Emory ATLANTA 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

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
Populations			
Total students	12,000		
Students living on campus	2,000		
Staff and faculty	15,780		
Natural history and clinical			
Latent period (days)	3	2	4
Infectious period (days)	7	6	8
Proportion severe - students	0.0224	0.0133	0.0456
Proportion severe - staff/faculty	0.055	0.0327	0.1122
Proportion fatal - students	0.0002	0.00007	0.0003
Proportion fatal - staff/faculty	0.0052	0.0029	0.0105
Proportion symptomatic - students	0.35	0.27	0.43
Proportion symptomatic - staff/faculty	0.51	0.41	0.59
Testing and quarantine			
Time from onset of infectiousness to testing (1/days)	2	7	1
Screening frequency (1/days)	7	None	3.5
Duration of quarantine (days)	14		
Number of contacts per case	2	1	7
Proportion of contacts reached	0.75	0.5	1
Proportion experiencing ILI symptoms per day	0.00333	0.003	0.003667
Proportion ILI flu positive	0.23		
PCR Sensitivity			
Day 2 of infectiousness	0.75	0.6	0.83
Day 4 of infectiousness	0.8	0.7	0.85
Day 7 of infectiousness	0.75	0.65	0.8
Transmission			
All students <-> all students	2	0.7	2.5
On campus students <-> On campus students	1	0.3	1.4
All students <-> staff/faculty	0.5	0.15	0.7
Staff/faculty <-> staff/faculty	0.5	0.15	0.7
Daily rate of community introduction	0.000719	0.00007	0.001
Risk reduction of NPIs	0.35	0.18	0.43
Time			
Semester Duration (days)	102		

Summary results

Measure	No screening	Screen 5000 per week (All)	Screen 15000 per week (All)	Screen 30000 per week (All)	Screen on-campus students only weekly
StudentCases	726 (336-1426)	584 (288-1099)	467 (240-824)	403 (213-680)	564 (287-1052)
StudentCasesPeak	23 (9-70)	14 (6-34)	7 (4-15)	4 (2-8)	15 (7-31)
StudentHosps	43 (12-124)	35 (11-92)	28 (9-68)	24 (8-58)	34 (10-87)
StudentDeaths	0 (0-1)	0 (0-1)	0 (0-1)	0 (0-0)	0 (0-1)
StudentIsolate	420 (186-915)	400 (192-786)	382 (199-670)	369 (198-624)	357 (176-677)
StudentIsolatePeak	60 (25-171)	53 (24-123)	49 (25-89)	46 (24-79)	47 (22-98)
StudentIsolateDays	5229 (2292-11880)	4961 (2372-9995)	4746 (2454-8357)	4583 (2447-7757)	4422 (2168-8496)
StudentQuarantined	1182 (276-3151)	1132 (273-2776)	1063 (267-2461)	1027 (263-2371)	1008 (242-2459)
StudentQuaPeak	169 (36-550)	152 (35-406)	136 (34-319)	128 (33-298)	133 (32-343)
StudentQuarantined Days	14674 (3389-40705)	14025 (3365-35157)	13186 (3300-30594)	12727 (3256-29513)	12469 (2992-30753)
StaffCases	724 (392-1228)	691 (377-1163)	660 (359-1108)	640 (345-1071)	702 (381-1193)
StaffCasesPeak	24 (13-43)	19 (10-33)	14 (7-24)	10 (5-17)	23 (12-39)
StaffHosps	73 (24-183)	69 (23-176)	67 (22-166)	65 (22-158)	71 (24-178)
StaffDeaths	7 (2-17)	6 (2-16)	6 (2-16)	6 (2-15)	7 (2-17)
Tests	13489 (11615-16123)	88746 (87255-90582)	240156 (238894-241593)	467867 (466744-469087)	45791 (44220-47769)
TestsPerCapita	0 (0-1)	3 (3-3)	9 (9-9)	17 (17-17)	2 (2-2)

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 representative
- 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	762 (656-911)	175 (151-210)
2	1978 (1703-2364)	455 (392-544)
3	2452 (2111-2930)	564 (486-674)
4	2328 (2004-2783)	535 (461-640)
5	1607 (1384-1921)	370 (318-442)
6	721 (621-862)	166 (143-198)
7	639 (550-763)	147 (126-176)
8	268 (231-320)	62 (53-74)
9	474 (408-566)	109 (94-130)
10	474 (408-566)	109 (94-130)
11	391 (337-468)	90 (78-108)
12	597 (514-714)	137 (118-164)
13	371 (319-443)	85 (73-102)
14	350 (302-419)	81 (69-96)
15	77 (67-92)	18 (15-21)

Model description

Spring model updates

- We adapted the model with scenarios where all students and staff are screened at intervals of 5000 per week, 15000 per week and 30000 per week.
- We also include a previous scenario requested by Emory which was to conduct weekly screening for on-campus students only
- 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 and Dekalb County's current rate of daily infections (averaged over the past 14 days). We assume 2x 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 RT-PCR. Off-campus students and faculty are not screened in the model. We assume that there is no contact tracing and quarantine initiated by **screening**.
  - **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.