Real-Time Estimation and Forecasting of COVID-19 Cases and Hospitalizations in Wisconsin HERC Regions for Public Health Decision Making Processes

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Purpose

- **The spread of the COVID-19 and surging number of cases across the United States have resulted in overtaxed healthcare systems.**
- **However, limited availability and questionable reliability of the data make outbreak prediction and resource planning difficult.**
- **Moreover, any estimates or forecasts are subject to high uncertainty and low accuracy when measuring such components.**
- **The aim of the study is to apply, assess, and automate a workflow for the real-time estimation and forecasting of COVID-19 cases and hospitalizations in Wisconsin HERC regions.**

Methods & Materials

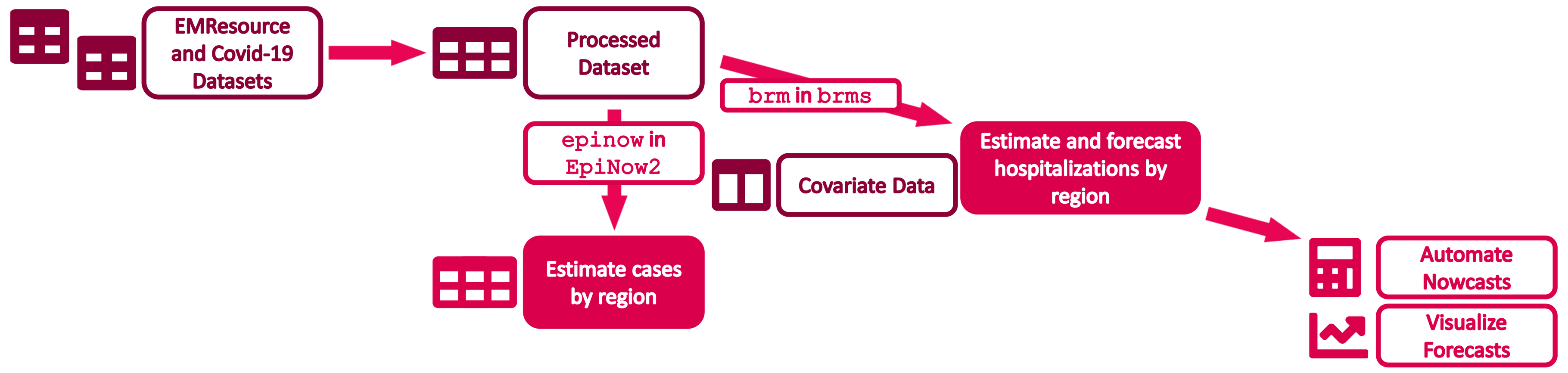

Figure 1. Workflow for estimating and forecasting cases and hospitalizations by Wisconsin HERC regions.

1. The EM Resources and COVID-19 Historical Data by County for Wisconsin datasets were used to estimate the cases and hospitalizations.
2. Positive cases were smoothed and adjusted for underreporting.
3. The time-varying effective reproduction number R_t and confirmed cases were estimated using a Bayesian latent variable model.
4. Hospitalization admissions were estimated using a Bayesian generalized non-linear multivariate multilevel model.
5. Assess forecasts at different time horizons (number of days into the future to forecast) via coverage probability (proportion of estimated values that are contained in the forecasted credible interval).
6. Automate for real-time estimation and forecasting via RStudio Connect

Results

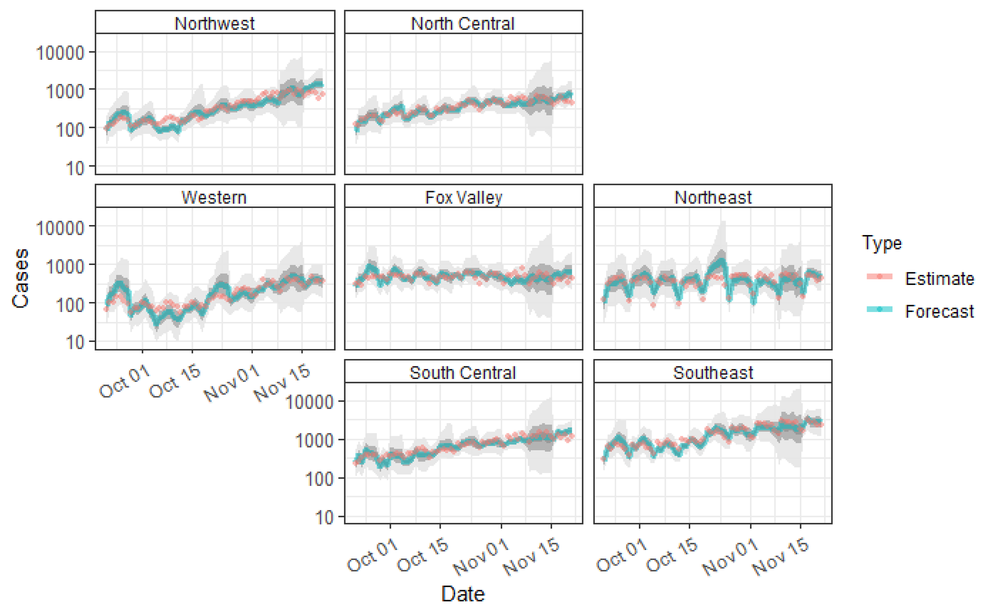

Figure 2. Geofacet of time series data for estimated and forecasted cases.
All three time horizons outperformed all three credible levels of the forecast. The 7-day period (20% CrI: 0.324, 50% CrI: 0.707, 90% CrI: 0.986) performed slightly better than both the 1-day period (20% CrI: 0.302, 50% CrI: 0.683, 90% CrI: 0.968) and the 3-day period (20% CrI: 0.302, 50% CrI: 0.677, 90% CrI: 0.979).

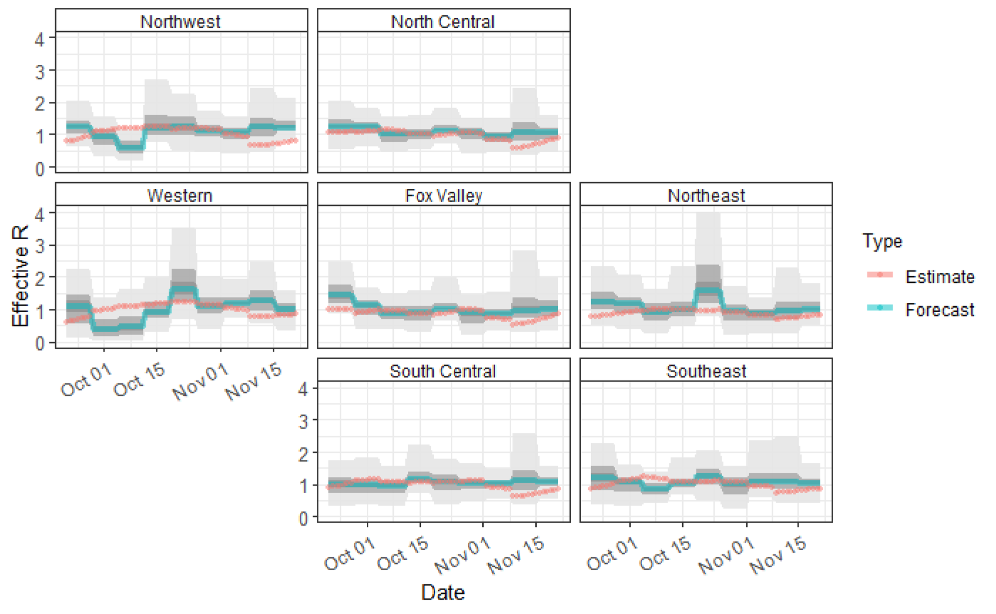

Figure 3. Geofacet of time series data for estimated and forecasted effective R_t.
All three time horizons outperformed all three credible levels of the forecast. The 7-day period (20% CrI: 0.263, 50% CrI: 0.705, 90% CrI: 0.970) overall performed slightly better than the 1-day period (20% CrI: 0.254, 50% CrI: 0.698, 90% CrI: 0.968) and 7-day period (20% CrI: 0.270, 50% CrI: 0.698, 90% CrI: 0.968).

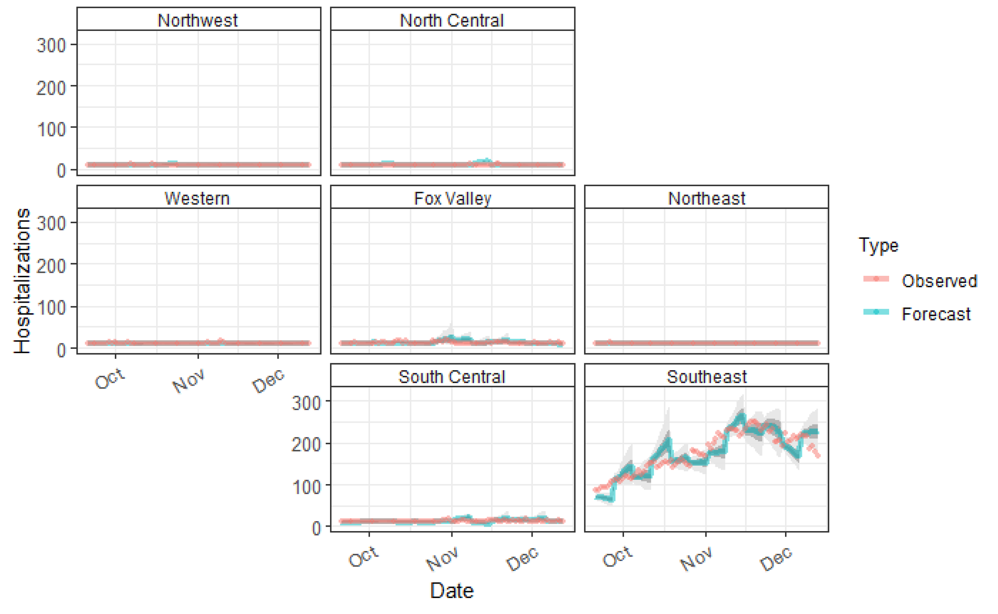

Figure 4. Geofacet of time series data for estimated and forecasted hospitalizations.
All three time horizons outperformed the 20% and 50% credible interval of the forecast. However, the 1-day and 3-day period underperformed the 90% credible interval. Only the 1-day period (20% CrI: 0.631, 50% CrI: 0.762, 90% CrI: 0.905) outperformed all three credible level of the forecast and performed considerably better than the 3-day period (20% CrI: 0.575, 50% CrI: 0.702, 90% CrI: 0.845) and 7-day period (20% CrI: 0.563, 50% CrI: 0.689, 90% CrI: 0.847).

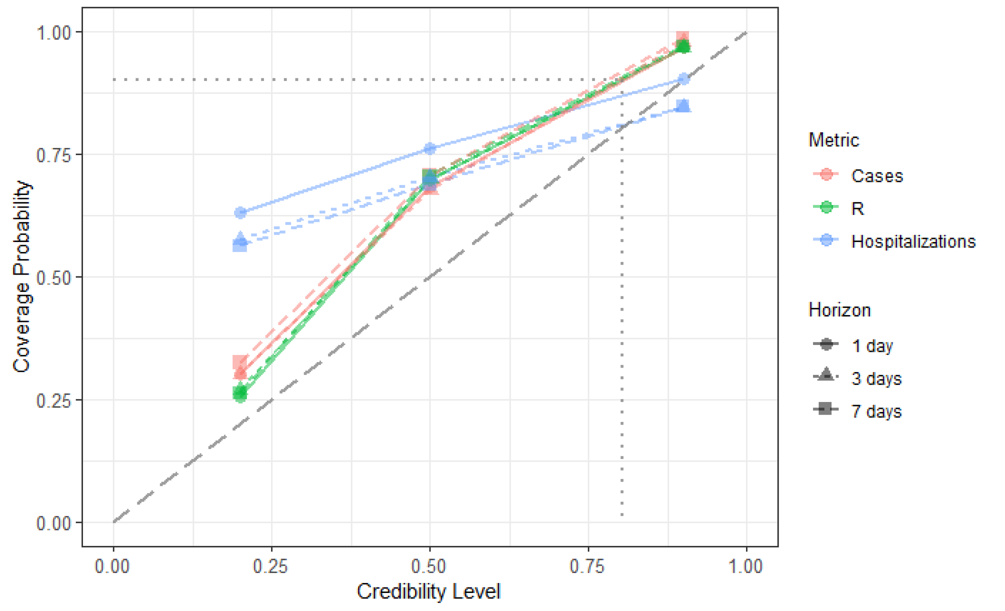

Figure 5. Coverage probability of time series data for estimated and forecasted cases, effective R_t, and hopitalizations.
The 20%, 50%, and 90% credible intervals underestimate the coverage probabilities for cases, R_t, and hospitalizations and 1-day, 3-day, and 7-day horizons except for two of the forecasts. The underestimation of the coverage probabilities by the credible intervals correspond to the data points above the dashed gray line.

Conclusions

- **The workflow was able to accurately forecast and estimate the uncertainty of the measurements.**
- **The models were able to infer short-term trends consistent with reported values at the HERC region level.**
- **All three credible intervals underestimated the coverage probabilities for all three metrics and at least one of the horizons.**
- **The uncertainty quantification should be reformulated as the frequentist coverage probability of the Bayesian credible interval to provide an accurate measurement.**
- **This study can help to elucidate which regions are most affected and which regions will encounter outbreaks as well as support decision making processes.**
- **This approach is updated daily for each region and implemented as a webpage: `https://data-viz.it.wisc.edu/cases-r-hosp-geofacet-wi-region/`.**

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