

# Modeling COVID-19 spread and control: Data needs and challenges

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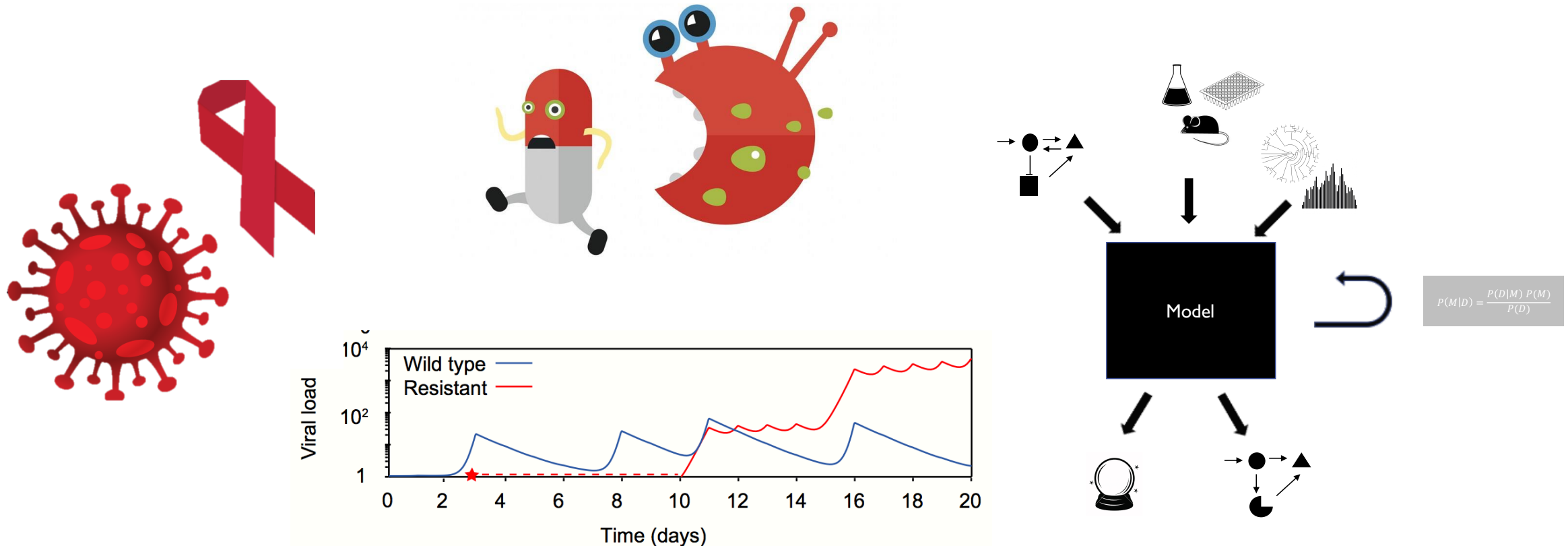
Disclaimers: 1) Like many, I am new to the field of coronavirus research. 2) With the rapid pace of research, things in this talk may be out-of-date or corrected by the time you view it.

# Summary of the epidemic

- A newly-recognized virus (**SARS-CoV-2**) which causes a disease (**COVID-19**) characterized by pneumonia and respiratory failure
- Since recognition as a disease syndrome in Dec 2019 and as a novel coronavirus (Jan 2020), has spread to nearly every country in the world
- As of May 14, 2020 12:48 UTC-5, ~4,400,000 recognized cases and ~300,000 deaths
- Like now ranked in Top 5 viral causes of death worldwide

# About me

- Infectious disease modeler focusing on HIV/AIDS and drug resistant infections



# Contributions to COVID-19 modeling

← → ↺ alhill.shinyapps.io/COVID19seir/ 🔍 ☆ 📄 📱 📧 NP 88 | 👤 ⋮

## Modeling COVID-19 Spread vs Healthcare Capacity

Disclaimer: This simulation is for research and educational purposes only and is not intended to be a tool for decision-making. There are many uncertainties and debates about the details of COVID-19 infection and transmission and there are many limitations to this simple model. This work is licensed under a [Creative Commons Attribution-ShareAlike 4.0 International \(CC BY-SA 4.0\) License](https://creativecommons.org/licenses/by-sa/4.0/)

Set clinical parameters...

**Duration of incubation period**

0 days 5 days 20 days

0 2 4 6 8 10 12 14 16 18 20

**Duration of mild infections**

0 days 6 days 20 days

0 2 4 6 8 10 12 14 16 18 20

**% of infections that are severe**

%0 %15 %100

0 10 20 30 40 50 60 70 80 90 100

**Duration of severe infection (hospital stay)**

0 days 6 days 10 days

0 1 2 3 4 5 6 7 8 9 10

**% of infections that are critical**

%5 %85

0 9 17 26 34 43 51 60 68 77 85

Set transmission rates...

**Mild infections**

0.5/day 3/day

0 0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3

**Severe infections**

0.1/day 3/day

0 0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3

**Critical infections**

0.1/day 3/day

0 0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3

**Allow seasonality in transmission?**

☐ Yes ☒ No

**Allow asymptomatic infections?**

☐ Yes ☒ No

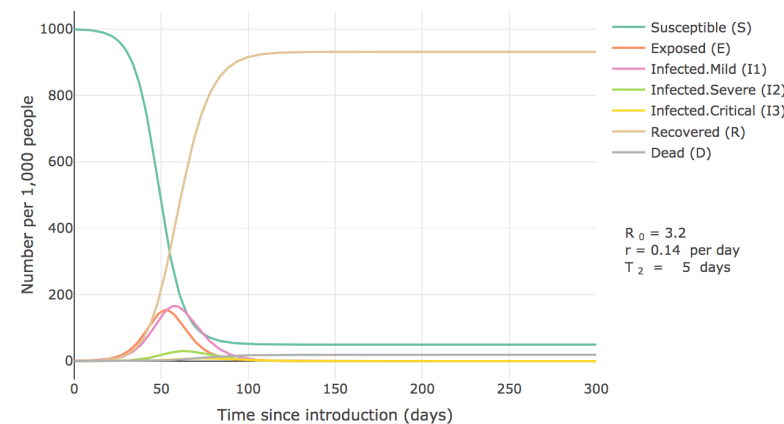
**Allow pre-symptomatic transmission?**

☐ Yes ☒ No

Output: Spread Intervention Capacity Model Sources Tutorial About

### Predicted COVID-19 cases by clinical outcome

Simulate the natural course of a COVID-19 epidemic in a single population without any interventions.



- Assisting regional health authorities, NGOs, consultants, educators, and other scientists with COVID-19 modeling projects

Interactive modeling app available at: <https://alhill.shinyapps.io/COVID19seir/>

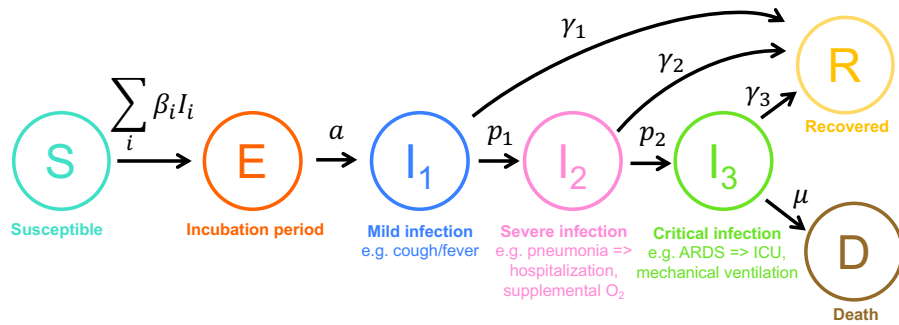


# Role of models in COVID-19 epidemic

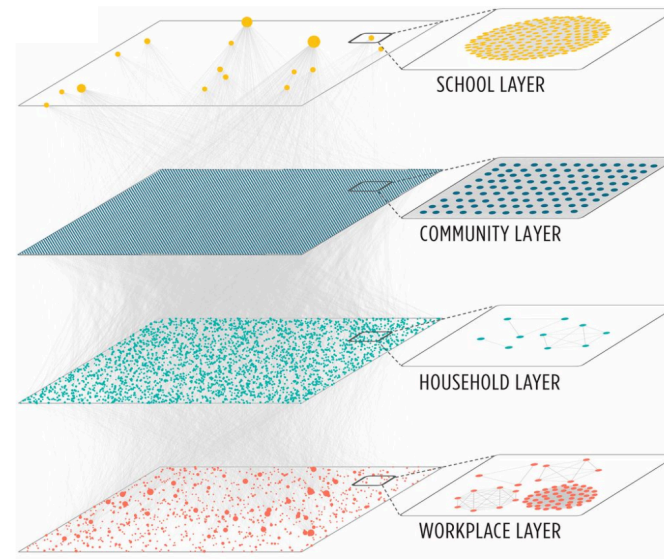
- Making short-term projections (exponential growth)
- Highlighting the risk of healthcare capacity overflow
- Promoting the idea of “flatten the curve”
- Motivating the implementation of strong interventions
- Projecting the course of the epidemic beyond spring 2020
- Estimating the potential impact of seasonality
- Estimating the total burden of infection
- Inferring the efficacy of interventions

# Ingredients of COVID-19 models

## Clinical course of infection



## Transmission networks

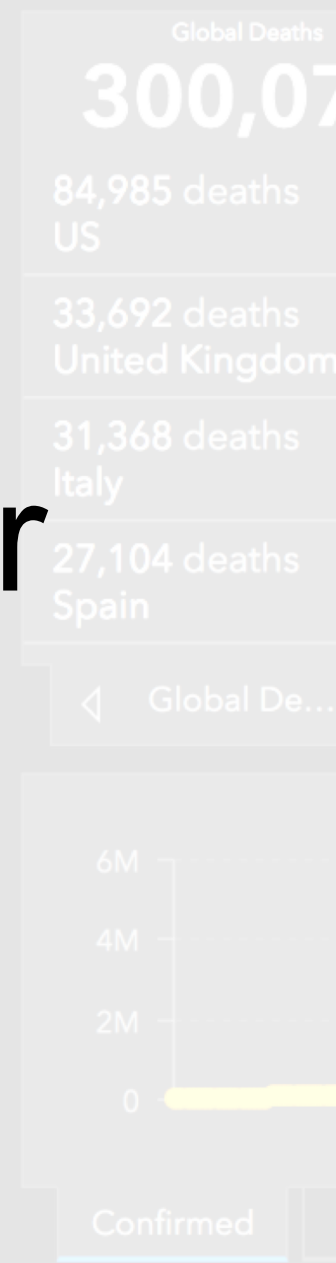
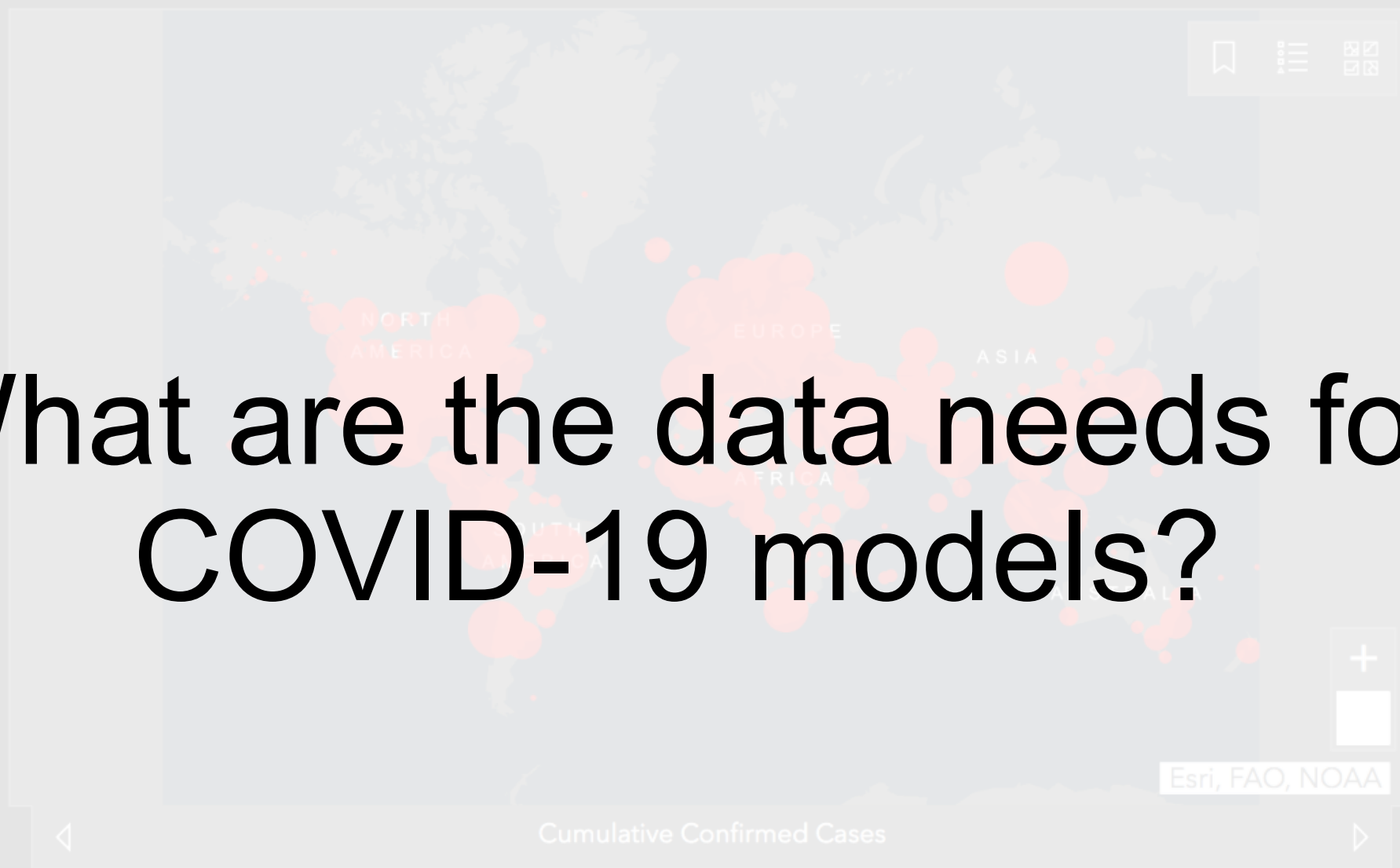


Healthcare resources available



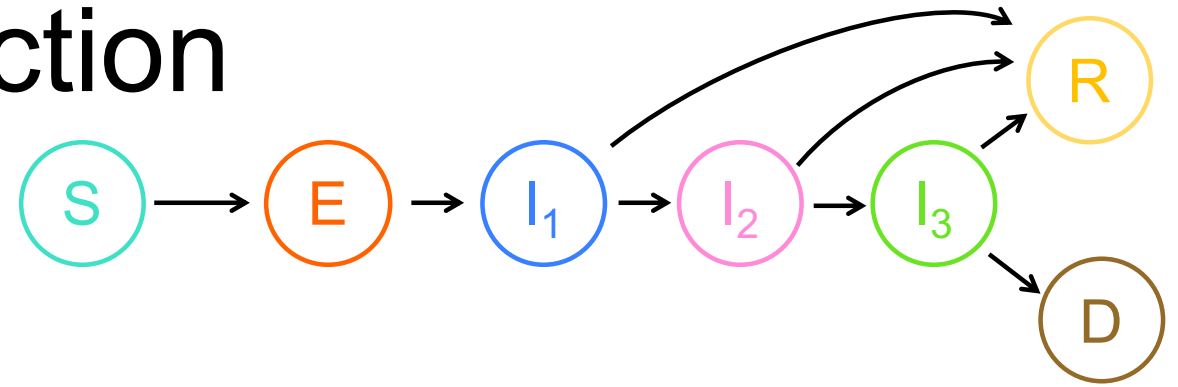
## Interventions





What are the data needs for  
COVID-19 models?

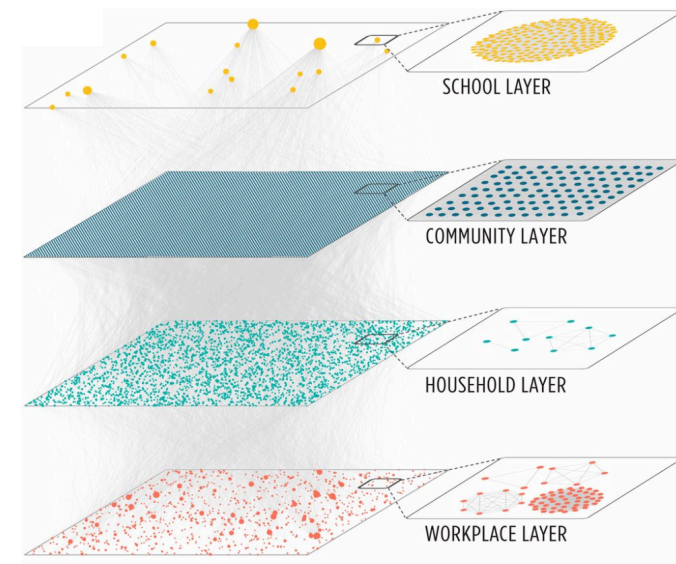
# Clinical course of infection



- Needs:
  - Duration of each stage of infection
  - Probability of progression/death/recovery at each stage
  - % asymptomatic infections
  - Infectiousness of each stage of infection (relationship to viral load, age)
- Gold standard:
  - Detailed cohort study with long-term follow-up
  - Contact tracing studies
  - Universal and centralized reporting
- Challenges
  - Estimating these quantities from population-level cumulative prevalence

# Transmission networks

- Potential networks vs realized network
- Questions
  - Who contacts whom, and where, for how long, how often, etc?
  - What type of contact is most risky? (e.g. physical proximity, indoor vs outdoor, duration, surfaces)
  - What setting is most important for transmission? (e.g. home, work, retail)
    - May depend on pre/post intervention, location, age, etc
  - How important is transmission in hospitals?
- Gold standard
  - Contact surveys; proximity tracking; contact tracing; genetic epidemiology
- Challenges: Privacy, resources, reporting infrastructure,



# Healthcare requirements vs capacity

- Needs
  - % cases requiring different levels of care vs age, comorbidity
  - Baseline and surge capacity for PPE, hospital beds, ICU beds, ventilators, masks for the general public, etc
  - Staffing needs
  - Geographic variation in resources (esp. in rural areas, low-income countries)
  - Willingness/ability to access care
  - Impact on non-COVID19 health care delivery
- Gold standard
  - National databases tracking medical resources
  - Real-time reporting of COVID-19 utilization
- Challenges
  - Finding/compiling alternative data sources



# Interventions (“non-pharmaceutical”)

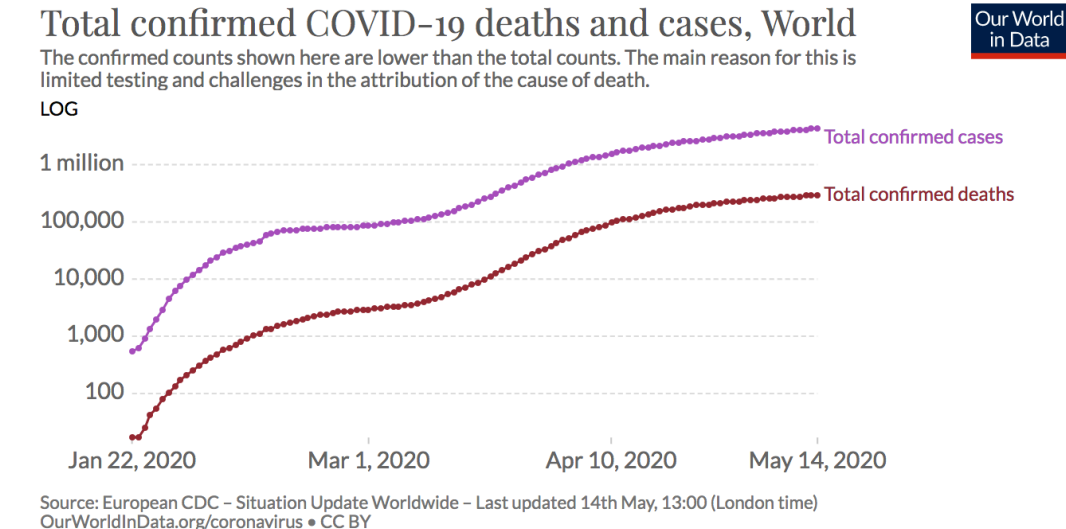
- Includes: mask wearing, case isolation, quarantine, school closures, closing of retail/dining, work-from-home policies, stay-at-home orders, complete lockdown
- Questions
  - What is the evidence base for interventions?
  - What was implemented, when and where?
  - How much do they reduce contacts relevant to transmission?
  - What level of adherence is there to interventions?
  - Are they working? Which ones?
- Gold standard: RCTs, surveys, knowledge of transmission networks
- Challenges: Relating alternative data sources to modeled “proportional reduction in transmission rate”





# What about the data we currently have?

- Current data: cases + deaths by region
- Pros
  - easily accessible to anyone from a central source
  - simple metrics that people understand
  - reported from centralized, official sources
- Cons
  - no individual level data
  - delays in time of onset or time of death
  - Imperfect reporting/testing
  - outcome of infection unknown
  - who is in hospital/ICU?
  - detailed geographic or age info





# Thanks!

- Anjalika Nande, Ben Adlam, Mike Levy, Sherrie Xie, Chris Rehman, Justin Sheen, Julianna Schinnick, Melanie Prague, Chloe Pasin, Irene Ballelli, Sam Scarpino, Moritz Kraemer

