



(Above) A digitally colorized scanning electron micrograph depicting red-colored salmonella bacteria invading a mustard-colored, ruffled immune cell. Every year, salmonella bacteria are estimated to cause 1 million illnesses in the United States, with 19,000 hospitalizations and 380 deaths. (Courtesy of the National Institute of Allergy and Infectious Diseases)

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PulseNet: Using Technology to Track Foodborne Illnesses

Nearly everyone has seen headlines or heard news reports announcing a large food recall — or, worse, a widespread foodborne illness outbreak. One in six Americans suffer from a foodborne illness each year. Anyone can be affected. Have you ever wondered how these outbreaks are discovered? A great deal of epidemiological investigation, some that is notably high-tech, goes into identifying the cause of foodborne illnesses that can affect unrelated individuals in different states, even different regions. Here, we will describe one very powerful tool, PulseNet, used in the

Epidemiology: The science of determining the who, what, where, when, and how of the spread of disease.

United States by epidemiologists to quickly identify foodborne illness outbreaks across the country and effectively stop such illnesses from spreading.

What constitutes a foodborne illness outbreak

First, let's define terms. A foodborne *illness* is any infection resulting from consumption of food that has been contaminated in some manner. Foodborne illnesses are most often associated with viruses and bacteria, and their symptoms can range from mild discomfort to diarrhea and vomiting to, in rare cases, death. A foodborne *illness outbreak* is when two or more individuals become ill from the same source. Because

Outbreak: When two or more individuals become ill from the same source.

the distribution system for the US food processing industry is far-reaching, if something goes wrong at a single food processing plant, the result can be widespread recalls, and perhaps even foodborne illness outbreaks.

PulseNet's role: It's all about bacteria

By quickly identifying when and where foodborne illness outbreaks occur— large or small — PulseNet seeks to limit the damage. The program, coordinated by the US Centers for Disease Control and Prevention (CDC; www.cdc.gov/pulsenet/), was established as a collaborative group of food safety laboratories in 1996. The decision to create the network — with just 10 labs — was spurred by a foodborne illness outbreak in the 1990s that was caused by a notorious type of *E. coli* known as *E. coli* 0157:H7. PulseNet has expanded to include labs in 46 states as well as food safety labs run by the US Food and Drug Administration and the US Department of Agriculture.

So PulseNet can cast a wide net in search of something very small — bacteria. Every bacterium has its own specific DNA. Investigators can use the unique DNA to essentially create a bacterial fingerprint. Essentially, PulseNet works like a detective, identifying the types of bacteria causing foodborne illness outbreaks, based on the fingerprints that the bacteria leave behind. (Learn more about the technology behind making bacterial fingerprints in the sidebar.)

Here's how a "typical" case might unfold. A person ingests food, becomes ill and visits a doctor, who suspects that the illness is food-related. A sample is collected from the patient and sent to a laboratory, where researchers attempt to identify microorganisms that could be the cause of the illness. If the responsible organism is a foodborne

bacterium, the original doctor and patient are notified and the sample is sent to a public health lab, where researchers work to create the DNA fingerprint, which they will share with a national database operated by the CDC. Epidemiologists and public health officials continually examine that database and other foodborne illness reports to determine if outbreak patterns are forming. If patterns are discovered, an investigation will begin. Often a foodborne illness outbreak affecting dozens or hundreds of individuals derives from a single source. Identifying the source allows health care professionals to respond quickly and appropriately, and often they are able to minimize the spread of the outbreak.

Challenges and benefits of PulseNet

By collecting a great deal of vital information in a central location, PulseNet makes pattern analysis, identification, and even appropriate actions simpler and more rapid. Mandatory requirements and qualifications for inclusion in the network help assure the quality of submitted samples and information. Standardization is crucial to ensure the accuracy of results. All participating laboratories must stringently follow the same protocol so that bacterial fingerprints generated in California are exactly the same as fingerprints generated in Virginia.

The advantages of PulseNet are vast and significant. But expectations can bump up against reality. PulseNet cannot identify all foodborne illnesses and outbreaks. Many individuals who become ill as a result of foodborne bacteria do not report the illness to a doctor. We commonly blame sudden gastrointestinal disturbances on a "24-hour bug." Therefore, when foodborne illness estimates are released in the United States, they are just that — estimates. It is impossible to know the exact number of individuals who experience a foodborne illness. The estimates use mathematical models to predict the real numbers.

Conclusions

One in six Americans suffer a foodborne illness each year, and no one is immune. Often we are not even aware that the cause of our gastrointestinal discomfort is the result of contaminated food. PulseNet aims to bring small spikes in foodborne illnesses to the attention of authorities before outbreaks become widespread or severe. Though the process may sound complicated, it provides many benefits to the general public by allowing health care professionals to respond quickly. In doing so, PulseNet helps ensure that the US food supply is among the safest in the world.

References and Resources

- Boxrud D, Monson T, Stiles T, Besser J. 2010. The Role, Challenges, and Support of PulseNet Laboratories in Detecting Foodborne Disease Outbreaks. *Public Health Reports*. 125:57-62.
- Centers for Disease Control and Prevention. 2015. Frequently Asked Questions: PulseNet Explained. Available online at: <http://www.cdc.gov/pulsenet/about/faq.html>. Last accessed June 2015.
- Centers for Disease Control and Prevention. 2015. PulseNet. Available online at: <http://www.cdc.gov/pulsenet/>. Last accessed June 2015.
- Gould LH, Walsh KA, Vieira AR, Herman K, Williams IT, Hall AJ, Cole D. 2013. Surveillance for Foodborne Disease Outbreaks - United States, 1998-2008. *MMWR*. 62:1-34
- Purayidathil FW, Ibrahim. J. 2012. A Summary of Health Outcomes: Multistate Foodborne Disease Outbreaks in the U.S., 1998-2007. *Journal of Environmental Health* 75:8-13.
- Swaminathan B Barrett TJ, Hunter SB, Tauxe RV. 2001. PulseNet: The Molecular Subtyping Network for Foodborne Bacterial Disease Surveillance, United States. *Emerging Infectious Diseases* 7:382-89.

Making a bacterial fingerprint

For foodborne illness outbreaks to be identified, bacterial fingerprints must be found. The first step is isolating the DNA from a bacterial sample. Then, thanks to restriction enzymes and agarose, things get interesting. (Cue the TV show theme music.)

PulseNet researchers cut the DNA into small fragments. Special enzymes — restriction enzymes — are used because they cut at specific locations, not randomly. That's crucial, because DNA is made up of sequences of four nucleotides — G, A, T and C. A restriction enzyme cuts only when it recognizes a specific sequence, such as GAATC. The sequences it recognizes always appear in the same place in DNA from a certain bacterium. The result is a long strand of DNA cut into fragments; the size and number of fragments is unique to each type of bacteria.

Now, the DNA fragments need to be visualized. That requires agarose, a gel-like substance, and an electric current.

The fragments are placed in agarose. DNA has a net negative charge, so when a current is applied, the DNA migrates through the gel, away from the negative charge and toward a positive charge. The fragments do not all move at once or at the same speed. Smaller fragments move faster and farther. After a set time, the DNA fragments have spread out across the agarose gel; the electric current is removed.

At this point, the DNA is still largely invisible to the naked eye. Adding a dye allows the DNA to fluoresce when exposed to UV light. The result is a pattern of glowing DNA fragments, arranged from smallest to largest, not unlike what is often seen in crime investigation TV shows. This pattern is the bacterium's unique fingerprint, which is submitted to the PulseNet database, where it is compared to others in the database. When patterns match, the PulseNet team launches an investigation and alerts laboratories of a potential foodborne illness outbreak.

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