Tracking Disease Outbreaks

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Tracking—and stopping—disease outbreaks is the province of specialists known as epidemiologists. Arguably, one of history's most remarkable feats of disease detecting was the work of John Snow, a 19th-century British doctor known as the "father of epidemiology." Snow painstakingly traced the source of a London cholera outbreak to a pump in the city's Lambeth neighborhood. He did so by mapping cases of the disease until he was finally able to pin down a particular communal water pump as the nexus of the disease's spread.

Snow's detecting presaged the sort of footwork that epidemiologists still conduct today. They begin with an "index case," the patient who first comes to the attention of health workers, and then "map" that person's contacts and activities. That is, they backtrack along the web of interactions associated with the index case in the hope of limiting a wider outbreak. A NOVA Online interactive gives you a chance to walk through this process and trace the origin of an infection, just as a working epidemiologist does.

How do "disease detectives" work?

Plain old detective footwork is critical in tracking and reining in a disease outbreak. The work can start with a report of a single case. Fortunately, the diseases that are of most concern to public health officials, like measles, must be reported: Clinicians are required to notify the appropriate public health authorities whenever they encounter a suspected case.

In the United States, the index case of a vaccine-preventable disease like measles tends to be an unvaccinated person who traveled overseas, picked up the virus, and carried it home. A measles-infected person can be contagious as early as four days before showing symptoms. Thus public health workers have to identify as many as possible of an infected person's connections during the days before a confirmed diagnosis is made—including, for example, fellow plane passengers. In 2013, disease detectives were kept busy with several U.S. measles outbreaks. Of the 159 cases in these outbreaks, 99% were traced to an overseas traveler who returned to the States infected but unaware of that fact. Disease detecting also showed that 82% of the cases involved people who were unvaccinated for measles.

In their investigations, epidemiologists often find that a low vaccination rate in a given population is a factor in the outbreak of a vaccine-preventable disease. Sometimes, the role of this factor is obvious because the outbreak happens in a culturally defined community with low vaccination rates. This scenario unfolded in a 2014 measles outbreak in Ohio among the Amish, many of whom are never vaccinated. But there are also places where cultural bonds aren't as obvious, such as Marin County, California, a region that is home to pockets of parents who have declined to have their children vaccinated; unlike the Amish community in Ohio, this is a scattered aggregation of people who can't be as easily traced by distinctive cultural connections.

The distribution of vaccinated and unvaccinated people can influence the course of an outbreak. Enlarge
Photo credit: Getty Images

What is the role of geographic overlap?

Because religious or cultural practices don't always exactly delineate clusters of unvaccinated people, disease detectives also examine the geographic overlap between vaccine exemption rates and outbreaks. Typically, outbreaks tend to concentrate where there are high rates of nonmedical vaccine exemptions—that is, people who have declined to be vaccinated for a reason not supported by medical necessity. For example, the three largest measles outbreaks in the United States between 2001 and 2008 arose in populations with high rates of vaccine exemptions for personal beliefs. Researchers have found similar patterns of overlap for pertussis, or whooping cough.

How do epidemiologists keep ahead of microbes?

Epidemiologists can also track whether or not microbes are changing enough to evade vaccine-triggered immunity. These molecular investigations involve interrogating microbes instead of people, using sophisticated tools to sequence a germ's DNA or proteins to see if it's changing its molecular appearance.

In addition, different regions of the world can host different types of a given microbe. These region-specific molecular clues can be as telling about where someone became infected as the person's travel history—contributing to the information needed to limit an outbreak.

What happens after an outbreak ends?

Footwork and geographic overlap analysis are among the methods that epidemiologists can use to trace, track, and try to limit an outbreak. But their work doesn't end there.

Even after an outbreak has ended, disease detectives still have plenty to do. Using the information gathered during the outbreak, they can compare disease rates among vaccinated and unvaccinated people. That calculation tells them exactly how risky it is to be unvaccinated when an infectious disease threatens a community. And this work isn't simply a math exercise. With these numbers, public health officials can then set target thresholds for immunization rates in a community. They can also use these numbers in public-health communications to inform people of the risks of forgoing vaccination.

A 2012 measles outbreak in the United Kingdom sent about 700 people to the hospital. Enlarge Photo credit: © WGBH Educational Foundation

Such data crunching has revealed a clear finding: Being unvaccinated greatly boosts a person's risk of infection. According to one study, for example, children whose parents choose not to have them vaccinated against chickenpox face a nine-fold greater risk of contracting the disease than do vaccinated children. A similar study of pertussis revealed a risk of getting the disease about six-fold greater for unvaccinated children. And going unvaccinated for measles increases as much as 22-fold the risk of contracting that disease.

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