How much will the coronavirus spread? It's a question of biology and math

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When a Lehigh Valley man came down with a fever, diarrhea, and cough, he made no connection between his symptoms and those of the more than 2,000 people who had been sickened with a mysterious new

virus that had emerged in China.

He hadn't been to China, nor anywhere else in Asia, where most cases had occurred.

Eleven days and two hospital visits later, it turned out he had the same illness they did: SARS. Researchers later determined that before his April 2003 diagnosis—at a time when he could have been spreading the virus—he had come into close, unprotected contact with 26 people: family members, healthcare workers, fellow patients, and one bank teller.

Yet in a reminder that predicting the spread of infectious disease is an inexact science, none of the 26 became ill with SARS—severe acute respiratory syndrome.

The new coronavirus, a cousin of the virus that causes SARS, also has sickened thousands. So far it appears to be less deadly, though it has killed 170 people in China, where it is thought to have emerged at a large live-animal market in Wuhan.

Will world health officials snuff it out as they did SARS, through a combination of travel restrictions, surveillance, and isolation of patients? Or will it persist like the flu, an annual, ever-morphing visitor that already has killed more than 8,200 Americans this season?

A key part of the answer is something called a reproduction number: the number of people that each patient with a given virus will infect, on average. That depends on biology: how well the virus survives in the environment, and how readily it penetrates human cells, where it makes millions of copies of itself to keep the cycle going.

So far, epidemiologists estimate that each person infected with the new

coronavirus is infecting roughly two people on average—putting it in the same realm as SARS and the flu, but well below measles, with a reproduction number as high as 18.

Left to its own devices, any virus with a reproduction number above one—meaning that each patient infects, on average at least one additional person—will continue to spread in a susceptible population. But with protective measures, such as vaccination and placing patients in isolation, the effective reproduction number of a virus can be driven below 1.

The more dangerous a virus is, the less it may spread. If it kills patients rapidly, or simply makes them too sick to leave home, a virus is less likely to be transmitted, said Alison A. Evans, an associate professor of epidemiology and biostatistics at Drexel University.

"The virus really wants to be out there infecting people as long as possible," she said.

And the spreadability of a given virus can vary widely, said David N. Fisman, a professor of epidemiology at the University of Toronto.

Take the one that causes SARS. While its average reproduction number is thought to be somewhere between two and three, a few patients in the initial outbreak were identified as "super-spreaders"—in one case, infecting more than two dozen additional people, Fisman said.

Yet the Lehigh Valley patient infected nobody.

The 52-year-old man was exposed to the virus in late March 2003 while attending a religious retreat in Toronto. He was among more than a dozen members who would eventually fall ill, apparently after one of them came in contact with a person who had become infected in Hong

Kong.

But the cluster was not identified until April 9—three days after the Pennsylvania man's first visit to a hospital emergency room, according to a review by CDC and state health officials. He was sent home but continued to feel ill. On April 14, he went to a second hospital, Lehigh Valley Hospital-Muhlenberg, in Bethlehem, where he was diagnosed with SARS after telling physicians he had been in Toronto.

The difference between whether a patient is a super-spreader or a "dead end" may depend on treatment, Fisman said. If the person has severe symptoms and nurses have to stick a breathing tube down the patient's throat, that procedure can generate clouds of tiny, virus-laden particles, he said.

"They're surrounded by a team trying to help them," Fisman said. "Everyone's crowded in close. All that generates a ton of aerosols."

That's a key reason the measles virus is so infectious: a patient can put virus in the air simply by breathing. The tiny particles can remain aloft, infecting someone else who enters the room up to two hours later.

But for some other respiratory viruses such as the flu and SARS, the infectious particles tend to be carried by heavier droplets from regular coughing and sneezing. These do not travel as far, said Mark Shelly, healthcare epidemiologist for the Geisinger health system in Danville, Pa.

In 2003, one patient who was hospitalized with SARS did not transmit the virus to patients in beds on either side, located three feet away. But the patient did transmit the virus to a person who came to visit, standing within the three-feet range, Shelly said.

Evidence so far suggests that the new coronavirus, like its cousin that causes SARS, is behaving similarly, he and Fisman agreed. Take precautions as you would with the flu: avoid sick people and wash hands.

"We're seeing pictures of people dressed up like they did for Ebola," Shelly said. "That's way more than we need for this problem."

But if the virus continues to spread, the world will need to invest in a vaccine. At least two such efforts already are underway.