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Bayesian spatio-temporal disease nowcasting using parametric time-varying functions of cumulative reporting probability

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Accurate real-time tracking of infectious diseases is often challenged by reporting delays. Existing nowcasting methods typically struggle with three major limitations: they either (1) oversimplify complex reporting delays; (2) ignore spatial connections by treating regions separately; or (3) are too computationally expensive when handling detailed spatio-temporal data, making them impractical for real-time use.

To solve these issues, we propose a flexible Bayesian spatio-temporal framework that incorporates a delay adjustment structure, allowing the framework to adapt to changing reporting behaviors while effectively capturing spatial dependencies. To ensure this complex model is fast enough for real-time applications, we implement it via inlabru using a novel linear approximation strategy. This method significantly improves computational efficiency, enabling scalable inference without the speed bottlenecks of traditional MCMC methods.

We validate the framework by monitoring dengue in Brazilian states during 2025. Our model outperforms the baseline model in 22 out of 26 states (85\% win rate), successfully capturing rapid trend shifts and providing more precise estimates compared to existing systems.

Our findings demonstrate that combining detailed delay dynamics with a spatio-temporal structure effectively balances model flexibility with computational speed. This offers a robust, scalable solution for monitoring epidemics in diverse geographical regions.