

Inferring underreporting in Lassa fever surveillance in Nigeria via simulation-based modelling with climatic covariates

Jibrin Jaafaru^{1,2, &}

¹Department of Computer Science, University of Jos, Jos, Nigeria, ²West African Centre for Emerging Infectious Diseases, Jos University Teaching Hospital, Jos, Nigeria

&Corresponding author: Jibrin Jaafaru, Department of Computer Science, University of Jos, & West African Centre for Emerging Infectious Diseases, Jos, Nigeria. **Email:** jibrinx@yahoo.com

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Introduction

Lassa fever remains a persistent public health challenge in West Africa, particularly in Nigeria, where outbreaks recur annually with varying intensity. Effective control and timely response depend on accurate epidemiological modeling, yet the reliability of reported case data is hindered by substantial under-reporting and inconsistent surveillance. Environmental factors such as rainfall, temperature, and vegetation strongly influence both disease transmission and the likelihood of detection, yet their role in shaping reporting patterns remains underexplored. Bridging this gap is critical for interpreting observed trends and guiding targeted public health interventions.

Methods

We propose a Bayesian simulation-based inference (SBI) framework that extends the classical SEIR (Susceptible–Exposed–Infectious–Recovered) model with a covariate-conditioned, time-varying reporting function. This function is parameterized by a neural network that maps weekly environmental covariates, including rainfall, temperature, and vegetation index (NDVI), to the probability of reported cases, thereby capturing seasonal and regional variation in surveillance performance. To estimate the joint posterior over epidemiological parameters and reporting dynamics, we use Sequential Neural Posterior

Estimation (SNPE) on historical Lassa fever data from Nigeria Center for Disease Control.

Results

Our method enables likelihood-free inference in the presence of latent, noisy, and partially observed data. Posterior predictive checks show strong agreement between observed and simulated case trajectories. Inferred reporting functions reveal geographic and temporal patterns of under-reporting.

Conclusion

By integrating climatic covariates into a neural network–parameterized reporting function within a Bayesian simulation-based framework, our approach disentangles true transmission dynamics from reporting noise. This allows us to infer spatiotemporal patterns of under-reporting and identify regions where surveillance is likely weakest. These findings highlight the dual value of environmental data in informing both transmission modelling and surveillance evaluation, with direct implications for improving epidemic forecasting, resource prioritization, and policy response to Lassa fever in Nigeria.