Pandemic Preparedness

the need for better data from a modelling perspective

Prof. Dr. Niel Hens

www.uhasselt.be/dsi-covid19
www.socialcontactdata.org
www.simid.be
www.infectieradar.be
covid-en-wetenschap.github.io

HELICON & AHEAD Webinar
Data needs during the COVID-19 crisis
27 April 2022

SIMID
Simulation Models of Infectious Diseases

Overview

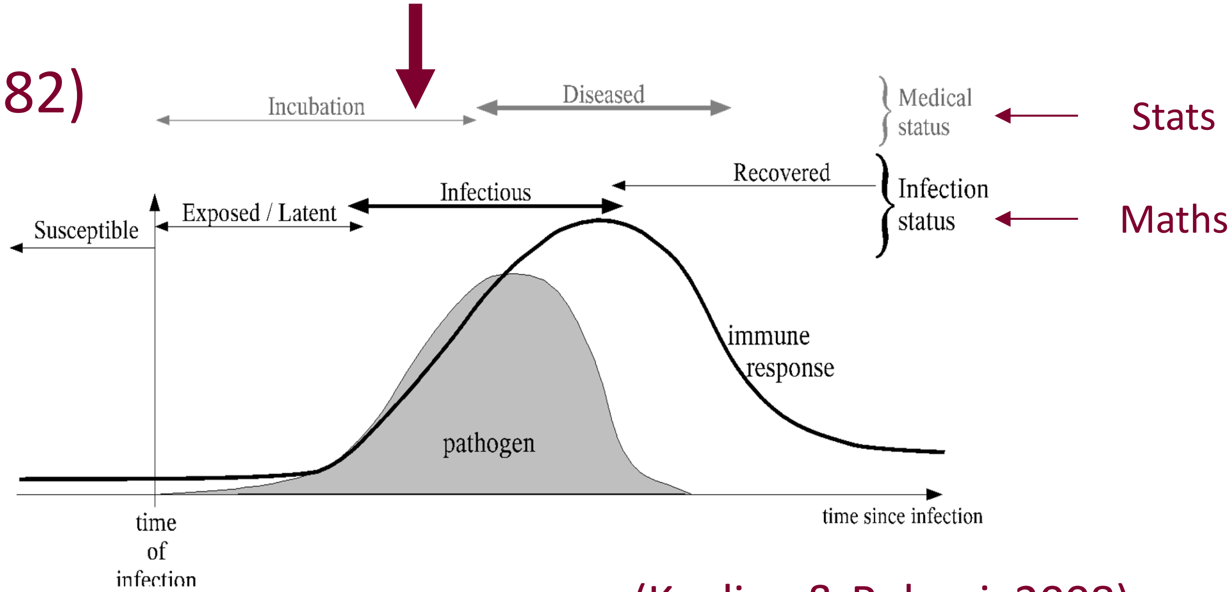
- Background
- Data needs
- Data challenges
- Mathematical modelling
- Lessons learned
- Discussion

Background

Daniel Bernoulli (1700 – 1782)

math model of smallpox

(1760-1766)



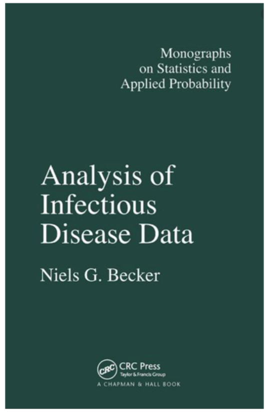
(Keeling & Rohani, 2008)

Mathematical epidemiology

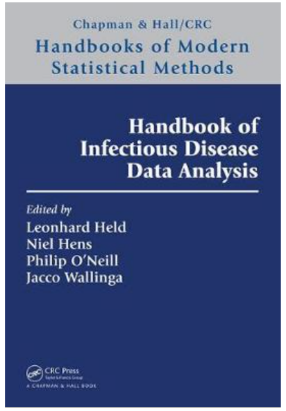
- understanding of disease transmision
- forecasting scenarios
- trade-off between accuracy, transparancy and flexibility

data driven

validation



Becker (1989)



Held et al. (2019)

Data-driven

Evidence-based

Past pandemics

- A(H1N1)pdm2009
- Ebola in West-Africa
- Zika

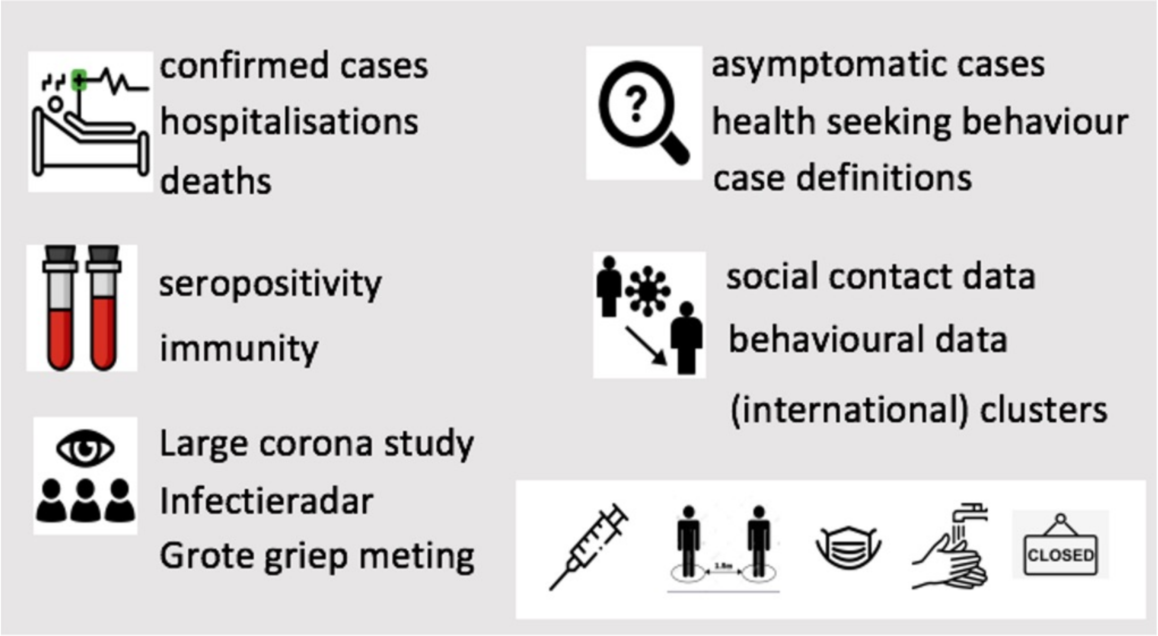
SARS-CoV-2 pandemic

- data sharing has greatly improved
- outstanding challenges

Pathogen X

- identification of data needs

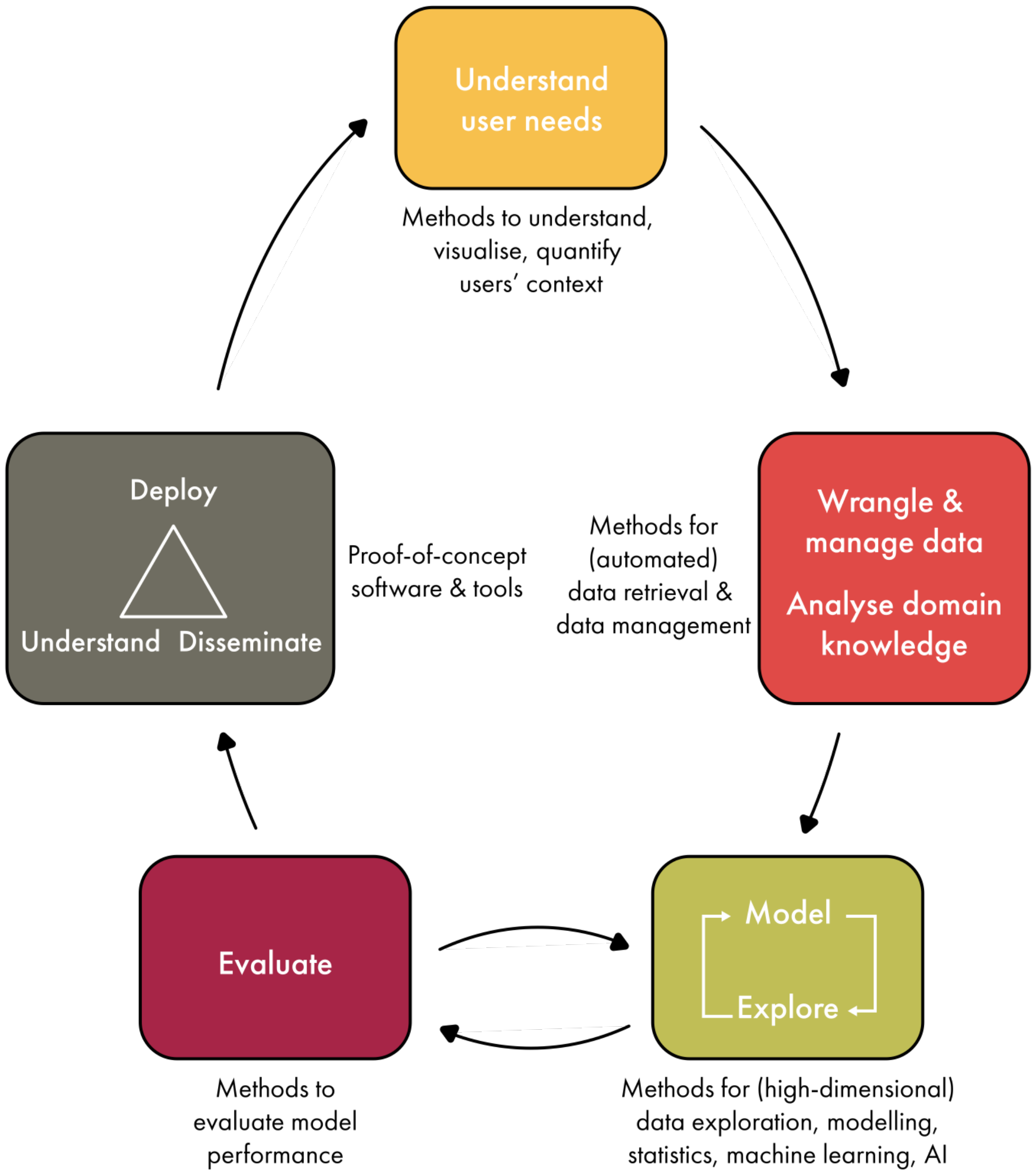
Data for BE included (not limited to):



Data Science Cycle

Data Science Institute @UHasselt

- infectious disease epidemiology as a specific case



Data needs: SARS-CoV-2

	Invasion (outbreaks)	Exponential growth	The dance	Control	Endemicity
Models	Branching processes	Renewal equation	Mathematical models (SIR, etc)	Next generation approaches (modified) herd immunity	Heterogeneity in susceptibility
Data	Well documented data on transmission chains	Incidence data (related to diagnostic testing strategies) with identification of a/symptomatic incidence	Surveillance data including(a)symp incidence, hospitalisation, genomic data Serological data Mobility & social contact data	Risk-group specific data Vaccination data (coverage, VEx) Serological data	Surveillance data as well as cohort-specific studies monitoring immunity
Management & policy	Characterisation of the disease and its transmission routes	Data on burden (hospitalisation, mortality, …)	Data on perception, adherence, mental health	Early-warning indicators – sewage data, syndromic surveillance	Multi-pathogen data

Data needs

Need for baseline data

- example: contact data

Need for realtime data

- example: serial intervals

Need for (rapid) cohort data

- example: immunological profiles

Need for population-based data

- example: serological data

Need for cost-effectiveness analysis of data streams

- example: genomic data

Need for specific protocols for infectious disease studies

- example: vaccine studies

…

Data challenges

Governance

- fragmented data landscape
- different regulatory frameworks for sharing public health data
- several issues with re-using privately held data (mobile phone data)

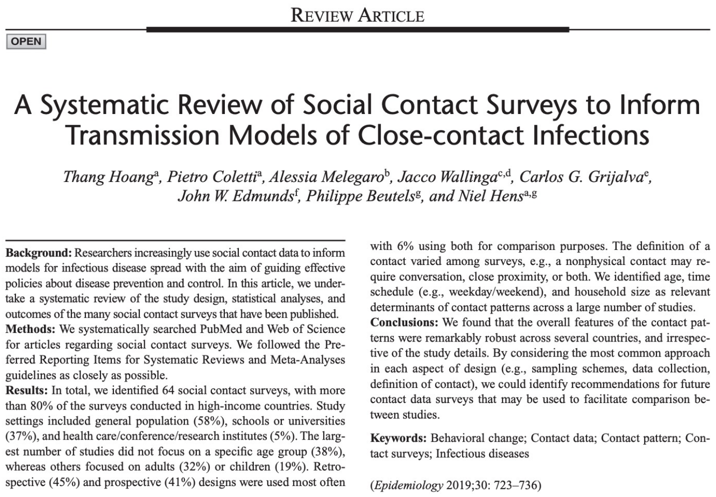
Open data

- open data as much as possible
- according to FAIR principles

(partial sollutions)

- synthetic data
- increased trust and pre-agreement on data access conditions

Example CoMix


Review Article

OPEN

A Systematic Review of Social Contact Surveys to Inform Transmission Models of Close-contact Infections

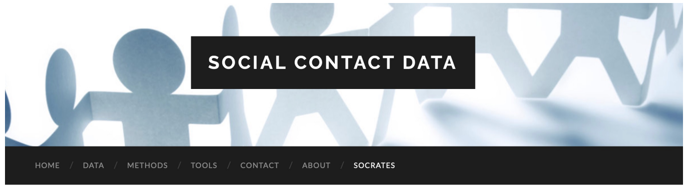
Thang Hoang[a], Pietro Coletti[a], Alessia Melegaro[b], Jacco Wallinga[c,d], Carlos G. Grijalva[e], John W. Edmunds[f], Philippe Beutels[g], and Niel Hens[a,g]

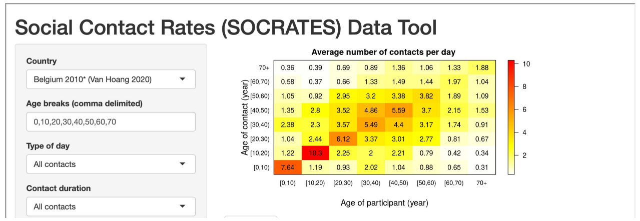
Background: Researchers increasingly use social contact data to inform models for infectious disease spread with the aim of guiding effective policies about disease prevention and control. In this article, we undertake a systematic review of the study design, statistical analyses, and outcomes of the many social contact surveys that have been published.
Methods: We systematically searched PubMed and Web of Science for articles regarding social contact surveys. We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines as closely as possible.
Results: In total, we identified 64 social contact surveys, with more than 80% of the surveys conducted in high-income countries. Study settings included general population (58%), schools or universities (37%), and health care/conference/research institutes (5%). The largest number of studies did not focus on a specific age group (38%), whereas others focused on adults (32%) or children (19%). Retrospective (45%) and prospective (41%) designs were used most often with 6% using both for comparison purposes. The definition of a contact varied among surveys, e.g., a nonphysical contact may require conversation, close proximity, or both. We identified age, time schedule (e.g., weekday/weekend), and household size as relevant determinants of contact patterns across a large number of studies.
Conclusions: We found that the overall features of the contact patterns were remarkably robust across several countries, and irrespective of the study details. By considering the most common approach in each aspect of design (e.g., sampling schemes, data collection, definition of contact), we could identify recommendations for future contact data surveys that may be used to facilitate comparison between studies.

Keywords: Behavioral change; Contact data; Contact pattern; Contact surveys; Infectious diseases

(*Epidemiology* 2019;30: 723–736)

(Hoang et al., Epi, 2019)





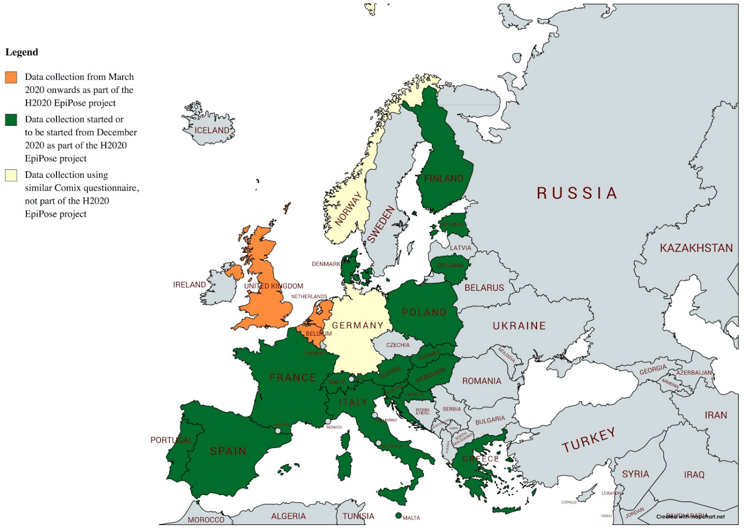
(Willem et al., 2020)

← POLYMOD

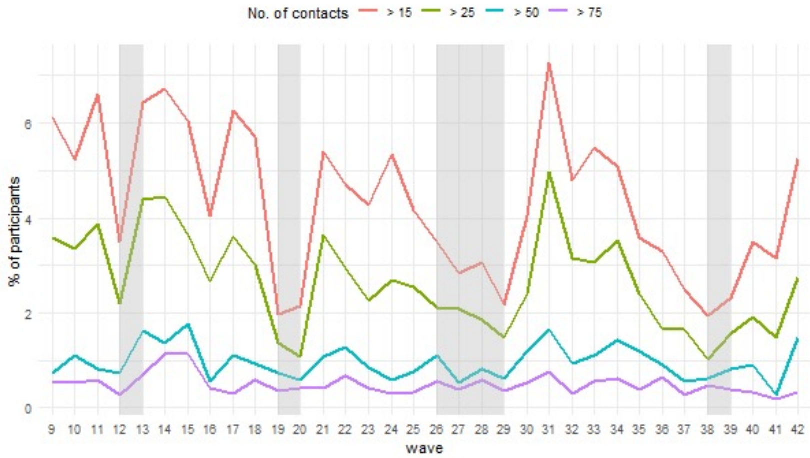
- FP6 Framework
- ERC TransMID

CoMix →

- EpiPose Consortium
- ECDC



(Verelst et al, 2021)



(Loedy et al, 2021)

Mathematical modelling

Mathematical models

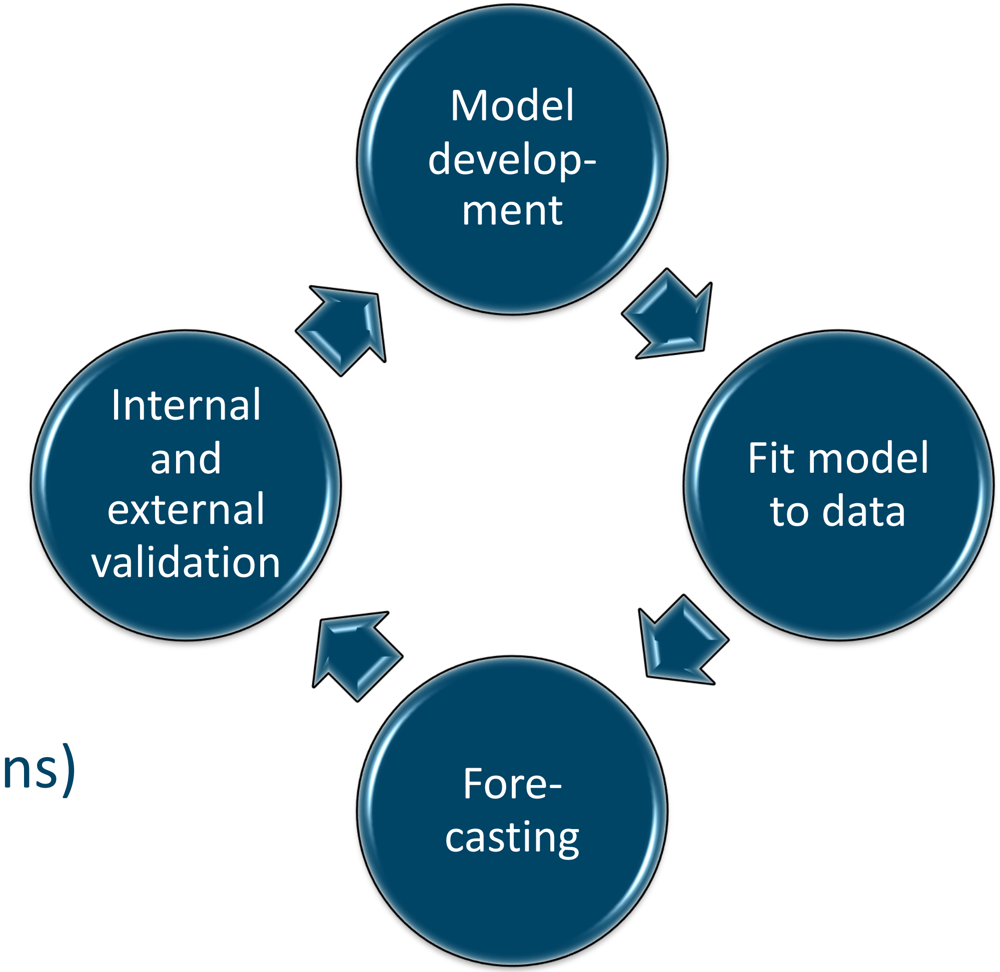
- Data assimilation/integration

Ecosystem

- Meta-population model
- Individual-based model
- Stochastic model (= reference model)

→ next generation approach

→ contact process models (specific populations)



The reference model

Stochastic compartimentel model (Abrams et al., 2021)

→ integration of different data sources

surveillance data, VE estimates, etc

- Calibration to
  - hospital admissions
  - hospital load
  - early serology
- Further calibration to growth rates
  - cases
  - genomic suveillance
- Forecasts based on CoMix data

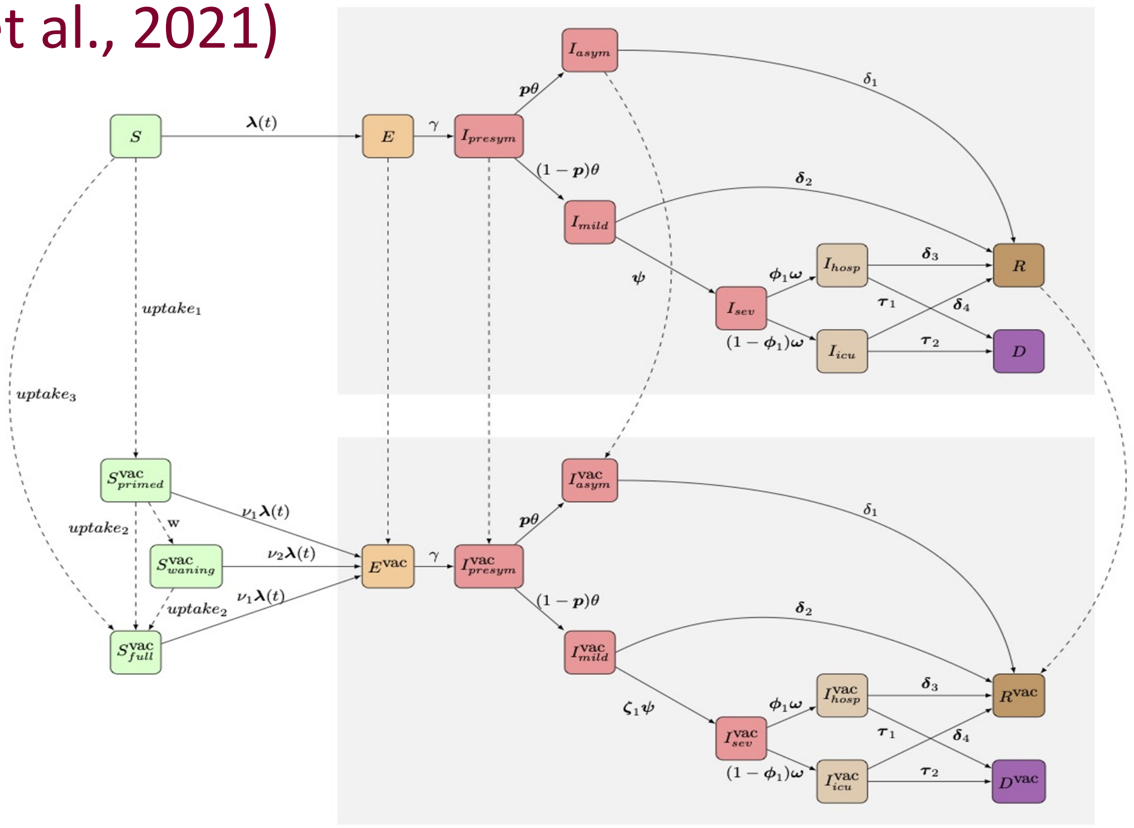
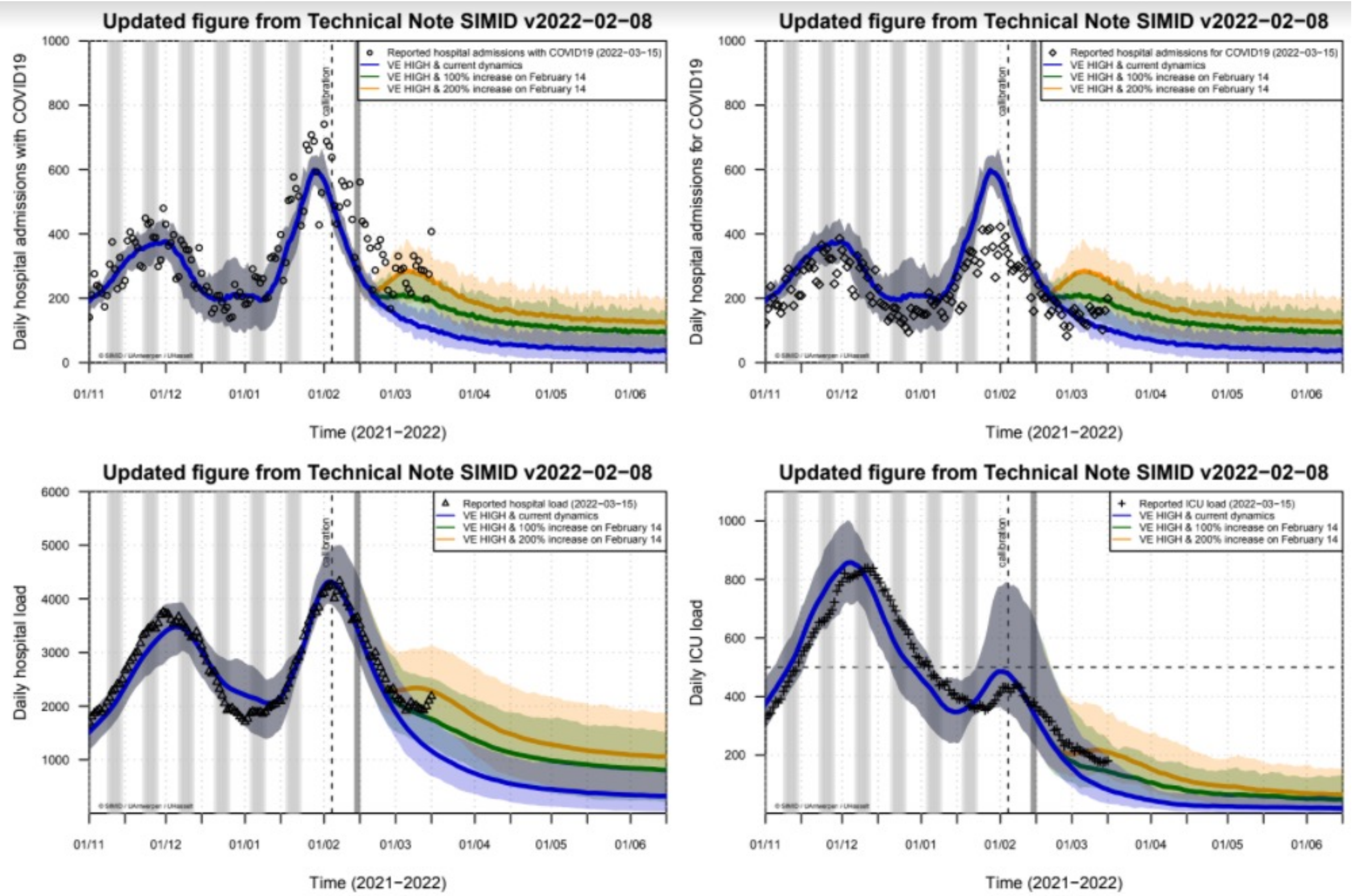


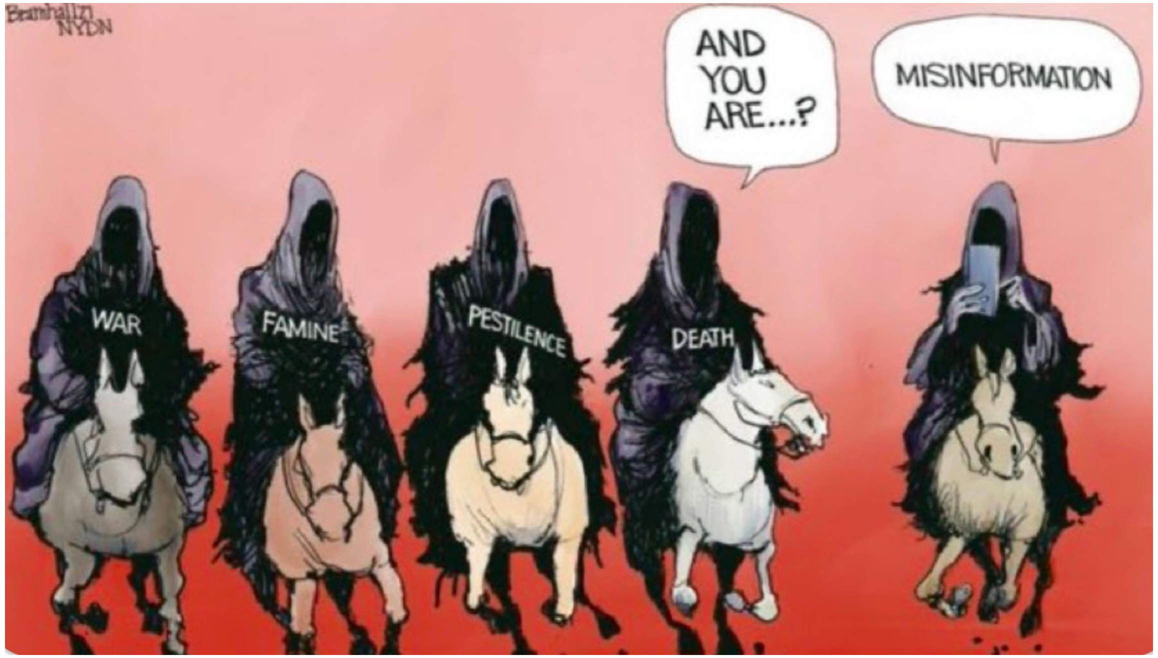
Figure 4: **Schematic overview of compartmental model including vaccination with vaccine-induced protection after 1 and 2 doses and waning immunity.** The gray boxes indicate the duplication we include for the VoC (see Figure 3).

The reference model



Infodemic

Faulty & misinformation: (non-)intential?



Elements:

- uncertainty
- lack of scientific foundation
- lack of nuance
- mix of (in)correct arguments
- science advances
- speed trumps perfection
- …

Infodemic

PROCEEDINGS B

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Research

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Avoidable errors in the modelling of outbreaks of emerging pathogens, with special reference to Ebola

Aaron A. King[1,2,3,4], Matthieu Domenech de Cellès[1], Felicia M. G. Magpantay[1] and Pejman Rohani[1,2,4]

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[4]Fogarty International Center, National Institutes of Health, Bethesda, MD 20892, USA

As an emergent infectious disease outbreak unfolds, public health response is reliant on information on key epidemiological quantities, such as transmission potential and serial interval. Increasingly, transmission models fit

Review

MDM
Medical Decision Making

Medical Decision Making
1–7
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The Use and Misuse of Mathematical Modeling for Infectious Disease Policymaking: Lessons for the COVID-19 Pandemic

Lyndon P. James, Joshua A. Salomon,
Caroline O. Buckee, and Nicolas A. Menzies

Mathematical modeling has played a prominent and necessary role in the current coronavirus disease 2019 (COVID-19) pandemic, with an increasing number of models being developed to track and project the spread of the disease, as well as major decisions being made based on the results of these studies. A proliferation of models, often diverging widely in their projections, has been accompanied by criticism of the validity of modeled analyses and uncertainty as to when and to what extent results can be trusted. Drawing on examples from COVID-19 and other infectious diseases of global importance, we review key limitations of mathematical modeling as a tool for interpreting empirical data and informing individual and public decision making. We present several approaches that have been used to strengthen the validity of inferences drawn from these analyses, approaches that will enable better decision making in the current COVID-19 crisis and beyond.

Keywords
COVID-19, infectious diseases, mathematical modeling, uncertainty, validation

Paradigm shift?

Rapid Science

- Time pressure
- Context
- Assumptions
- 'early evidence'
- Uncertainty
- ...
- Example: role of children

'Slow' Science

- More details
- Country comparisons
- Generalisability
- ...
- Example: behaviour

Preparedness

- International community
- Interdisciplinary research
- Peace-time efforts
- ...
- Example: demography & disease transmission

Discussion

Better data

- realtime data
- well-designed surveys
- serosurveillance
- genomic surveillance
- …

Open Science as much as possible

- misintepretation is not the argument

Peacetime research

- (inter)national collaborations should be set up in peacetime

Methodology

- learning from the past
- heterogeneity is key
- validation is key
- optimizing NPIs
- …

References

Sources:

info:
- www.simid.be
- www.uhasselt.be/dsi

socrates:
- www.socialcontactdata.org

blog:
- covid-en-wetenschap.github.io

Citizen science projects:

Large Corona Study

Infectieradar

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