used
1	Abburi et al. 2024	AI algorithms for remote foetal heart rate monitoring	Wearable technology accuracy and noise reduction	AI algorithms, wearable sensors
2	Aghadavod et al. 2024	Textile-based electrodes for foetal ECG signal analysis	Reliability of textile-based electrodes in clinical settings	Textile-based ECG electrodes
3	Al Duhayyim et al. 2023	Ensemble learning for foetal health classification	Optimizing ensemble learning for high accuracy	Ensemble learning models
4	Albakoor et al. 2024	Decision tree algorithms for early prediction of foetal malformations	Limitations in early detection accuracy of malformations	Decision tree algorithms
5	Alkurdi et al. 2024	Machine learning on cardiotocogram data	Data quality and feature selection issues	Machine learning classifiers
6	Alzakari et al. 2024	AI-driven predictive framework for stillbirth detection	Complexity in predictive frameworks and false positives	AI-based predictive models
7	Amanda et al. 2024	Integrated feature selection with machine learning	Choosing optimal machine learning models	Feature selection with ML algorithms
9	Bahar et al. 2022	Model structuring for foetal health status prediction	Structuring predictive models effectively	Predictive model structures
10	Dash and Kumar 2024	Ensemble-based stage prediction approach	Combining multiple models for stage-wise prediction	Ensemble machine learning
11	EFEVBERHA-OGODO et al. 2024	Predictive ML model for maternal mortality	Maternal health data availability and predictive limitations	Predictive ML models
12	Hardalaç et al. 2024	Feature elimination and hyperparameter	Feature selection and hyperparameter tuning complexity	Feature elimination, hyperparameter optimization

		optimization on cardiotocography		
13	Innab et al. 2024	Light gradient boosting model with SHAP explainable AI	Balancing model interpretability and predictive power	Light gradient boosting, SHAP explainability
14	Jain et al. 2024	Generative adversarial networks in foetal health applications	Data augmentation and model generalization	Generative adversarial networks
15	Jiang et al. 2023	Data analysis and optimal prediction model search using CTG data	Finding the optimal model among many possibilities	CTG-based predictive models
16	Jijiet et al. 2024	SVM classifier for real-time sensory sonography foetal abnormality detection	Real-time accuracy and robustness of SVM models	SVM classifiers
17	Khamis 2024	Deep neural networks for foetal health monitoring using cardiography	Training deep networks with limited cardiography data	Deep neural networks
18	Margret et al. 2024	Machine learning-based box models for pregnancy care	Accuracy and real-world application of box models	Box models, ML classifiers
19	Mehbodniya et al. 2024	ML-based foetal health classification using cardiotocographic data	Ensuring model reliability in clinical applications	Cardiotocographic ML classifiers
20	Mennickent et al. 2024	Narrative review of ML applications in pregnancy disease prediction	Lack of extensive data on pregnancy diseases	Machine learning models for pregnancy health
21	Mistry 2022	Comparative analysis of various foetal risk prediction algorithms	Trade-offs between different risk prediction algorithms	Various foetal risk prediction algorithms
22	Mondal et al. 2023	Maternal health risk prediction model for IoMT framework	Scalability of IoMT-based maternal health prediction	IoMT-based ML models
23	Moutaib et al. 2024	Random forest-based foetal electrocardiogram prediction	Feature selection and overfitting risks in random forest models	Random forest models

24	Muntaha and Dewanjee nd	XAI with Hybrid BiGRU-BiLSTM for maternal-foetal risk monitoring	Balancing explainability and accuracy in hybrid deep models	XAI, Hybrid BiGRU-BiLSTM
25	Mushtaq and Veningston 2024	AI-driven interpretable deep learning for foetal health classification	Interpretable deep learning challenges	Interpretable deep learning models
26	Nagavibha et al. 2024	Empirical and statistical ML analysis for foetal health classification	Choosing optimal ML models for statistical classification	Various ML classifiers
27	Naidile et al. 2024	Machine learning-based foetal health status prediction	Data quality and feature selection in ML models	Machine learning classifiers
28	Nasir et al. 2024	Federated learning for foetal health with cardiotocography	Decentralized learning challenges in federated ML	Federated learning, cardiotocography
29	Nwokoro et al. 2023	Adaptive explainable AI for maternal outcome improvement	Adaptive AI model training on diverse maternal health data	Explainable AI models
30	Olayemi and Olasehinde 2024	ML-based foetal health prediction from cardiotocography	Applying ML in low-resource healthcare settings	Machine learning on cardiotocography data
31	Pa and Premalathab nd	1D CNN for foetal health cardiotocographic classification	Handling large-scale cardiotocographic data with CNN	1D CNN models
32	Page et al. 2021	PRISMA 2020 guidelines for systematic review in foetal health research	Standardization and replicability in systematic reviews	PRISMA methodology
33	Pouramirarsalani and Rajebi nd	Feature vector optimization for SVM-based foetal classification	Optimizing feature selection for SVM models	SVM with feature optimization
34	RAMESH et al. 2024	ML-based cardiotocography analysis for foetal health classification	Ensuring robustness of ML models for cardiotocography	Machine learning models for cardiotocography
35	Sade 2024	Adaptive Neural Fuzzy Inference System for	Fuzzy logic model accuracy and optimization	Adaptive Neural Fuzzy Inference System

		foetal health assessment		
36	Saeed 2024	Decision tree-based early prediction of foetal malformations	Decision tree performance in congenital anomaly prediction	Decision trees
37	Salini et al. 2024	ML models for cardiotocography-based foetal health classification	Handling variability in cardiotocographic data	Various ML classifiers
38	Saragodu et al. 2024	ML-based foetal health prediction using cardiotocography	Generalizability of ML models to different healthcare settings	ML models for cardiotocography
39	Shastry et al. 2024	Adaptive weighted diversity ensemble learning for foetal health	Ensemble learning trade-offs between accuracy and efficiency	Adaptive weighted ensemble learning
40	Sirisha et al. 2024	Dynamic Multi-Layer Perceptron for cardiotocography analysis	Deep learning parameter tuning and model complexity	Multi-Layer Perceptron
41	Spairani 2024	AI-driven multiparametric approach for foetal heart rate variability	Processing foetal heart rate data with multi-parametric AI	Multi-parametric AI approaches
42	Sridevi nd	Deep learning for foetal health classification	Training deep learning models with limited foetal health datasets	Deep learning classifiers

To visually represent the results, forest plots were employed as shown in Figure 2

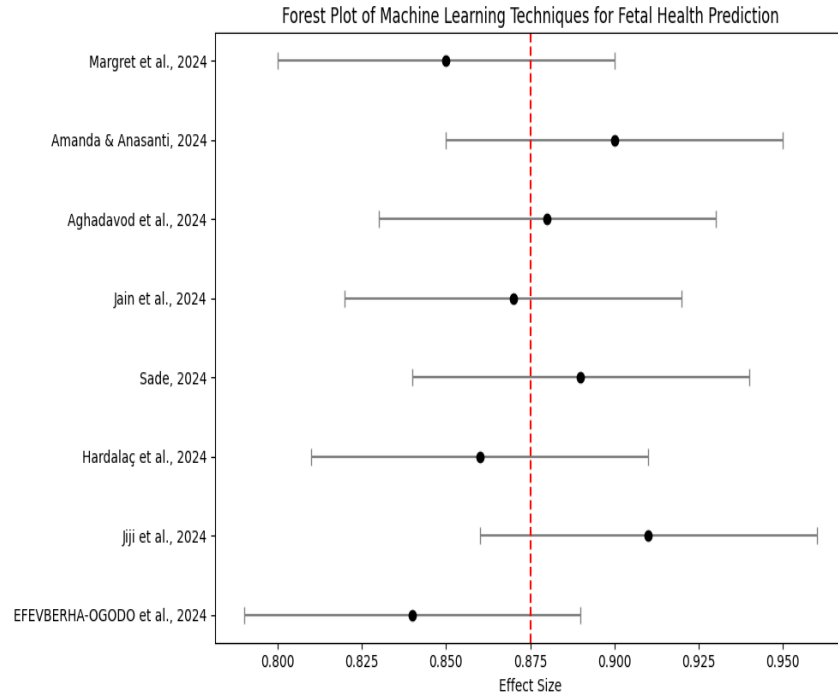


Figure 2. Forest Plot of Machine Learning Techniques for Foetal Health Prediction

3. Results and Discussion

The use of machine learning (ML) in healthcare, especially in maternal and foetal health, has shown great potential in predicting and managing pregnancy-related issues. Many studies highlight that ML-based models improve the accuracy of predicting foetal health outcomes and help reduce maternal and neonatal mortality. The ability of ML to process large amounts of clinical data allows for better insights compared to traditional statistical methods (Abburi et al. 2024). Research has demonstrated that ML models trained on cardiotocography (CTG) data can effectively assess foetal health and predict potential complications (Al Duhayyim et al. 2023). This section presents numerical and graphical results from different studies, discusses improvements, and evaluates the reliability of ML models in this field.

3.1 Technologies

Various studies have applied ML models to predict foetal health conditions using different approaches. This review includes studies that utilize deep learning, neural networks, ensemble learning, support vector machines (SVM), and decision tree algorithms. Deep neural networks (Khamis, 2024; Sridevi, nd) have been employed for foetal health monitoring using cardiotocography data, showing significant improvements in prediction accuracy. Ensemble learning techniques, such as adaptive weighted diversity models (Shastry et al. 2024) and random forest models (Moutaib et al. 2024), have been used to optimize foetal health classification outcomes. Additionally, SVM classifiers (Jijiet al. 2024; Pouramirarsalani and Rajebi, nd) have demonstrated effectiveness in real-time sonography foetal abnormality detection when combined with optimized feature selection methods. Federated learning (Nasir et al. 2024) and explainable AI (Muntaha and Dewanjee nd; Nwokoro et al., 2023) have also emerged as promising technologies for foetal health prediction.

3.2 Models Used

While a formal meta-analysis was not conducted, the following statistical methods were considered if the data had allowed. Meta-analysis models would have been applied, with a preference for a random-effects model due to the anticipated heterogeneity among the studies (Dettori et al. 2022). This model is appropriate when studies differ significantly in terms of design and populations. In an ideal scenario where meta-analysis was feasible, heterogeneity assessment tools such as the I^2 statistic would have been employed to quantify heterogeneity among studies, along with visual inspections of forest plots (Dettori et al. 2022). Should a meta-analysis have been conducted, software

such as R (version 4.1.0) with the 'metafor' package would have been utilised for data analysis and synthesis. By combining these approaches, the researchers hoped to reduce the impact of any reporting biases on the findings of this research. However, it is critical to acknowledge that the possibility of bias owing to missing results is a complex issue that requires additional research to develop more rigorous approaches for identifying and mitigating bias.

To assess the certainty of the evidence for each outcome, the GRADE (Grading of Recommendations Assessment, Development, and Evaluation) approach was used (Nasir et al. 2024). This paradigm considers four essential domains when evaluating the quality of evidence. The risk of bias evaluates the methodological quality of the included studies, including randomization, allocation concealment, blinding, and selective outcome reporting. Inconsistency assesses the degree of difference in out-comes between trials, taking into account statistical heterogeneity and clinical variability. Indirectness evaluates the extent to which the evidence applies to foetuses and the intervention of interest. Imprecision determines the precision of effect estimates while considering factors such as sample size and data variability. By utilising the GRADE approach, we aim to provide a transparent and rigorous assessment of the certainty in the evidence for each outcome. This will enable readers to interpret the findings with confidence and make informed decisions.

4. Conclusion

The findings of this systematic literature review emphasize the transformative potential of machine learning (ML) technologies in the prediction of foetal health status. The review revealed that ML techniques, including decision trees, neural networks, support vector machines, and ensemble learning models, have significantly enhanced predictive accuracy compared to traditional methods such as cardiotocography (CTG) interpretation. These advanced algorithms allow for the identification of subtle patterns within large datasets, offering earlier and more reliable detection of foetal distress and other complications. However, the analysis also underscores that the current application of ML algorithms and techniques in foetal health prediction is still in its nascent stages, with issues related to data quality, generalisability, availability, and model interpretability impeding broader clinical implementation. The results indicate that while ML holds great promise in improving prenatal care, there is a pressing need for more robust, diverse datasets and standardised methodologies to ensure consistent model performance across different populations.

Several recommendations emerge from this review to guide future research and practical applications in foetal health prediction. Firstly, the development of standardised data collection protocols across healthcare institutions is essential to mitigate data variability and enhance the generalisability of ML models. Furthermore, collaborative efforts between data scientists and healthcare professionals should be prioritized to ensure that predictive models are both clinically relevant and ethically sound. Explainable AI (XAI) techniques should also be integrated into ML frameworks to improve model transparency and foster trust among clinicians. In addition, the incorporation of federated learning approaches may provide a solution to privacy concerns by enabling the training of models on decentralized datasets without compromising patient confidentiality. Addressing these recommendations would not only improve the reliability of ML-based foetal health prediction but also facilitate the seamless integration of these technologies into routine prenatal care.

Despite the promising potential of ML in foetal health prediction, this study is not without limitations. The review relied solely on peer-reviewed articles published in English between 2021 and 2024, which may have excluded relevant studies in other languages or unpublished data. Moreover, the heterogeneity of the included studies in terms of model selection, input features, and outcome measures made direct comparisons challenging. The absence of a formal meta-analysis further limits the ability to draw quantitative conclusions regarding model performance. Future research should focus on conducting meta-analyses to quantify the overall predictive performance of different ML models and identify the most effective techniques. Additionally, efforts to improve data diversity and transparency will be critical to overcoming biases and ensuring equitable health outcomes across diverse populations. By addressing these limitations, future studies can contribute to the establishment of more reliable and ethical ML applications in foetal health prediction.

References

Abhuri, R., Hatai, I., Jaros, R., Martinek, R., Babu, T.A., Babu, S.A. and Samanta, S., Adopting artificial intelligence algorithms for remote foetal heart rate monitoring and classification using wearable foetal phonocardiography, *Applied Soft Computing*, vol. 165, p.112049, 2024.

- Aghadavod, R., Zarrebini, M., Shanbeh, M., Shayegh, F. and Sabet, F., Investigation of fetal ECG signal using textile-based electrodes, *The Journal of The Textile Institute*, vol. 115, no. 1, pp.29-40, 2024.
- Al Duhayyim, M., Abbas, S., Al Hejaili, A., Kryvinska, N., Almadhor, A. and Mughal, H., Ensemble Learning for Fetal Health Classification, *Computer Systems Science & Engineering*, vol. 47, no. 1, 2023.
- Albakoor, M., Saeed, K., Masouh, A. and Aljneidi, B., August. Early Predicting Congenital Foetus Malformations Based on Decision Trees Algorithm, *In International Conference on Computer Information Systems and Industrial Management*, pp. 215-228, Springer Nature, Switzerland, 2024.
- Alkurdi, A. and Abdulazeez, A.M., Comprehensive Classification of Foetal Health Using Cardiotocogram Data Based on Machine Learning, *Indonesian Journal of Computer Science*, vol. 13, no. 1, 2024.
- Alzakari, S.A., Aldrees, A., Umer, M., Cascone, L., Innab, N. and Ashraf, I., Artificial intelligence-driven predictive framework for early detection of still birth, *SLAS technology*, vol. 29, no. 6, p.100203, 2024.
- Amanda, L.R. and Anasanti, M.D., Assessing Performance Across Various Machine Learning Algorithms with Integrated Feature Selection for Fetal Heart Classification, *International Journal of Artificial Intelligence Research*, vol. 8, no. 1, pp.1-14, 2024.
- Arya, S., Kaji, A.H. and Boormeester, M.A., PRISMA reporting guidelines for meta-analyses and systematic reviews, *JAMA surgery*, vol. 156, no. 8, pp.789-790, 2021.
- Bahar, E., Agushinta, D., Arimbi, Y.D. and Reksoprodjo, M., Model Structure of Fetal Health Status Prediction, *JUITA: Jurnal Informatika*, vol. 10, no. 2, pp.159-166, 2022.
- Dash, D. and Kumar, M., An ensemble-based stage-prediction machine learning approach for classifying fetal disease, *Healthcare Analytics*, vol. 5, p.100322, 2024.
- Dettori, J.R., Norvell, D.C. and Chapman, J.R., Fixed-effect vs random-effects models for meta-analysis: 3 points to consider, *Global Spine Journal*, vol. 12, no. 7, pp.1624-1626, 2022.
- EFEVBERHA-OGODO, O., EGBOKHARE, F.A. and CHETE, F.O., Towards the Development of a Predictive Machine Learning Model for Maternal Mortality, *International Journal of Computer Science and Information Security (IJCSIS)*, vol. 22, no. 4, 2024.
- Hardalaç, F., Akmal, H., Ayturan, K., Acharya, U.R. and Tan, R.S., A Pragmatic Approach to Fetal Monitoring via Cardiotocography Using Feature Elimination and Hyperparameter Optimization, *Interdisciplinary Sciences: Computational Life Sciences*, pp.1-25, 2024.
- Innab, N., Alsubai, S., Alabdulqader, E.A., Alarfaj, A.A., Umer, M., Trelova, S. and Ashraf, I., Automated approach for fetal and maternal health management using light gradient boosting model with SHAP explainable AI, *Frontiers in Public Health*, vol. 12, p.1462693, 2024.
- Jain, R., Pant, M. and Triapthti, N.K., Generative Adversarial Networks in Healthcare Sector, *International Journal of Geoinformatics*, vol. 20, no. 6, pp.26-42, 2024.
- Jiang, S., Lian, T. and Wei, Y., Data Analysis and Optimal Prediction Model Search based on CTG Data. *Highlights in Science, Engineering and Technology*, vol. 54, pp.335-341, 2023.
- Jiji, G.W., Rajesh, A. and Muthuraj, A., Automated interpretation of fetal abnormalities over real-time sensory sonography using SVM classifier, *Multimedia Tools and Applications*, pp.1-22, 2024.
- Khamis, H.A., January. Deep Neural Networks for Fetal Health Monitoring Through Cardiography Data Analysis, *In International Conference on Forthcoming Networks and Sustainability in the AIoT Era*, pp. 443-456, Springer Nature, Switzerland, 2024.
- Lee, S.W. and Koo, M.J., PRISMA 2020 statement and guidelines for systematic review and meta-analysis articles, and their underlying mathematics: Life Cycle Committee Recommendations, *Life Cycle*, vol. 2, 2022.
- Margret, I.N., Rajakumar, K., Arulalan, K.V. and Manikandan, S., Machine Learning-Based Box Models for Pregnancy Care and Maternal Mortality Reduction: A Literature Survey, *IEEE Access*, 2024.
- Mehbodniya, A., Lazar, A.J.P., Webber, J., Sharma, D.K., Jayagopalan, S., K, K., Singh, P., Rajan, R., Pandya, S. and Sengan, S., Fetal health classification from cardiotocographic data using machine learning, *Expert Systems*, vol. 39, no. 6, p.e12899, 2022.
- Mennickent, D., Rodríguez, A., Opazo, M.C., Riedel, C.A., Castro, E., Eriz-Salinas, A., Ap-pel-Rubio, J., Aguayo, C., Damiano, A.E., Guzmán-Gutiérrez, E. and Araya, J., Machine learning applied in maternal and fetal health: a narrative review focused on pregnancy diseases and complications, *Frontiers in Endocrinology*, vol. 14, p.1130139, 2023.
- Mistry, J., Comparative Analysis of Various Algorithms for Fetal Risk Prediction, 2022.
- Mondal, S., Nag, A., Barman, A.K. and Karmakar, M., Machine learning-based maternal health risk prediction model for IoMT framework, *Int J Exper Res Rev*, vol. 32, no. 1, pp.145-59, 2023.

- Moutaib, M., Fattah, M., Farhaoui, Y., Aghoutane, B. and El Bekkali, M., Fetal electro-cardiogram prediction using machine learning: a random forest-based approach, *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 33, no. 2, pp.1076-1083, 2024.
- Muntaha, S. and Dewanjee, S., Integrating XAI with Hybrid BiGRU-BiLSTM Model for Comprehensive Maternal-Fetal Health Risk Monitoring.
- Mushtaq, G. and Venington, K., AI driven interpretable deep learning based fetal health classification, *SLAS technology*, vol. 29, no. 6, p.100206, 2024.
- Nagavibha, R., Satheesh, M.M., Chandy, M.P. and Prathap, B.R., March. An Empirical and Statistical Analysis of Fetal Health Classification Using Different Machine Learning Algorithm, *In 2024 4th International Conference on Data Engineering and Communication Systems (ICDECS)*, pp. 1-7, 2024.
- Naidile S, S., Shreedhara N, H. and Harprith, K., Prediction of Fetal Health Status Using Machine Learning, *Journal of Data Science*, vol. 2024, no. 17, pp.1-7, 2024.
- Nasir, M.U., Khalil, O.K., Ateeq, K., Almogadwy, B.S.A., Khan, M.A., Azam, M.H. and Adnan, K.M., Federated Machine Learning Based Fetal Health Prediction Empowered with Bio-Signal Cardiocography, *Computers, Materials & Continua*, vol. 78, no. 3, 2024.
- Nwokoro, C.O., Kumar, P., Uzoka, F.M., Inyang, U.G., Eyoh, I.J., Augustine, O., Kelechi, D., Nwokoro, C. and Chinmanma, O., Improving maternal outcomes: An adaptive and explainable AI solution for mothers in the childbearing age, *J. Comput. Biol. Bioinf. Res.*, vol. 17, pp.1-12, 2023.
- Olayemi, O.C. and Olaschinde, O.O., Machine Learning Prediction of Fetal Health Status from Cardiocography Examination in Developing Healthcare Contexts, *Journal of Computer Science Research*, vol. 6, no. 1, pp.43-53, 2024.
- Pa, S. and Premalathab, K., Prediction and Classification of Fetal Health Cardiocographic Data Using 1d-Convolutional Neural Network.
- Page, M.J., Moher, D., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Sham-seer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E. and Chou, R., PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews, *Bmj*, vol. 372, 2021.
- Pouramirarsalani, S. and Rajebi, S., Fetal health classification by support vector machine based on feature vector optimization.
- RAMESH, J.V.N., YANG, M. and CHALAPATHI, M.M.V., Cardiocography Data Analysis for Fetal Health Classification Using Machine Learning Models, 2024.
- Sade, J., Fetal Health Assessment Using an Adaptive Neural Fuzzy Inference System, *ICAMΣ'24*, p.97, 2024.
- Saeed, K., Early Predicting Congenital Fetus Malformations Based on Decision Trees, *In Computer Information Systems and Industrial Management: 23rd International Conference, CISIM 2024*, Bialystok, Poland, September 27-29, 2024, Proceedings, vol. 14902, p. 215, Springer Nature, 2024.
- Salini, Y., Mohanty, S.N., Ramesh, J.V.N., Yang, M. and Chalapathi, M.M.V., Cardiocography Data Analysis for Fetal Health Classification Using Machine Learning Models, *IEEE Access*, 2024.
- Saragodu, N.S., Hegde, S.N. and Kaur, H., Prediction of Fetal Health Status Using Machine Learning, *Journal of Data Science*, 2024.
- Shastri, K.A., Mohan, S.G., Kumar, T.M., Karthik, D.U., Sushma, V. and Subashree, D., Adaptive weighted diversity ensemble learning approach for fetal health classification on cardiocography data, *IEEE Access*, 2024.
- Sirisha, U., Srinivasu, P.N., Padmavathi, P., Kim, S., Pavate, A., Shafi, J. and Ijaz, M.F., Dynamic Multi-Layer Perceptron for Fetal Health Classification Using Cardiocography Data, *Computers, Materials & Continua*, vol. 80, no. 2, 2024.
- Spairani, E., Artificial intelligence solutions for processing, analyzing and classifying fetal heart rate variability series: a multi-parametric approach, 2024.
- Sridevi, G., Babu, K.V., Sarath, K., Satyanarayana, G.S. and Reddy, J.H., Fetal Health Classification Using Deep Learning.
- SUNGE, A.S., ABDURACHMAN, E. and YAYA HERYADI, I.H., PERFORMANCE COMPARISON OF DECISION TREE, RANDOM FOREST, AND XGBOOST MODELS; AND ITS INTERPRETABILITY USING SHAP FOR RECOGNIZING THE NECESSITY OF CAESAREANS SECTION OF CHILDBIRTH, *Journal of Theoretical and Applied Information Technology*, vol. 101, no. 9, 2023.
- Swain, S., Patra, K.J., Jayasingh, S.K., Mohanty, M.N. and Pattanayak, B.K., The Role of Ensemble Learning in Advancing Child Fetal Health: A Focus on Voting and Bagging Techniques, *In 2024 1st International Conference on Cognitive, Green and Ubiquitous Computing (IC-CGU)*, pp. 1-6, 2024.
- Talukder, M.S.H. and Akter, S., An Improved Model Ensembled of Different Hyper-parameter Tuned Machine Learning Algorithms for Fetal Health Prediction, *arXiv preprint arXiv:2305.17156*, 2023.

- Talukder, M.S.H. and Akter, S., An improved ensemble model of hyper parameter tuned ML algorithms for fetal health prediction, *International Journal of Information Technology*, vol. 16, no. 3, pp.1831-1840, 2024.
- Veeramachaneni, N., Kumar, J.N. and Srinivasan, N., Embryo growth analysis using algorithmic approach, *In AIP Conference Proceedings*, vol. 3075, no. 1., 2024.
- Wang, C.W., Kuo, C.Y., Chen, C.H., Hsieh, Y.H. and Su, E.C.Y., Predicting clinical pregnancy using clinical features and machine learning algorithms in in vitro fertilization, *Plos one*, vol. 17, no. 6, p.e0267554, 2022.
- Yang, L., Gaussian Process-Based Models for Prediction of Fetal Well-Being From Cardiotocographic Signals, *Doctoral dissertation*, State University of New York at Stony Brook, 2024.
- Yaseen, I. and Rather, R.A., A Theoretical Exploration of Artificial Intelligence's Impact on Feto-Maternal Health from Conception to Delivery, *International Journal of Women's Health*, pp.903-915, 2024.
- Yulistiani, R. and Kurniadi, F.I., September. Feature Selection Using Grey Wolf Optimization for Fetal Health Classification, *In 2024 International Conference on ICT for Smart Society (ICISS)*, pp. 1-5, 2024.

Biographies

Faith Kabanda is a distinguished data professional, with a robust background in data analysis and project management. She earned her Bachelor of Science Honours Degree in Actuarial Science from UCSI University and is currently a master's student in Big Data Science at National University of Science and Technology (NUST). Throughout her career, Faith has gained collective work experience across the insurance, non-governmental, and consultancy sectors, honing her skills in data cleaning, analysis, visualization, and machine learning. Complementing her technical expertise, she excels in creativity, teamwork, presentation, team building, networking, and project management. Faith is driven by a passion to leverage her knowledge and experience to address social and economic challenges, crafting informed, data-driven solutions. In her professional journey, Faith currently holds the position of Junior Data Analyst and Project Assistant at L-IFT, where she contributes significantly to data-driven projects and initiatives. In 2019, Faith co-authored a scholarly paper titled "Effects of High Frequency Trading on the Malaysian Stock Market" alongside Ali Alaali and Hong Keat Yap. This publication underscores her dedication to contributing to the academic discourse in her field.

Melissa Sharon Tubili, born on April 5, 1991, in Hwange, Zimbabwe, is a certified ICT Security analyst professional dedicated to advancing her career in the Information Technology sector. Her educational journey began at Bulawayo Polytechnic, where she earned National Diplomas in Information Technology. Melissa furthered her studies at the National University of Science and Technology (NUST), where she obtained a Bachelor of Science Honours Degree in Informatics. She later certified in CompTIA Security Plus and is currently a master's student at NUST. Professionally, she began her career as an IT Technician Intern at ZPC Hwange Power Station, following this internship, she transitioned to the private sector at First Pack Services Pvt Ltd, and is currently in the banking sector working for the Reserve Bank of Zimbabwe under their cyber security team as a SOC Analyst.

Caroline Mhlanga is a master's student in Big Data Science at the National University of Science and Technology (NUST). With a keen interest in healthcare analytics, Caroline is dedicated to harnessing the power of data to improve patient outcomes. In addition to her studies, Caroline did her undergraduate degree at NUST, where she studied Computer Science. She is passionate about using her skills to contribute to meaningful solutions in healthcare and hopes to pursue a career in health informatics upon graduation. Outside of academia, Caroline enjoys reading novels, spending time with friends and family and engaging in community service initiatives that support women's health and education.

Frederick Mlungisi Dandure is a Technology and Peacebuilding Officer at Mennonite Central Committee (MCC), where he integrates digital tools into peacebuilding and development work across Africa. He holds a Bachelor of Science Degree in Computer Science (2018) and has since honed a versatile set of digital skills, including Web Development, Digital Marketing, Learning Management, and Data Analytics. With a strong command of various digital platforms, ranging from web systems and project management tools to social media management, Frederick plays a key role in supporting organisational efficiency and outreach. He is currently deepening his expertise through a master's degree in Big Data Science at the National University of Science and Technology (NUST) in Zimbabwe. Frederick is particularly passionate about the intersection of technology and social impact. He has a keen interest in Natural Language Processing and is actively developing skills in Artificial Intelligence, exploring how emerging technologies can be used to drive meaningful change in education, peacebuilding, and community development.

Angeline Rutendo Coffee is a driven and analytical professional with a strong background in mathematics and statistics. Holding a Bachelor of Science Honours Degree in Applied Mathematics from the National University of Science and Technology (NUST), Angeline began her career as a Junior Statistician at ZIMSTATS in 2012 before transitioning to a teacher in government in 2014. After resigning from teaching in 2022, Angeline is currently pursuing her master's degree in Big Data Science, further expanding her expertise in data analysis and insights. With her unique blend of teaching, statistical analysis, and big data expertise, Angeline is poised to make a lasting impact in her future endeavours.

Sibusisiwe Dube has a PhD in Information Systems from the University of Cape Town in South Africa. She also holds a Master of Science degree in Computer Science from the National University of Science and Technology in Zimbabwe. Sibusisiwe also holds a Bachelor of Science honours degree in Information Systems obtained from the Midlands State University in Zimbabwe. Sibusisiwe is currently teaching at the National University of Science and Technology. She has published several peer-reviewed publications. She coordinates the post graduate program in the department of Informatics and Analytics. She has examined two PhD student dissertations and is currently supervising three PhD students and several Masters students.

Sinokubekezela Princess Dube is currently studying for a Master of Science Degree in Construction Management in the faculty of Engineering at the University of Zambia in Lusaka Zambia. She holds a bachelor of science degree in Property management from the National University of Science and Technology in Zimbabwe. Sinokubekezela has is an upcoming researcher who has a number of publications accessible via Google scholar. She has a research passion that has seen her attend and present her work at international conferences.