Science You Can Use

Jack K. Horner

Dear Science: TV "talking heads" are saying that the number of novel coronavirus (COVID-19) infections is "increasing exponentially" or "growing exponentially". They don't explain what this means. Can you help? -- Buck R.

Dear Buck: Here's a short answer. In the US, the rate of increase in COVID-19 infections is so large that we must sharply reduce typical person-to-person contact, if we are to avoid overrunning the health care system.

Here's some detail.

How much will we have to reduce person-to-person contact ("increase social distance"), starting 19 March 2020, in order to "flatten the infection curve" to the level we won't overload the healthcare system? On *average*, across the country, we'll have to reduce the time we usually spend in body-to-body contacts at least 50% to make a meaningful difference. That translates to at least halving the time we usually spend in grocery stores, gas stations, work, bars and restaurants, barbers and beauty salons, sporting events, libraries, schools, and everywhere else but our houses.

For 80% - 90% of the people who become infected with the virus in the US, the disease will be no more inconvenient than a case of the flu. But that's not the crux of the problem. Let's assume that over the next year, as little as 30% of the US population is infected by the virus (Germany and France are assuming 50% - 70% of their populations will be). Let's assume that one half of one percent of those infected will die. Then the number of deaths the US will suffer this year from the virus will be comparable to each of the two leading causes of death – cancer, and heart disease -- about 500,000 people each. About five times that number will need hospitalization. If (5 x 500,000 =) 2.5 million coronavirus cases had to be hospitalized at the same time, US hospitals would be able to accommodate at most 20% of them.

To understand how exponential growth in the number of infections can overrun healthcare resources, let's look at a closely related, slightly idealized example, distill some observations from it, and then apply those observations to the COVID-19 pandemic.

Example. Suppose that you own a 1-acre pond and

a. you plant one water lily in it on the first day of a 30-day month
b. the surface area that the lily covers doubles every day
c. the lily covers the entire surface of the pond on the last day of that month
d. it takes 10 days to remove half an acre of lily growth

On what day of the month will the water lily cover half of the surface of the pond? Many people will answer this question with "Halfway through the month – on Day 15." The correct answer, however, is "Day 29". On Day 30 it will double in size, covering the entire pond. Note

especially that even on Day 29, the lily coverage still *seems* to be controllable before the plant overruns the pond. But it isn't.

The spread of the COVID-19 is like the lily example, where the pond plays the role of the total population, and the increase in the lily's size plays the role of the increase in the number of infections. In the example, the size of the lily doubles every day; in the case of the virus, the number of infected people can, in densely populated urban areas like New York City (NYC), double in two to three days.

How long does it take COVID-19 to overrun the healthcare resources of NYC? Let's assume the NYC data we had on COVID-19 as of 18 March 2020. Suppose that on Day 1, one individual is infected with COVID-19. Suppose that over a period of two days, that individual infects one other. At the end the first two days, therefore, 1+1 = 2 individuals have been infected. Each of these two, in turn, infects one other over the next two days, so, 2 + 2 = 4 individuals are now infected. In another two days, 4 + 4 = 8 individuals are infected, and so on. *In about 48 days* at this rate, more than 70% of the entire NYC population (currently about 8 million) would be infected if the transmission of the disease from person-to-person is not dramatically reduced, now. Based on NYC's current rate of hospitalization for the disease, about 23% of those with active infections would have to be hospitalized at the same time. NYC healthcare experts say NYC would need about 100,000 coronavirus-ready hospital beds (including trained staffing, ventilators, testing and safety equipment, etc.), to meet this demand. Currently NYC has only about 50,000 beds.

Although the doubling time for the spread of coronavirus infections in rural regions is longer than two to three days, the majority of residents in those regions would have to travel more than 100 miles to access a coronavirus-ready facility.

For further information, see Josh Katz, Margo Sanger-Katz, and Kevin Quealy, "Could Coronavirus Cause as Many Deaths as Cancer in the U.S.: Putting Estimates in Context", *The New York Times*, 16 March 2020.

Jack Horner is a systems engineer.