An overview of the impact of COVID-19 pandemic on epidemic modeling research

Jian Li, Tulane University

On behalf of COVID-19 modeling workgroup

Webinar series on COVID-19 impact analysis, January 15, 2021

Organized by China Data Institute

Workgroup members (alphabetically)

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- Jian Li, Tulane University, New Orleans, LA, USA
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- Wenwei Qi, Tianjin Medical University, Tianjin, China
- Shan Wu, Nanjing University, Nanjing, China
- Feng Xu, Peking University, Beijing, China
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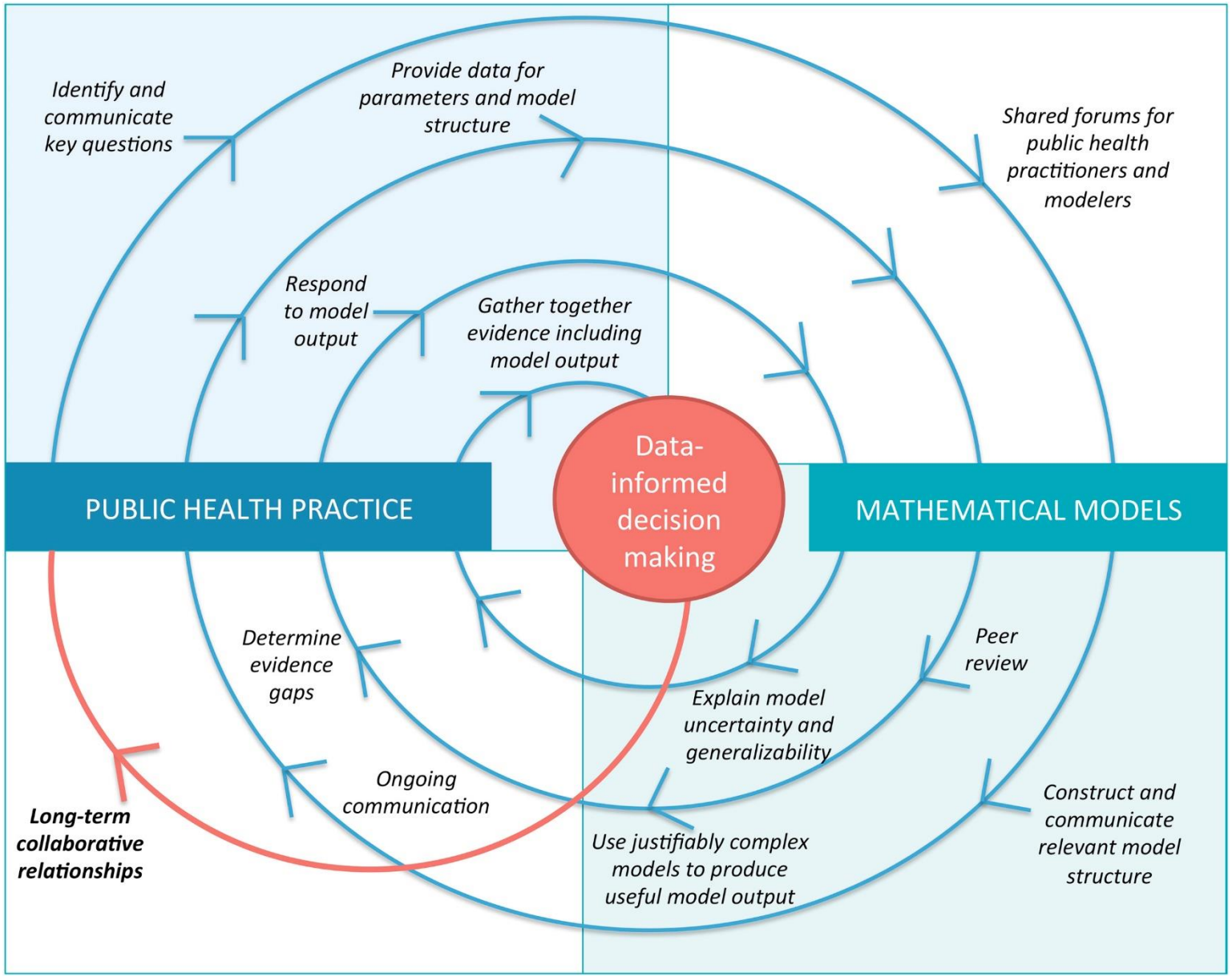
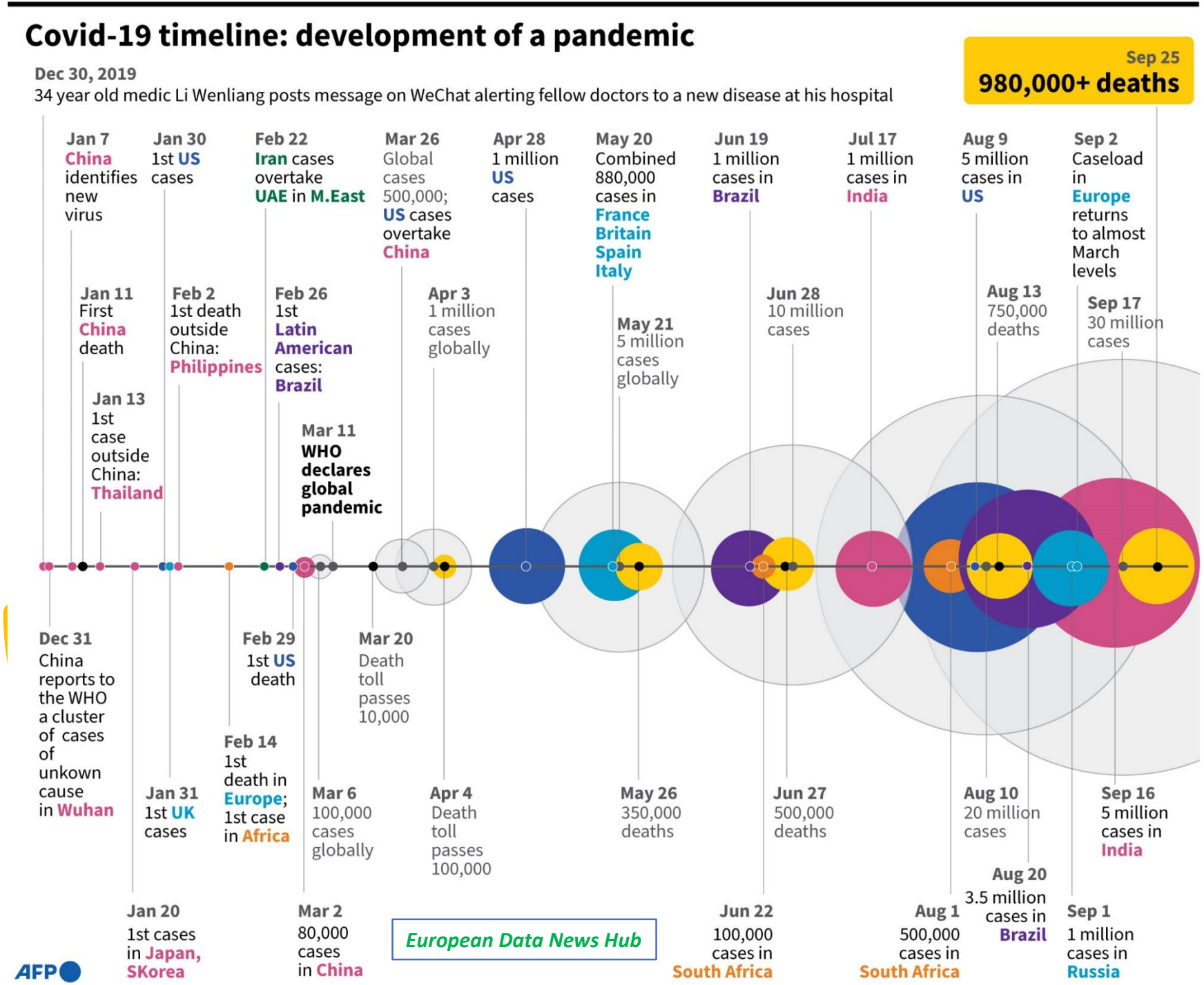
- Xiaoqi Zhang, Southeast University, Nanjing, China

Motivation



Knight et al. International Journal of Infectious Diseases. 2016. 42: 17-23



At pandemic time …

Jan. 15, 2021

Coronavirus Cases:

93,536,554

view by country

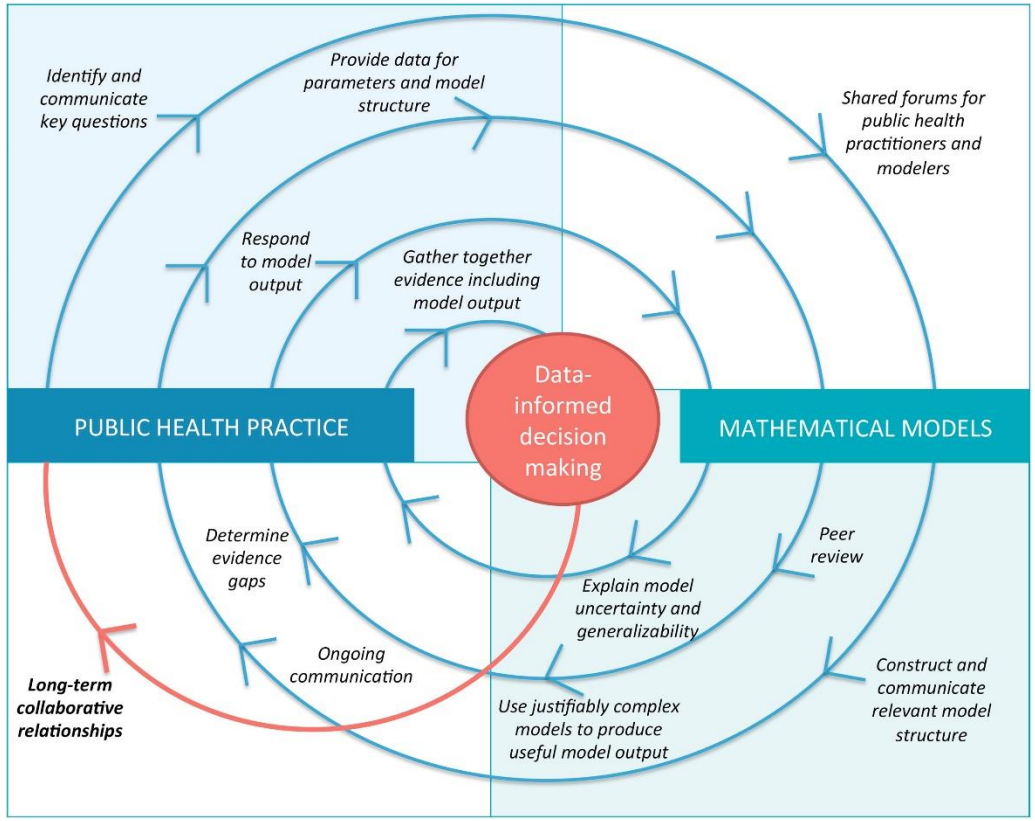
Deaths:

2,002,465

Recovered:

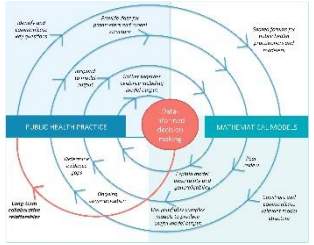
66,835,146

At normal time …



2-3 years

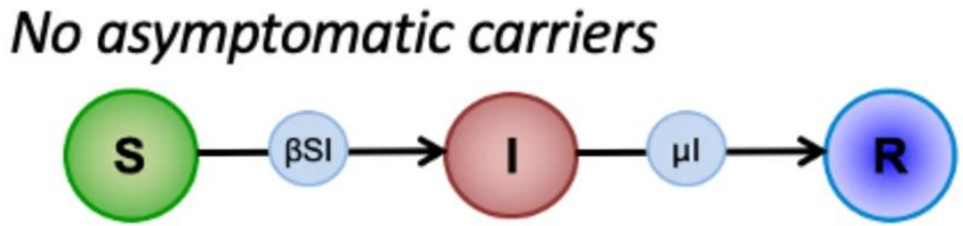
At pandemic time …

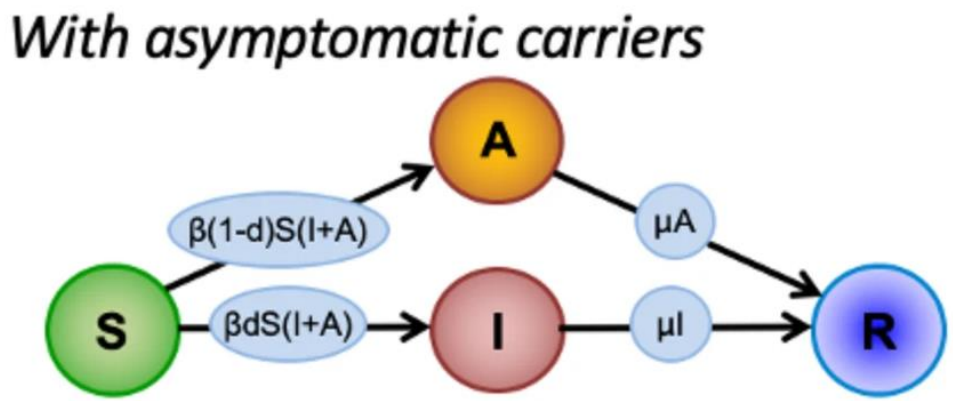


2-3 months

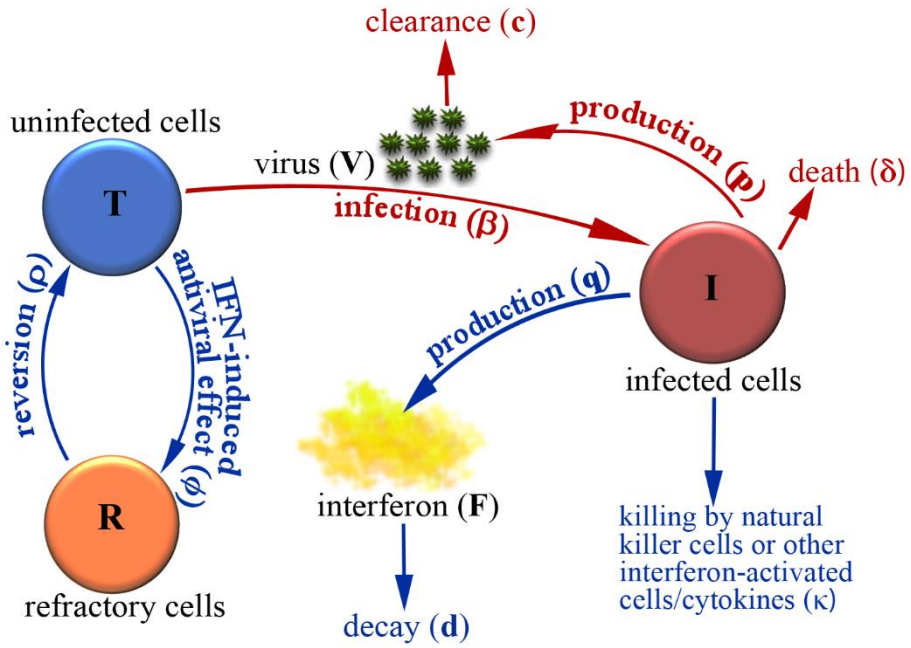
What is our focus here …

- **Epidemic models**
  - Models used to characterize the infectious disease dynamics at the population level





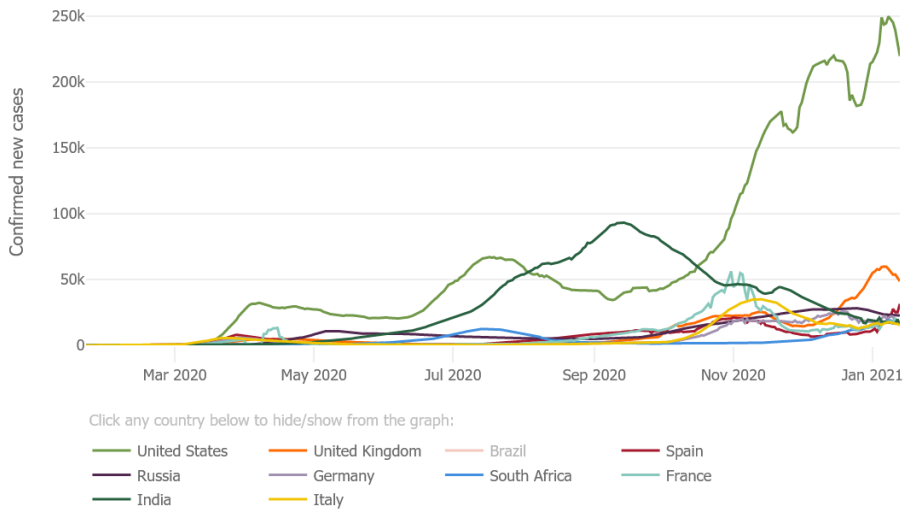
Thompson. BMC Medicine. 2020. 18: 152



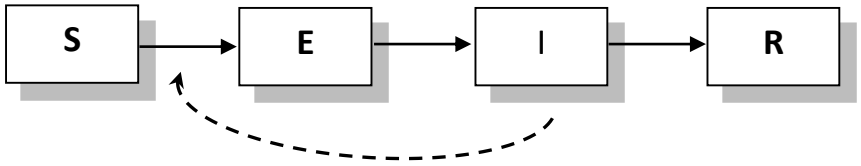
Pewelek et al. PLoS Comp. Biol. 2012.

What we are looking at …

- Models and model development
- Data collection, sharing, and usage
- Storage and computational resource
- Information dissemination
- Application



JHU Coronavirus Resource Center



$$\frac{dS}{dt} = \mu - \beta IS - \mu S$$

$$\frac{dE}{dt} = \beta IS - (\sigma + \mu)E$$

$$\frac{dI}{dt} = \sigma E - (\gamma + \mu)I$$

$$\frac{dR}{dt} = \gamma I - \mu R$$

Impacts of the pandemic …

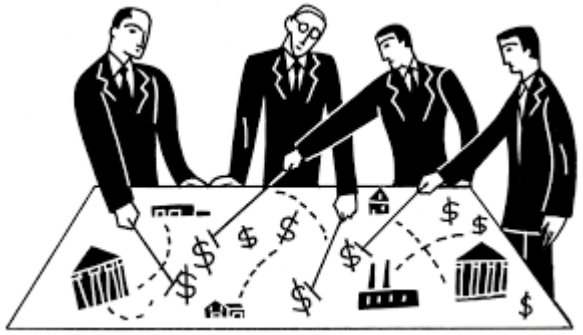
In general sense

- Expedited process
- Widened collaboration and coordination
- Broadened range and scopes
- Increased interest and awareness
- …

A real-life illustration: investigator composition

Out of 13 workgroup members:

- 2 Biostatistician
- 1 Clinician
- 2 Computer scientists
- 1 Data scientist
- 2 Economists
- 1 Epidemiologist
- 2 Geographers
- 1 Mathematician
- 1 Public health practitioner

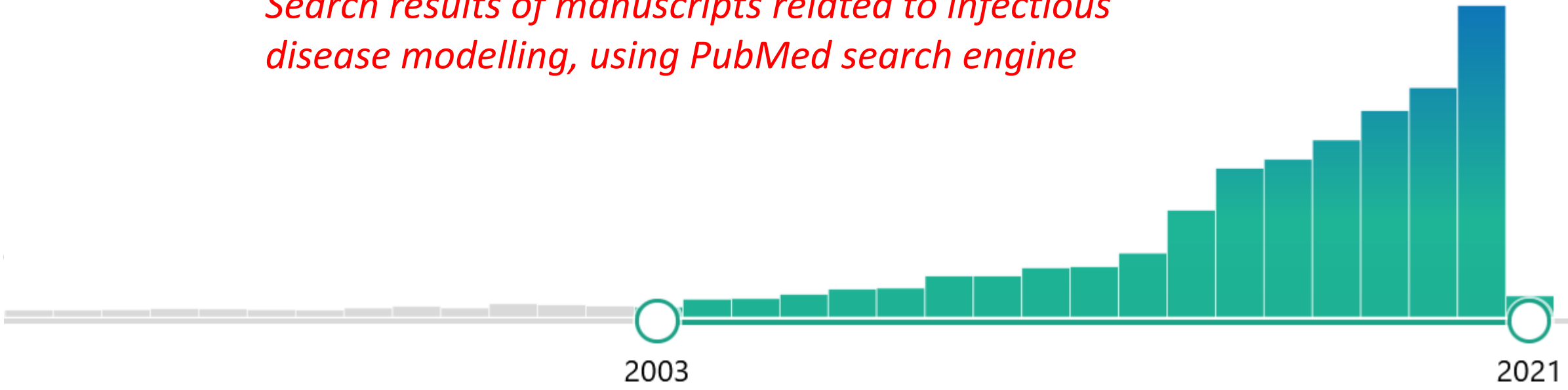


Model and method development

- Explosion of new methods for characterizing and/or analyzing COVID-19 dynamics

2,775 results

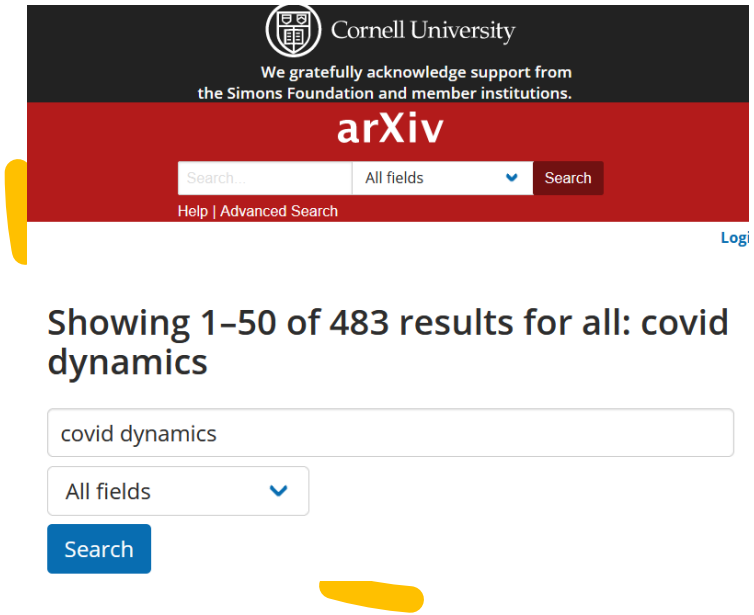
Search results of manuscripts related to infectious disease modelling, using PubMed search engine

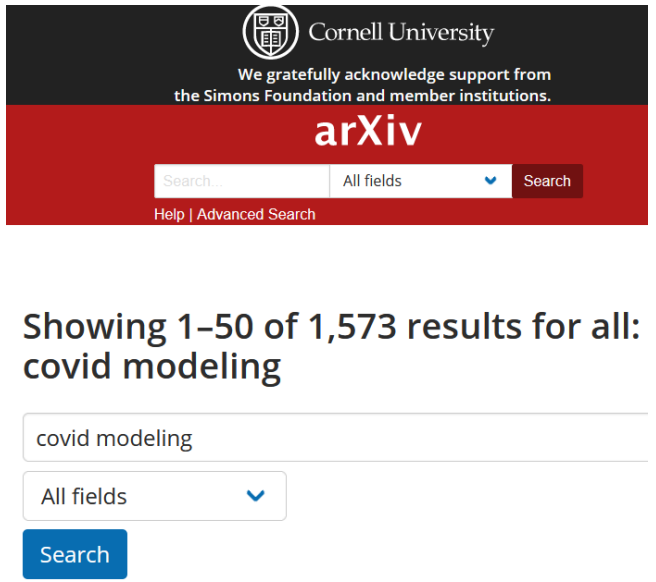


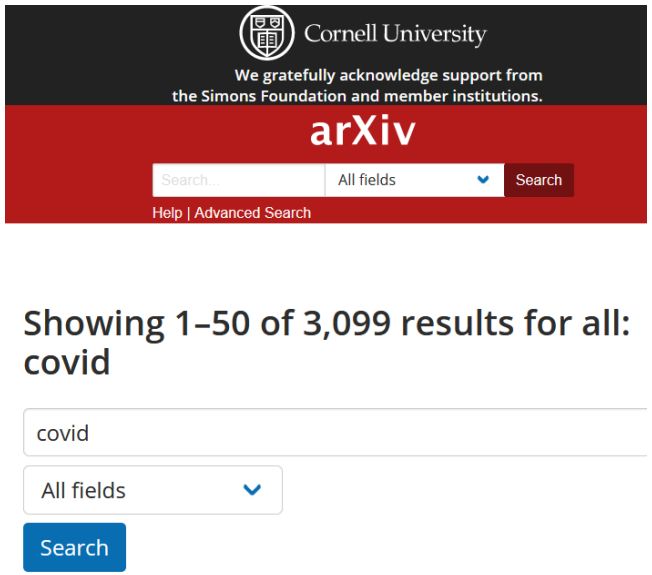
Model and method development

- Explosion of new methods for characterizing and/or analyzing COVID-19 dynamics

Search results of arxiv.org (which contains mainly methodological pre-prints)

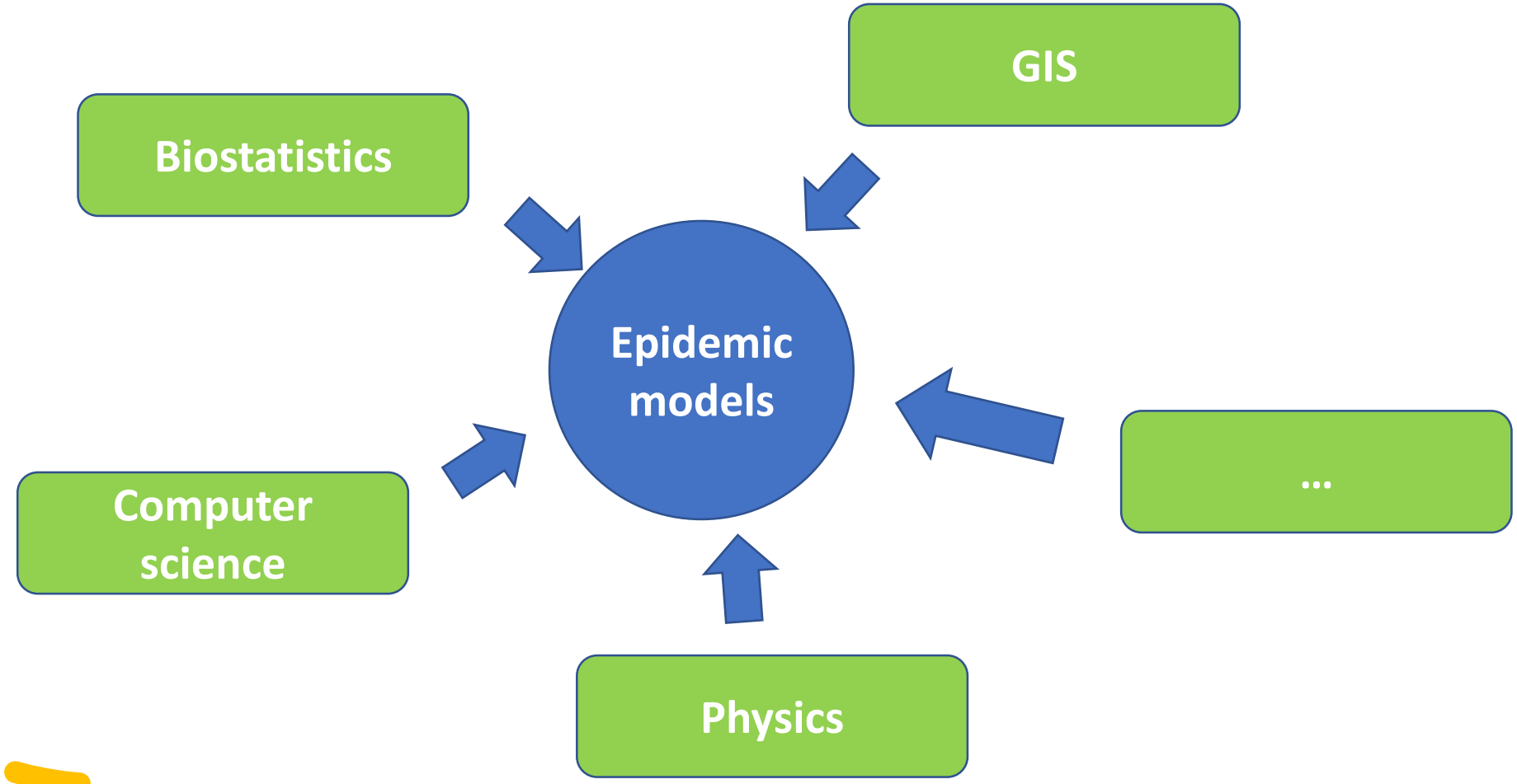






Model and method development

- Contribution/Method development from a broad range of scientific fields



Model and method development

- Contribution/Method development from a broad range of scientific fields

JAMA | Original Investigation

Association of Public Health Interventions With the Epidemiology of the COVID-19 Outbreak in Wuhan, China

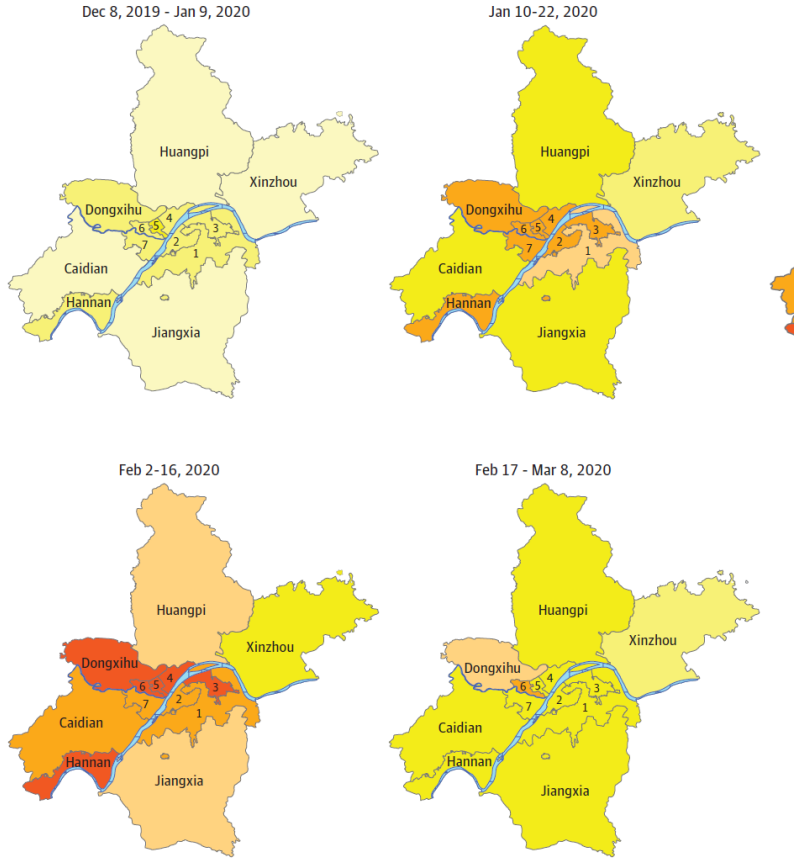
An Pan, PhD; Li Liu, MD, PhD; Chaolong Wang, PhD; Huan Guo, MD, PhD; Xingjie Hao, PhD; Qi Wang, MD, PhD; Jiao Huang, PhD; Na He, PhD; Hongjie Yu, PhD; Xihong Lin, PhD; Sheng Wei, MD, PhD; Tangchun Wu, MD, PhD

IMPORTANCE Coronavirus disease 2019 (COVID-19) has become a pandemic, and it is unknown whether a combination of public health interventions can improve control of the outbreak.

OBJECTIVE To evaluate the association of public health interventions with the epidemiological features of the COVID-19 outbreak in Wuhan by 5 periods according to key events and interventions.

Editorial page 1908

Supplemental content



Model and method development

- Contribution/Method development from a broad range of scientific fields

IEEE Open Journal of Engineering in Medicine and Biology

Technology

COVID-19 Artificial Intelligence Diagnosis Using Only Cough Recordings

Jordi Laguarta, Ferran Hueto, and Brian Subirana

Abstract*—*Goal: We hypothesized that COVID-19 subjects, especially including asymptomatics, could be accurately discriminated only from a forced-cough cell phone recording using Artificial Intelligence. To train our MIT Open Voice model we built a data collection pipeline of COVID-19 cough recordings through our website (opensigma.mit.edu) between April and May 2020 and created the

***Impact Statement*—**We present the dataset, model architecture and performance of a zero-cost, rapid and instantly distributable COVID-19 forced-cough recording AI pre-screening tool achieving 98.5% accuracy, including 100% asymptomatic detection rate. An orthogonal set of biomarkers may be developed to diagnose COVID-19, Alzheimer's and perhaps other conditions.

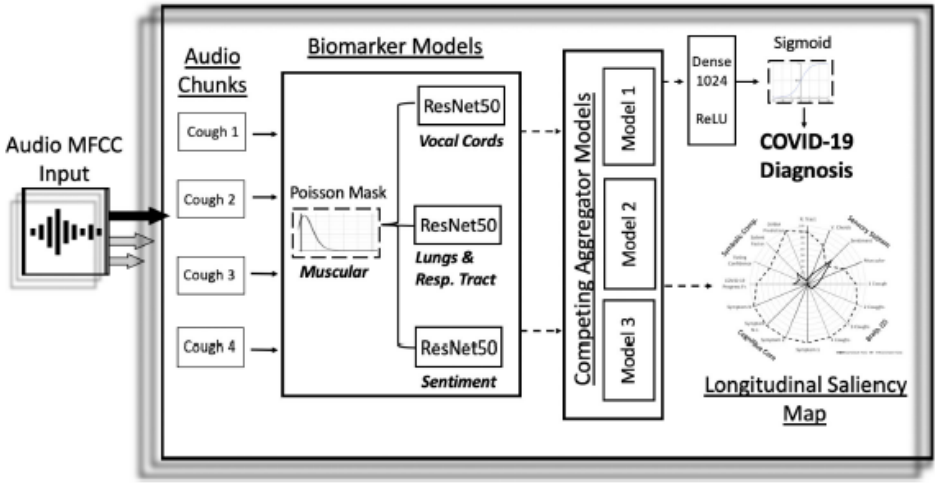


Fig. 1. Overview architecture of the COVID-19 discriminator with cough recordings as input, and COVID-19 diagnosis and longitudinal saliency map as output. A similar architecture was used for Alzheimer's [11].

Model and method development

- Contribution/Method development from a broad range of scientific fields

Article

Population flow drives spatio-temporal distribution of COVID-19 in China

https://doi.org/10.1038/s41586-020-2284-y
Received: 18 February 2020
Accepted: 21 April 2020
Published online: 29 April 2020
Check for updates

Jayson S. Jia[1], Xin Lu[2,3], Yun Yuan[4], Ge Xu[5], Jianmin Jia[6,7]✉ & Nicholas A. Christakis[8]

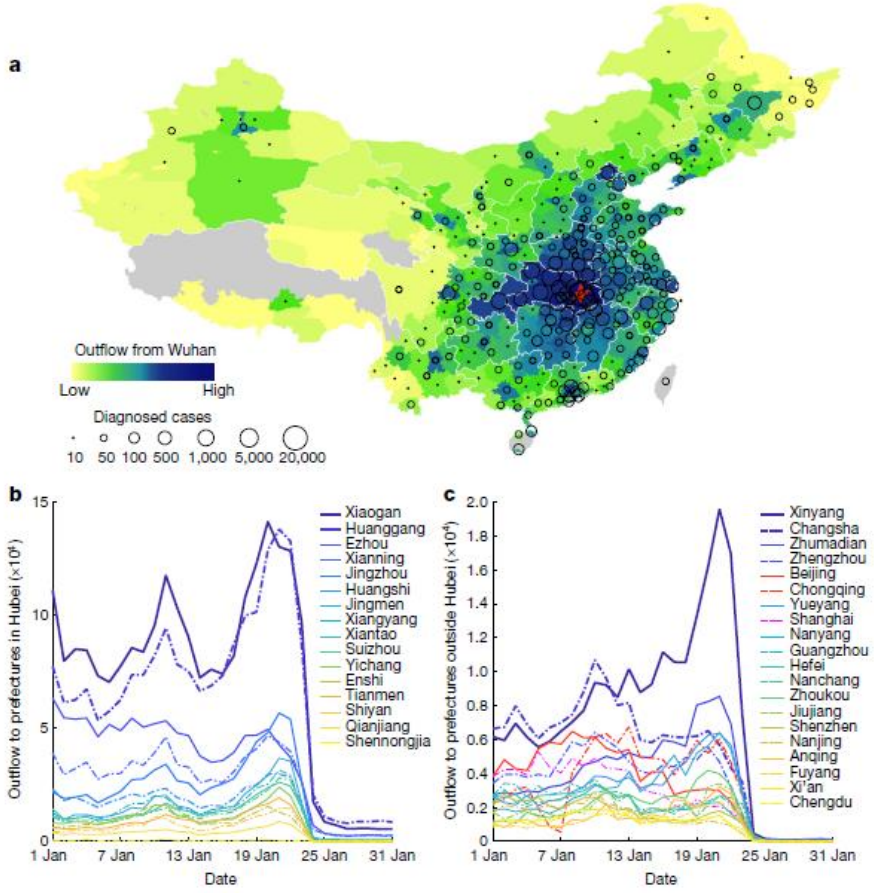
Sudden, large-scale and diffuse human migration can amplify localized outbreaks of disease into widespread epidemics[1–4]. Rapid and accurate tracking of aggregate population flows may therefore be epidemiologically informative. Here we use 11,478,484 counts of mobile phone data from individuals leaving or transiting through

We first modelled the effect of outflow on infection by using the following multiplicative exponential model:

$$y_i = c\prod_{j=1}^{m} e^{\beta_j x_{ji}} e^{\sum_{k=1}^{n} \lambda_k I_{ik}} \quad (1)$$

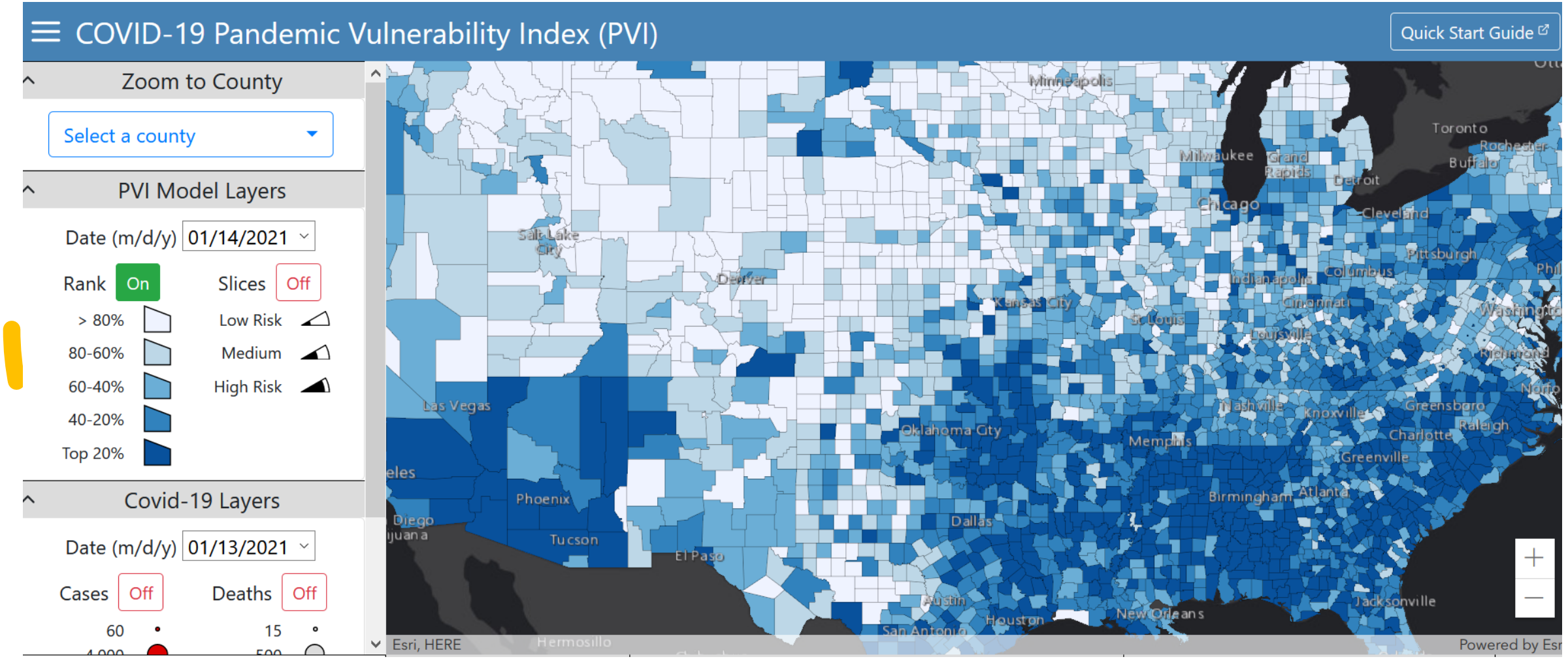
logistic, generalized logistic or Gompertz functions[26,27]) that epidemics typically follow:

$$\lambda(t|x_i) = \lambda_0(t)\left(\prod_{j=1}^{m} e^{\beta_j x_{ji}}\right) e^{\sum_{k=1}^{n} \lambda_k I_{ik}} \quad (2)$$



Model and method development

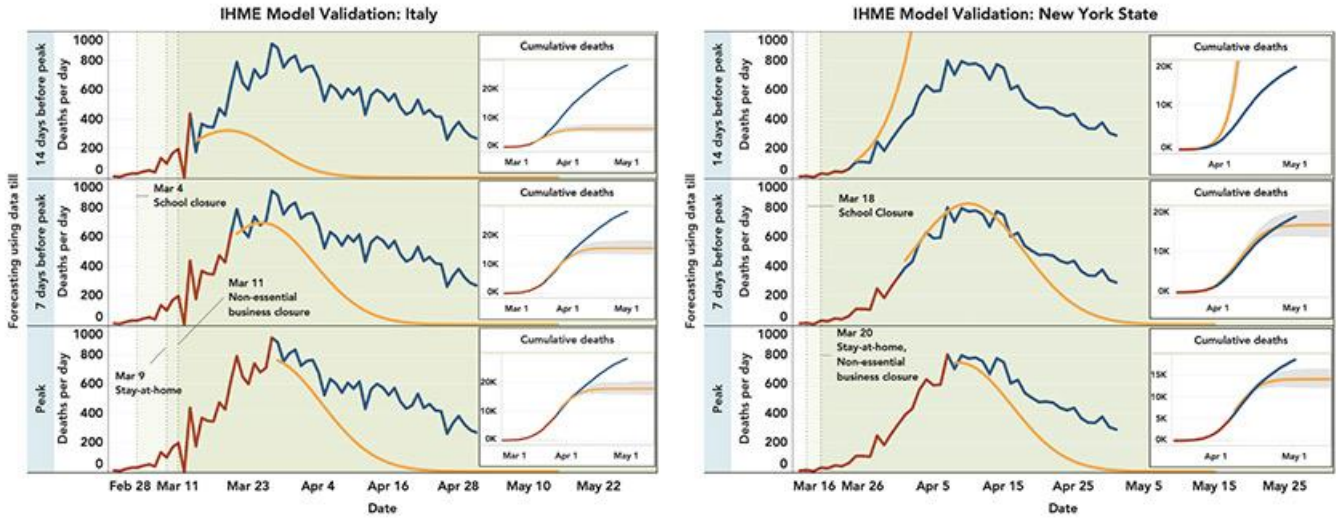
- Integrative analysis of multiple types of data



Model and method development

Challenges

- Model assessment and validation
- Reproducibility



Jin et al. COVID-19: Academic Resources and Tools

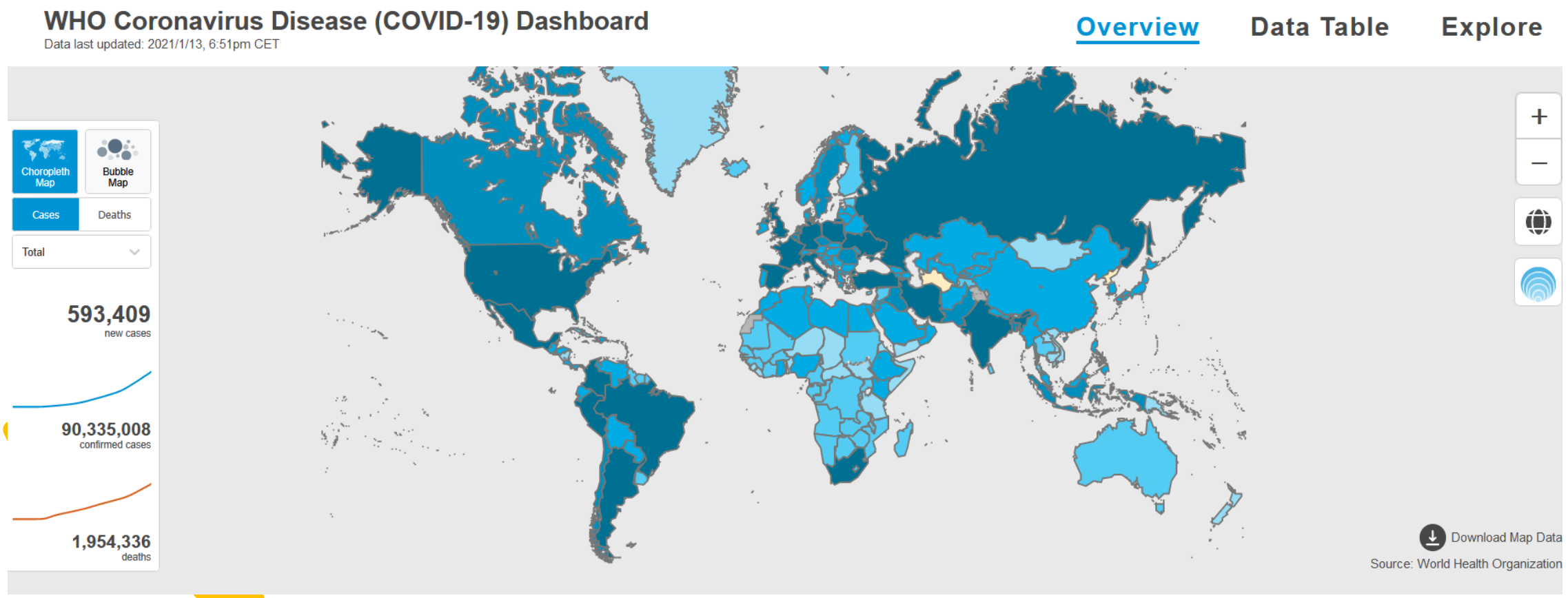
"If you won't help me validate myself, will you at least validate my parking?"

Data collection and usage

- Broad collaboration on data sharing and collection

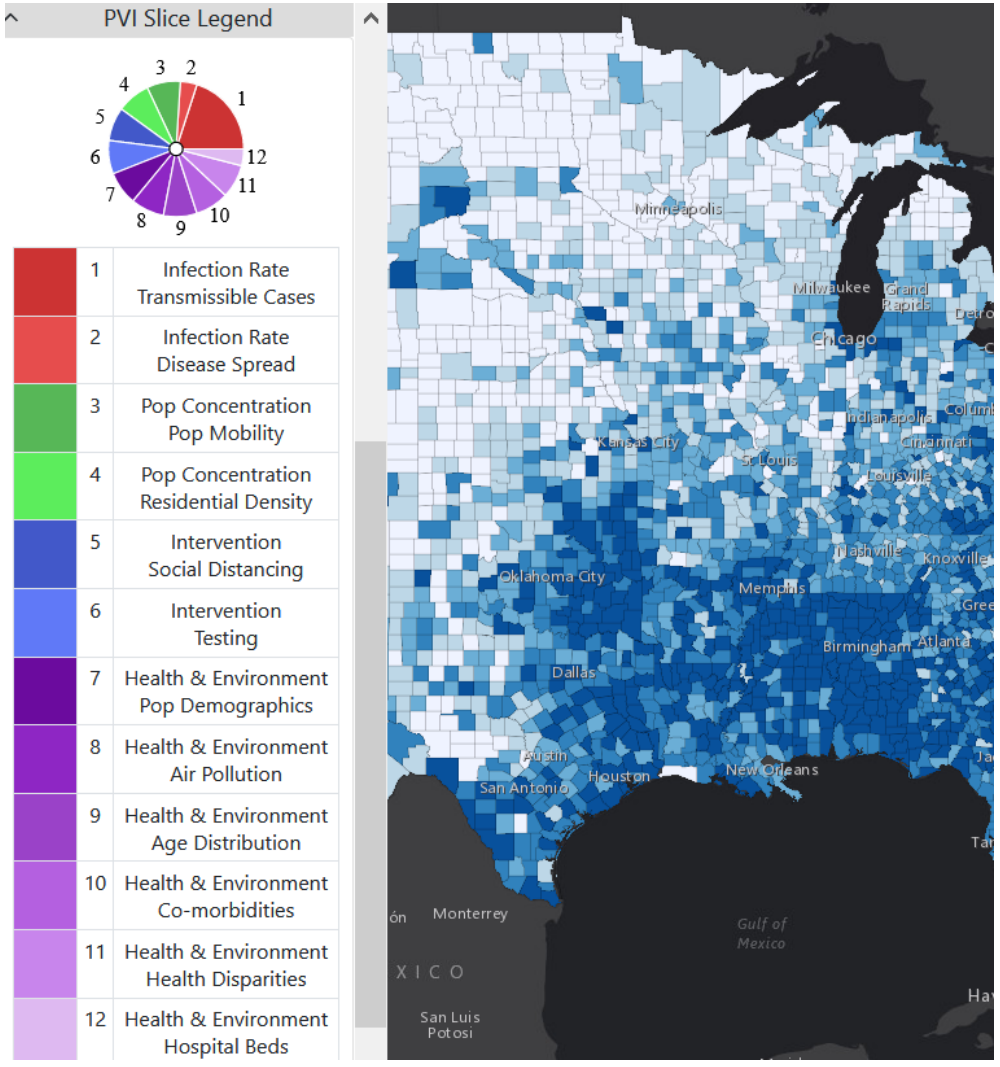
Data collection and usage

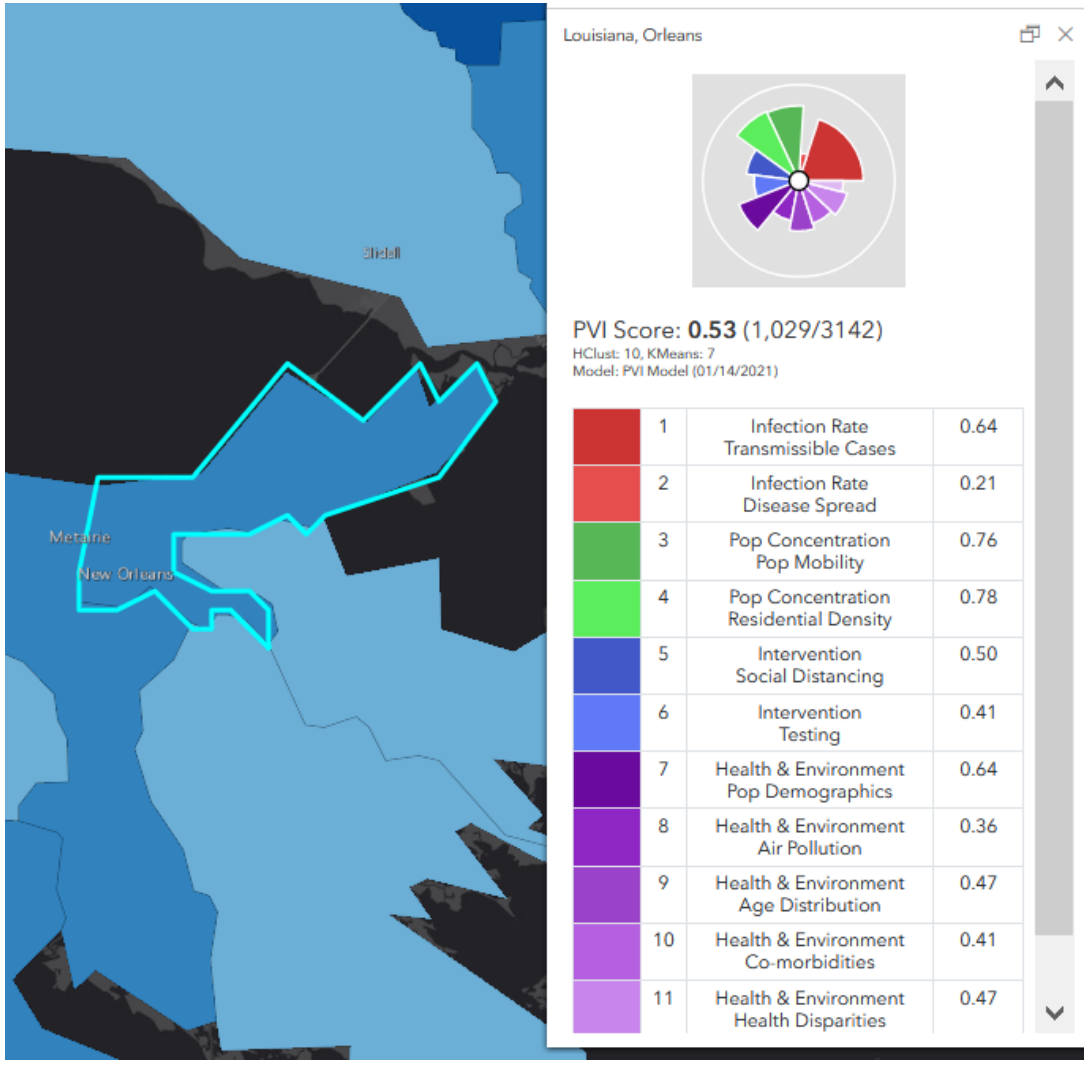
- Broad collaboration on data sharing and collection



Data collection and usage

- Integration of multiple types of data

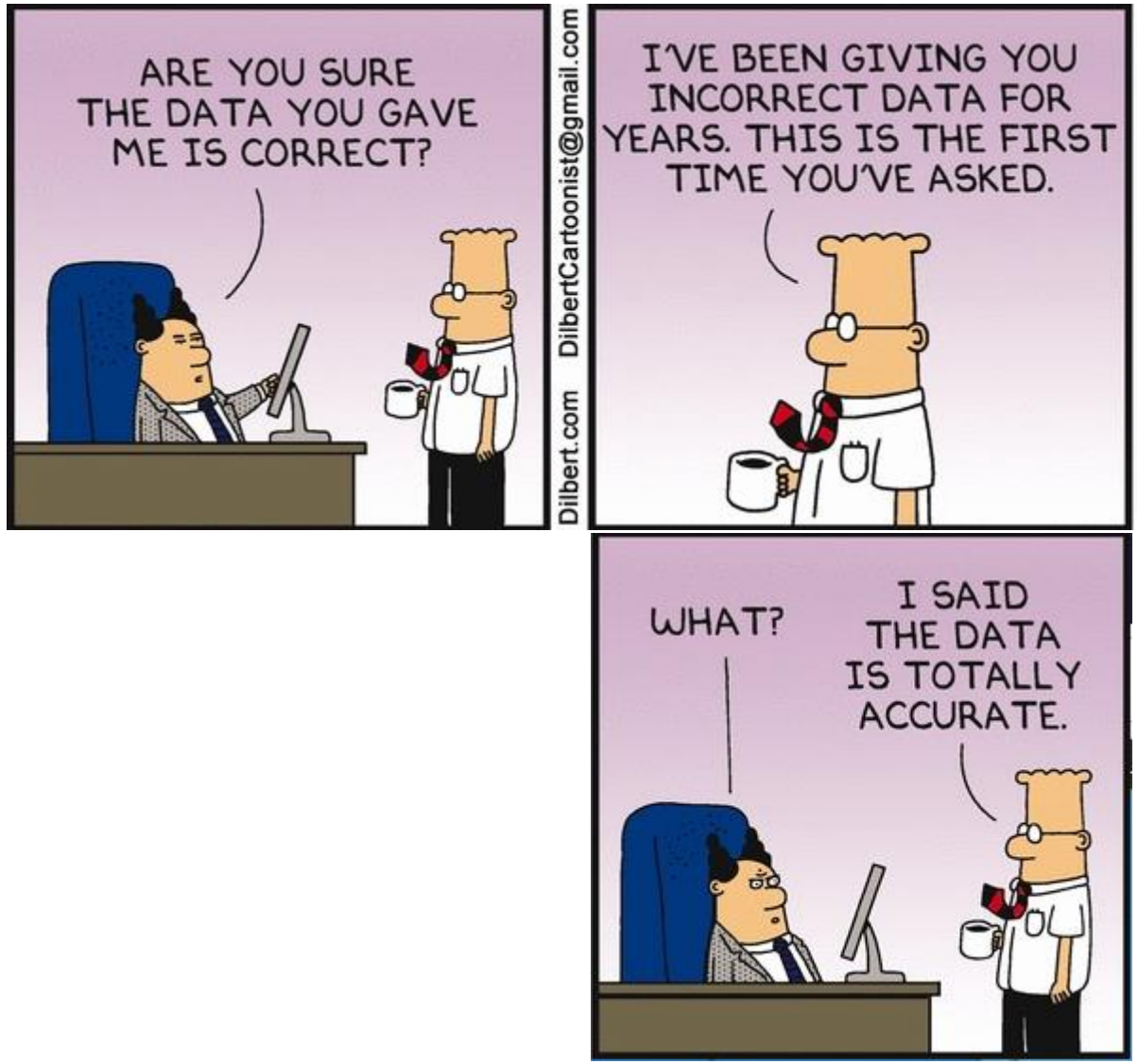




Data collection and usage

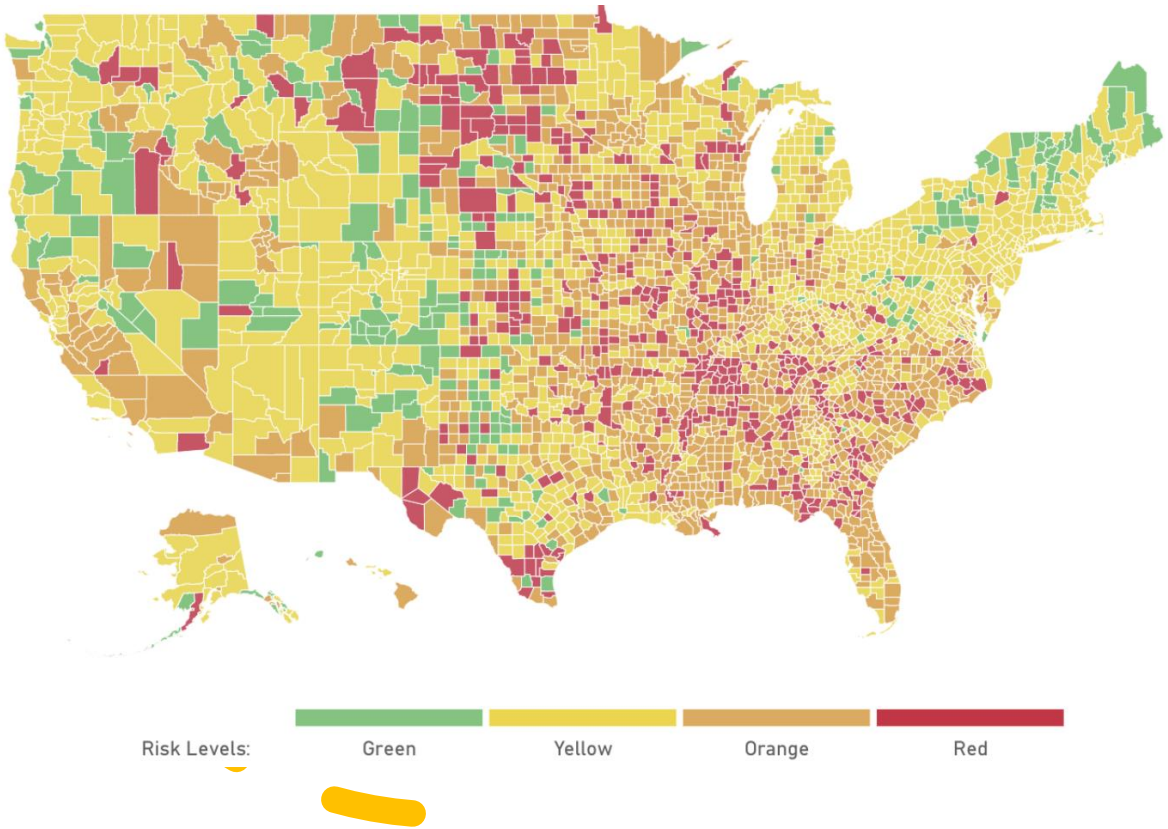
Challenges

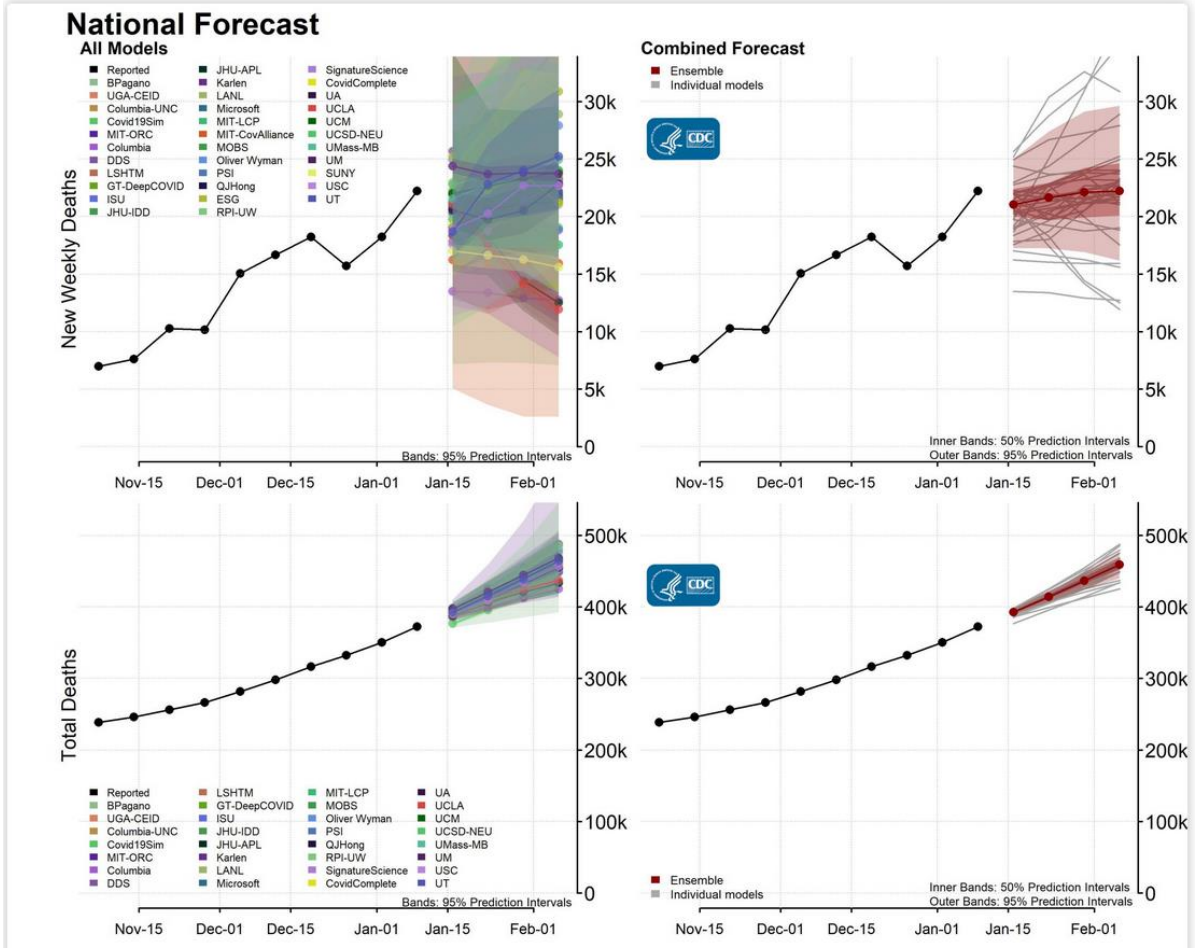
- Scaling
- Integration
- Reliability/Quality
- Government Transparency
- Privacy (individual –level data)



Computational resource

- Increasing usage of cloud-based application



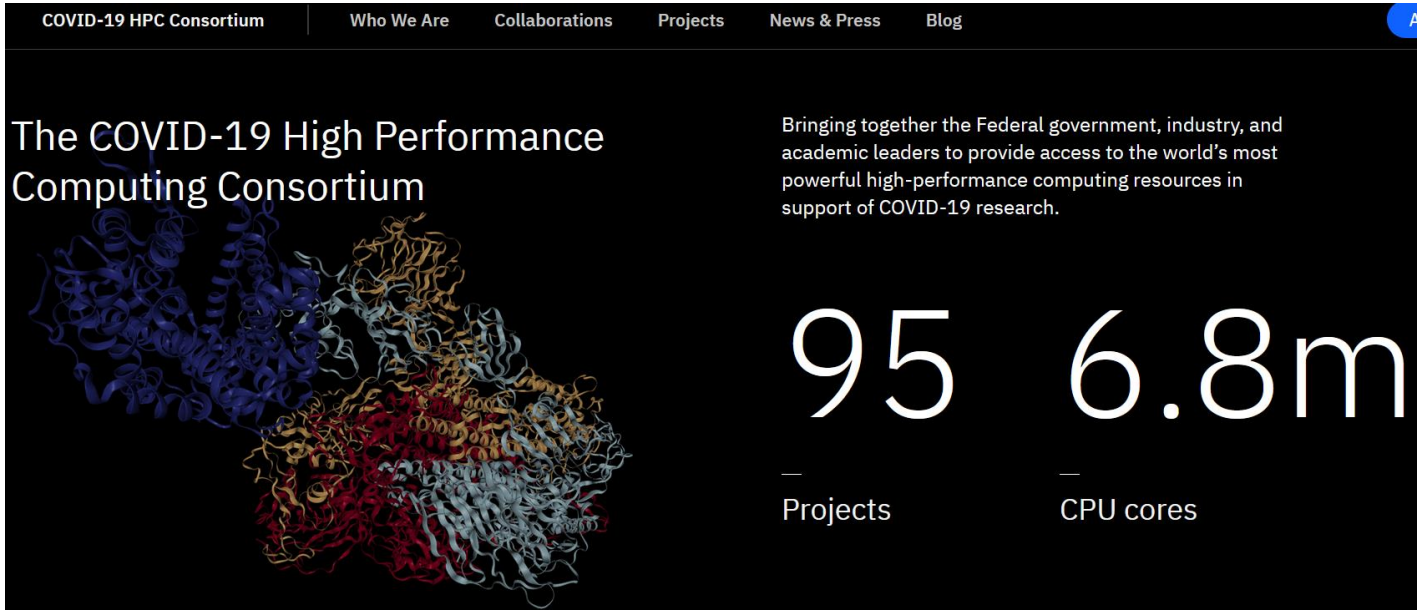


Computational resource

- Coordination and collaboration in building more computational power, with involvement of all stockholders

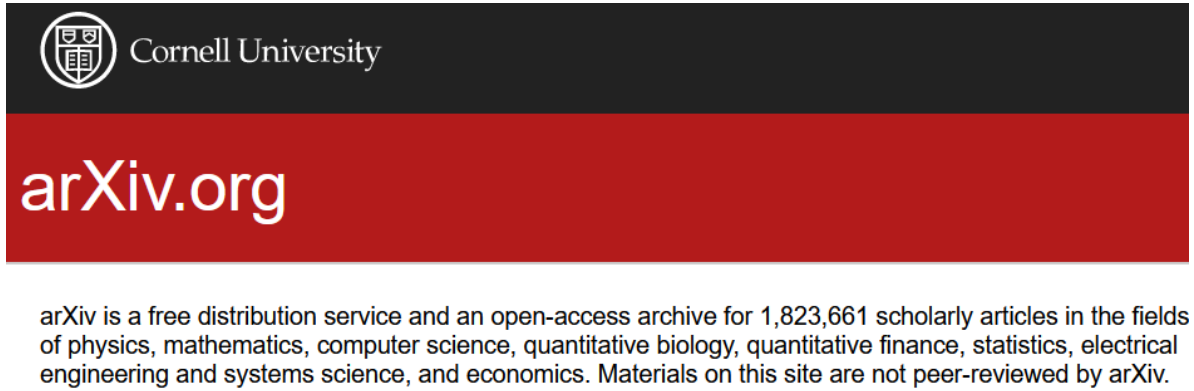
MOBS LAB

Laboratory for the
Modeling of Biological +
Socio-technical Systems



Information dissemination

- Widened venues for publication and dissemination



YouTube

bioRxiv

THE PREPRINT SERVER FOR BIOLOGY

BMJ Yale

Information dissemination

- Widened venues for publication and dissemination

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bioRxiv is receiving many new papers on coronavirus SARS-CoV-2. A reminder: these are preliminary reports that have not been peer-reviewed. They should not be regarded as conclusive, guide clinical practice/health-related behavior, or be reported in news media as established information.

COVID-19 SARS-CoV-2 preprints from medRxiv and bioRxiv

12,280 Articles (9,550 medRxiv, 2,730 bioRxiv)

Most recent first

Page 1: Articles 1-10 | Next

SARS-CoV-2 spike protein arrested in the closed state induces potent neutralizing responses

Carnell, G. W., Ciazynska, K. A., Wells, D. A., Xiong, X., Aguinam, E. T., McLaughlin, S. H., Mallery, D., Ebrahimi, S., Ceron-Gutierrez, L., James, L. C., Doffinger, R., Heeney, J. L., Briggs, J. A. G.

10.1101/2021.01.14.426695 — Posted: 2021-01-14

Subject Areas

All Articles

Animal Behavior and Cognition

Biochemistry

Bioengineering

Information dissemination

- Widened venues for publication and dissemination

Information dissemination

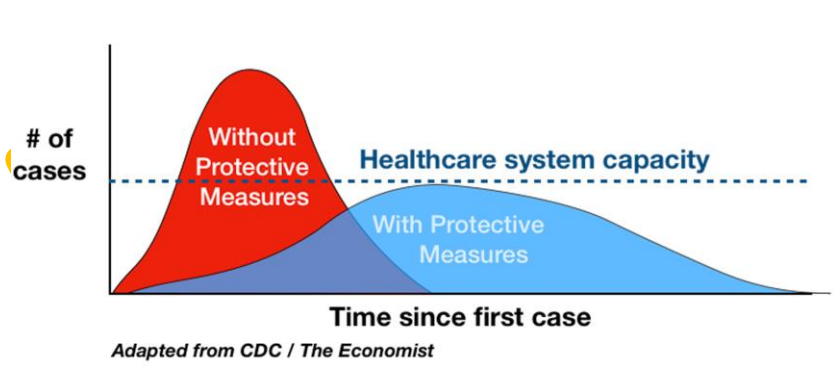
- Dramatically increased interest and awareness in general public

The Washington Post
Democracy Dies in Darkness

Health

Why outbreaks like coronavirus spread exponentially, and how to "flatten the curve"

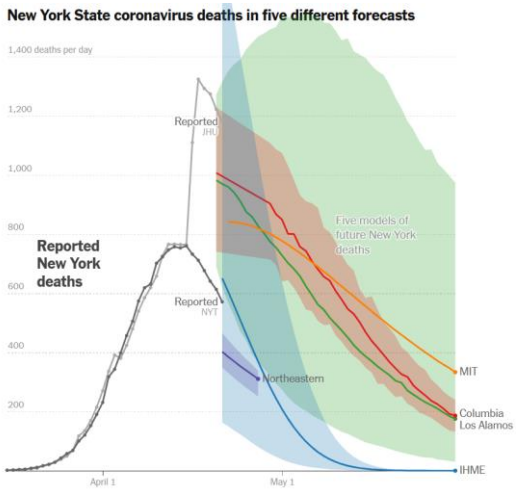
By Harry Stevens March 14, 2020



The New York Times

What 5 Coronavirus Models Say the Next Month Will Look Like

By Quoctrung Bui, Josh Katz, Alicia Parlapiano and Margot Sanger-Katz April 22, 2020



Information dissemination

Challenges

- Fake news
- Misinformation
- Conspiracy theories

Scene by Alec Baldwin in comedy show "SNL"

Journal List › SAGE Public Health Emergency Collection › PMC7506181

SAGE Public Health Emergency Collection

Public Health Emergency COVID-19 Initiative

SAGE Public Heal

Media International Australia. 2020 Aug 27 : 1329878X20952165. PMCID: PMC7506181

Published online 2020 Aug 27. doi: 10.1177/1329878X20952165

COVID-19, 5G conspiracies and infrastructural futures

James Meese, Jordan Frith, and Rowan Wilken

▸ Author information ▸ Copyright and License information Disclaimer

Coronavirus: Call for apps to get fake Covid-19 news button

By David Molloy & Leo Kelion
Technology reporters

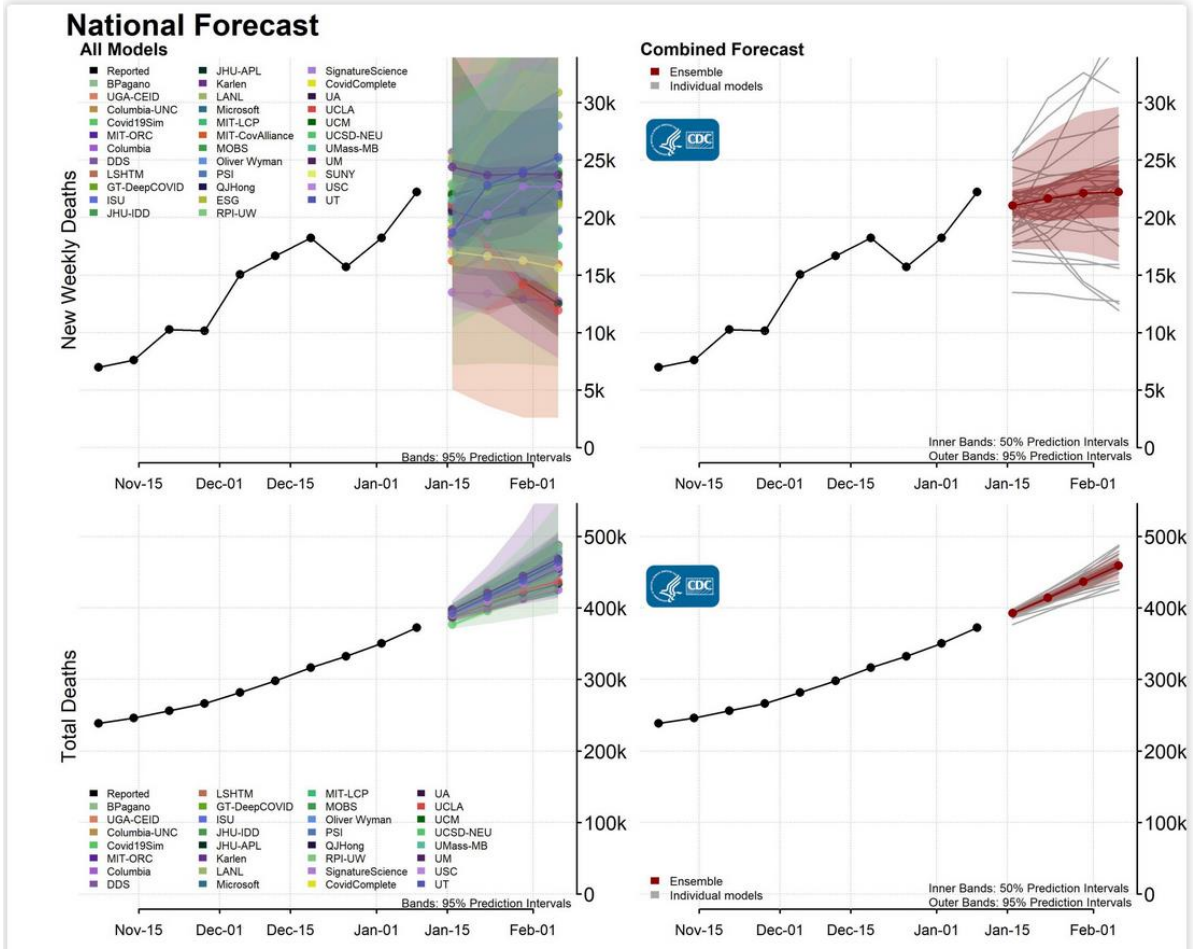
8 April 2020

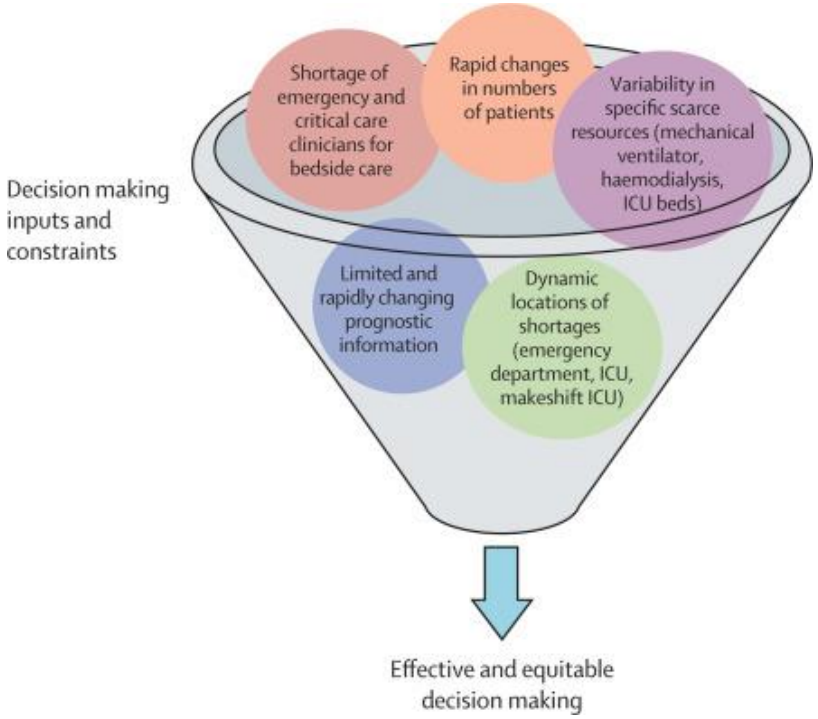
Coronavirus pandemic

BBC NEWS

Application

- Potential increased involvement of modelers in policy making process

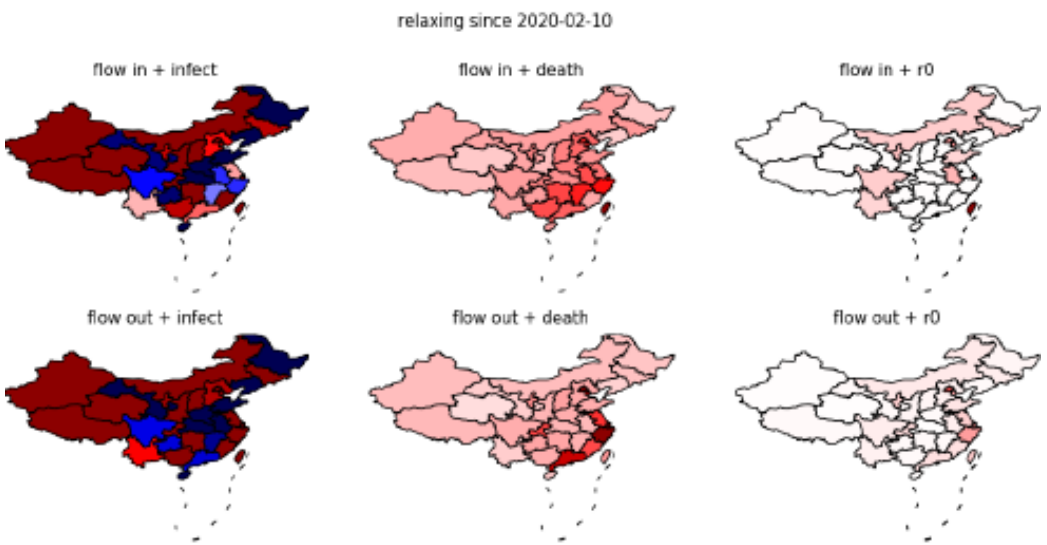


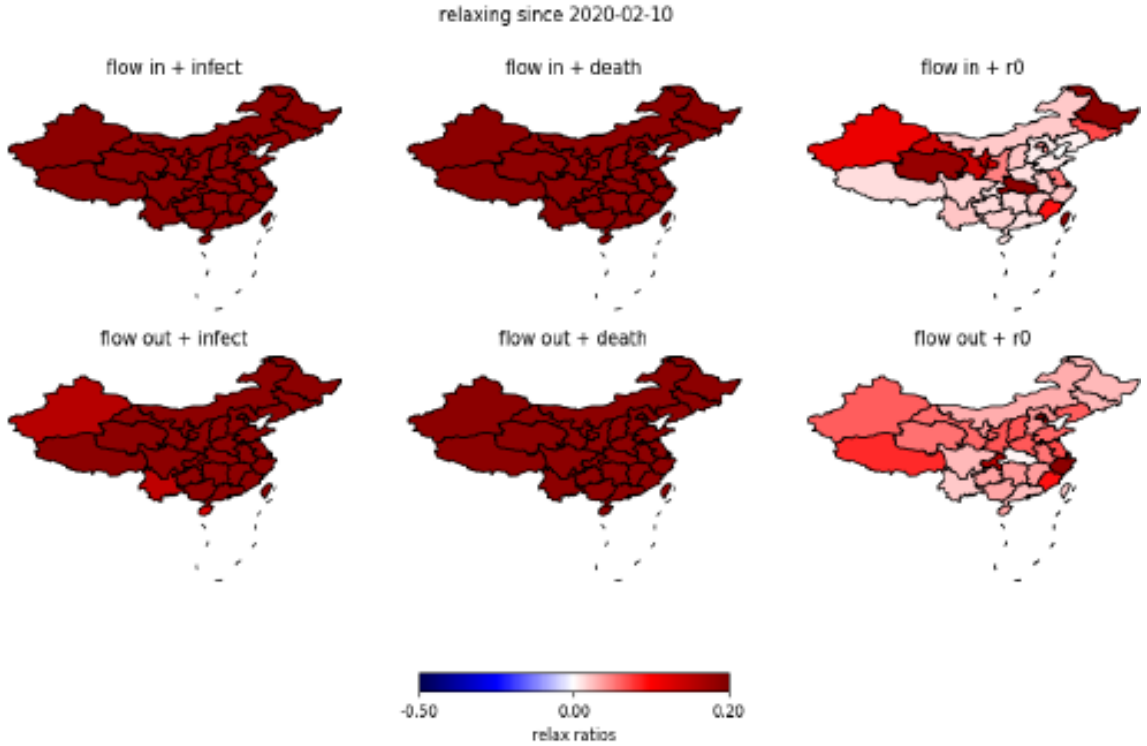


Supady et al. Lancet Respiratory Med. Jan 12, 2021

Application

- Potential increased involvement of modelers in policy making process





Evaluating the effect of city lock-down on controlling COVID-19 propagation through deep learning and network science models

Xiaoqi Zhang[1], Zheng Ji[1], Yanqiao Zheng[2], Xinyue Ye[3], Dong Li[4]

Summary of the impacts

- Expedited development of analytical methods for epidemic modeling
- Considerably broadened the range and type of data used and data sharing capacity
- Vastly widened the venue of information dissemination
- Dramatically increased the model interpretability

Where the future may stand …

- Interdisciplinary modeling
- Model flexibility
- Model interpretability
- Specialization
- Modeling vaccination in the real world

Acknowledgement

- China Data Institute
- All the relevant funding agencies