Emory OXFORD Spring 2021 COVID Model

A model analysis of COVID-19 tranmssion and control at Emory University

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Authors

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Summary

Emory University is exploring prevention and control strategies for the Spring 2021 school semester in response to the COVID-19 pandemic. A key question is to understand the impact of screening strategies targeting on-campus students. To provide a framework to address this question, we use an susceptible-exposed-infectious-recovered (SEIR) type of deterministic model developed for the spring semester. Compared to a static model, this approach has the advantage that it captures the transmission process, therefore estimates the indirect (transmission-mediated) effects of control strategies. For example, by testing and identifying COVID-19 infected students, the model captures the effects of them being isolated, their contacts being quarantined, as well as all the infections averted by preventing the chains of transmission that would have otherwise occurred.

Interventions

Here we present three scenarios detailed below

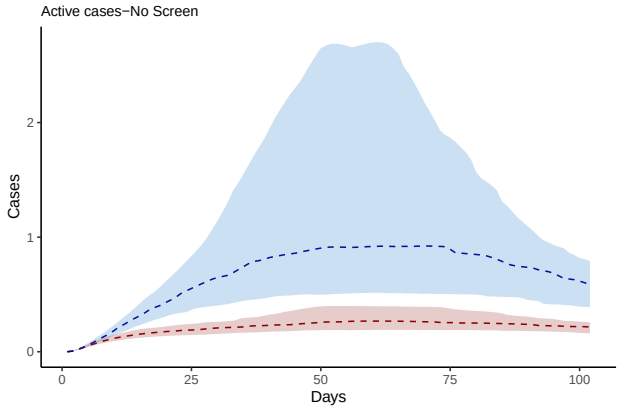
Intervention	Screening on-campus students	Screening off-campus & staff
No screening	None	None
Weekly screening	Weekly	None
Biweekly screening	Biweekly	None

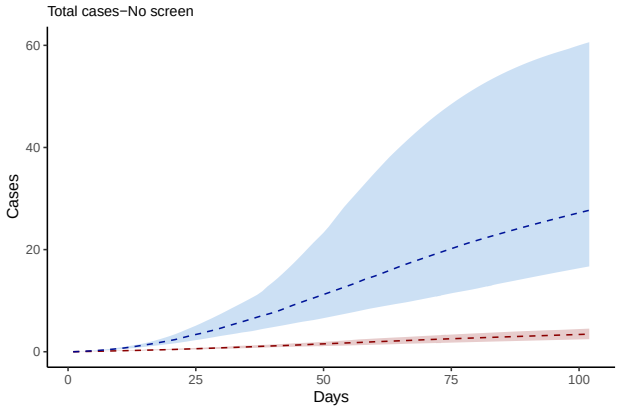
Parameters

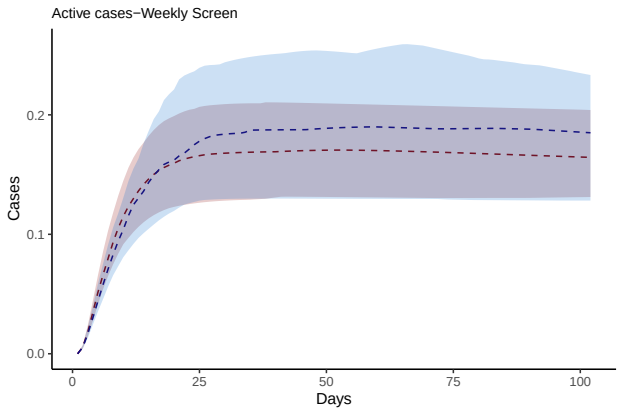
This table shows the parameter inputs into the model and their ranges used in sensitivity analysis. The 'value' column shows our base case scenario for what we expect to be the most likely set of conditions and interventions.

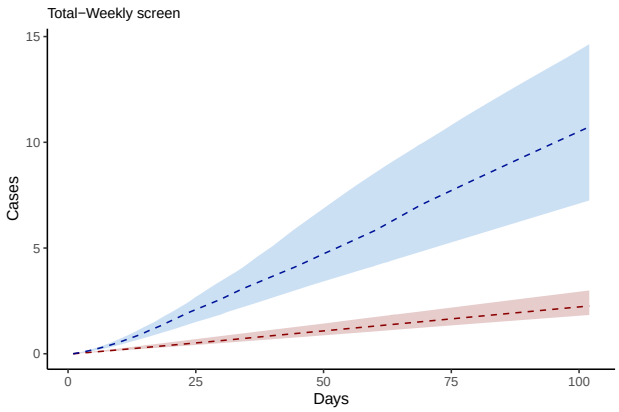
Parameter	Value	Lower	Upper
Total students	469.00		
Students living on campus	469.00		
Staff and faculty	160.00		
Latent period (days)	3.00	2	4
Infectious period (days)	7.00	6	8
Proportion severe - students	0.02	0.0133	0.0456
Proportion severe - staff/faculty	0.06	0.0327	0.1122
Proportion fatal - students	0.00	0.00007	0.0003
Proportion fatal - staff/faculty	0.01	0.0029	0.0105
Proportion symptomatic - students	0.35	0.27	0.43
Proportion symptomatic - staff/faculty	0.51	0.41	0.59
Time from onset of infectiousness to testing (1/days)	2.00	7	1
Screening frequency (1/days)	7.00	None	3.5
Duration of quarantine (days)	14.00		
Number of contacts per case	2.00	1	7
Proportion of contacts reached	0.75	0.5	1
Proportion experiencing ILI symptoms per day	0.00	0.003	0.003667
Day 2 of infectiousness	0.75	0.6	0.83
Day 4 of infectiousness	0.80	0.7	0.85
Day 7 of infectiousness	0.75	0.65	0.8
All students <-> all students	2.00	0.7	2.5
On campus students <-> On campus students	1.00	0.3	1.4
All students <-> staff/faculty	0.50	0.15	0.7
Staff/faculty <-> staff/faculty	0.50	0.15	0.7
Risk reduction of NPIs	0.35	0.18	0.43
Semester Duration (days)	102.00		

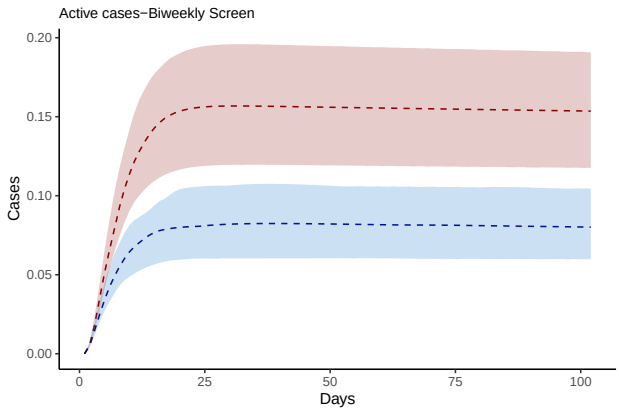
Plots for all scenarios

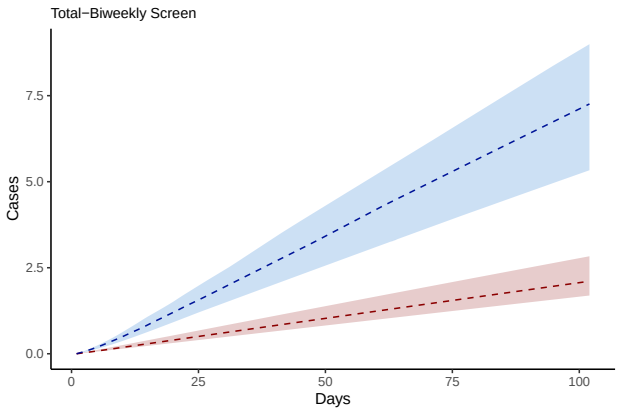












Summary results

Measure	No screening	Weekly screening	Biweekly screening
StudentCases	28 (7-98)	11 (4-27)	7 (3-14)
StudentCasesPeak	1 (0-8)	0 (0-1)	0 (0-0)
StudentHosps	2 (0-9)	1 (0-2)	0 (0-1)
StudentDeaths	0 (0-0)	0 (0-0)	0 (0-0)
StudentIsolate	14 (3-56)	15 (5-38)	14 (6-25)
StudentIsolatePeak	3 (1-17)	2 (1-7)	2 (1-4)
StudentIsolateDays	171 (41-741)	179 (66-456)	165 (69-299)
StudentQuarantined	39 (9-166)	38 (9-155)	33 (8-110)
StudentQuaPeak	7 (1-45)	6 (1-24)	5 (1-16)
StudentQuarantinedDays	463 (102-2140)	453 (107-1863)	402 (99-1324)
StaffCases	3 (1-8)	2 (1-5)	2 (1-4)
StaffCasesPeak	0 (0-0)	0 (0-0)	0 (0-0)
StaffHosps	0 (0-1)	0 (0-1)	0 (0-0)
StaffDeaths	0 (0-0)	0 (0-0)	0 (0-0)
Tests	269 (222-453)	6997 (6971-7021)	13756 (13734-13777)
TestsPerCapita	0 (0-1)	11 (9-11)	21 (19-22)

Weekly distribution of tests and influenza cases

- Testing data is based on the average weekly distribution of ILI care provided by Emory Student Health Services from 2016 to 2020.

- The fraction of tests for ILI that are flu cases is based on the % positive by week from the 2020 season (pre-COVID). This can be updated in order to be more repreentative
- These numbers are likely severe overestimates, because we assume that anyone with ILI gets tested and the flu positivity rates applies to all these tests even though many will be mild.
- There is **no uncertainty or variability** from ILI testing or flu data included in the model. The simulation intervals only reflect variability in other parameters, as in previous version of the model.

Week	Tests	FluCases
1	15 (13-26)	4 (3-6)
2	40 (33-66)	9 (7-15)
3	49 (40-82)	11 (9-19)
4	46 (38-78)	11 (9-18)
5	32 (26-54)	7 (6-12)
6	14 (12-24)	3 (3-6)
7	13 (11-21)	3 (2-5)
8	5 (4-9)	1 (1-2)
9	9 (8-16)	2 (2-4)
10	9 (8-16)	2 (2-4)
11	8 (6-13)	2 (1-3)
12	12 (10-20)	3 (2-5)
13	7 (6-12)	2 (1-3)
14	7 (6-12)	2 (1-3)
15	2 (1-3)	0 (0-1)

Model description

Spring model updates

- We adapted the model so that on-campus students are screened. Staff/faculty and students residing off-campus are not.
- We assume that symptomatic people are tested on their 4th day of infection, on average.
- Contacts are reduced substantially, inline with the numbers Neel provided. However, we did not include different number of contact for staff/faculty and students.
- We updated the student mortality rates in line with lower CDC estimates. However, we did not change the staff/faculty value – that's not changed much, according to the CDC recommended model parameters.
- For the range of community introduction values we used: Emory's testing and screening case counts (combined) for the lower value and Fulton County's current rate, assuming 5x infection:reported case ratio, as per CDC sero-surveillance.

General model description

This is a model of transmission of SARS-COV-2 among Emory students, staff and faculty. The model includes the following features and assumptions.

- Three populations with different degree of interactions among them
  - Students living **on campus**
  - Students living **off campus**
  - Staff and faculty
- We assume that students living on campus have a higher risk than those living off campus (R0 = 3.5 and 2.5 respectively). Staff/faculty can be infected by students and can infect other staff/faculty. We track campus-acquired and community-acquired infections for students and staff
- Staff and faculty have higher risk of severe illness and death (given infection) than students
- A fraction are *asymptomatic*. We assume (conservatively) that asymptomatically-infected persons are as infectious as those with symptoms. However, asymptomatic infection is more common among students (given their generally younger age) than staff/faculty.
- There is a daily risk of infection constantly being introduced on campus – this is based on case detections in Fulton and Dekalb Co.
- The model runs for 102 days from the start of spring term until the end of spring term
- Interventions are initiated by diagnotics. Infected persons can be identified by PCR through either testing or screening, as defined below.
- Diagnostics. For both control strategies, we assume that only a fraction of people tested are positive – positives are immediately isolated upon testing. We assume that the PCR diagnostic has imperfect sensitivity.
  - **Screening**: On-campus students are screened at a given frequency (ranging from biweekly to no screening) using antigen detection assays. Off-campus students and faculty are not screened in the model. We assume that there is contact tracing and quarantine initiated by **screening** as described below for **testing**.

  - **Testing**: **Symptomatic** students, staff and faculty come forward and are tested using RT-PCR. Most people have symptoms that are non-covid. We assume that only a fraction of people tested are positive – those people are immediately *isolated* We assume that the diagnostic has imperfect sensitivity. Testing also results in contact tracing. When a case is detected, (a proportion of) their contacts are *quarantined*. Some of those quarantined contacts might have been incubating but are now no longer able to infect since they are under quarantine. There is evidence that PCR sensitivity increases, reaching a peak around day 7 of infection (or day 4 of infectiousness), then declines again. We include the trade off of early testing where cases are detected faster, with a lower sensitivity of the diagnostic.

- We assume that the infectiouness (R0) is between 2.5 and 3.5 for students and that non-pharmaceutical interventions reduce R0 by 65%
- We perform a probabilstic sensitivity analysis to determine the range of credible outcomes, given uncertainty in model parameters.
- Note that in all projections, we assume that infections are continuously imported onto campus. When interventions are effective, the majority of cases are importations rather than transmission on campus.