A DISTRIBUTED LAG NON-LINEAR MODELLING APPROACH TO COMPARING CLIMATE-RESPONSE PATTERNS ACROSS DENGUE, LEPTOSPIROSIS, AND LEISHMANIASIS IN SRI LANKA

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Abstract

Dengue, leptospirosis, and leishmaniasis are major climate-sensitive notifiable diseases in Sri Lanka. They are transmitted through mosquitoes, contaminated floodwater, and sandflies, respectively, and all have been linked to monsoon rainfall. Sri Lankan studies have applied distributed lag non-linear models (DLNM) to dengue and different methods to leptospirosis, but no study has applied a consistent framework across these diseases. Although Sri Lanka's Epidemiology Unit has begun introducing climate-informed early warning tools, it remains unclear which diseases are sufficiently climate-predictable to support their implementation. This study aimed to compare climate-response patterns and forecasting performance across these diseases using weekly district-level surveillance data (2019-2025) extracted from Weekly Epidemiological Reports, with leishmaniasis limited to five endemic districts, integrated with NASA POWER climate data and 2024 Census population estimates. Associations were modelled using negative binomial DLNM with rainfall lags of 0-4 weeks, adjusting for temperature, seasonality, trend, and district, with block-bootstrap significance tests accounting for autocorrelation. Forecasting was evaluated using rolling-origin holdout validation across 51 periods, up to eight weeks ahead, measuring the percentage reduction in mean root mean squared error against each district's historical average, and comparing models including recent case counts with and without climate terms. Dengue showed a hump-shaped response, peaking near 209 mm weekly rainfall (relative risk 2.90) before declining. Leptospirosis showed a monotonically increasing response with no observed upper threshold (relative risk 3.82), while leishmaniasis showed a weak response. Rainfall associations were significant for dengue ($p < 0.05$) and leptospirosis ($p < 0.001$), but not leishmaniasis. Recent case counts improved dengue forecasts by 18.9% (95% CI 4.7 - 34.4%), but climate data did not clearly improve forecasts for any disease. These findings show how dengue and leptospirosis respond to rainfall and that AI-enabled early warning systems in Sri Lanka should build on timely surveillance data, with climate inputs rigorously validated.

Keywords: Dengue, Leptospirosis, Leishmaniasis, Distributed lag non-linear model, Early warning systems