Modelling COVID-19 Infection Dynamics and the Effectiveness of NPIs in Northern Ireland

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CP-ABM Methodology

- Combination of **Changepoint Detection** (CP) and **Agent-Based Modelling** (ABM) techniques for modelling COVID infection dynamics

- CP component is used to identify key non-pharmaceutical interventions (NPIs) that led to change in the contact behaviour of the population

- ABM component relies on the outputs from the CP component to adapt the behaviour of its agents to introduced NPIs
  - realistically simulates infection spread in the population
  - quantifies the effectiveness of introduced NPIs

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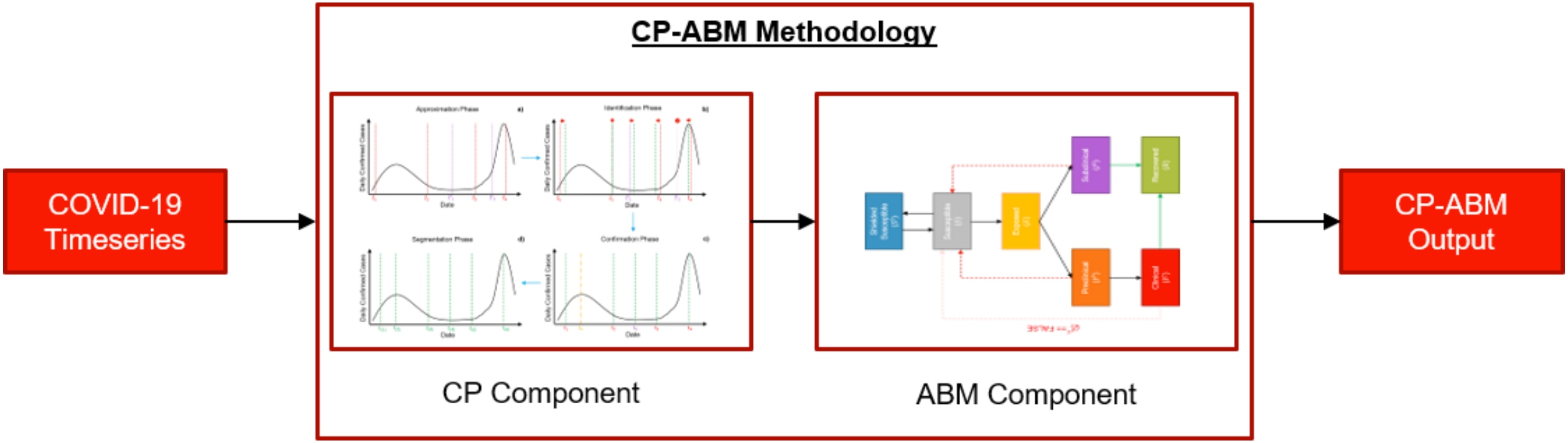
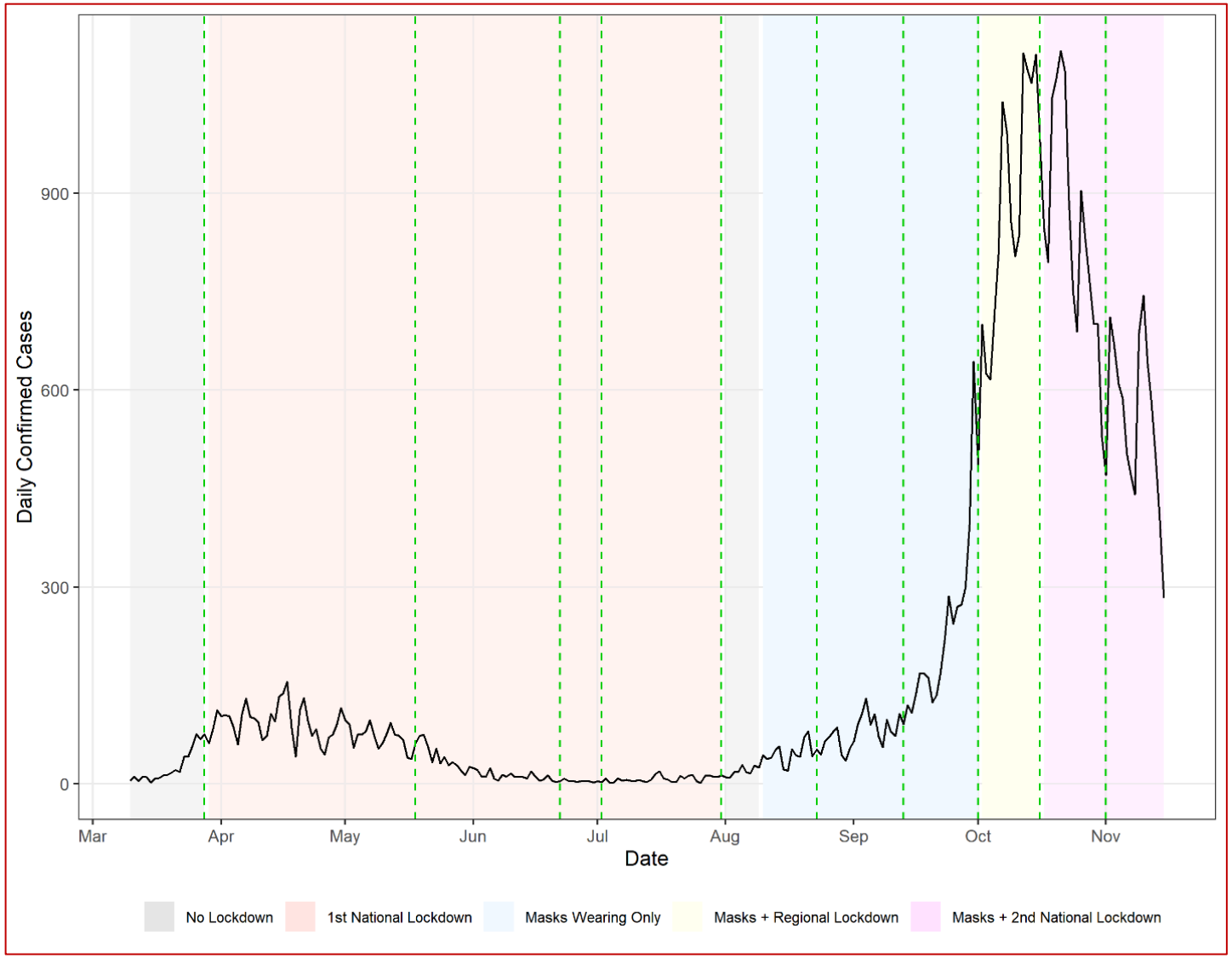
CP-ABM Methodology



Key NPIs Identified by Change points



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Infection Dynamics Simulation

The ABM Component consists of two types of entities:

- **Agents**
  - represents individuals in the population
  - assumes that the susceptibility to infection of the agent depends on their age
  - NI model consists of 1,893,667 agents that have age characteristics that exactly match the demographic projections for NI population for 2019, provided by NISRA.

- **Cells**
  - represent infection statuses (S, S^S, E, I^P, I^C, I^S, R)
  - one cell can contain multiple agents
  - one agent can be located only at one cell at the time and inherits infection status of the cell it is located at

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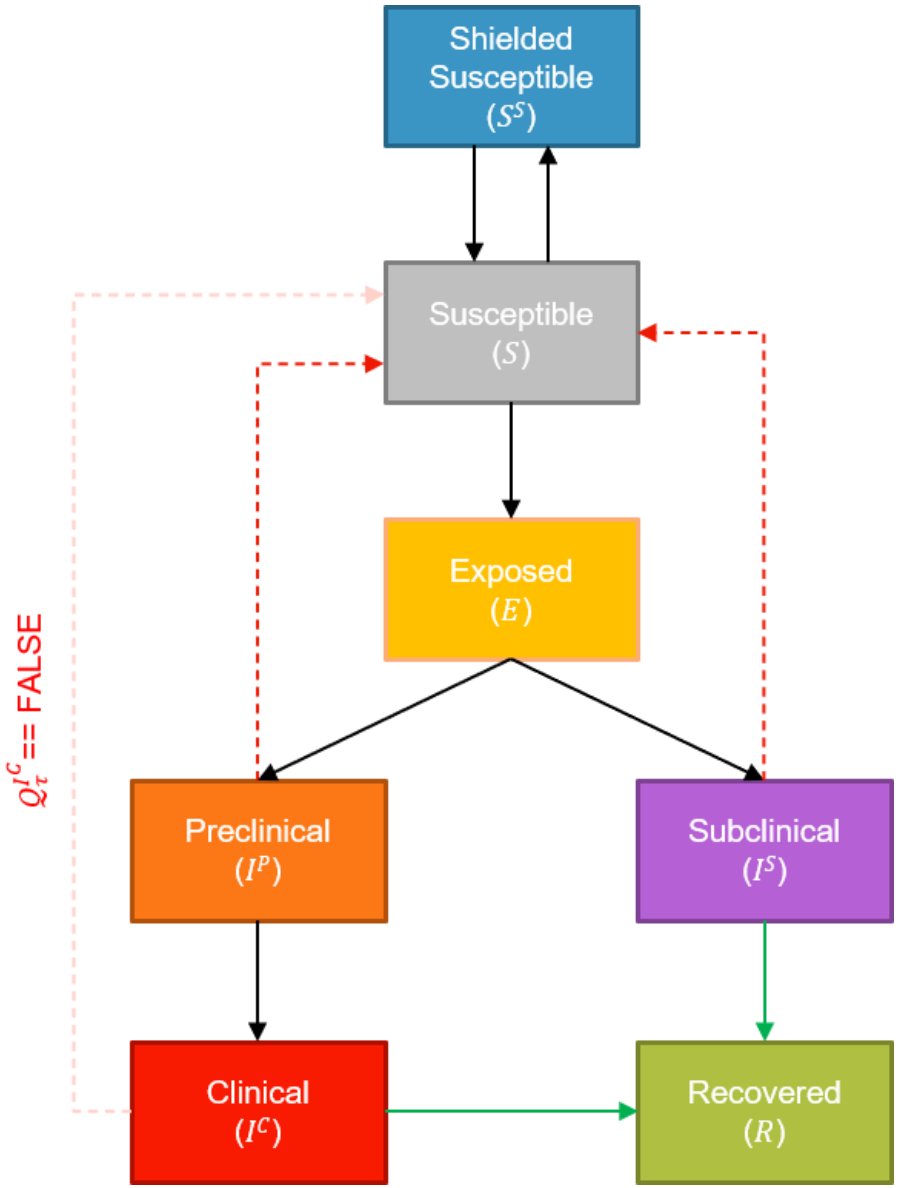
Infection Dynamics Simulation



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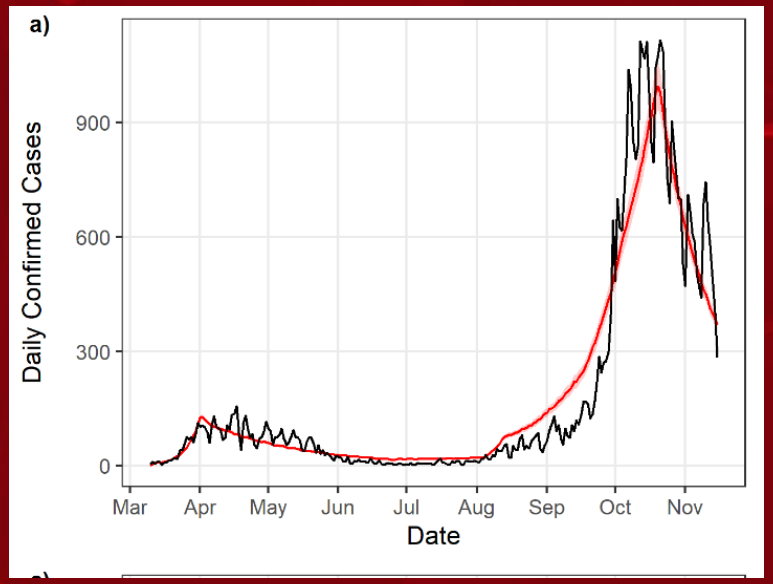
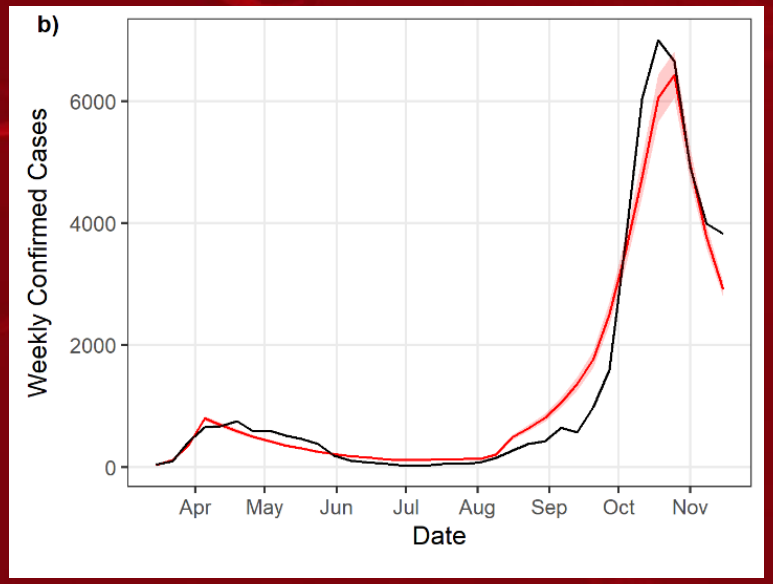
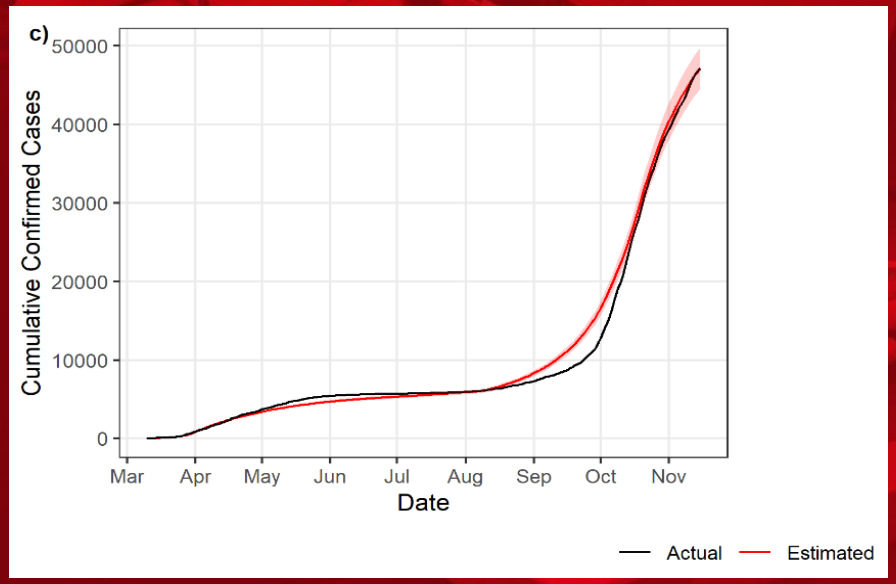
Demo time

Infection Dynamics Simulation







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Results

- CP-ABM is able to capture the COVID19 infection dynamics for NI over a 250 day time period capturing the first two waves of the pandemic.
- Quantified the effects of NPIs at a national level capturing the effects that wearing masks and one partial and two national lockdowns had on the virus spread reduction.
- Successfully estimates the role that subclinical (asymptomatic) patients have had on the spread of the virus.
- Proposed methodology is programming language agnostic and enables models that can run and calibrate on consumer grade hardware.
- Used for predicting future scenarios such as the return of schools.
- Used in NI to inform policy and government interventions.

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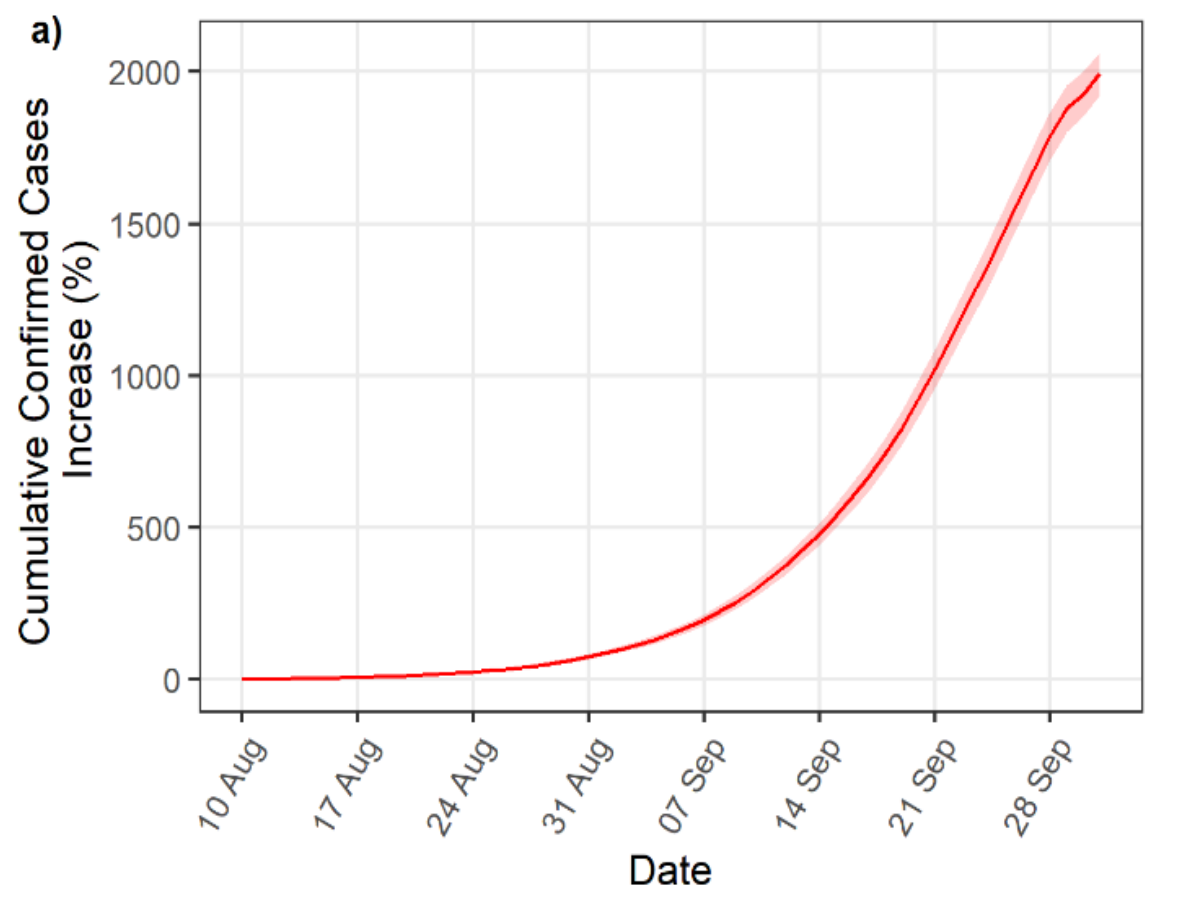
Impact of Wearing Masks



- In the period between the 10th August & 1st October only the wearing of masks was compulsory.
- Quantification of mask effectiveness was performed by simulating the scenario of no mandatory mask wearing and comparing the estimated new cases with actual data.
- Approximately a 46% increase in the number of reported cases the 19th day after mask wearing became mandatory.
- Agrees with Mitze et al. who suggest that after becoming compulsory, face masks reduce new cases by 45%.
- Additionally, cases would double after 24 days and triple after 30 days.

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T. Mitze, R. Kosfeld, J. Rode, K. Walde, Face masks considerably reduce COVID-19 cases in Germany, Proc. Natl. Acad. Sci. U. S. A. 117 (2020) 32293–32301. https://doi.org/10.1073/pnas.2015954117.

Further Work

- The model can be expanded to have the functionality to capture the number of agents on each cell and their interactions at each tick during simulations. This can be utilised in future work to consider the interaction between agents in different settings.

- Extended to evaluate scenarios for considering the impact of vaccines, new COVID-19 variants and detailed analysis of clusters dynamically changing over time.

- We demonstrated the CP-ABM capabilities through the implementation of the model on the NI population but the model is not unique to NI and therefore it can be applied to other countries and geographical areas (both large and small).

- The methodology is not COVID-19 specific and may be used as a basis for creating epidemiological models to capture infection dynamics properties and the assessment of the NPI effects of other diseases both in human and animal health.

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