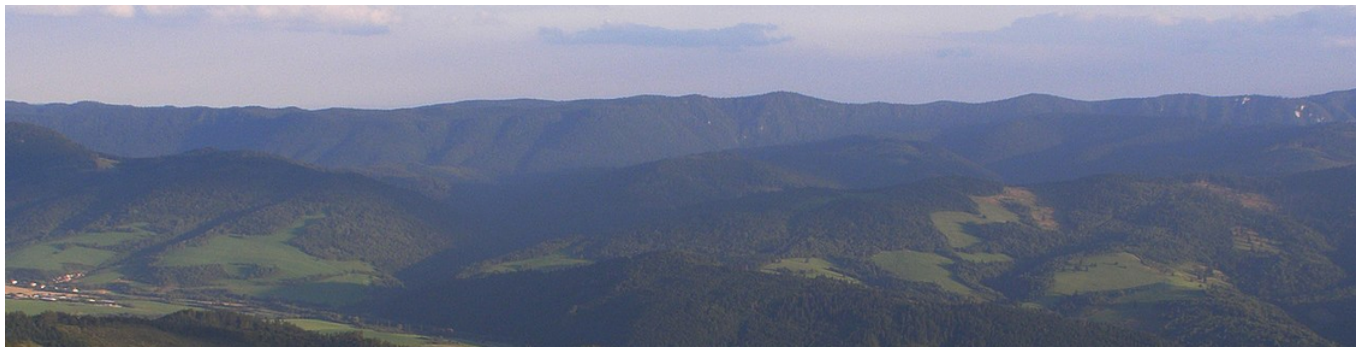
Simulation of non-pharmaceutical interventions in an agent based epidemic model

Petra Vidnerová, et al.

ÚI AV ČR & BISOP



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Data from PAQ and MEDIAN.

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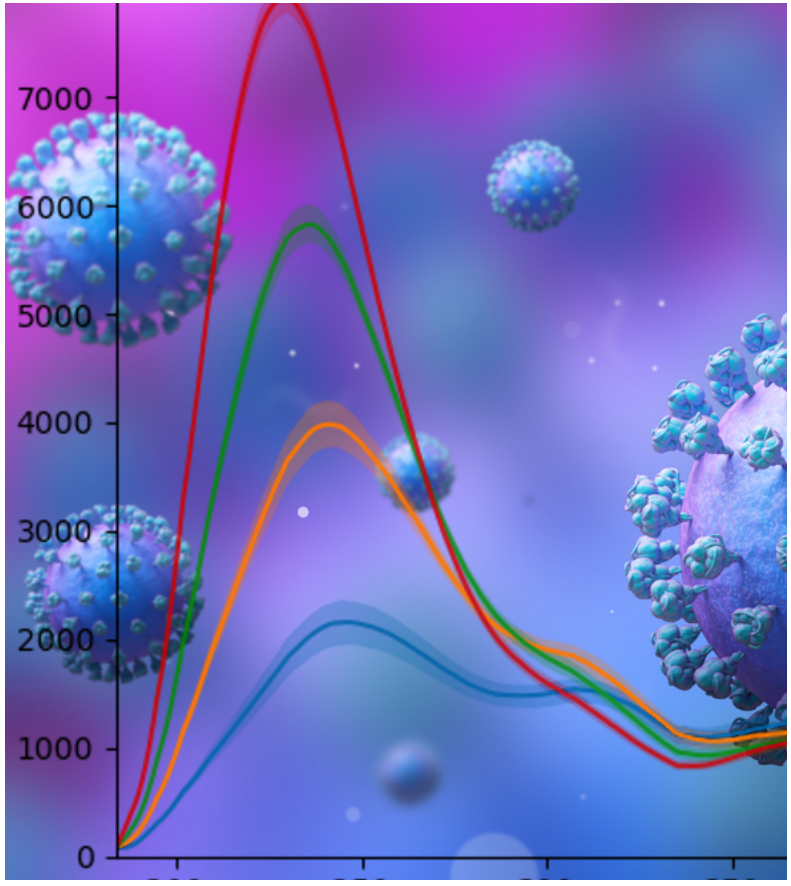


Introduction

Modelling

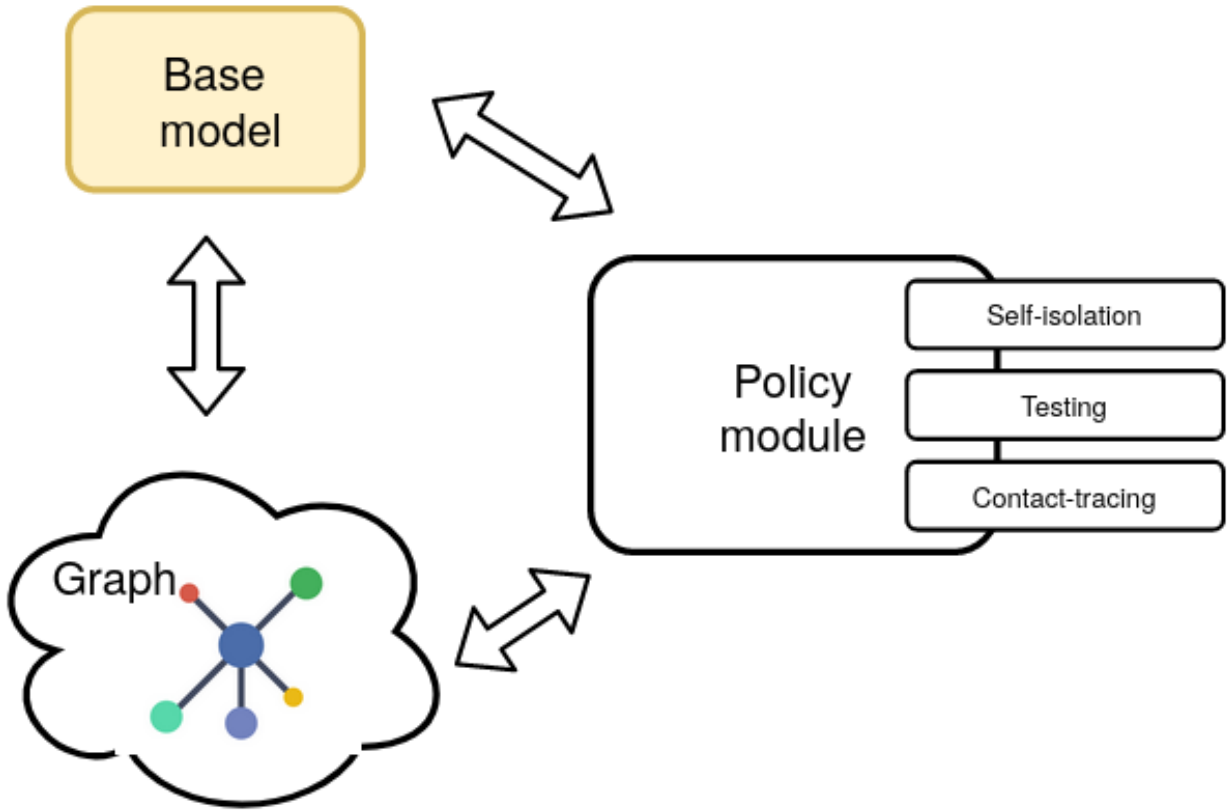
- Modelling is an important tool in epidemic control
- Non-pharmaceutical interventions slow down the spread of a virus
- Models has to reflect the interventions valid at the moment

Interventions

- Protective measures - masks, hygiene, distancing, cautiousness
- Contact restrictions
  - Flat closures - closed schools, pubs, shops, etc.
  - Individual - isolation, quarantine

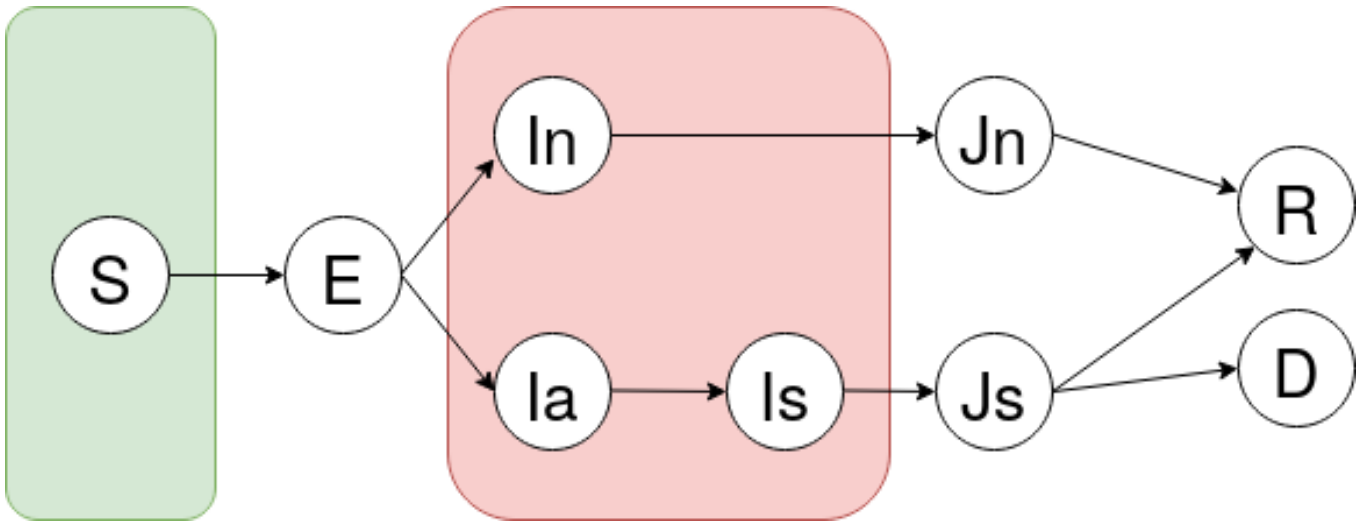
Model M

- Agent based model
- Uses a realistic contact graph
- Focus on comparing interventions (not on precise forecasting)

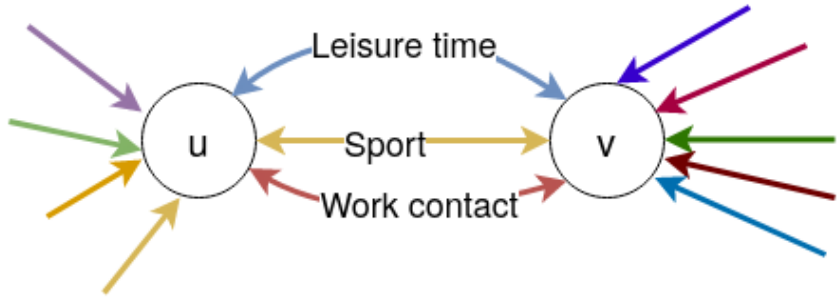


Model M - SEIR model

- Works with population of individuals
- Each individual is in exactly one of possible states
- Iterates on daily basis
- Transition $S \rightarrow E$ is given by β and contact graph
- Other transitions depends on parameters of the infection only



Model M - graph

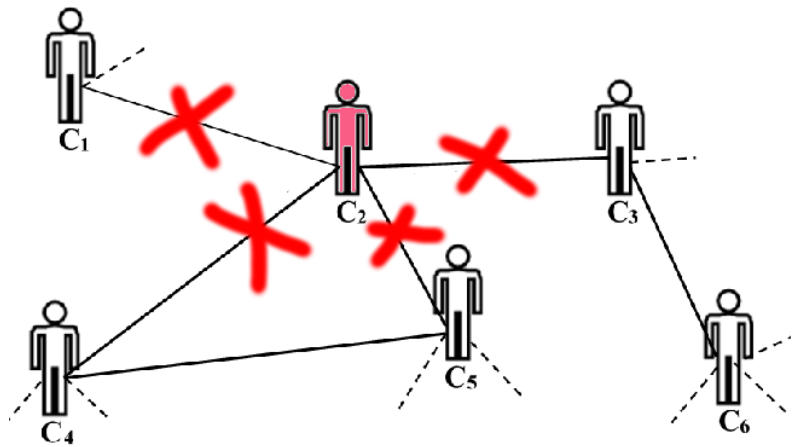


- Model of a real Czech county
- Multi-graph
- Edges organised in layers
- Edges parameters: contact probability p, intensity i a layer type l
- Each day an edge is activated with probability $w_l * p$ (w_l layer weight)
- Probability of infection transmission

$$p_{S \to E}(e) = \begin{cases} \beta * i & \text{if the edge is active} \\ 0 & \text{otherwise} \end{cases}$$

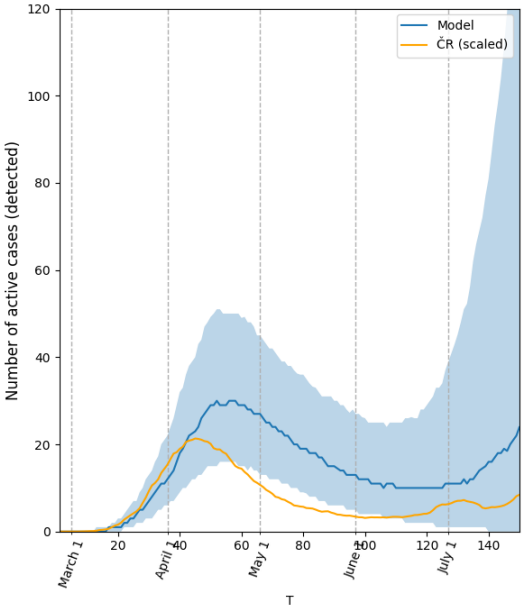
Model M - policy module

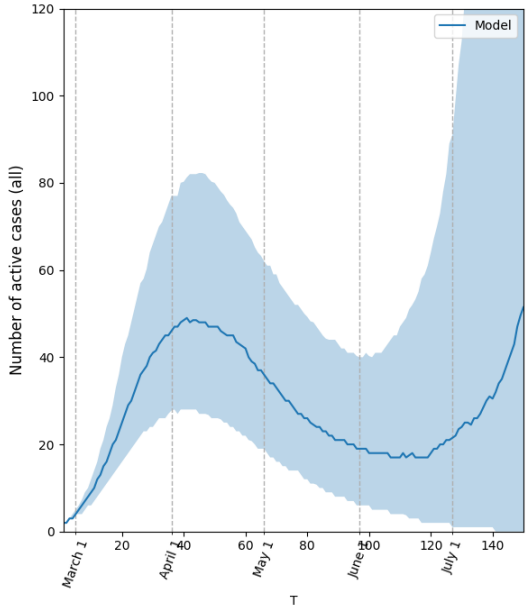
- Implements various interventions
- Controls and change model parameters
- Protective measures – reduction of β
- Flat contact restrictions
  - Switching off whole layers
- Individual isolation
  - Testing, self-isolation – individuals with symptoms
  - Contact tracing – different levels of contact tracing (family, school & work, leisure time, others)

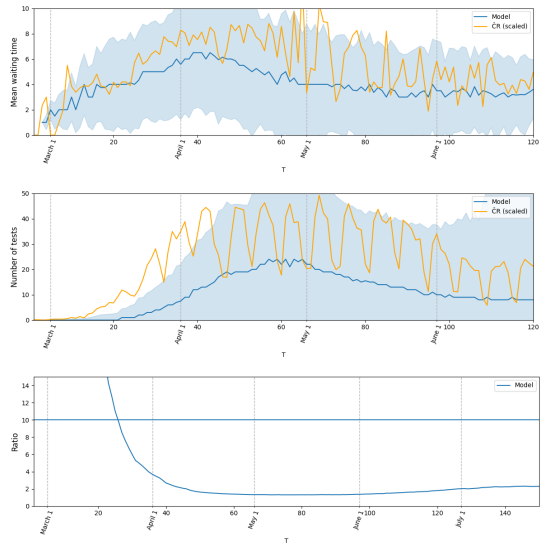


Examples of experiments

Calibration





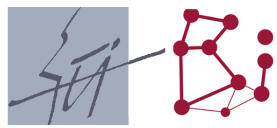


- Finding parameters to fit the history
- Using grid search and CMA-ES

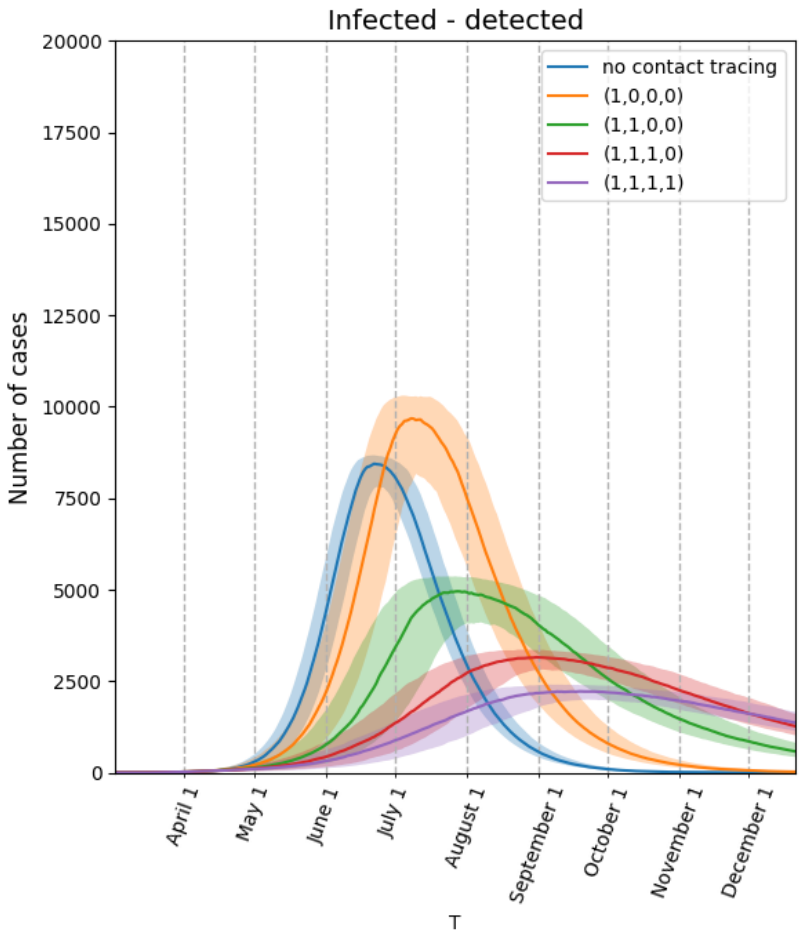
Examples of experiments

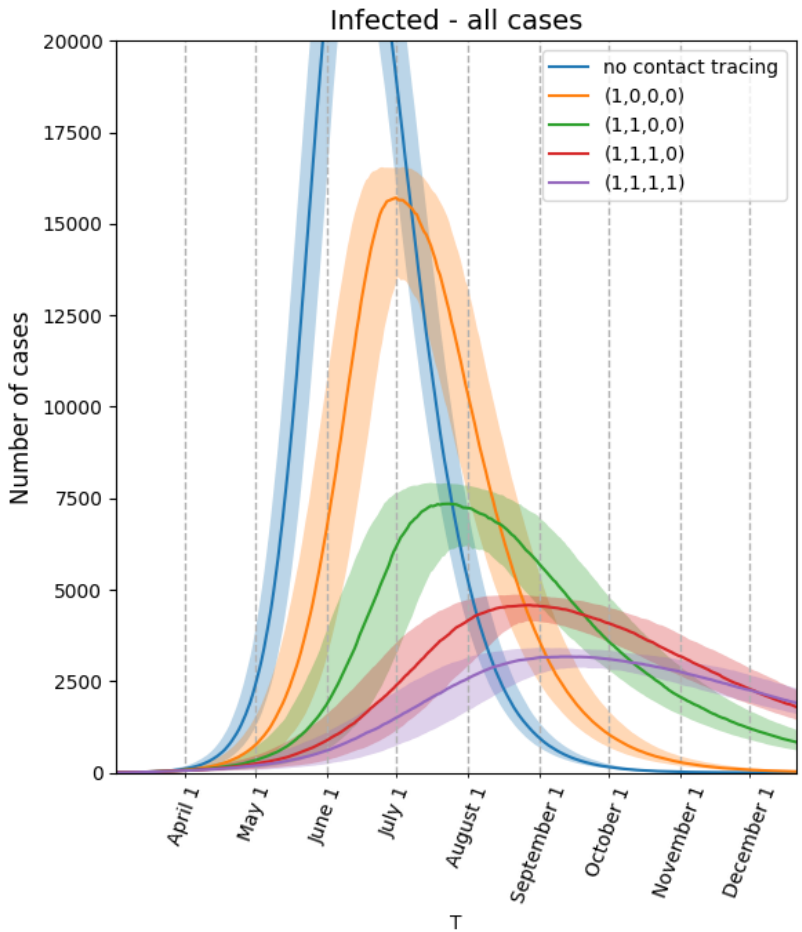
Experiment I

- Compare different levels of contact tracing – layers (family, school & work, leisure time, others)
- Two scenarios – with and without flat restrictions
- Flat restrictions corresponds to spring 2020 in the Czech Republic
- 1000 simulations for each setup (model is stochastic)
- Plotting medians and interquantile ranges

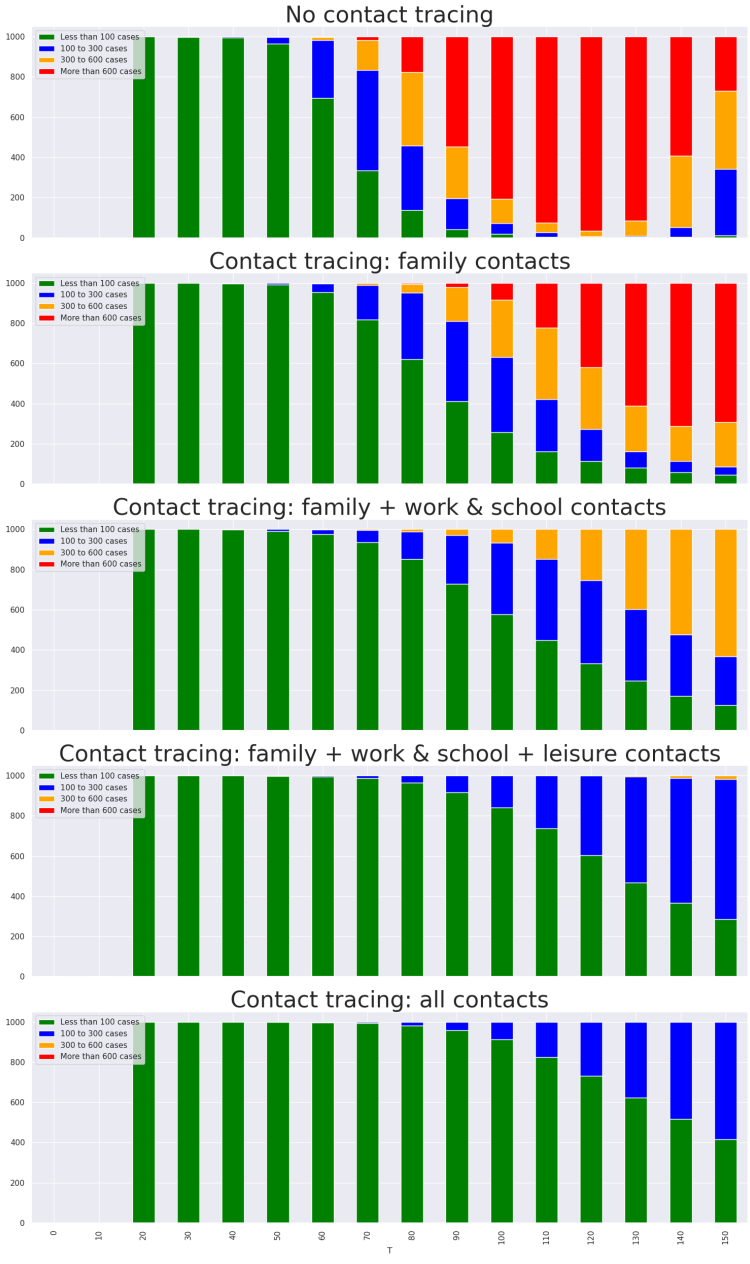


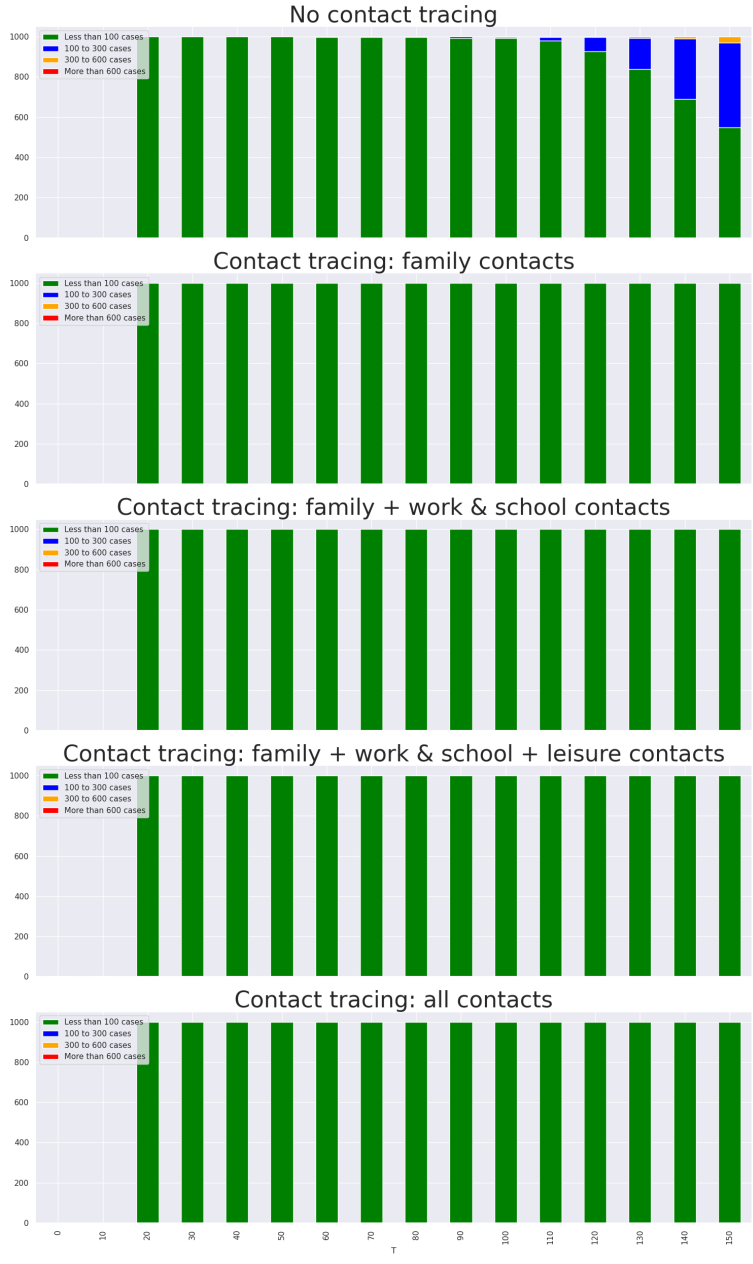
Different levels of contact tracing comparison





Distribution of individual simulation runs by epidemic level

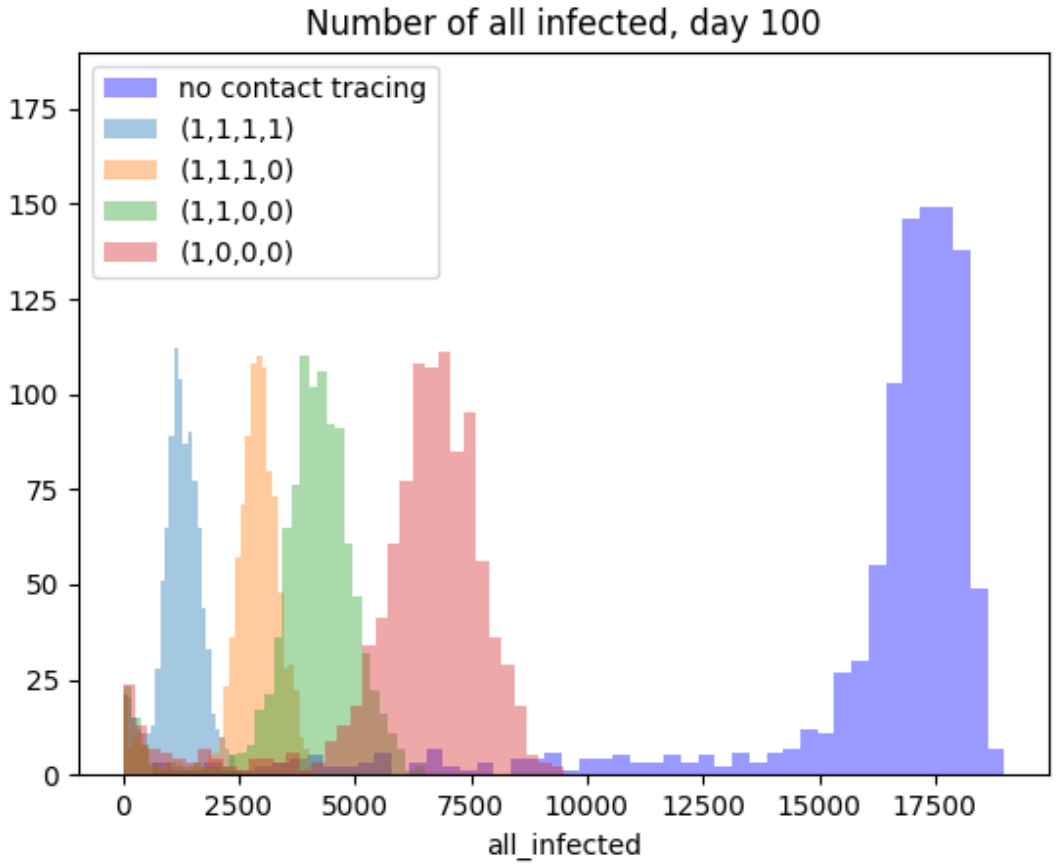




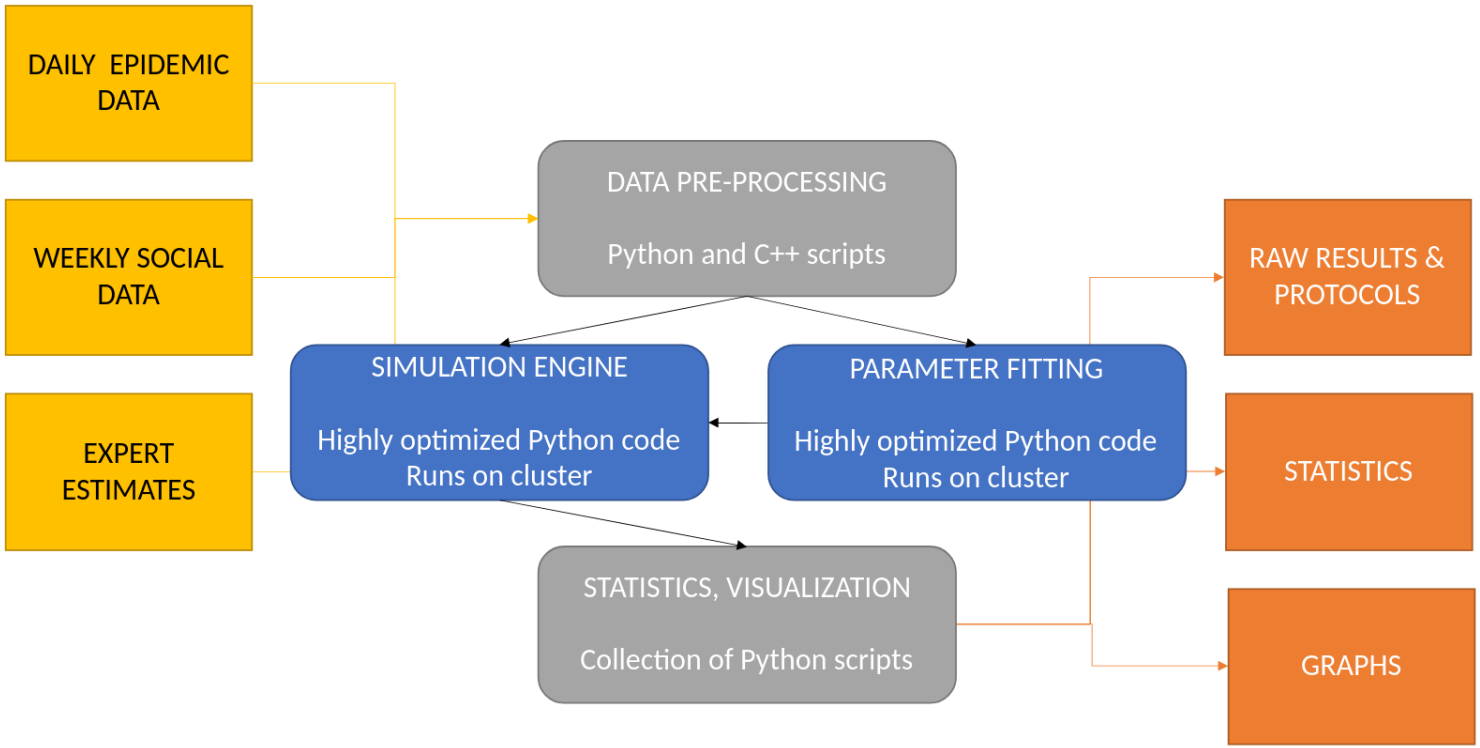
Histogram of simulation runs – scenario with a mass event

Experiment II

- A mass event
- Once a week
- 300 individuals
- 14 000 edges



Software



github.com/epicity-cz/model-m

(Release v1.0 available on September 30.)

Conclusion

Summary

- Agent based epidemic model with a realistic graph
- Enables simulation of various interventions
- High number of parameters – difficult to fit
- Modular and extendable (different graphs, vaccination, etc.)

Future work

- Export nodes (outside epidemic)
- Comparisons of simulations with our graph and with synthetic population

Thank you! Questions?