Covid-19 Modeling and Control via Policy Interventions

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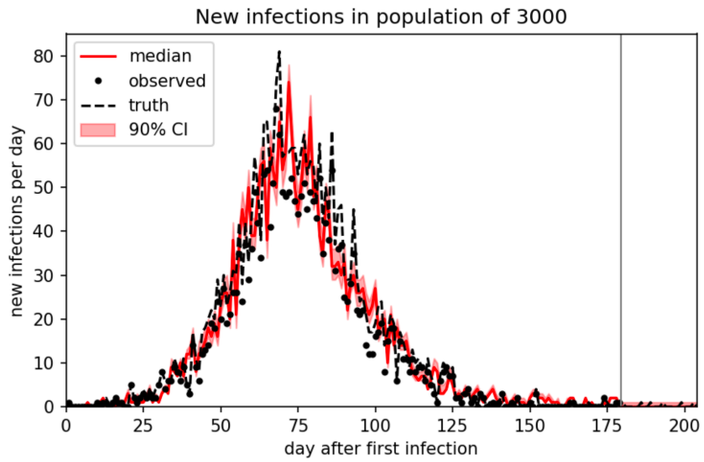
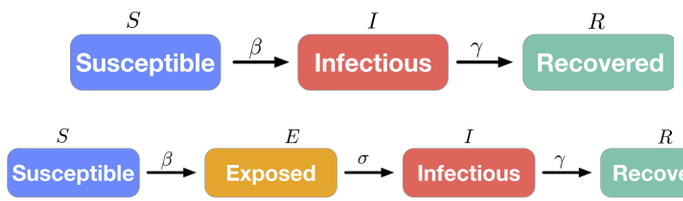
We demonstrate an approach to replicate and forecast the spread of the SARS-CoV-2 (COVID-19) pandemic using the toolkit of probabilistic programming languages (PPLs).

Compartmental Models

Our goal is to use compartmental disease models to study the impact of policy interventions enacted to limit the spread of infectious diseases. Using existing models we show how to use inference in PPLs to obtain posterior estimates for disease parameters.





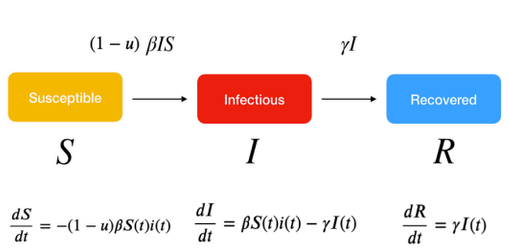
We then improve popular existing models to reflect practical considerations such as the under-reporting of the true number of COVID-19 cases and motivate the need to model policy interventions for real-world data. We design an SEI3RD model as a reusable template and demonstrate its flexibility in comparison to other models.

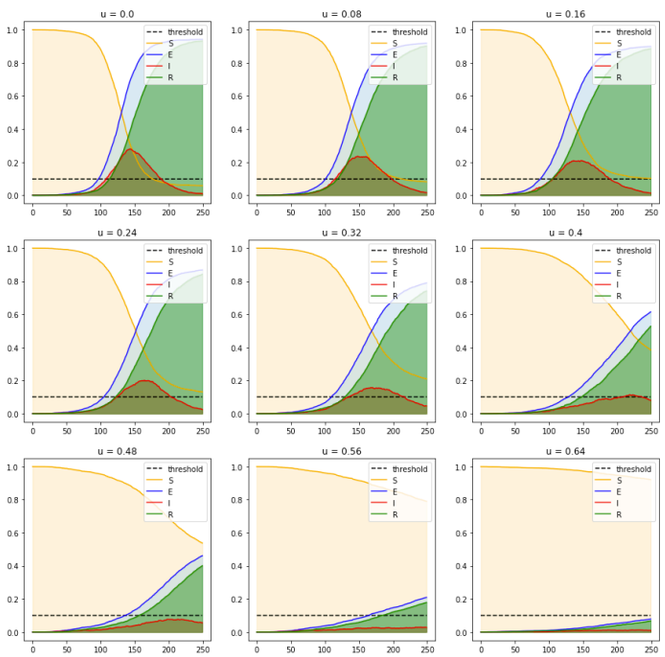
Contributions

- Improve compartmental models via the under-reporting of COVID-19 cases and decoupling non-pharmaceutical interventions from disease parameters.
- Evaluate our parameter estimates through empirical comparisons with those in prevalent literature, highlight the relative consistency of our predictions.
- Model fixed policy interventions and describe an algorithm to select adaptive policy interventions to aid government efforts to limit the spread of disease.
- Highlight the ease of using PPLs to design, extend, and fit SEI3RD models using approximate inference to obtain posterior disease parameter estimates

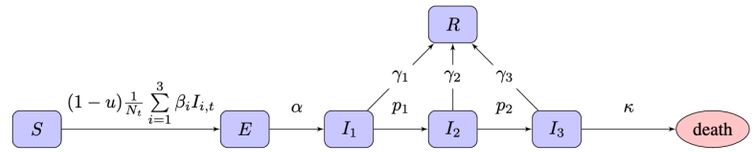
Policy Interventions

The use of surgical face masks and face shields by healthcare and non-healthcare workers alike has been shown to significantly reduce or prevent the transmission of human coronaviruses and influenza viruses through respiratory droplets from symptomatic individuals in confined spaces. This is an example of a type of intervention that falls into the class of NPIs which are important to model in light of the time it requires to implement substantial pharmaceutical interventions (PIs) such as vaccines. Our simulation, therefore, focuses on the modeling of NPIs, or policy interventions, to allow us to build world-models that are reflective of disease spread in the absence of effective PIs.

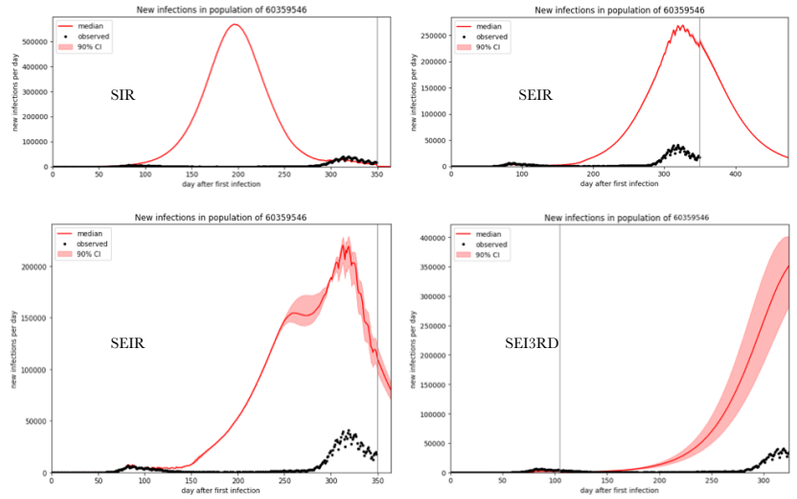




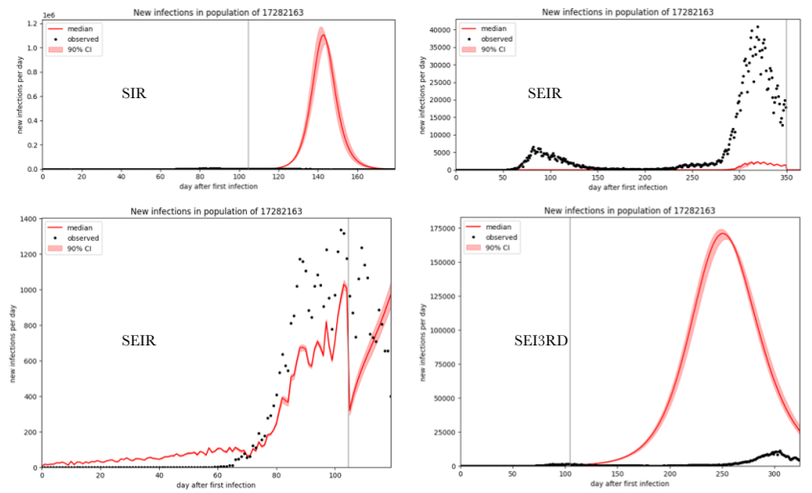
SEI3RD Model



Italy



Netherlands



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