

# The Norovirus: A Study in Puked Perfection *by* Carl Zimmer

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Today, *The Guardian* relayed one of those stunning medical stories that causes me to clean off my glasses and take another look to make sure I'm reading it clearly. They report that an outbreak of norovirus in Britain this winter has struck more than 1.1 million people with vomiting and diarrhea.

*That's right: 1.1 million. In Britain alone.*

What is this fearsome bug, you may be asking, and why isn't it the subject of a Hollywood horror movie?

Noroviruses are one of virology's great open secrets. In a recent issue of *The Journal of Infectious Diseases*, Aron Hall of the Centers for Disease Control declared, "Noroviruses are perhaps the perfect human pathogen."

Here's what inspires awe in scientists like Hall:

Each norovirus carries just nine protein-coding genes (you have about 20,000). Even with that skimpy genetic toolkit, noroviruses can break the locks on our cells, slip in, and hack our own DNA to make new noroviruses. The details of this invasion are sketchy, alas, because scientists haven't figured out a good way to rear noroviruses in human cells in their labs. It's not even clear exactly which type of cell they invade once they reach the gut. Regardless of the type, they clearly know how to exploit their hosts. Noroviruses come roaring out of the infected cells in vast numbers. And then they come roaring out of the body. Within a day of infection, noroviruses have rewired our digestive system so that stuff comes flying out from both ends.

To trigger diarrhea, the viruses alter the intestinal lining, causing cells to dump out their fluids, which then gets washed out of the body—along with many, many, many noroviruses. Each gram of feces contains around five billion noroviruses. (Yes, billion.)

Noroviruses also make us puke. And if you can gather enough strength to think clearly about this, virus-driven vomit is a pretty remarkable manipulation of a host. Vomiting occurs when our nerves send signals that swiftly contract the muscles lining the stomach. Vomiting does us a lot of good when we're hurling out some noxious substance that would do us harm. But repeated projectile vomiting of the sort that noroviruses cause serve another function: they let the viruses to find a new host.

To get us to throw up so violently, noroviruses must tap into our nervous systems, but it's not clear how they do so. Here's one particularly creepy hint: some studies indicate that during a norovirus infection, our stomachs slow down the passage of food into the intestines. In other words, they seem to load up the stomach in preparation for vomiting. Every particle of that stored food is a potential vehicle for noroviruses when it comes flying out of the mouth.

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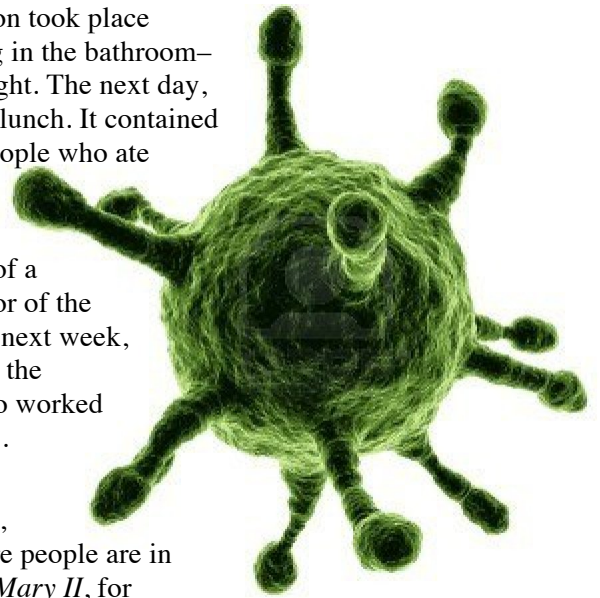
Once the norovirus emerges from its miserable host, it has to survive in the environment. Noroviruses have no trouble doing so, it seems. Fine droplets released from sick people can float through the air and settle on food, on countertops, in swimming pools. They can survive freezing and heating and bleaching. In 2010, scientists surveyed a hospital for noroviruses and found 21 different types sitting on a single countertop. It takes less than twenty noroviruses slipping into a person's mouth to start a new infection.

This natural history makes for Olympic-level feats of transmission. In 2010, for example, nine members of a girl's soccer team got sick with noroviruses while on a trip for a tournament in Oregon. The outbreak began with one girl coming down with stomach pains one Saturday evening. She moved from her hotel room to stay with a chaperone, where she then had diarrhea and vomited through the night. The chaperone took her back home in the morning (and also became sick later). Only on Tuesday did the rest of her team get sick.

Epidemiologists figured out that the first step in the transmission took place in the chaperone's hotel room. There was a reusable grocery bag sitting in the bathroom—which the first girl never touched as she went in and out through the night. The next day, another chaperone got the bag and brought it to another hotel room for lunch. It contained sealed containers of chips, cookies, and grapes. Seven of the eleven people who ate that food got sick.

Another display of the norovirus's tenacity came with a study of a New Zealand plane in which an infected passenger threw up on the floor of the economy section. A flight attendant cleaned up the mess, and over the next week, the plane continued to fly without any cases of vomiting. Nevertheless, the norovirus managed to infect new hosts. Out of 63 flight attendants who worked in the plane over the next six days, 29 got sick—an attack rate of 42.9%.

No one can say how the current outbreak in Britain got its start, but its timing is typical: January is peak norovirus season. Places where people are in close quarters are especially good incubators for the virus. The *Queen Mary II*, for example, is currently getting scrubbed down after a bad outbreak. But cruise ships are hardly the only place where noroviruses thrive. Schools get cleared out from time to time by the pathogens (the name norovirus comes from Norwalk, Ohio, where it was first isolated from a school during a 1968 outbreak). Nursing homes are fertile ground, too, in part because people there often have weak immune systems. While healthy people can clear out a norovirus after a couple of exhausting days, the virus can cling to people with weak immune systems for months or even years.



Noroviruses are so good at spreading that it's quite likely that at some point in your life, you've had a norovirus infection. (You may have wrongly called it a stomach flu. Flu—short for influenza—only infects people's airways.) It's estimated that in the United States alone, noroviruses infect at least 23 million people a year. Seventy thousand of them end up hospitalized, and nearly 800 die. Things are worse in developing countries, where people are less likely to get rigged to an IV to get pumped full of fluids. It's estimated that noroviruses kill 200,000 children under the age of five every year in developing countries.

It would be very nice if we only had to worry about getting noroviruses once and then could enjoy protection from them for the rest of our lives. Unfortunately, it seems that we only have a brief protection of perhaps a few months, and then we're fair game again. As a strain of norovirus encounters this short-lived defense, it evolves new ways to evade our immune systems. A modified strain can then sweep around the world in as little as three months.

While some drugs show promise in blocking noroviruses from infecting cells, none have passed muster in a clinical trial on people. The best hope to put a real dent in the reign of noroviruses may be vaccines. Last year, scientists at Baylor College of Medicine reported that a vaccine could provide some protection against the virus. When people were exposed to noroviruses, 69% of people who got the placebo became sick, compared to only 37% of the vaccinated subjects.

A vaccine that leaves more than a third of people vulnerable to a virus is not exactly a silver bullet. But against such a perfect pathogen, even a little relief can ease a lot of pain.