Module 4

Lecture 4

Predicting the effect of interventions

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New briefing– new data!

CONFIDENTIAL OUTBREAK INVESTIGATION
DAY 4 BRIEF

OUTBREAK UPDATE — INTERVENTION MODELING
TO: Industry modeling consultants hired by UVA
FROM: UVA Student Health & Wellness

DATE: March 10, 2026

NEW INFORMATION
Case surveillance now includes daily case counts through day 120. It appears that the disease spread has peaked, and case counts are now decreasing.

NEW DISEASE EPICENTER
Unfortunately, the disease seems to have spread to Virginia Tech and has been spreading for 70 days. While the disease spread parameters are the same, VT has a much larger undergraduate population. The VT team requests that you model what would happen if different intervention strategies are adopted at day 70.

UPDATED VIROLOGY KNOWLEDGE
- **Genome**: Positive-sense RNA (~10 kb); Virus can be directly translated and does not require transcription
- **Virus has a small size:** 50-80nm

CURRENT TASKS
- Using the information about the peak of infections in the new data, **compare your model-predicted peak to the new data**.
- Recommend a best **intervention strategy to reduce the spread** of the disease while minimizing disruptions to campus life and student learning at Virginia Tech.

- Data to day 120
- Pull from GitHub upstream remote
- **What you should have at this point:**
  - A fitted ODE model with best values for beta, gamma, & sigma
- **What we will do next:**
  - Calculate the error of your model against the true data
  - For recommending interventions at VT:
    - Use VT's student population as S0
    - I0 = 1
    - R0 = 0
    - E0(VT) = E0(UVA)
    - Use **the same** best fit parameters from above to model the epidemic for 70 days
    - At day 70 (until day 120), we will model different interventions
    - Compare the baseline (no intervention) to each intervention to recommend one to implement

Calculating error

- Two main sources of error when comparing our dataset to our model:

Numerical error
Definition: Errors arising from the inability of a computer to represent real numbers precisely and the approximation techniques used to solve equations.

- Round-off error
- Truncation error

Model error
Definition: The gap between the mathematical model's predictions and the actual, real-world system being studied.

- Model is limited, incomplete, & makes assumptions
- Data is noisy

True error & percent relative error

When you know the true value.

true error (E_t)

$$E_t = true\ value - approximation$$

true % relative error (% e_t)

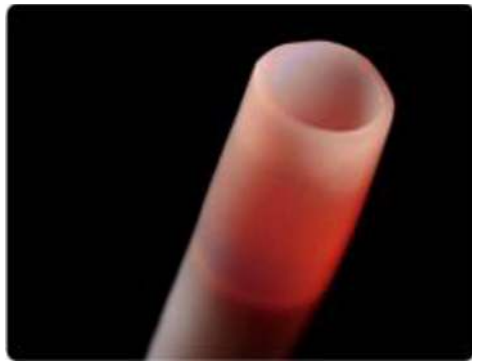
$$\%\ e_t = \frac{true\ -approx}{true} * 100\%$$

Find $\%\ e_t$ for both L and D:

L = 50 cm, D = 2.5 mm, E_t = 0.5 mm

$$\text{L: } \%\ e_t = \frac{0.5\ mm}{50\ cm} * 100\% = 0.1\%$$

$$\text{D: } \%\ e_t = \frac{0.5\ mm}{2.5\ mm} * 100\% = 20\%$$



Example of a commercially developed tissue-engineered blood vessel. http://cytograft.com/tebv.html

Find the true % relative error between the data and your model prediction…

- For the peak # of cases (error in y)

- For the peak day in days since the beginning of the epidemic (error in x)

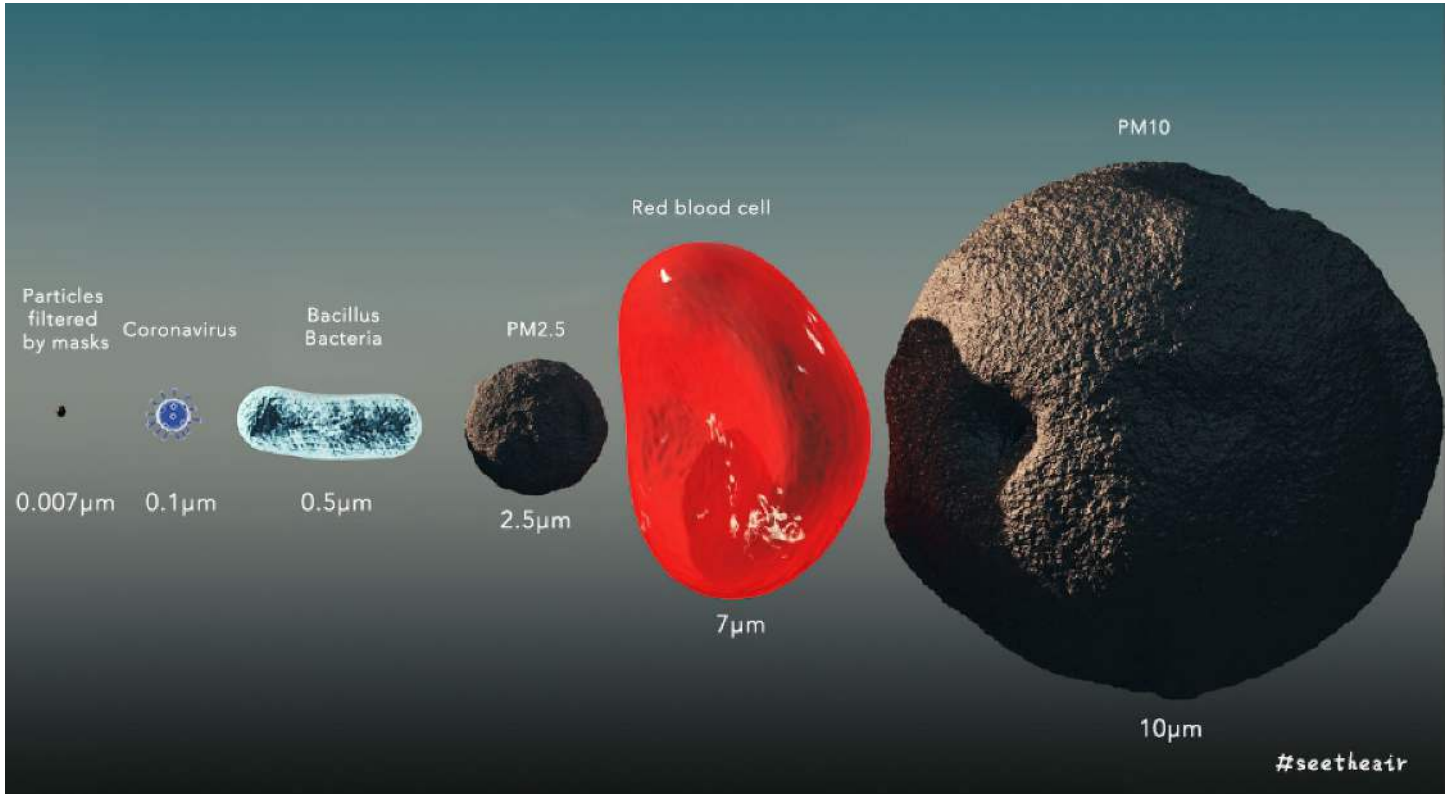
- With your partner and in your report, discuss why your model has the error it does (i.e. model limitations) and whether the error level is too high to trust your predictions.

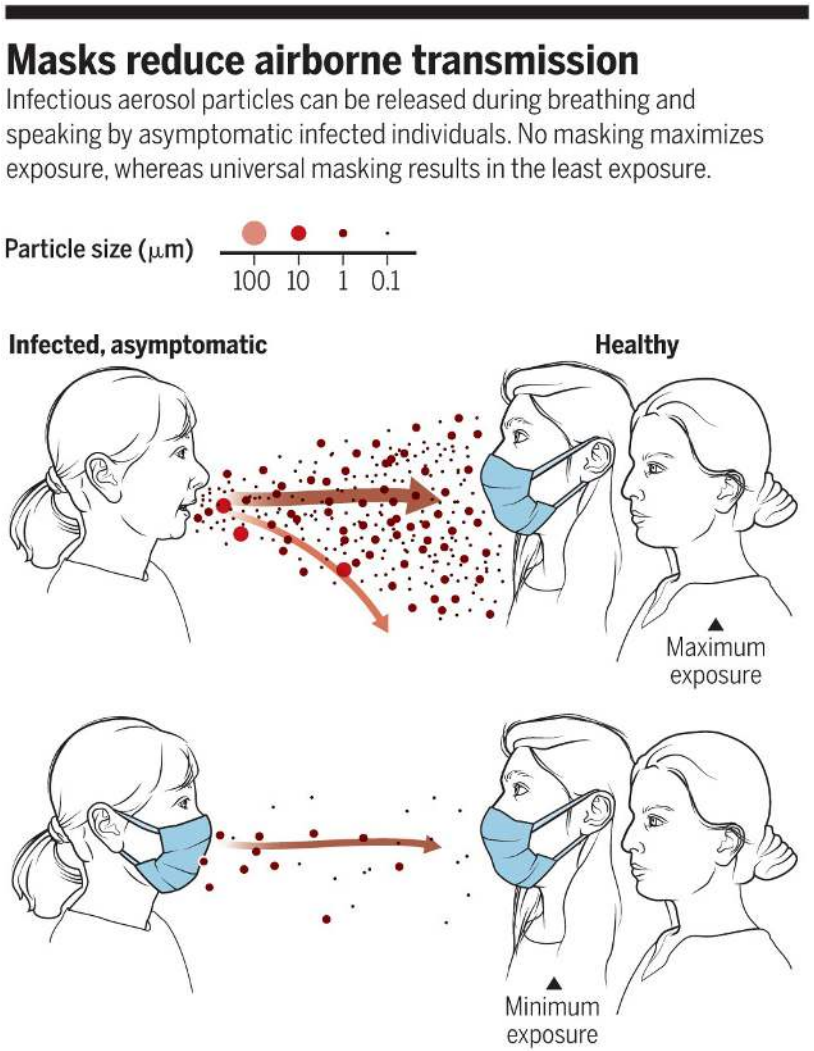
Modeling interventions at day 70

- **Your group should pick 3 of the 5 possible interventions (over the next few slides)**
- Each intervention will change some parameter (or move a population to a new compartment) at day 70
- You will compare these changes to the baseline prediction for VT
- As you model them from days 70-120, compare the following to no intervention:
  - Peak infections with intervention
  - Total cases (over days 70-120) prevented with intervention
- Cost & feasibility
- Compliance risk?
- Which would you recommend to VT?

Masking mandates

- **Immediate masking mandate implemented from day 70 on**
  - Reduces transmission by 40%





https://www.sciencedirect.com/science/article/pii/S2352431620301802?via%3Dihub#appSB

Vaccine interventions

- **Vaccine campaign: single event on day 70**
  - Vaccinate 2000 students on day 70 with 90% efficacy
- **Vaccine rollout:**
  - Vaccinate 1000 students on each: day 70, day 80, day 90



The Vanderbilt community turned out in force for Wednesday's Flulapalooza vaccination event. (photo by Susan Urmy)

Flulapalooza doubles record for vaccinations

Vanderbilt University more than doubled the current world record for the total number of vaccinations given in an eight-hour period.

From 6:50 a.m. until 2:50 p.m. on Wednesday, 12,647 University and Medical Center faculty, staff and students received free influenza vaccinations at Flulapalooza, a mass vaccination drill and simultaneous attempt to break the current Guinness World Record.

Organizers of the event, who won't know until paperwork is submitted whether Vanderbilt will be officially awarded the world record by Guinness, said the turnout exceeded expectations. The current world record stands at 6,215 and is held by Kaiser Permanente. Flulapalooza had surpassed 6,300 vaccinations within the drill's first four hours.

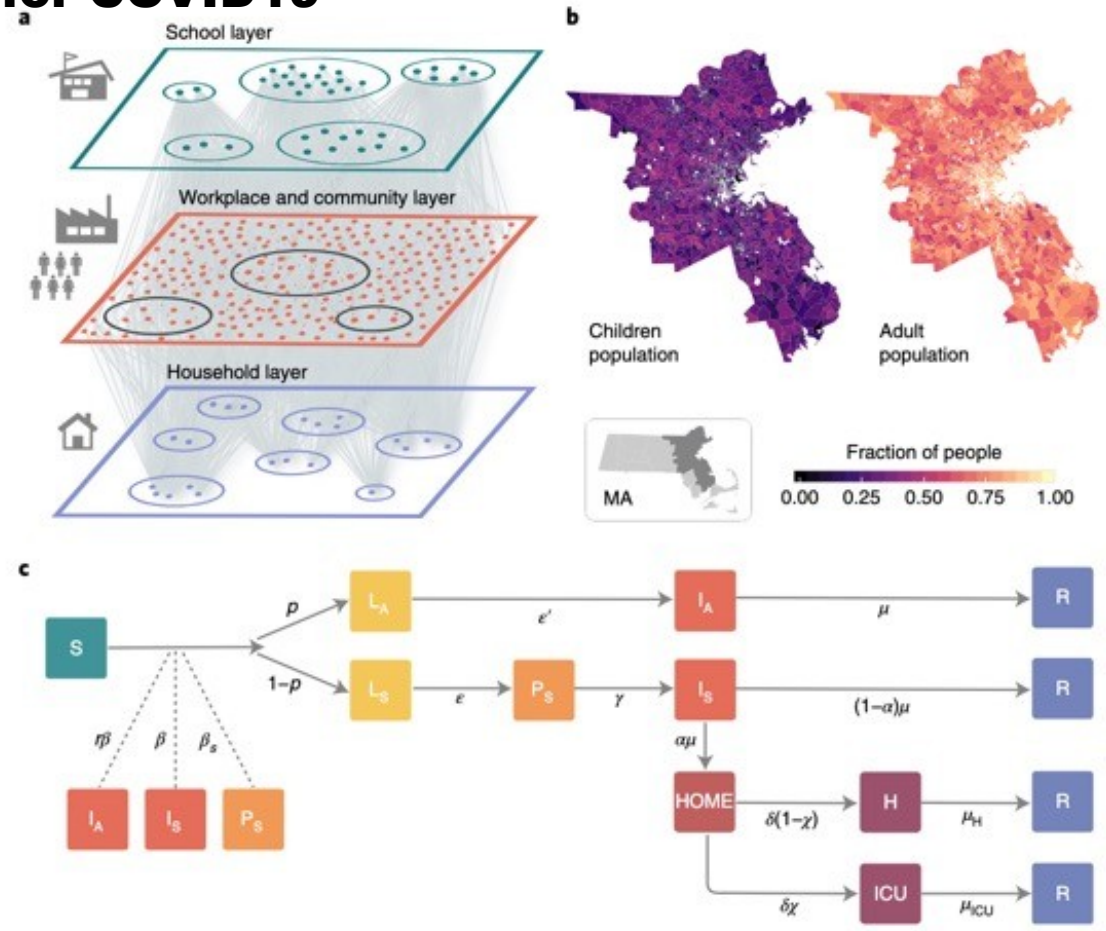
About 14,000 prefilled syringes were on hand for the event, and more than 300 volunteers assisted keeping participants moving quickly and smoothly through the tent on the grassy lawn between Vanderbilt's Light Hall and the Nashville VA Medical Center Campus.

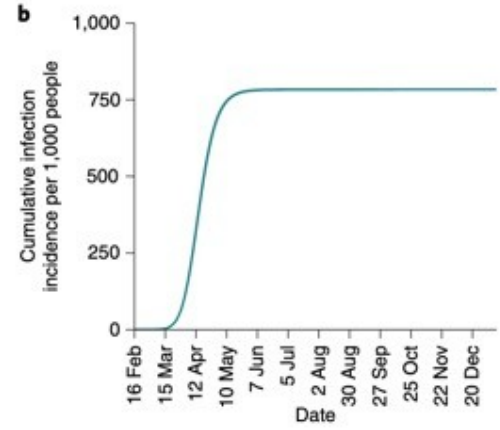
https://ajph.aphapublications.org/doi/10.2105/AJPH.2017.303953

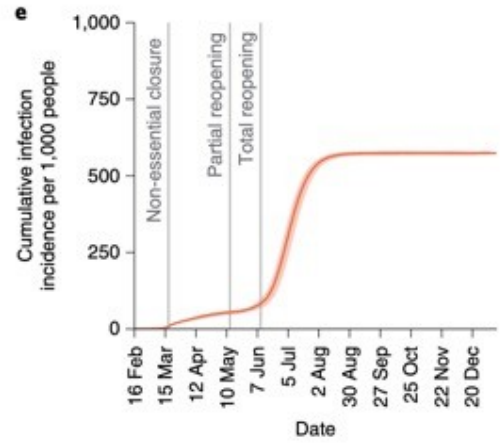
Testing & quarantine

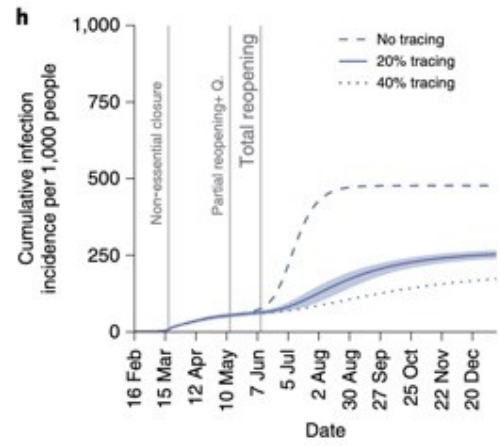
- **Testing + quarantine starting day 70**
  - Reduces infectious period by 2 days (due to delays in testing & low compliance)
- **Close school for 2 weeks**
  - During closure, only 20% of normal contacts
  - After closure, contact rate returns to normal

Testing, contact-tracing, and quarantining for COVID19









https://www.nature.com/articles/s41562-020-0931-9.epdf

https://news.mit.edu/2020/modeling-impact-of-testing-contact-tracing-quarantine-0908

Some questions you could answer to “exceed expectations”

- How does the % reduction in cases depend on the effectiveness of masking?
  - What about if masking was implemented earlier?
- How does the % reduction in cases depend on the length of the school closure?
- How does earlier testing & quarantine effect the number of cases?
  - What if compliance for testing was only 50%?
- What if the vaccines were available earlier?
  - How does the peak number of infections depend on the timing of a vaccination event?
- Which interventions would burden certain groups disproportionately?
- Are any of the changes to the I(t) plot surprising to you?
- Try modeling all 5 interventions!
- Anything else you are interested in comparing!

Looking ahead…

- **Next Tuesday:** final project due
  - Look at the notebook **template** and make sure it is completed.
  - It can reference code from other python files (methods/functions), but all of the **plots, results, and your thought processes** should be in the single notebook as a **report**
  - **Section 3 should include plotting the full dataset against your model; error estimates and discussion, and intervention strategies**
- **Presentations**:
  - Follow the same **template** as Module 1 (or a variation!)
  - You can present as if you are giving **recommendations** to the UVA epidemiological modeling team about the mystery virus (the background section of your presentation will look a little different!)