One Health through the Eyes of Clinical and Public Health Microbiology

Scientists from a variety of disciplines are needed to understand infectious diseases and prevent human infections

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Clinical and public health microbiologists have long collaborated when responding to infectious disease problems to identify microbial pathogens. These investigative efforts include veterinary and environmental laboratory colleagues, taking advantage of their special skills in these arenas. These collaborations are helping us to realize the value of the One Health concept, which integrates human, animal, and environmental health when dealing with infectious diseases. This integrated approach also matches with what officials at the World Health Organization now recommend, and reinforces the value of taking a broad view of disease ecology. Our growing understanding of these important interfaces is providing insights into the complex chains that lead to human and animal illnesses.

Both clinical and public health microbiology are science driven and outcome focused. Whereas clinical microbiology efforts are directed mostly at the health of individual patients, those of public health microbiologists are directed at population health. Microbiologists working in clinical laboratories often interact directly with infection control, pharmacy, and infectious disease specialists. Clinical microbiologists thus evaluate and interpret laboratory results, applying interpretive judgment before reporting clinically relevant findings that affect the care of individual patients.

Public health microbiologists are responsible for guarding the health of the population, and their approach to fulfilling this responsibility is built around surveillance, epidemiology, reference testing, and state-driven mandates. Working together, specialists within these two different venues can create a powerful approach to detecting, diagnosing, and combating infectious diseases.

Because many infectious disease problems include human, animal, and environmental components, we need to take a fresh look into those areas where we might need additional expertise to fully understand their root causes. When clinical and public

Summary

• The One Health concept integrates human, animal, and environmental health to provide valuable insights when dealing with infectious agents.
• Investigating emerging pathogens benefits when the skills and knowledge of those specializing in human and animal infectious diseases are brought together, thus increasing the likelihood of identifying ways to prevent such illnesses.
• The One Health concept is illustrated well by approaches to dealing with foodborne diseases because many agents have zoonotic sources.
• Recognizing that fluoroquinolone use in poultry led to fluoroquinolone-resistant Campylobacter infections in humans, officials at the FDA in 2005 withdrew approval for the use of these antimicrobial agents in the drinking water of poultry.
• Several case studies trace how investigations of bacterial isolates from patient specimens, when sent from clinical laboratories to public health laboratories for serotyping and subtyping, can provide critical insights for those analyzing public health problems.

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health colleagues work in partnership with their veterinary and environmental colleagues, root causes can be more quickly identified and preventive measures can be instituted.

**Infectious Disease Complexity Demands Broad Collaborations**

The growing complexity of emerging infections, novel pathogens, and outbreaks is part of the impetus behind closer ties being forged across disciplines. Examples are the Rift Valley fever outbreak in 2000, the anthrax events of 2001, norovirus outbreaks in 2002, SARS in 2003, Marburg virus in 2004, the ongoing influenza H5N1 epizootic with pandemic potential, and the influenza H1N1 pandemic in 2009.

Approximately 60% of emerging and re-emerging pathogens, which also include hantavirus, *Yersinia pestis*, and West Nile virus, are zoonotic, with clear links leading to human cases from wild, domestic, or companion animals, or insect vectors. The 2003 report “Microbial Threats to Health: Emergence, Detection, and Response,” from a committee of the Institute of Medicine in Washington, D.C., states that many infectious diseases emerge following the convergence of four critical elements: physical and environmental factors; ecological factors; social, political, and economic factors; and genetic and biological factors.

Experts in human, animal, and environmental health provide the basis for the discipline called infectious disease ecology. As we begin to train people to work within this integrated new discipline, we cannot forget that clinical microbiologists focus primarily on one species of animal—humans—while our veterinary colleagues work with many of the rest. Importantly, we all benefit when the skills and knowledge of both groups are brought together.

**Foodborne Illness Investigations Illustrate One Health Approach**

The One Health concept can be effective when dealing with many types of infectious diseases. For example, there are more than 250 types of foodborne diseases. Each year, foodborne diseases cause millions of illnesses, leading to more than 100,000 hospitalizations and more than 1,000 deaths in the United States. Many cases arise from foods that are contaminated with animal pathogens that are brought into homes and restaurants on raw meat, poultry, and produce.

For example, in 1982 the emergence of the deadly *Escherichia coli* O157:H7 bacterium was recognized when ground beef was the vehicle for an outbreak of human illnesses. This occurrence exemplifies how a microorganism that animals carry asymptomatically can enter the food supply to devastating effect. In 1994, officials of the U.S. Department of Agriculture declared *E. coli* O157:H7 an adulterant of ground beef, which means that finding it in such meat products results in their mandatory recall. In many investigations that led to the ground beef recalls, clinical microbiologists identified *E. coli* strains from stool specimens, reported their results to physicians who were caring for patients and to public health authorities, and then sent strain samples to public health laboratories for subtyping in PulseNet, the national molecular subtyping network. In 2003, after a series of recalls lowered consumer confidence in the safety of ground beef, many beef industry companies began following a “test and hold” approach.
policy that required release of ground beef lots only after they were tested and found not to be contaminated with *E. coli* O157:H7. These efforts helped to reduce the contamination of ground beef and that decline, in turn, may have led to the decrease in laboratory-confirmed *E. coli* O157:H7 cases measured in the U.S. FoodNet active surveillance system.

Many factors throughout the food production and distribution system affect safety. For meat products, what happens on farms, after animals are transported to feed lots, and in slaughterhouses, and then how meat products are handled on their way to stores and to dinner tables can have a major effect on human health. For instance, bacterial or other microbial pathogens in animal feces contaminate the environment in which animals are raised and kept awaiting slaughter. Indeed, cattle and pig hides often become coated with feces that can contaminate other parts of the animal carcasses during slaughter and subsequent meat processing.

Similarly, infectious agents spread readily within large populations of birds on poultry farms. When birds are slaughtered, tanks of hot water are used to assist in removing their feathers, a processing step that can allow intestinal contents to contaminate the tanks and also the raw carcasses. For example, *Campylobacter*, which is often part of the microbiota in chicken intestines, is a pathogen for humans. At the retail level, as many as 50% of chickens are contaminated with *Campylobacter* sp.; as a result, poultry is a major source of *Campylobacter* infections in humans. People become infected by consuming inadequately cooked poultry or other foods that become cross-contaminated via contact with poultry. Even infants riding in shopping carts containing raw poultry are at increased risk, according to one recent study.

**Collaborations That Trace the Route of Antimicrobial Resistance Illustrate the One Health Concept**

While clinical laboratories focus on detecting antimicrobial resistance in individual patients, public health officials monitor resistance across populations, evaluate new resistance patterns, and set the agenda for protecting affected populations. Antimicrobial agents are used widely for treating infectious diseases of both humans and animals. Importantly, the use of antimicrobial agents in food animals can lead to antimicrobial-resistant infections in humans.

Treating individual patients with antimicrobial agents after they develop *Campylobacter*-associated diarrhea can be effective in ameliorating their illness. Fluoroquinolones are considered one of the drugs of choice. These agents are also used to treat and prevent illnesses in animals that are being raised on farms for food. In 1995, officials of the Food and Drug Administration (FDA) approved the use of fluoroquinolones in poultry.

Meanwhile, public health officials at the Centers for Disease Control and Prevention (CDC) recognized that exposure to antimicrobial agents can exert selective pressure leading to the development of resistance to those agents in intestinal flora, including *Campylobacter*. By 1997 the CDC began surveillance for fluoroquinolone resistance in *Campylobacter* isolated from humans with diarrheal disease. By 2002, fluoroquinolone resistance in such isolates had increased to more than 20%.

Because most *Campylobacter* infections are thought to be related to consuming or handling contaminated poultry, there appeared to be a direct link between practices on the farm and the increase in antimicrobial-resistant human infections involving this pathogen. Moreover, diarrheal illnesses in persons infected with fluoroquinolone-resistant *Campylobacter* lasted longer than those in persons with fluoroquinolone-susceptible *Campylobacter*. These factors led FDA officials in 2005 to withdraw approval for the routine use of fluoroquinolones in the drinking water of poultry.

**Enteric Bacterial Illness Investigations Illustrate One-Health Concepts**

Determining the root cause of some disease outbreaks sometimes depends on the use of skill sets from both human and animal medicine. For example, in Alaska from 2000 to 2008, there was an increase in the incidence of *Campylobacter* infections during the summer months. In 2005, the spike in those infections was traced to the consumption of raw peas. A similar spike in cases occurred in 2008, again implicating raw peas.

Here is what the investigators learned. After harvest, shelled peas were bagged and labeled with directions for blanching, according to
Tracey Gardner and Joe McLaughlin of the CDC Epidemiology Intelligence Service (EIS) and their team. However, some vendors re-packed the peas into units that did not include directions for blanching. Furthermore, at local farmers markets, the raw peas were sold as ready-to-eat items. While some observers might surmise that peas became contaminated during processing, the EIS officers ultimately determined that the vegetables were contaminated by droppings from sandhill cranes feeding in the pea fields. Pulsed-field gel electrophoresis (PFGE) confirmed this by showing that some Campylobacter bacteria isolated from stool specimens of patients were indistinguishable from strains isolated from the feces of the sandhill cranes.

Human contact with animals of many types and in various settings carries a risk of infectious illnesses. Petting zoos and similar venues, for example, can be particularly risky for children, particularly when handwashing facilities are also inadequate. For instance, in 2004 in North Carolina, 108 individuals, mostly children, developed E. coli O157 infections after attending a state fair. However, their infections did not trace back to what they ate while visiting the fairgrounds. Instead, their infections came from their visits to the petting zoo at the fair, which included sheep and goats, and being exposed to feces-contaminated materials in that setting. Cultures of specimens from patients, animals, and samples from the immediate environment in which the animals were held yielded the outbreak strain. Investigators found evidence that the outbreak strain was present on the ground where visitors were walking. For example, cultures of swabs of a child’s sneaker and a stroller also yielded the culprit strain, according to Brant Goode, now of the Hawaii State Department of Health in Honolulu and his collaborators.

Small turtles (those with carapaces less than 4 inches across) are another animal species with which contact by small children is risky. Several decades ago, when turtles were recognized as a major source of Salmonella infections in children, U.S. officials banned their sale as pets. However, they continue to be traded illegally and to cause illnesses in this vulnerable human population.

Other, less direct associations with animals can also lead to illnesses from infectious agents. For example, in June of 2007, epidemiologists in the Pennsylvania State Department of Health noticed that many specimens from patients that were then being sent to their labs for analysis contained the Schwarzengrund serotype of Salmonella, which is rarely isolated. Their internal review led them to recognize an outbreak that, once investigated, encompassed 79 cases—mostly in young children—in 21 states. From initial focused interviews of eight Pennsylvania residents infected with the Schwarzengrund serotype, investigators suspected that exposure to dogs or dry dog food could be the source of infection. The epidemiologists next collected stool specimens from dogs in the patients’ households as well as samples from open bags of dry dog food; these tests yielded the outbreak strain. Further investigation revealed that dry dog food in patients’ homes that had been sold under many labels was produced by the same manufacturer. A case-control study indicated that children who were infected with that strain were also likely to have fed a pet in the kitchen and to have a primary caregiver who...
had contact with pet treats, according to an article by Casey Barton Behravesh of CDC. Their investigation led to the closing of the factory where that pet food was produced.

This investigation provides yet another example of how pathogen isolates from clinical laboratories that are sent to public health laboratories for serotyping and subtyping can prove useful in recognizing and analyzing public health problems of national significance.

SUGGESTED READING


