Lab #2 – simulating Covid in a population

What simulations to run:

Run the simulations indicated in the table below, and then fill in the rest of the table.

beta	days_in_IL	days_in_II	days_in_IV	Total infections	R_0	Herd immunity
.25	3	3	5	4	.75	N/A
.25	3	4	5	13	1	N/A
.5	3	3	5	60	1.5	33
.5	3	4	5	81	2	50
.5	8	4	5	81	2	50
.5	3	4	10	81	2	50

The first four columns are the simulation parameters for you to set. “Total infections” is the total number of people who have been infected by the end of the simulation. R_0 is the basic infectivity discussed in class. “Herd immunity” is the number of infected people required to reach herd immunity.

Questions

After filling in the table, please answer the following questions:

1. Compare the top four lines of the table. Consider the large change in the total number of people infected across the four lines, and the relatively small changes in the various parameters. What does this say about our ability to predict the course of an epidemic such as Covid?
   It says that prediction is hard! Small changes in population behavior can make huge changes in outcome ☹.
2. A little bit of math says that if each person contacts R_0 other people, then at the beginning of a pandemic when $|S| \approx P$ the number of infections vs. time is roughly $R_0^{t/\tau}$, where τ is the average time lag for one person to transmit the virus to another. The “new” B.1.1.7 strain has roughly R_0=1.5x higher than the original strain. If $\tau \approx 4$ days, and if our current measures are effectively creating R_0=1 for our original strain, then how long would it take until one infected person infects 1M others?
   The new strain is 1.5x more infectious than the original one. It thus has $R_0 \approx 1.5$, and the number of infections rises as $1.5^{(t/4\text{ days})}$. We thus have the equation $1000000 = 1.5^{(t/4)}$, or $t/4$=34.1, or $t \approx 136$ days. So, about 4 months, and then doubling again every week or so.

3a. Does the total number of infected people change when you change *days_in_IV*? Explain why or why not.
It does not. IV is the infected-visible stage, where we assume that people are quarantined. Once they are in quarantine, they are not infecting anyone else, and are irrelevant to the simulation.

3b. Even though herd immunity is the point where the epidemic is essentially under control, clearly it does not exactly match with the total number of infections (as shown by the two relevant columns in the table). Why not?

Herd immunity is the point where each infected person infects one other person in turn. It is the point where the pandemic “turns around,” and the total number of newly-infected people starts decreasing rather than increasing. However, at this point the infection doesn’t stop dead – it still takes time to stop, and thus many more people may still be infected.

3c. The slides show how to compute the herd-immunity threshold (which is presumably how you filled in the table above). Is there a way you can look at the graph and read the herd-immunity threshold reasonably well, without needing the equation?

You can essentially read the herd-immunity threshold by seeing the point on the plots where new infections (which is roughly the IL category) hit a peak, and then reading the size of S at that point.