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An artificial intelligence approach to predict infants' health status at birth

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Highlights

- A machine learning-based prediction model was developed to assess neonatal health status.
- To determine top-scored features, the MRMR algorithm was used.
- Classifiers including SVM, Ensemble, KNN, NB, and Decision tree were used.
- The SVM classifier had the best performance (accuracy: 75%).

Abstract

Background

Machine learning could be used for prognosis/diagnosis of maternal and neonates' diseases by analyzing the data sets and profiles obtained from a pregnant mother.

Purpose

We aimed to develop a prediction model based on machine learning algorithms to determine important maternal characteristics and neonates' anthropometric profiles as the predictors of neonates' health status.

Methods

This study was conducted among 1280 pregnant women referred to healthcare centers to receive antenatal care. We evaluated several machine learning methods, including support vector machine (SVM), Ensemble, K-Nearest Neighbor (KNN), Naïve Bayes (NB), and Decision tree classifiers, to predict newborn health state.

Results

The minimum redundancy-maximum relevance (MRMR) algorithm revealed that variables, including head circumference of neonates, pregnancy intention, and drug consumption history during pregnancy, were top-scored features for classifying normal and unhealthy infants. Among the different classification methods, the SVM classifier had the best performance. The average values of accuracy, precision, recall, F1-score, and area under the receiver operating characteristic curve (AUC) in the test group were 75%, 75%, 76%, 76%, and 65%, respectively, for SVM model.

Conclusion

Machine learning methods can efficiently forecast the neonate's health status among pregnant women. This study proposed a new approach toward the integration of maternal data and neonate profiles to facilitate the prediction of neonates' health status.

Introduction

The neonatal period is an extremely critical phase prone to many neonate health problems that might even lead to death [1]. Worldwide, nearly 43% of child deaths occur during the neonatal period. Of these deaths, almost 99% occur in developing countries. Therefore, most of the health systems have been trying to investigate influencing factors on the reduction of neonates' mortality and morbidity [2]. Some identified factors such as maternal malnutrition, poor socioeconomic conditions, and inadequate prenatal healthcare services have proven effects on neonatal health [3], [4], However, numerous other factors may influence neonatal health. Pan American Health Organization also acknowledged the importance of maternal anemia, the mother's age, short birth interval, and complications in the delivery process on the newborn's health status. Other factors include maternal infections, malnutrition, and micronutrient deficiency in women even before pregnancy [5], [6].

Several studies have also affirmed that newborn health cannot be completely realized by merely emphasizing maternal health interventions. Demographic and socio-economic characteristics of mothers are among critical issues that considering their effects on neonates' health, can be decisive in adopting appropriate health promotion policies [6], [7]. Furthermore, it was reported that most neonates' mortality is associated with factors such as inadequate or low-quality obstetric care coverage [8], [9]. According to the Nigeria Demographic and Health Survey, most deliveries were performed by unskilled assistants with insufficient capacity for emergency obstetric care [10]. Furthermore, studies have shown that infants born from old mothers are at the highest risk of mortality compared to younger ones [11]. It was reported that poor household economic conditions, mothers with low education, and birth in rural and deprived areas have been proven to influence newborn survival and health [12]. Similarly, a study conducted in South-West Ethiopia highlighted the key role of socioeconomic factors on neonatal mortality, particularly among the most underprivileged and uneducated families who live in areas far from health facilities [13]. Some other factors, including the child's gender, birth size, birth order, and birth interval, were cited as determinants of newborns' mortality [14].

In pursuit of strategies to promote neonatal health, various national, international, and local institutions focused on maternal and child health emphasize the connection between maternal socio-economic factors and newborn well-being. In addition, many countries, remarkably in developing regions, had little progress in recent years and still need to thoroughly consider socioeconomic and health development indicators as the critical components of childbirth health programs [15].

Machine learning models can be used to predict and diagnose different health problem and diseases by recognition of patterns, visualization, analysis of various trends, and identifying the regularities in data [16], [17], [18], [19]. In a study, a review of the application of artificial intelligence and machine learning algorithms for the prediction of various neonatal health problems such as bronchopulmonary dysplasia, sepsis, necrotizing enterocolitis, retinopathy of prematurity, intraventricular hemorrhage, and mortality among neonates was carried out. This review shows that machine learning algorithms have breakthrough performance in forecasting neonatal diseases [20].

Despite the abundant research conducted to determine the factors affecting neonatal mortality and health, there is insufficient evidence to identify all the factors that can affect neonatal health by machine learning approach. Machine learning models indeed possess the advantage of being able to consider and analyze numerous parameters to identify the most relevant ones within a complex model. In this study, our goal was to comprehend the crucial parameters associated with neonatal health and survival. To achieve this, we employed machine learning algorithms that integrated maternal demographic parameters, socio-economic characteristics, and neonates' anthropometric profiles to identify the most significant factors influencing newborn health. Additionally, we constructed a machine learning model to precisely predict neonatal health status and survival based on these collected data.

Section snippets

Study design and data collection

This analytical, cross-sectional study was conducted to identify the predictors of neonatal health status referred for receiving antenatal care. Pregnant women between 28 and 40 weeks of gestation were asked to participate in the research. The inclusion criteria were being 18–45 years of age, having a single, and low-risk pregnancy. Those with a history of infertility, placental abruption, premature rupture of membranes, preeclampsia, mental illness, and drug addictions were excluded from the…

Results

The heat map of correlation values among the evaluated parameters is shown in Fig. 1, confirming significant correlations between newborns' weight, height, head circumference, and health status at birth. The correlation data depicted that the infants with lower weights,

smaller head circumferences and heights were more likely to be born with a congenital disability. Furthermore, there were positive correlations between pregnancy intention, household income, and infant morbidity. The black…

Discussion

The early prediction and management of neonatal diseases are crucial factors in treatment and have received significant attention from investigators and clinical decision-makers. Artificial intelligence as a novel prognosis/diagnosis tool has been widely used in the detection and diagnosis of different diseases and health problems [28]. In this study, we implemented five classification models, including SVM, Ensemble, KNN, NB, and Decision tree classifiers, considering various parameters…

Conclusion

This study employed various machine learning algorithms to predict and diagnose the health status of neonates, taking into account both maternal data and neonate profiles. Machine learning methods proved effective in forecasting neonatal health status and differentiating between normal and sick infants. The SVM classifier demonstrated the highest performance among all classification models, in terms of accuracy, precision, recall, F1-score, and AUC.…

CRediT authorship contribution statement

Tua Halomoan Harahap: Writing – review & editing, Validation, Supervision, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Sofiene Mansouri:** . **Omar Salim Abdullah:** Resources, Methodology, Investigation, Formal analysis, Data curation. **Herlina Uinarni:** Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Formal analysis. **Shavan Askar:** Software, Resources, Data curation, Conceptualization. **Thaer L. Jabbar:**…

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

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