COVID Back-To-School

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1 Use: Identify Appropriate Social Distancing Measures

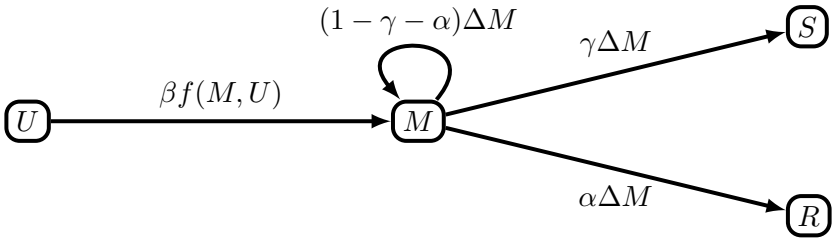
To control spread of COIVD, we must implement social distancing measures. Rather than arbitrarily implementing measures against COVID spread, we have built a tool that gives you a quantitative approach to controling spread. COVID Back-To-School is a tool for generating actionable information on how to reopen schools (elementary, secondary, boarding), universities, workplaces, etc. There are three basic steps:

(1) Tell us about your school, pre-COVID.
(2) Tell us about where your population is coming from upon reopening. To do this you upload a CSV file indicating how many people come from each county in the US, and for international entities, each country in the world.
(3) Tune the social distancing knobs until you achieve the outcome you desire.

For different settings of the social distancing knobs, you can find out how the infection will spread in your school/university/organization. You can tune the knobs until the spread is a tolerable level for you. The settings for these knobs will then tell you what social distancing protocols you need in place to accomplish that level of tolerable spread.

2 The Model

We use a simple SEIR-type compartmental aggregate infection model for the pandemic spread, modified to include an incubation time for the disease, captured by the lag parameter k.



$$
\begin{aligned}
U(t) &= U(t-1) - \beta f(U(t-1), M(t-1)) \\
M(t) &= M(t-1) + \beta f(U(t-1), M(t-1)) - (\gamma+\alpha)\Delta M(t-k) \\
S(t) &= S(t-1) + \gamma \Delta M(t-k) \\
R(t) &= R(t-1) + \alpha \Delta M(t-k)
\end{aligned}
\tag{1}
$$

The main parameter in this model is β. This parameter β is determined based on the social distance setting and school parameters that the user provides as input.

3 User Tunable Social Distancing Knobs

(1) Tell us about your school Pre-COVID.

- *dormmates0*: Pre-COVID Number of residence life interactions per day (not in class)[1]
- *meals0*: Pre-COVID Number of dining hall meals per day
- *mealmates0*: Pre-COVID Number of interactions during meals per day
- *classesperday0*: Pre-COVID Classes per day in person
- *classinteractions0*: Pre-COVID Number of interactions attending an in-person class
- *nstudents0*: Pre-COVID population size
- *RegionIdx*: Region in which school is located
- *InfDef*: Pre-COVID fraction of population to get infected (population succeptibility)

(2) *When you reopen*, tell us about where your students are coming from.

- *RegionCounts*: CSV file specifying regions from which students arrive upon opening

(3) *When you reopen*, tell us about what measures you would like to implement, including modifying some of your school parameters to enforce social distancing measures, masks and testing.

- *dormmates*: Number of residence life interactions per day (outside of class)
- *meals*: Number of dining hall meals per day
- *mealmates*: Number of interactions during meals per day
- *classesperday*: Classes per day in person
- *classinteractions*: Number of interactions going into, out of and during class
- *ClassSkip*: Fraction of classes skipped
- *NumCommunity*: Number of daily interactions outside of the school
- *SDfactor*: Mask effectiveness
- *MaskCompliance*: Fraction of population complying with masks
- *TestBudget*: Total budget of individuals that can be tested
- *TestFreq*: Number of days between testing of students
- *TestFrac*: Fraction of students tested
- *TestFracU*: Maximum fraction of students that can be tested in a day
- *TestErr*: False negative rate of a test
- γ: Fraction of infections which become symptomatic
- *StatusQuo*: Indicator of whether to model world regions using status quo social distancing or gradual relaxing of current social distancing toward reopening fully
- *ShowSymp*: Plot only symptomatic infections or show all infections
- *M0*: Number of starting infections if overiding region based infections
- *M0override*: Overide region based infections with user specified starting infections
- *ImmDef*: Fraction of students with immunitu if overiding region based immunity
- *Immoverride*: Overide region based immunity with user specified immunity
- *RollAvg*: Number of days over which to show new infections
- k: Incubation time in days of the disease after which symptoms present

[1]By interaction we mean any encounter in which the virus *may* transmit from one person to another.

4 Case Study: A School Like SUNY Albany

(1) Pre-COVID description of the school.

Knob	Value	Comment
dormmates0	3	Assuming A student living in campus housing might have 2 roommates and meet 4 other people in common spaces like bathrooms, lounges, kitchens, ..., for a total of 6. A commuting student interacts with 0. Assuming 50% of students are commuting, the average per student per day is 3.
meals0	1.5	On campus student may have 2 per day. Commuting will be 1. Average=1.5.
mealmates0	8	Have meal with 3 students and interact with 5 more.
classesperday0	2	Average, including lecture, lab, recitations.
classinteractions0	20	6 while filing into class (3 behind you and 3 in front); 8 around you while seated in class; 6 while filing out.
nstudents0	17308	Estimate from web.
RegionIdx	Albany, NY	
InfDef	0.8	This is an estimate of the succeptibility. If one person is infected, what fraction of students will get infected with no measures? Probably 40% is low (given that the flu infected 15% with a vaccination campaign) and perhaps 80% is high. We are going conservative

You may worry that these numbers are difficult to estimate accurately. Decent estimates will suffice. Their main purpose is to set the baseline for the school. It is against this baseline that, for example, social distancing measures will be calibrated. For example, later when you want to tune parameters, say you wish to reduce during-a-class interactions by 50%. Then set classinteractions to 10.

(2) We now need the CSV file that details the counties from which students are from. For SUNY Albany, Let us assume all students are from NY and proportionately represent each county according to the county's size. We show the file below. The first line, for example, says that 272 students are from Albany NY. The relevant part of the CSV looks like.

```
272,New York,Albany,1861
41,New York,Allegany,1862
170,New York,Broome,1863
0,New York,BuffaloNY,1864
0,New York,CapitalDistrictNY,1865
68,New York,Cattaraugus,1866
69,New York,Cayuga,1867
113,New York,Chautauqua,1868
75,New York,Chemung,1869
42,New York,Chenango,1870
72,New York,Clinton,1871
53,New York,Columbia,1872
43,New York,Cortland,1873
40,New York,Delaware,1874
0,New York,DownStateNY,1875
262,New York,Dutchess,1876
817,New York,Erie,1877
33,New York,Essex,1878
45,New York,Franklin,1879
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48,New York,Fulton,1880
51,New York,Genesee,1881
42,New York,Greene,1882
4,New York,Hamilton,1883
55,New York,Herkimer,1884
98,New York,Jefferson,1885
24,New York,Lewis,1886
56,New York,Livingston,1887
0,New York,LongIslandNY,1888
64,New York,Madison,1889
659,New York,Monroe,1890
44,New York,Montgomery,1891
1206,New York,Nassau,1892
7407,New York,New York,1893
186,New York,Niagara,1894
204,New York,Oneida,1895
410,New York,Onondaga,1896
98,New York,Ontario,1897
342,New York,Orange,1898
36,New York,Orleans,1899
105,New York,Oswego,1900
53,New York,Otsego,1901
88,New York,Putnam,1902
141,New York,Rensselaer,1903
290,New York,Rockland,1904
205,New York,Saratoga,1905
138,New York,Schenectady,1906
28,New York,Schoharie,1907
16,New York,Schuyler,1908
31,New York,Seneca,1909
96,New York,St. Lawrence,1910
85,New York,Steuben,1911
1312,New York,Suffolk,1912
68,New York,Sullivan,1913
43,New York,Tioga,1914
91,New York,Tompkins,1915
158,New York,Ulster,1916
0,New York,UpstateNY,1917
57,New York,Warren,1918
55,New York,Washington,1919
80,New York,Wayne,1920
860,New York,Westchester,1921
36,New York,Wyoming,1922
23,New York,Yates,1923
```
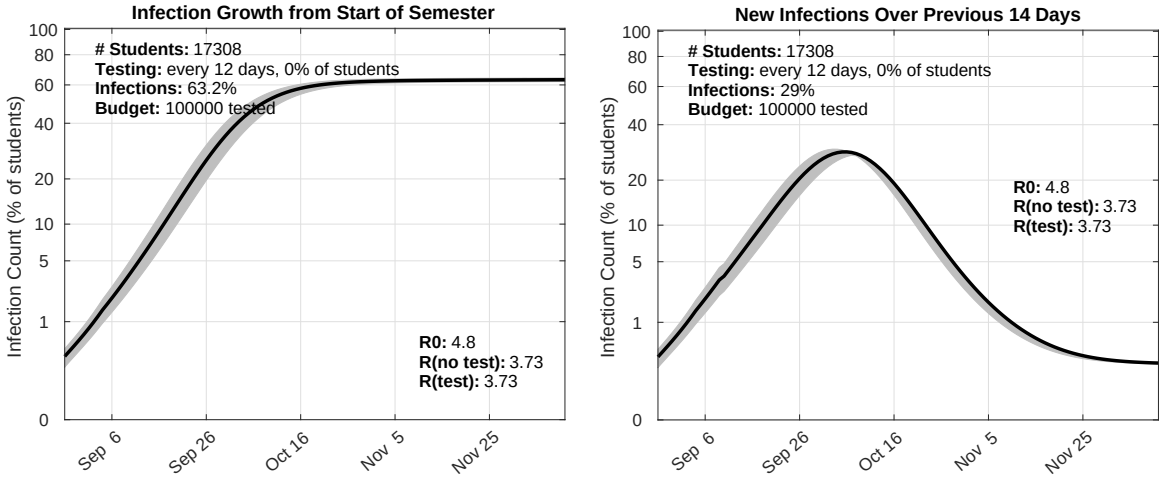

Of course, the numbers of students from each county are not completely correct. SUNY Albany does attract students from other states, and even international students. An administrator with this knowledge can provide a more accurate breakdown of the student points of origin.

Total infections, SUNY-Albany. No Measures Taken.



From the left curve, you will note that infections do not start at 0. In fact, they start at about 0.75% of the population. This is based on model predictions infection levels in each county assuming those regions do gradually continue to reopen. You will also note that only about 65% of the population gets infected, instead of the 80% succeptibility that we started with. This is because some students arrive with immunity based on the immunity present in each region from which students arrive. Immunity significantly reduces the infection spread for two reasons. First, fewer students are available to be infected. Second the propensity to spread is also diminished as the immune students function like damping rods. The data for region-by-region infections and immunity was obtained from:

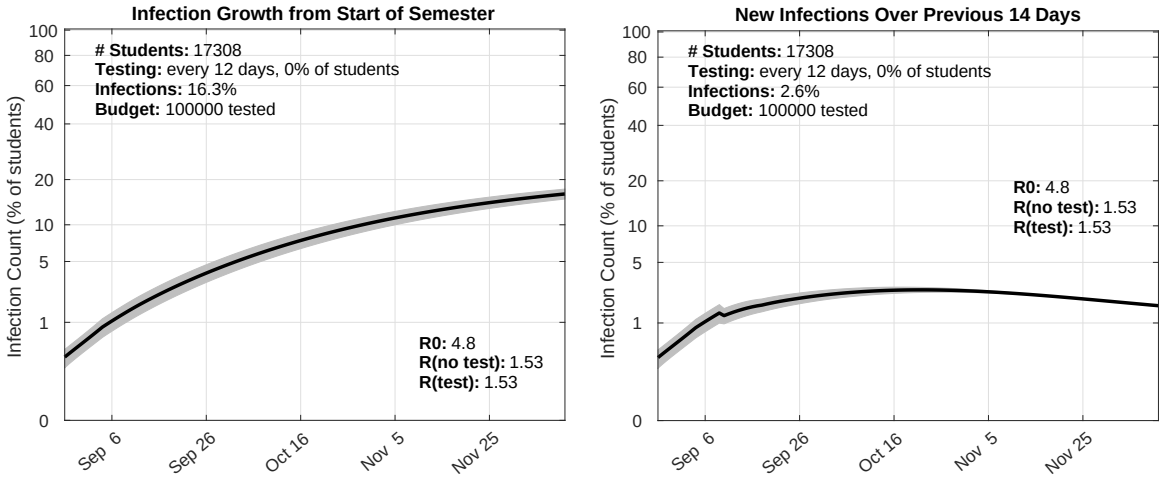
covidwarroom.idea.rpi.edu

Note, there are 14-day periods where about 30% of the students get infected.

(3) Now let us see what happens when we start implementing preventative measures. Also, we no-longer treat the school as a closed system but allow interactions with the community, in this case Albany County. Let us reduce class interactions by 25% (it is up to the school how to do this) and ask students to skip 1 out of every 4 classes (the skipped class will be online). Further let us ask students to reduce unnecessary residence life and meal interactions by about 50%. We set these parameters.

Knob	Value	Comment
dormmates	2	2 roommates and meet 2 other people in common spaces for a total of 6. 0 for communters. Average=2.
meals	1.5	(no change)
mealmates	5	Have dinner with 2 student and interact with 3 more.
classesperday	2	(no change)
classinteractions	15	(Take measures to reduce by 25%)
ClassSkip	0	(No online option)
NumCommunity	3	1 per day for in-residence students and (say) 5 per day for commuters (commuters in Albany usually use car not public transportation).
SDfactor	0.6	Typical reasonably priced mask.
MaskCompliance	0.5	People are reasonably good, 50% compliance.
TestBudget	0	No testing
TestFreq	NA	
TestFrac	NA	
TestFracU	NA	
TestErr	NA	
γ	0.05	typical user wouldn't change this.
StatusQuo	No	typical user wouldn't change this.
ShowSymp	No	typical user wouldn't change this.
M0	1	typical user wouldn't change this.
M0override	Use regions	typical user wouldn't change this.
ImmDef	0	typical user wouldn't change this.
Immoverride	use retions	typical user wouldn't change this.
RollAvg	14	typical user wouldn't change this.
k	8	Based on dissease – typical user wouldn't change this.

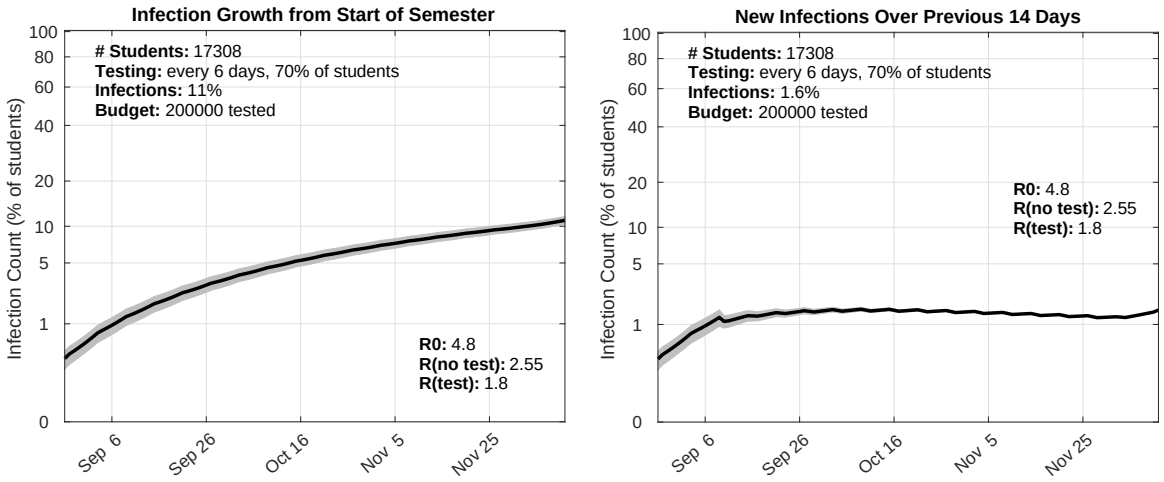
Total infections, SUNY-Albany. Social distancing plus masks.



We can achieve a similar effect with business as usual plus masks and testing.

Knob	Value	Comment
dormmates	3	
meals	1.5	
mealmates	8	
classesperday	2	
classinteractions	20	
ClassSkip	0	
NumCommunity	3	
SDfactor	0.6	
MaskCompliance	0.5	
TestBudget	200000	Entire semester budget of students tested. With optimal test-pooling, this can be significantly fewer than 200000 tests.
TestFreq	6	The tool tessls you the optimal testing interval.
TestFrac	0.7	
TestFracU	0.7	Maximum fraction testable on a day.
TestErr	0.3	Property of test.

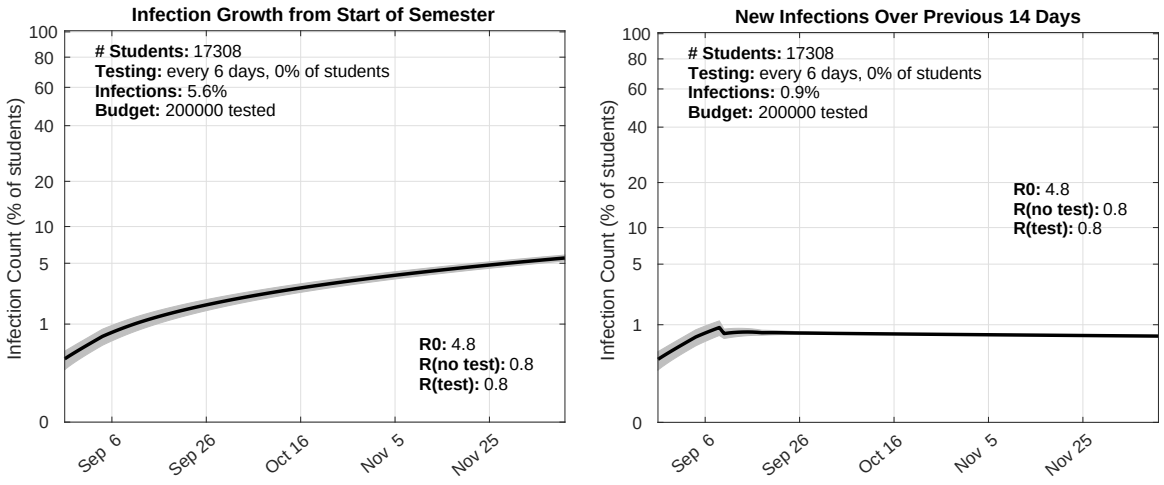
Total infections, SUNY-Albany. Masks plus testing. No Social Distancing



We can now ask the effect of a hybrid curriculum with say students skipping 50% of classes and taking them online.

Knob	Value	Comment
dormmates	2	2 roommates and meet 2 other people in common spaces for a total of 6. 0 for communters. Average=2.
meals	1.5	(no change)
mealmates	5	Have dinner with 2 student and interact with 3 more.
classesperday	2	(no change)
classinteractions	15	(Take measures to reduce by 25%)
ClassSkip	0.5	(No online option)
NumCommunity	3	1 per day for in-residence students and (say) 5 per day for commuters (commuters in Albany usually use car not public transportation).
SDfactor	0.6	Typical reasonably priced mask.
MaskCompliance	0.5	People are reasonably good, 50% compliance.
TestBudget	0	No testing
TestFreq	NA	
TestFrac	NA	
TestFracU	NA	
TestErr	NA	

Total infections, SUNY-Albany. Social distancing plus masks plus 50% online.



We do not recommend any particular measures. Given a school's capabilities, and testing budget, it is up to you to determine what works best for you.

5 Case Study: Shaker High School, Latham, NY

(1) Pre-COVID description of the school.

Knob	Value	Comment
dormmates0	8	Getting on and off bus.
meals0	1	lunch only
mealmates0	8	Sit with 3 students and interact with 5 more.
classesperday0	3	3 main periods where class composition changes (languages+social sciences, math, sciences).
classinteractions0	20	
nstudents0	2100	Estimate from web.
RegionIdx	Albany, NY	
InfDef	0.9	(conservative)

Notice how we interpret the parameters slightly differently because the type of entity changed.

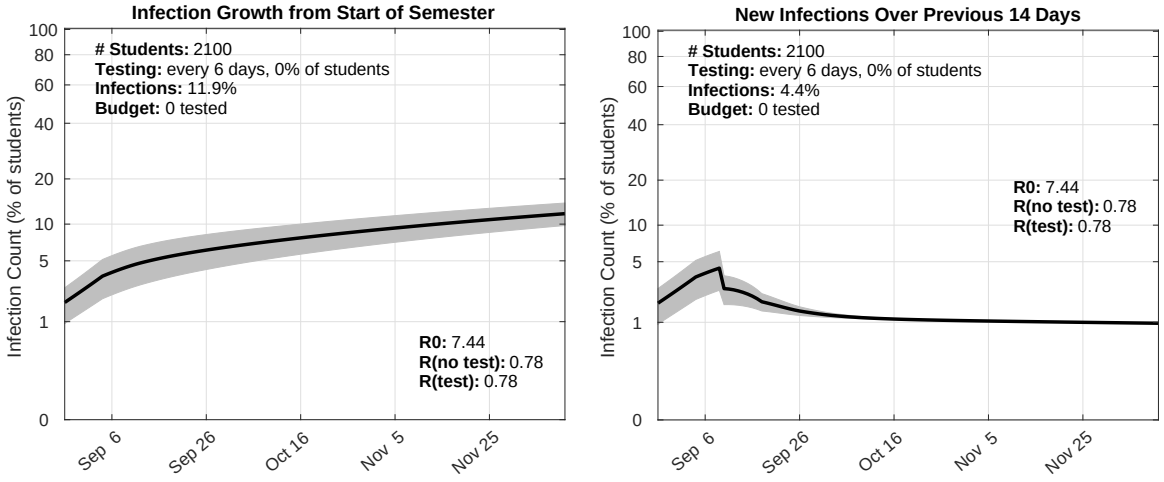
(2) The relevant part of the CSV looks like for student origins looks like:

```
2100,New York,Albany,1861
```

(3) Let us consider implementing minor social distancing with masks and a hybrid curriculum with 50% online. Also we must accept that Shaker is not a closed system and will interact with Albany county.

Knob	Value	Comment
dormmates	8	
meals	1	
mealmates	4	Sit with 2 and interact with 2 others.
classesperday	3	
classinteractions	15	reduce by 50%
ClassSkip	0.5	hybrid with online
NumCommunity	6	2 parents, sibling, plus outside school activities.
SDfactor	0.6	
MaskCompliance	0.5	Okay for high-schoolers. May be high for younger students.
TestBudget	0	No testing in schools
TestFreq	NA	
TestFrac	NA	
TestFracU	NA	
TestErr	NA	

Total infections, Shaker. Social distancing plus masks plus 50% online.



6 Other Organizations

COVID Back-to-School can be used with other organizations (workplaces, etc.), not just schools and universities. The trick is to figure out how to map your organization to the parameters that are input to the model.

If you need help doing this, please do not hesitate to contact us. One of our spread-consultants will be happy to help.