Infecting the World

By Laker Newhouse

Six months ago, I infected millions of people. Luckily, they were virtual. Why was I simulating a global epidemic? My studio project for Term 2 of the 2017-2018 school year at Khan Lab School was to model globalization. Globalization, as defined in Martin Albrow's *Globalization, Knowledge, and Society*, "refers to those processes by which the peoples of the world are incorporated into a single world society, [a] global society." Globalization has undeniably had many positive effects, but it has also created more paths than ever for disease to spread. For example, an infected passenger in London might fly to Paris and infect Parisians. My team simulated these infected airplane flights spreading disease between cities. As we programmed our epidemic simulation (arongil.com/disease), I pondered what could model the same phenomenon mathematically.

My model lay in the pages of an old textbook my math teacher had lent me: Markov chains. An everyday analogy for how Markov chains work is the weather. From experience, the weather isn't completely random. If yesterday was rainy, today is more likely to be rainy; and if yesterday was sunny, today is more likely to be sunny. Markov chains capture this relationship. Each state, sunny and rainy, has one number for the chance of continuing and another number for the chance of switching.

Applied to my disease model, the Markov chain's states weren't rainy and sunny; they were whether any given city was healthy or infected. Instead of inputting the chance of the clouds gathering or clearing, I inputted the chance of the disease staying put or spreading from one city to another by air travel. For example, an infected Los Angeles would have a much higher chance of infecting New York than Berlin.

Now, I could compare the sizes of epidemics caused by the same infection originating in different cities. An infection starting in a low population city like Seattle, as you can imagine, would be much less dangerous than the same infection starting in a high population city like Beijing. While the model wasn't perfect, as it only factored in the distance between and population of two cities when estimating spread, it still revealed certain cities to be more dangerous origination sites than one might expect.

It was good validation when the Markov chain predicted that the world's largest city, Tokyo, was the most dangerous to infect. Surprisingly, however, it didn't predict that the world's second largest city was the second worst to infect. Instead, the top eight spots on the danger list were all held by other Japanese cities near Tokyo. If the infection began in any of them, the model predicted that, like lighting a fuse, they would quickly infect Tokyo. The insight gleaned was that the danger of an infection originating in a city is a combination of its own size and its proximity to other cities dangerous to infect.

The looming question is what you can do to mitigate the risk of epidemics. Returning to our computer simulation, the answer is clear. The most important variable in the spread of a disease is how easily it spreads. By washing your hands, you can play your part in uniting the world under globalization while taming its ugly underbelly.