Modeling school closures across 35 countries

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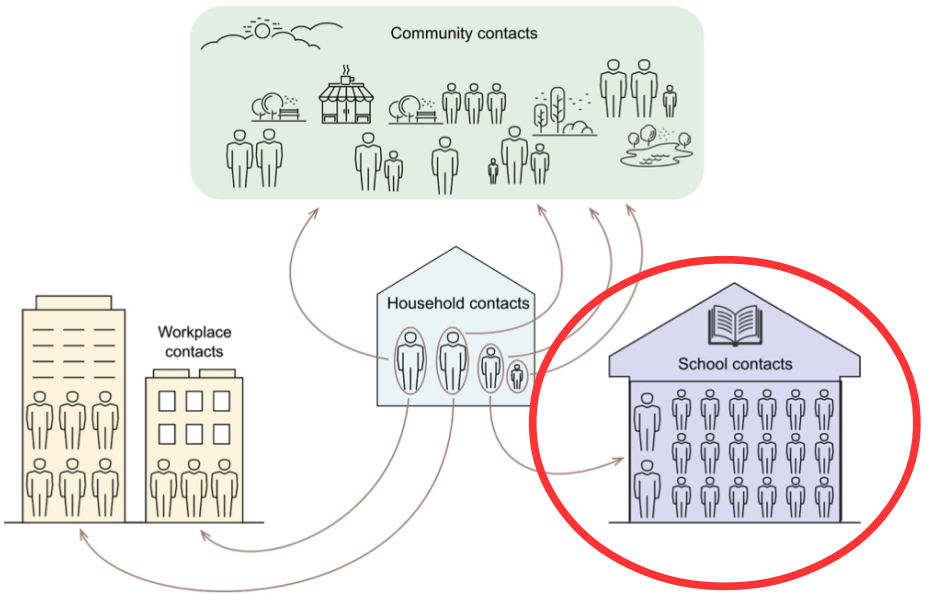
Introduction

- Query from Bill Hanage during July 31 meeting:
  - Contrast Finland vs Sweden interventions
- Generalize to:
  - Interventions at per-country level
  - Age-stratified non-pharmaceutical interventions
- Covasim applied to UK school closures [Panovska-Griffiths et al, The Lancet Child & Adolescent Health]
- Covid-19 Control Strategies List [Complexity Science Hub, Vienna]

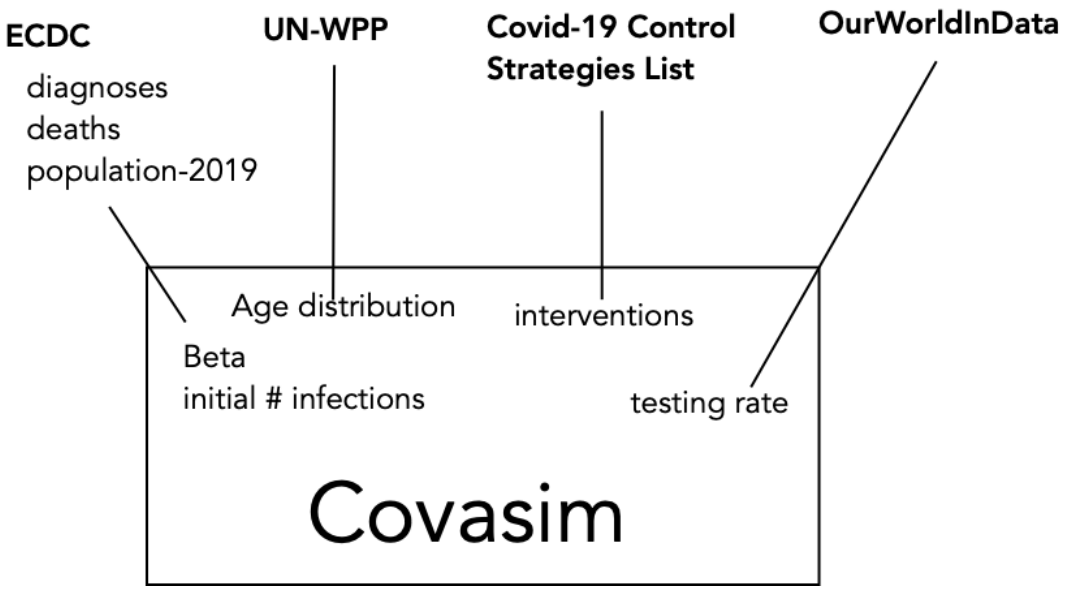
Covasim

- Cliff Kerr et al, Institute for Disease Modeling
- Agent (aka individual) -based modeling
- Compare/contrast with compartmental models (SEIR, etc)
- Modeling of fine-grained individual interactions within specific network “levels”
- Model parameter calibration via CMAES (Covariance Matrix Adaptation Evolution Strategy optimization, vs. TPE (Tree-structured Parzen Estimator)



Data sources

- ECDC
  - Population, number diagnosed, deaths
- OWID
  - Number of tests
- UN age distribution
- Covid-19 Control Strategies List
  - School closure interventions



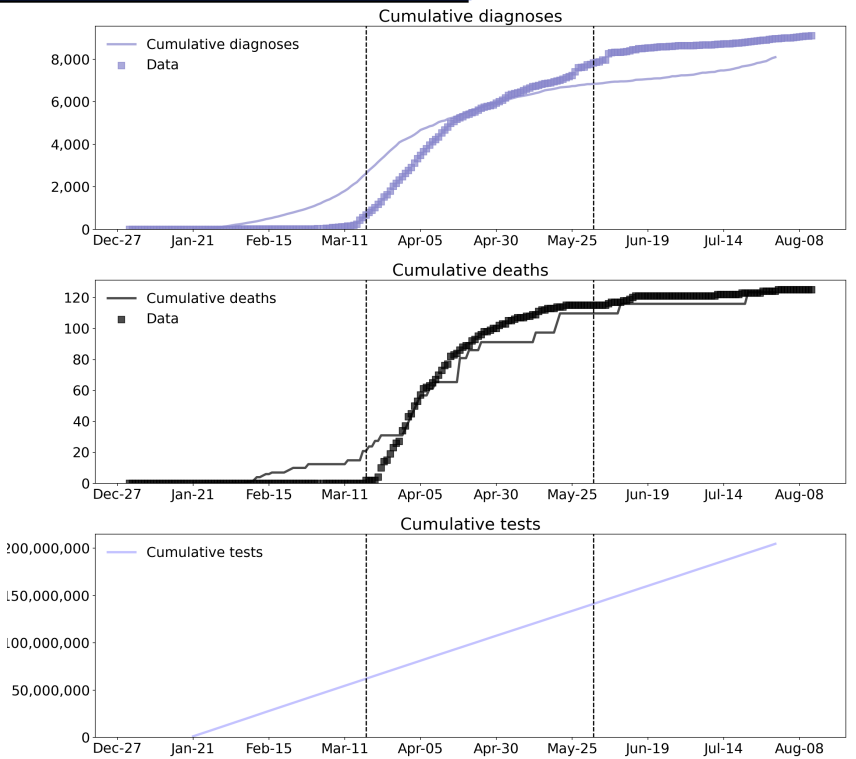
Modeling educational interventions

- Countries' school closures were captured for all educational level (kindergarten, primary, secondary, university) and treated as a separate, age-specific interventions in specific Covasim levels

CName	Date	Levels	CName	Date	Levels
Albania	03/08/20	k, p, s, u	Italy	03/05/20	k, p, s, u
Austria	03/16/20	u	Japan	03/02/20	p, s
Austria	03/18/20	k, p, s	Kazakhstan	04/06/20	p, s
Belgium	03/13/20	p, s	Kuwait	03/01/20	k, p, s, u
Switzerland	03/16/20	k, p, s, u	Lithuania	03/16/20	k, p, s, u
Czechia	03/11/20	u, p, s	Mexico	03/20/20	k, p, s, u
Czechia	04/20/20	u	North_Macedc	03/10/20	k, p, s, u
Germany	03/17/20	k, p, s	Mauritius	03/18/20	k, p, s, u
Denmark	03/13/20	u, s	Malaysia	03/18/20	k, p, s, u
Denmark	03/16/20	k, p	Netherlands	03/16/20	k, p, s
Ecuador	03/13/20	p, s	Norway	03/12/20	u, p, s
Ecuador	03/14/20	u	New_Zealand	03/25/20	k, p, s, u
Spain	03/17/20	k, p, s, u	Poland	03/11/20	k, p, s, u
Estonia	03/16/20	k, p, s, u	Portugal	03/12/20	k, p, s, u
Finland	03/18/20	u, p, s	Romania	03/11/20	k, p, s
France	03/16/20	u, p, k, s	Romania	05/15/20	u
Ghana	03/16/20	k, p, s, u	Senegal	03/16/20	k, p, s, u
Greece	03/10/20	k, p, s, u	Singapore	04/08/20	k, p, s
Honduras	03/12/20	k, p, s, u	El_Salvador	03/11/20	k, p, s, u
Croatia	03/13/20	k, p, s, u	Serbia	03/15/20	k, p, s, u
Hungary	03/12/20	u	Slovakia	03/12/20	k, p, s, u
Hungary	03/16/20	p, s	Syria	03/14/20	k, p, s, u
India	03/16/20	k, p, s, u	Taiwan	02/02/20	k, p, s
Ireland	03/12/20	k, p, s, u	Taiwan	02/03/20	u

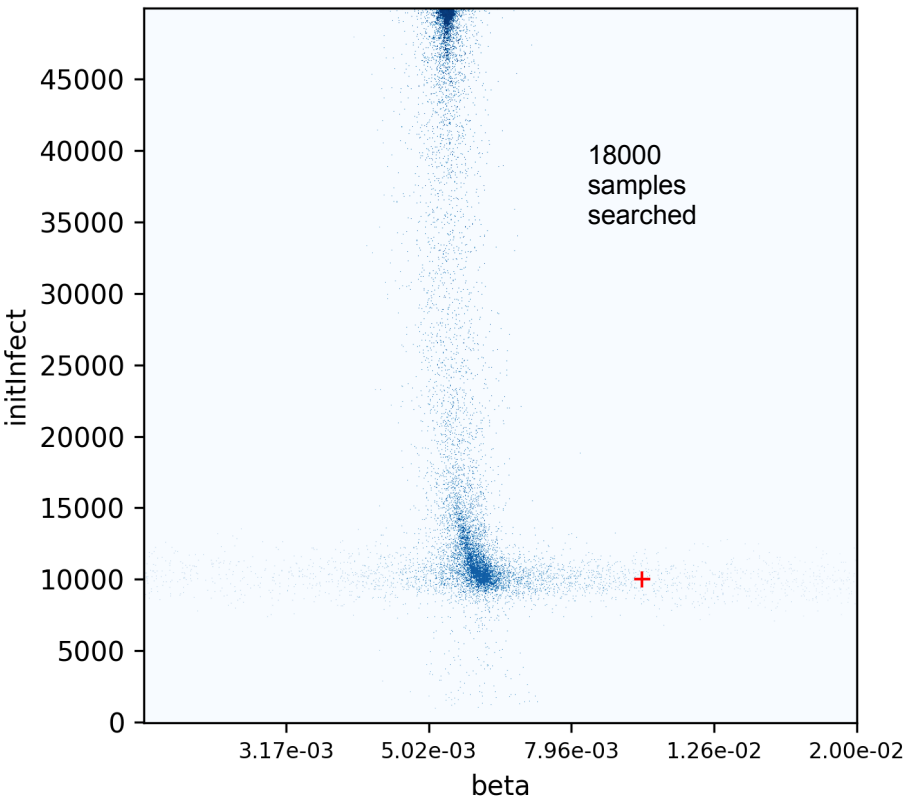
Validating model against data

- Covasim model specified:
  - Age-specific interactions across network levels
  - interventions over these
- the goal becomes to best fit available data, varying key model parameters
- Multi-criterial: Matching diagnoses *and* deaths *and* numbers of tests



Searching for model parameters

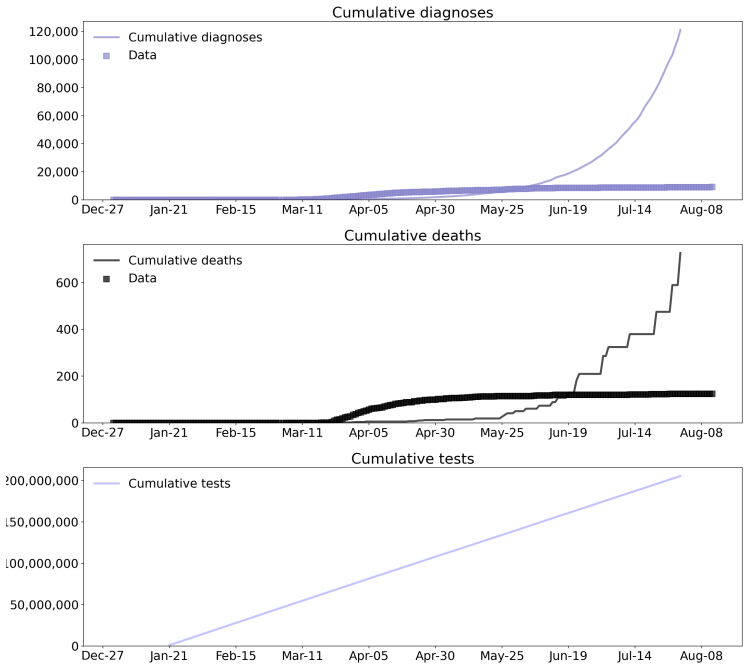
- *Number of initial infections* and baseline *beta* are free parameters
- EG: Austria has multiple solution “attractors”
  - CMA-focused sampling
- Testing rate can also be searched for, vs. using data



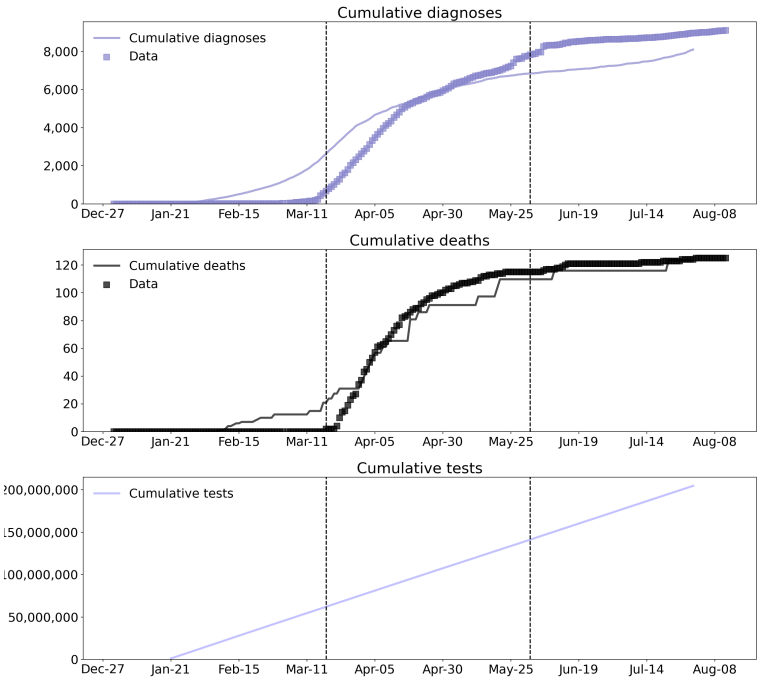
Results

Malaysia

No interventions

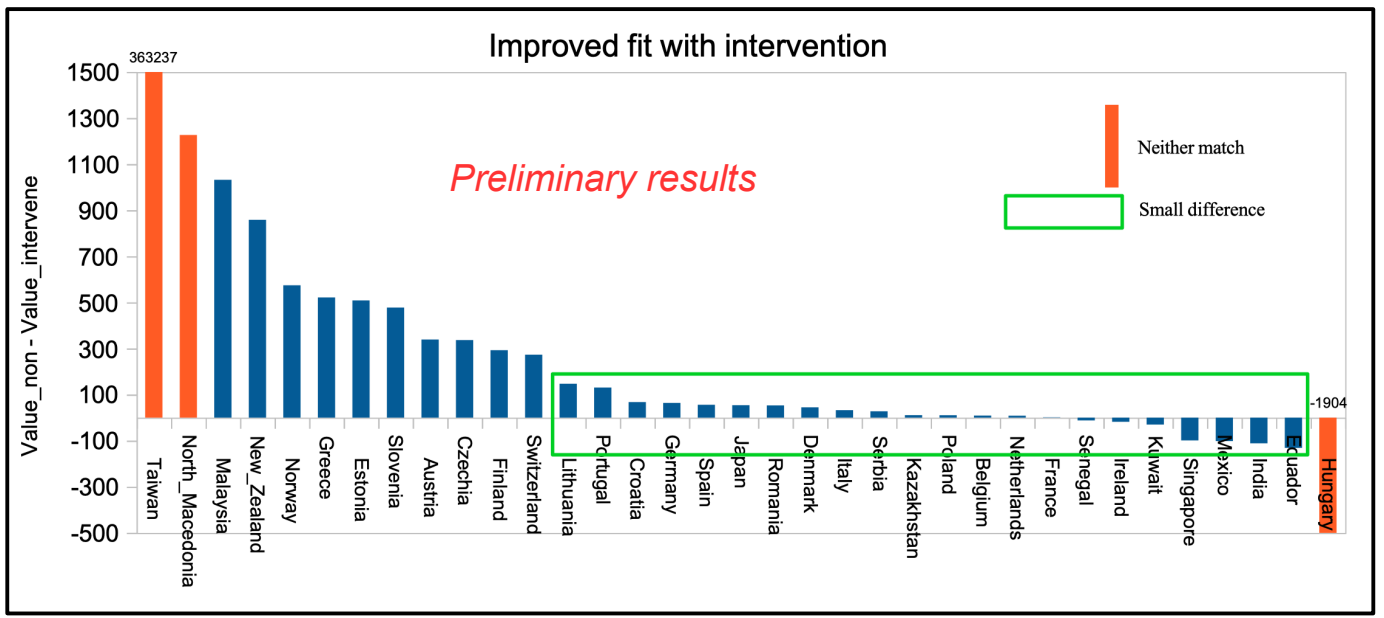


Interventions modeled



Results(2)

- Incorporating the intervention generally improves model fit
- But results for different countries' models varied



Scientific sharing, publishing and open source models

- The expressive power of agent-based models allows evaluation of many intervention strategies
- Open source modeling systems like Covasim allow independent model components to be investigated and incorporated separately
- The publishing of full model implementation, like that included with the [Panovska-Griffiths] publication is an excellent example
- Fast-paced scientific sharing like that demanded by COVID-19 is catalyzed by such interactions

References

- Covasim
  - https://www.medrxiv.org/content/early/2020/05/15/2020.05.10.20097469
  - https://github.com/InstituteforDiseaseModeling/covasim
- Panovska-Griffiths, J.; Kerr, C. C.; Stuart, R. M.; Mistry, D.; Klein, D. J.; Viner, R. M.; Bonell, C. Determining the optimal strategy for reopening schools, the impact of test and trace interventions, and the risk of occurrence of a second COVID-19 epidemic wave in the UK: a modelling study. *The Lancet Child & Adolescent Health*
  - https://github.com/Jasminapg/Covid-19-Analysis
- Desvars-Larrive, A. et al. A structured open dataset of government interventions in response to COVID-19.
  - https://www.medrxiv.org/content/early/2020/05/08/2020.05.04.20090498
  - https://github.com/amel-github/covid19-interventionmeasures
- Comments, questions: rbelew@ucsd.edu
  - https://github.com/rbelew/cvsim