

Climate-Driven Malaria Prediction in Southwest Nigeria: Early Results from a Weighted Deep Learning Ensemble Framework

Abstract

Malaria remains a critical public health challenge in Nigeria, accounting for nearly one-third of global malaria deaths [1]. Climate variability strongly influences *Anopheles* mosquito dynamics and malaria transmission [2], yet its relationship with malaria incidence in southwestern Nigeria remains underexplored. Limited datasets often constrain existing studies, narrow geographic focus [3], and underutilization of advanced ensemble learning approaches, restricting predictive reliability and practical application.

This study addresses these gaps through four objectives: (i) investigating the climatic factors influencing malaria incidence in Southwest Nigeria, (ii) forecasting malaria incidence with a weighted-average deep learning ensemble model that combines Convolutional Neural Networks (CNN), Long Short-Term Memory (LSTM), and Gated Recurrent Units (GRU). (iii) benchmarking model performance against conventional machine learning ensemble methods, and (iv) deploying the model on web platforms. This approach's novelty is in the weighted combination of complementary deep learning ensemble methods architectures, which captures both spatial and temporal dependencies in malaria-climate interactions more effectively than traditional ensemble or single-model frameworks.

Malaria incidence data (2015–2024) from the National Malaria Elimination Program were combined with climate data from the European Centre for Medium-Range Weather Forecasts. Preprocessing included data cleaning, feature engineering, and normalization, with model evaluation based on RMSE, MAE, and R^2 .

Preliminary results reveal that, using a 0.2 correlation threshold, temperature showed a consistent negative relationship with malaria incidence across the six southwestern states, while dewpoint, relative humidity, windspeed, and precipitation exhibit moderate to strong positive correlations, reflecting regional climatic variability. The weighted-average deep learning ensemble model achieved superior performance over Random Forest, Ridge Regression, and XGBoost, with RMSE values from 0.04 (Osun) to 0.11 (Ekiti) and R^2 from 0.74 (Ogun) to 0.91 (Ekiti), demonstrating improved predictive reliability.

These findings highlight the promise of combining climatic drivers with advanced deep learning ensemble for malaria incidence forecasting, with ongoing efforts directed toward fine-tuning and deployment on web platforms for broader accessibility. This approach has strong potential to inform early-warning systems, guide targeted interventions, and strengthen evidence-based malaria control strategies in Nigeria and other climate-sensitive regions.

References

- [1] WHO (2021). World malaria report. Geneva: World Health Organization.
- [2] Makinde, O. S., Abiodun, G. J., Ojo, O. T. (2021). Modelling of malaria incidence in Akure, Nigeria: negative binomial approach. *Geojournal*, 86:1327–1336
- [3] Adeboye, N. O., Abimbola, O. V., & Folorunso, S. O. (2020). Malaria Patients in Nigeria: A Data Exploration Approach. *Data in brief*, 28, 104997.