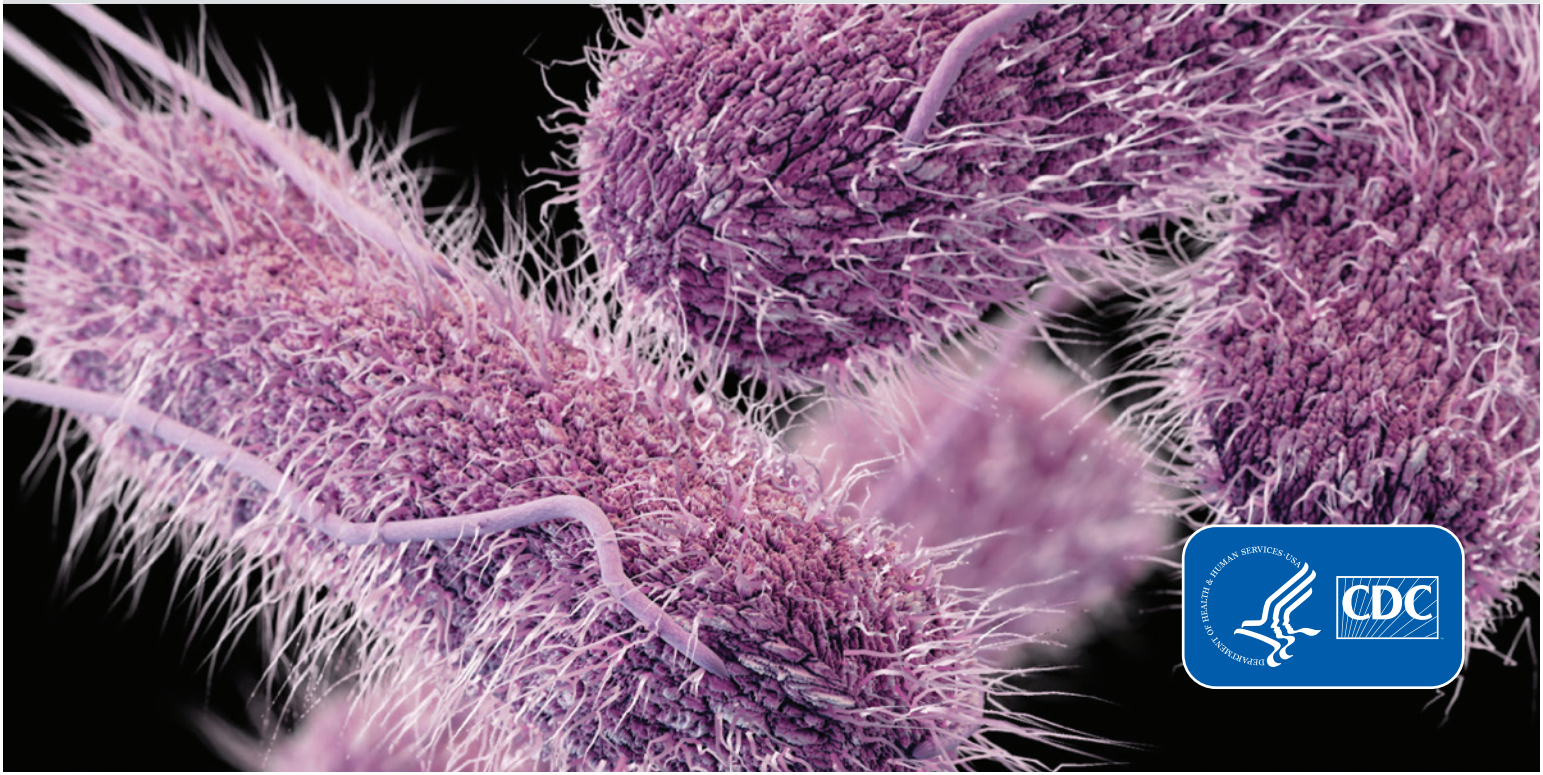
EMERGING AND ZOONOTIC INFECTIOUS DISEASES



WHAT WE DO

If CDC is in the headlines, chances are good that it's a story we're involved in. That's because the work of the **National Center for Emerging and Zoonotic Infectious Diseases (NCEZID)** is about protecting America's health, safety, and security. We do this by keeping people safe from hundreds of infections ranging from A to Z–anthrax to sepsis, *Salmonella* food poisoning to Zika.

NCEZID is ground zero when there's an outbreak of infectious disease. We have world-class scientists, researchers, laboratories, and emergency responders to protect people from

- Foodborne, waterborne, and fungal infections
- Deadly diseases like Ebola
- Bioterror threats like anthrax
- Infections like rabies, Lyme disease, and Zika that spread between people, animals, and bugs
- Illnesses spread in healthcare settings and drug-resistant threats
- Illnesses that cross borders and affect travelers and people entering the country

Infectious diseases can pose a major threat to our national security.

NCEZID was at the forefront of CDC's battle to contain the spread of Ebola virus in Africa in 2014.

ABOUT OUR NAME:
National Center for **Emerging and Zoonotic Infectious Diseases**

Emerging diseases are infections that have increased recently or are threatening to increase in the near future. These infections could be

- newly discovered (like the sometimes-deadly Bourbon virus that was identified in 2014 in Bourbon County, Kansas).
- completely new to an area (like Zika virus in the Western Hemisphere).
- reappearing in an area (like dengue in south Florida, Texas, and Hawaii).
- caused by bacteria that have become resistant to antibiotics, like the so-called "nightmare bacteria" CRE (carbapenem-resistant Enterobacteriaceae).

Zoonotic means infectious diseases spread between animals, insects, ticks, and people. Examples include

- Lyme disease (spread by ticks)
- *Salmonella* infections (spread by poultry and other animals)
- rabies (spread by mammals)

Infectious diseases are illnesses caused by germs (such as bacteria, viruses, and fungi) that enter the body, multiply, and cause an infection.

- Some infectious diseases are contagious, that is, spread from one person to another.
- Other infectious diseases can be spread by germs carried in air, water, food, or soil. They can also be spread by insects, ticks, or animals.

75% of new or emerging infectious diseases in people are spread from animals.

FRONT COVER
Top: Ebola (virus)
Bottom: *Salmonella* (bacteria)

In 2016, almost 900 people got *Salmonella* infection from keeping chickens and ducks in backyard flocks. Children have an even greater chance of getting sick from handling live poultry.

RESPONDING TO OUTBREAKS

Perhaps what NCEZID is best known for is responding to outbreaks of infectious disease. Here are a few large-scale responses that NCEZID has led since 2010:

- 1st outbreak of Zika virus in the Western Hemisphere, which was linked to birth defects
- Largest Ebola epidemic in history, which killed more than 11,000 people
- Fungal meningitis outbreak caused by contaminated steroid injections
- 2nd-largest outbreak of West Nile virus infections that sickened 5,600 people in the US
- Outbreak of cholera in Haiti, which killed at least 10,000 people

We work to protect Americans from well-known outbreaks (Ebola) to outbreaks you're more likely to encounter—like *Salmonella* food poisoning.

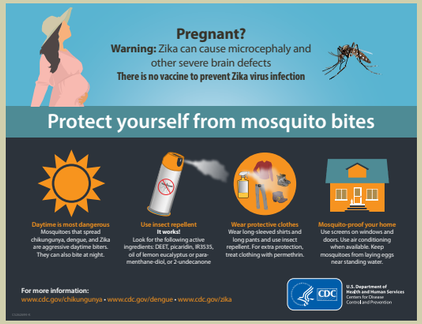
NCEZID provides rapid assistance to states and foreign ministries of health through formal requests called epidemic-assistance investigations, or Epi-Aids. Each year, NCEZID conducts almost half (~25) of all CDC's Epi-Aid investigations of outbreaks—large and small, domestic and international. Recent examples of Epi-Aids and other outbreak investigations that NCEZID participated in include:

- ***E. coli*** **(*Escherichia coli*) infections among children** who visited a goat farm in Connecticut
- Emerging, drug-resistant **fungal infections (*Candida auris*) that spread among patients** in healthcare settings
- Rarely seen **bloodstream infections (*Elizabethkingia*)** in patients in Wisconsin
- Illness caused by ***E. coli*-tainted flour** that infected people in more than 20 states
- ***Listeria*** **bacteria in packaged salads** that hospitalized 19 people, killing 1

IMAGE (LEFT): NCEZID staff collect samples while investigating an *E. coli* outbreak linked to a Connecticut dairy goat farm that sickened more than 40 people, many of them young children. Recommendations (like reduce direct contact with goats and their soiled bedding; provide handwashing stations) will help prevent illness in the future.

DID YOU KNOW?

NCEZID scientists helped confirm the connection between Zika virus infection during pregnancy and microcephaly and other birth defects.



TAKING A ONE HEALTH APPROACH

More than half of all infections that people get are spread by animals. Diseases like rabies, *Salmonella* infection, and West Nile virus are examples of zoonotic diseases—diseases that can be shared between animals and people. Animals can sometimes serve as early warning signs of potential illness in people. For example, birds often die of West Nile virus before people get sick with West Nile virus fever.

NCEZID's One Health Office recognizes that the health of people is connected to the health of animals and the environment. A One Health approach encourages collaborative efforts of many experts (like physicians and veterinarians) working across animal, human, and environmental health to improve the health of people and animals, including pets, livestock, and wildlife.

What we're doing:

- The One Health Office is working with multiple partners to **educate rural youth in agricultural organizations** like 4-H and the Future Farmers of America about preventing the spread of diseases shared between people and animals like zoonotic influenza viruses. The project has reached thousands of young people and their families in Arizona, Georgia, Iowa, Michigan, Minnesota, and Ohio, many of whom are actively involved in exhibiting livestock or farming.
  - One important outcome of the project was the rapid response to an outbreak of flu in people who had attended agricultural fairs in Ohio and Michigan. Partnerships formed during the project helped pinpoint the source of illness—infected swine exhibited at the fairs.
- On the global front, One Health is taking a strategic, targeted approach to controlling infectious disease. Experts from the One Health Office lead **One Health Zoonotic Disease Prioritization Workshops** so that countries with limited resources can focus on the top zoonotic diseases (for example, rabies and Ebola) of greatest national concern. Workshop participants include a wide-ranging group of people who protect health—of people, animals, or the environment—and they identify that country's top 5 diseases to target. Prioritizing diseases means countries can more efficiently build lab capacity, conduct disease surveillance, plan outbreak response and preparedness activities, and create disease prevention strategies to reduce illness and death in people and animals.

Pet owners need to know about zoonoses and how to prevent them, so they can enjoy their pets without getting sick.

KEEPING BORDERS SECURE AND TRAVELERS SAFE

One of CDC's best-kept secrets is the people in NCEZID who focus on preventing the importation and spread of infectious diseases into the United States. More than a million people travel to the United States each day. Americans stay on the go, too, taking about 74 million trips each year. All international travelers face increased risk of getting and spreading infectious diseases.

What we're doing:

- NCEZID oversees 20 **quarantine stations**, strategically located at US airports, land borders, and seaports. Staff at these Q stations, as they are called, work hard to protect the public's health from threats, both foreign and domestic. The work extends to cover all ports of entry (more than 300) into the United States. Every day NCEZID staff work with Customs and Border Protection and other federal agencies, the airlines and cruise lines, and state and local public health departments to prevent the spread of infectious disease to US communities.
- The **Travelers' Health website** provides outbreak updates and travel notices, travel-related disease information, interactive maps, and other destination-specific recommendations for travelers and their healthcare providers.
- NCEZID publishes The **Yellow Book** (*CDC Health Information for International Travel*), the definitive US travel medicine reference for clinicians advising patients before and after travel.
- We **alert travelers at airports** about disease outbreaks and steps they can take to protect themselves.
- NCEZID **responds to sick travelers** who arrive in the United States at major airports, seaports, or land border crossings.
  - For example, when sick passengers are on a flight, the airline lets CDC know. We evaluate whether they might be contagious to others on the plane.

A CDC quarantine public health officer takes a call from an airline crew alerting him that a flight is about to land at Los Angeles International Airport with a sick passenger onboard. *Courtesy of Julie Konidakis*

- We **restrict the importation of animals** and products that may carry disease, such as monkeys, bats, small turtles, cats, and dogs.
- Because we are located at airports, we can **send life-saving drugs** on the next flight to save the life of someone with malaria, botulism, or diphtheria. These drugs are difficult to obtain commercially, but we make them available to US clinicians for patients who meet certain requirements.

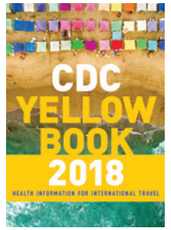
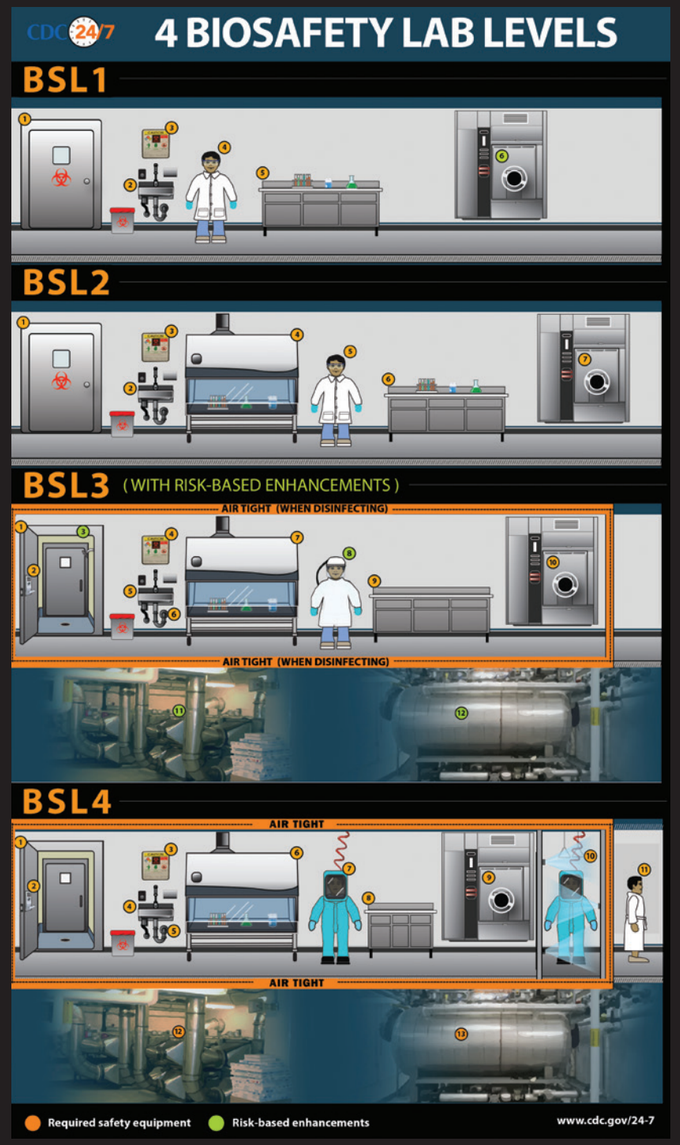


IMAGE (LEFT): The flight map shows ~60,000 flight patterns in a 24-hour period. Blue lines are shorter flights; purple lines longer flights. *Courtesy of Dr. Kamran Khan, BlueDot*

- **BSL1** – these labs handle agents that pose minimal risks and are not known to consistently cause disease in healthy adults
- **BSL2** – these labs handle agents that pose only moderate risks to lab staff or the environment
- **BSL3** – these labs handle agents that can cause serious or fatal disease
- **BSL4** – the highest level of lab safety in the world, these labs handle the deadliest germs that cause life-threatening and frequently fatal disease

NCEZID laboratorians quickly detect harmful pathogens—whether spread by people, animals, insects, food, or a bioterrorist.



LABORATORY EXPERTISE

NCEZID laboratories serve as vital reference laboratories for the United States and the world, aiding in critical disease detection, investigation, training, and public health research. In addition to managing the Laboratory Response Network (*see p. 29*), NCEZID provides oversight for a number of highly specialized laboratories.

NCEZID laboratories include:

- The **Infectious Disease Pathology Lab** is the primary unit at CDC that tests and evaluates tissues from patients with infectious diseases of unknown origin; they can test for more than 200 viruses and bacteria.
- **Viral special pathogens** labs work with some of the world's most dangerous viruses that need to be handled at the highest biosafety level (BSL4) containment laboratory (*see p. 10*). Laboratorians sometimes deploy to the field, as they did during the Ebola epidemic to set up a laboratory in Bo, Sierra Leone.
- **Bacterial special pathogens** labs work on anthrax and other potentially deadly bacteria.
- **Rickettsial zoonoses** labs provide expertise in the diagnosis of diseases such as Rocky Mountain spotted fever and discovery of other tickborne disease pathogens. Tests developed by the labs have improved the speed and sensitivity of rickettsial pathogen detection.
- **PulseNet** labs and enteric (gastrointestinal) diseases labs are critical in rapidly identifying foodborne pathogens and helping control foodborne disease outbreaks.
- **Healthcare-associated infections** (HAIs) laboratories look at causes of infectious illnesses occurring in patients who receive health care. They also issue protocols that partners can use for testing for specific pathogens causing HAIs.
- The **Biotechnology Core Facility** is a collection of six laboratories that use cutting-edge technologies like genomic sequencing to test for infectious and biothreat agents. It also evaluates emerging technologies for improving diagnostic tests as part of the Advanced Molecular Detection Program (*see page 17*).

Some important work NCEZID laboratories have produced includes:

- Discovering and **characterizing new infectious disease threats**.
- Providing an **early warning system** for new or emerging viruses like chikungunya.
- **Monitoring changes** in known germs that hurt people, including new drug-resistant strains like carbapenem-resistant Enterobacteriaceae (CRE) in hospital settings.
- **Preparing reference materials** (strains, cultures, and blood samples) that help confirm germs and providing quality assurance for other laboratories.

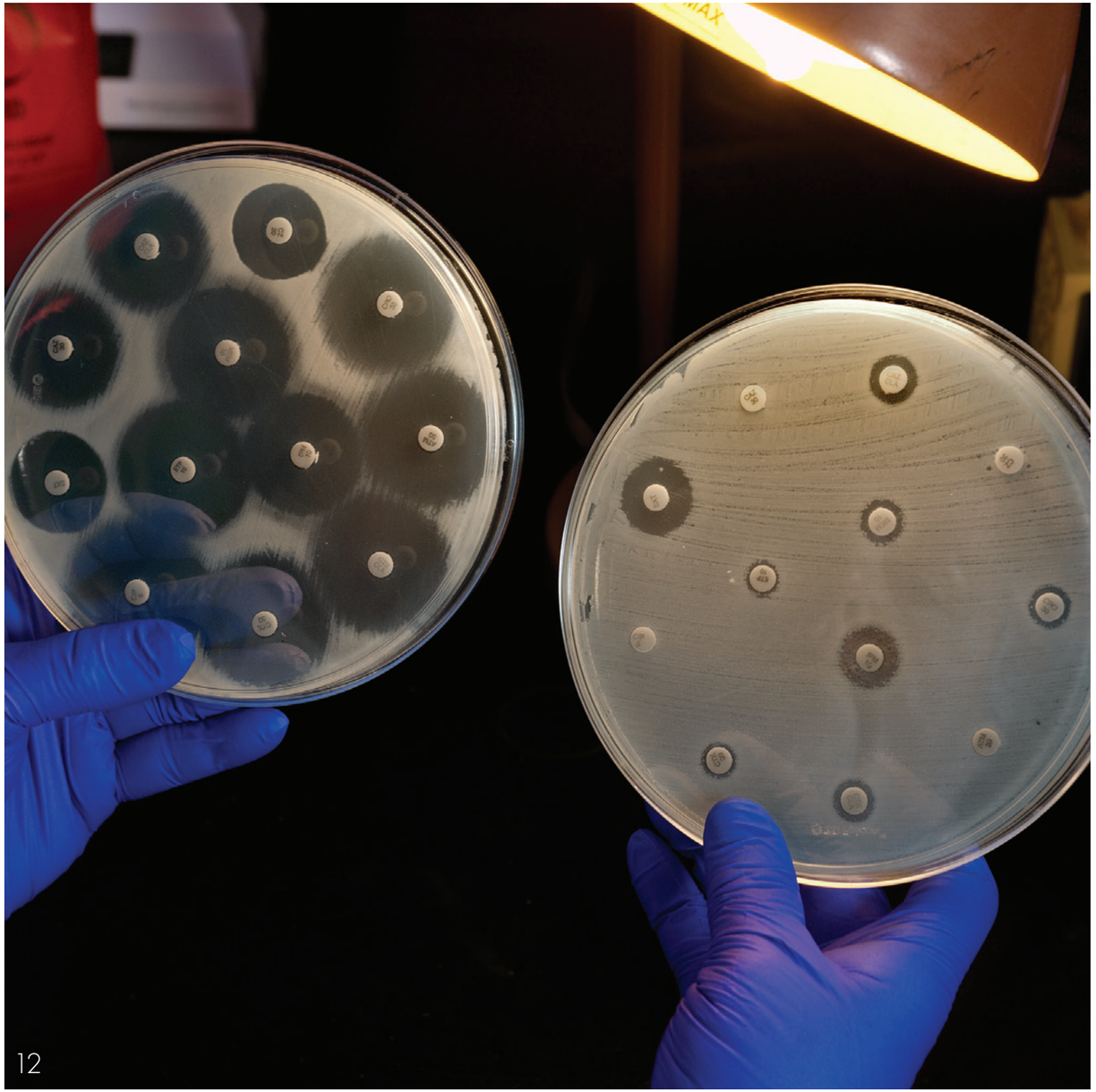


Photo: Jim Gathany

FIGHTING ANTIBIOTIC RESISTANCE

Each year in the United States, at least 2 million people become infected with bacteria that are resistant to antibiotics. Antibiotic resistance (AR) is the ability of microbes to resist the effects of drugs—that is, the germs are not killed, and their growth is not stopped. At least 23,000 people die each year as a direct result of these infections. Although some people are at greater risk than others, no one can completely avoid the risk of antibiotic-resistant infections. Infections with resistant organisms are difficult to treat, requiring costly and sometimes toxic alternatives. Some of the current trends in resistance:

- Antibiotics are among the most commonly prescribed drugs used in human medicine, but up to 50% of the time antibiotics are not prescribed properly (for example, often given when not needed or with incorrect drug dosing or duration).
- The germs that contaminate food can become resistant because of the use of antibiotics in food animals as well as people. Studies have shown that the use of antibiotics in food animals can lead to resistant infections, like those caused by *Salmonella* and *Campylobacter* in people.
- The other major factor in the alarming growth of antibiotic resistance is spread of resistant strains of bacteria from person to person, or from contaminated sources in the environment.

What we're doing:

In 2016, Congress appropriated $160 million for CDC to fight antibiotic resistance. With this investment, NCEZID is working with others to detect, respond, contain, and prevent resistant infections. Some key activities include:

- **Investing in states and communities** across the US for better response, containment, and prevention of AR threats.
- Establishing **the AR Lab Network** made up of CDC labs, 7 regional labs in health departments, and expanded capacity of all state and local health department labs. The new lab network will conduct nationwide testing to fill data gaps and inform how we respond to some of the most serious antibiotic-resistant threats like the nightmare bacteria CRE (carbapenem-resistant Enterobacteriaceae), gonorrhea, and *Salmonella*.
- **Funding innovation** to understand how antibiotics disrupt a healthy microbiome, the community of naturally occurring microbes in and on our bodies.

We are in a post-antibiotic era where doctors and patients are faced with untreatable infections.

IMAGE (page 12): What antibiotic resistance looks like. The bacteria on the right plate almost touch the discs of antibiotics, meaning they are antibiotic resistant. The antibiotics are ineffective against the bacteria. The bacteria on the left plate can't grow next to the discs of antibiotics, meaning the bacteria are susceptible and can be treated with antibiotics.

VECTOR-BORNE DISEASES (caused by bites from mosquitoes, ticks, or fleas)

Everyone—in the United States and around the world—is vulnerable to diseases spread by infected insects or ticks, also called vectors. Increasing global travel and urbanization are contributing to vector-borne disease outbreaks in new regions and countries. These diseases can be difficult to prevent and control, particularly since vaccines are available for only a few of them. NCEZID's work, directed by national and international leaders in vector-borne pathogens, is focused on priority diseases, including:

- Zika (causes severe birth defects), chikungunya (causes debilitating joint pain), and dengue (can be deadly), which are caused by bites of infected *Aedes aegypti* and *Aedes albopictus* mosquitoes. Forty percent (40%) of the world's population is at risk for dengue infection.
- West Nile virus is now native to the United States, and outbreaks are reported each summer. The deadliest West Nile virus outbreak in the United States occurred in 2012. Although most people infected with West Nile virus will have no symptoms, about 1 in 5 will experience fever with other symptoms, and less than 1% will develop a serious, sometimes fatal disease.
- Lyme disease is the most commonly reported vector-borne illness in the United States, with an estimated 300,000 infections occuring each year. Other tickborne diseases like Rocky Mountain spotted fever are also a serious public health problem and can be deadly within days if not treated promptly with antibiotics.

What we're doing:

- NCEZID has worked with partners on recent **vector-borne outbreaks** including Zika and chikungunya in Latin America, dengue in Hawaii, plague in Yosemite National Park, and Rocky Mountain spotted fever in Arizona and New Mexico.
- Early in the Zika outbreak, NCEZID scientists **developed a new test** called the Trioplex that detects Zika virus, dengue, and chikungunya in a single test.
- CDC is partnering with the Minnesota Department of Health and the Mayo Clinic to obtain up to 30,000 clinical specimens from patients with suspected tickborne illness over a 3-year period. CDC will use genetic sequencing methods to **identify the specific tickborne bacterium** that caused these patients' illnesses.
- NCEZID scientists have found **nootkatone,** an ingredient found in Alaska yellow cedar trees, some herbs, and citrus fruits, to be an effective repellent and insecticide for use against mosquitoes, ticks, and other pests. Efforts are now underway to bring this product to market.

Photo: Jim Gathany

Since 2004 in the US, scientists have discovered 7 new tickborne viruses in people.

IMAGE (LEFT): The brown dog tick is one of the ticks that spreads Rocky Mountain spotted fever.

Photo: Jim Gathany

INNOVATING SOLUTIONS

Pathogens constantly evolve. Protecting Americans demands that we develop better tools to keep us one step ahead of emerging infectious diseases. Innovation is taking place across NCEZID.

What we're doing:

Examples of innovations worked on by NCEZID scientists include:

- **Advanced Molecular Detection (AMD)** combines two powerful technologies (DNA sequencing and advanced computing) to solve complex infectious disease mysteries—the who, what, where, when, and how microbes harm people. Since the Office of Advanced Molecular Detection was established in 2014, AMD has played a pivotal role in:
  - Identifying the genetic makeup of Ebola and Zika during each of those outbreaks.
  - Solving foodborne outbreaks involving *Listeria* infection faster by linking food sources to clusters of illness.
- **New diagnostics** like these are ensuring that diseases are accurately and quickly diagnosed and treated:
  - A test kit for yellow fever gives results in 4 hours that used to take 2 days.
  - A new tool that screens for antifungal resistance when treating invasive candidiasis, the most common cause of healthcare-associated bloodstream infections in the United States. The new tool provides rapid and cost-effective screening tool for *Candida*.
- Safer and more effective **vaccines against rabies** for use in people and animals.
- An electronic platform called **ePathology** allows physicians and scientists from anywhere in the world to electronically submit images and scanned pathology slides to CDC pathologists for evaluation.
  - Doctors working in the most remote and resource-limited villages just need an internet connection to share slides of their patient's specimens with pathologists at NCEZID.

Photo: Jim Gathany

Advanced Molecular Detection means that it took 3 weeks to develop a test protocol for Zika. Before AMD, it would have taken 3 months.

HEALTHCARE-ASSOCIATED INFECTIONS

Healthcare-associated infections (HAIs)–infections patients can get while receiving medical treatment in a hospital or other healthcare facility–are a major, yet often preventable, threat to patient safety. On any given day, about 1 in 25 hospital patients has at least one HAI.

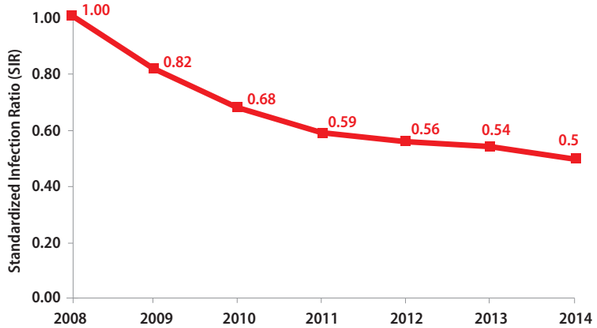
Modern healthcare employs many types of invasive devices and procedures to treat patients and to help them recover. Infections can be associated with devices used in medical procedures, such as central lines, catheters, or ventilators. Infections may also occur at surgery sites, known as surgical site infections.

What we're doing:

Our mission is to protect patients and healthcare personnel and promote safety, quality, and value in healthcare delivery systems. NCEZID's HAI experts, together with healthcare and public health partners, work to bring increased attention to HAIs and prevention. And studies show it works: when healthcare facilities take steps to target prevention of specific HAIs, they can decrease these infections by more than 70%.

HAI data are used to identify problem areas, measure progress of prevention efforts, and ultimately eliminate HAIs. NCEZID provides data on HAIs through:

- NCEZID's **National Healthcare Safety Network (NHSN)** is the nation's most widely used HAI tracking system. NHSN provides facilities, states, regions, and the nation with data needed to identify problem areas, measure progress of prevention efforts, and ultimately eliminate HAIs. In addition, NHSN allows healthcare facilities to track antimicrobial use and resistance, healthcare safety issues, and important healthcare process measures such as influenza vaccination status of healthcare personnel and infection control adherence rates.
- CDC's annual *National and State Healthcare-Associated Infections Progress Report* (HAI Progress Report) provides **a closer look at the HAIs** most commonly reported to CDC's NHSN. This report describes national and state progress in preventing central line-associated bloodstream infections, catheter-associated urinary tract infections, select surgical site infections, hospital-onset *Clostridium difficile* infections, and hospital-onset methicillin-resistant *Staphylococcus aureus* (MRSA) bacteremia (bloodstream infections).



Central line-associated bloodstream infections **declined 50%**

FOODBORNE DISEASE (food poisoning)

CDC estimates that each year roughly 48 million people (1 in 6) gets sick from a foodborne illness, 128,000 are hospitalized, and 3,000 die. Many different disease-causing microbes, or pathogens, can contaminate foods, so there are many different foodborne infections.

According to CDC estimates, the most common foodborne illnesses are caused by norovirus and by the bacteria *Campylobacter*, *Salmonella*, and *Clostridium perfringens*.

What foods are associated with foodborne illness?

- Fruits and vegetables consumed raw are a particular concern. Washing can decrease—but not eliminate—contamination.
- Raw meat and poultry, raw eggs, unpasteurized milk, and raw shellfish.
- Filter-feeding shellfish (like oysters) are especially likely to be contaminated with viruses and bacteria.
- Foods that combine the products of many individual animals, such as bulk raw milk, pooled raw eggs, or ground beef, are particularly hazardous because a pathogen in one of the animals may contaminate the whole batch.

What we're doing:

CDC provides the vital link between illness in people and the food safety systems of government agencies and food producers. We take action by:

- **Collaborating at the federal level** with the US Food and Drug Administration and the US Department of Agriculture's Food Safety and Inspection Service. State and local health departments and the food industry also play critical roles in all aspects of food safety.
- **Tracking** the occurrence of foodborne illnesses.
- Facilitating and **leading outbreak investigations.**
- Managing the **DNA fingerprinting network** for foodborne illness-causing bacteria in all states to detect outbreaks.
- **Using whole genome sequencing** to show which bacterial strains are most alike genetically.
- Attributing **illnesses to specific foods** and settings.
- Targeting **prevention measures** to reduce illness and death.
- **Providing data and analyses** to inform food safety action and policy.

***Listeria*, associated with soft cheeses, raw milk, and certain refrigerated foods, is a deadly foodborne bacteria. About 1 in 5 people who get sick from listeriosis die.**

Almost 1 in 8 pool inspections conducted during 2013 resulted in an immediate closure.

WATERBORNE AND FUNGAL INFECTIONS

Water is essential for life but can also lead to illness when it is contaminated by disease-causing organisms. Examples of **waterborne disease** include:

- Cholera, a severe diarrheal disease, often caused by drinking *Vibrio cholerae*-contaminated water.
- An infection called microbial keratitis, which can occur when germs invade the eye. These germs can be associated with improper use and care of contact lenses.
- Cryptosporidiosis, giardiasis, and other gastrointestinal diseases caused by swallowing contaminated water.
- An infection caused by the rare but often fatal brain-eating ameba (*Naegleria fowleri*) that can occur when people go swimming or diving in warm freshwater places like lakes and rivers, and contaminated water enters through the nose.

Fungal diseases are a concern in the medical and public health community for several reasons. Increasing numbers of people with weakened immune systems (like cancer patients and organ transplant recipients) are especially vulnerable to fungal infections. Changes in healthcare practices provide opportunities for new and drug-resistant fungi to emerge in healthcare settings. Other fungal diseases, like valley fever, are caused by fungi that live in soil.

What we're doing:

NCEZID has world-class scientists who are experts in the fields of preventing and controlling waterborne and fungal diseases. Recent accomplishments include:

- Tested more than 150 clinical samples in the US for **free-living amebas**, including *Naegleria fowleri*, the "brain-eating" ameba.
- Launched **CryptoNet**, the first system that uses molecular fingerprints for tracking a parasite. *Cryptosporidium* is a major cause of US waterborne disease outbreaks.
- Released the 2nd edition of the **Model Aquatic Health Code** to help state and local health departments prevent drowning, injuries, and the spread of recreational water illnesses at public swimming pools and spas.
- Provided epidemiological field support to ministries of health in multiple countries to prevent and **control outbreaks of cholera and typhoid**.
- Helped conduct **fungal disease outbreak investigations**, including mucormycosis outbreaks in Kansas, Colorado, and Pennsylvania. Mucormycosis typically affects people with weakened immune systems, such as people who have had an organ transplant.
- Applied new **laboratory tools to detect valley fever** (coccidioidomycosis) in the environment and used whole genome sequencing to understand the emergence of this fungus in new geographic areas.
- Investigating **new cases of *Candida auris* infections**, an emerging drug-resistant fungus that can spread through healthcare settings and cause serious and sometimes deadly bloodstream infections that have limited treatment options.

A multistate outbreak of fungal meningitis sickened more than 750 people and killed nearly 65 in 2012. NCEZID fungal experts helped nail the culprit: contaminated injections of a steroid linked to a compounding pharmacy. Photo: Jim Gathany

DEADLY AND UNEXPLAINED DISEASES

Germs that cause Ebola, anthrax, rabies, smallpox, and plague, also called "high-consequence pathogens," require expert oversight, especially because of the threat of bioterrorism. NCEZID places a high priority on understanding and tracking these diseases domestically and globally, operating state-of-the-art laboratories that can identify them, and preventing their spread.

What we're doing:

- NCEZID studies diseases caused by **highly hazardous bacteria** (like anthrax) **and viruses** (like Ebola). After the Ebola epidemic of 2014, scientists continue to conduct follow-up studies with survivors to learn what long-term symptoms they may face, how long the virus can persist, and how some people are better able to survive Ebola.
- NCEZID scientists also investigate **unexplained deaths and diseases** of unknown origins. Uncovering new infectious diseases contributed to the identification of the agents that cause SARS and hantavirus pulmonary syndrome. Recently, NCEZID pathologists were amazed when they found a new disease—tapeworms growing inside a person essentially getting cancer that spreads to the person, causing tumors. It is the first-known case of a person becoming ill from cancer cells that arose in a parasite—in this case, the dwarf tapeworm, the most common tapeworm in people.
- An important part of the mission to keep deadly diseases at bay is to investigate and find new ways to **prevent zoonotic infections** that spread between animals and people. Although rabies is a vaccine-preventable disease, close to 60,000 people die from the disease around the world each year. The NCEZID Rabies Team has traveled throughout the world to reduce rabies in countries like Ethiopia, Vietnam, and Haiti, where rabies from dogs is common.

The dwarf tapeworm is the most common tapeworm found in people.

NCEZID has world-renowned experts in the world's deadliest diseases like Ebola, anthrax, and rabies.

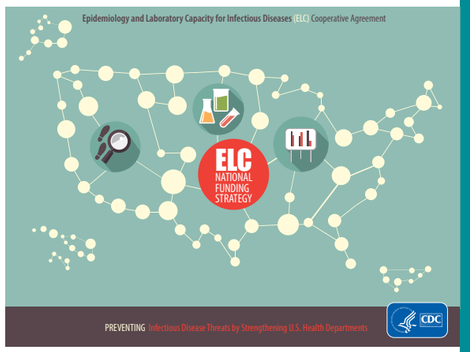
IMAGE (LEFT): In Haiti, the Rabies Team and partners vaccinated more than 37,000 dogs in just 18 days in 2017 as part of a months-long campaign.

SUPPORTING STATES

State, local, and territorial health departments work to combat emerging and reemerging infectious diseases (like Zika), improve public health (like food safety surveillance), and respond to public health emergencies like outbreaks of *E. coli* or *Salmonella* infections. NCEZID supports their work in a variety of ways.

What we're doing:

- Each year, CDC awards millions of dollars to states through the **Epidemiology and Laboratory Capacity for Infectious Diseases (ELC) Cooperative Agreement**, one of CDC's key nationwide cooperative agreements, which is managed by NCEZID.
  - The ELC oversees an array of cross-cutting epidemiology, laboratory, and health information systems activities that help domestic public health departments respond to complex infectious disease threats like Zika and antibiotic resistance.
- NCEZID's innovative online tool, **MicrobeNet**, provides laboratorians in all 50 states unprecedented—and free—access to CDC's library of information about more than 2,400 rare and emerging infectious bacteria and fungi.
  - This tool helps doctors and laboratorians get the information they need to accurately diagnose unknown causes of diseases faster and save lives.
- The **Arctic Investigations Program** (AIP) focuses on reducing and preventing infectious diseases that disproportionately affect Alaska Native people. For more than 40 years, AIP has collaborated with partners to tackle infectious disease threats by using state-of-the-art diagnostics, epidemiology, outbreak investigations, and targeted research.
  - Approximately 20% of rural Alaska homes lack running water and sanitation services. AIP studies showed that running water and sanitation in homes prevent the spread of infectious diseases like bloodstream infections, pneumonia, and skin infections. This work resulted in policy changes that have made it easier to get water and sewer grants, which can help to provide more homes with running water.
- The **Emerging Infections Program** (EIP), a network of state health departments and their collaborators, quickly translates surveillance and research activities into informed policy and public health practice. For example, EIP work has been instrumental in evaluating and honing strategies for preventing severe disease in newborns caused by group B *Streptococcus*.



Every year, NCEZID awards millions of dollars to states to help them control infectious disease.

PROTECTING AMERICANS FROM BIOTERRORISM

At NCEZID, our first priority is to keep people safe. Preparing for infectious disease threats—naturally occurring or intentional—is one of the mission-critical activities of NCEZID. We do not know when—or if—a national health emergency like the anthrax attacks of 2001 might happen again. What we do know is that if anthrax or another biological agent were intentionally released, NCEZID will be central to CDC's response because of three primary and unique assets:

1. We have the scientific expertise. At CDC, the scientists who specialize in the scariest pathogens work at NCEZID. NCEZID's epidemiologists and microbiologists are among the world's leading experts in highly pathogenic bacteria and viruses like those that cause anthrax, botulism, plague, smallpox, and Ebola. They also handle less-familiar but dangerous germs that cause brucellosis, tularemia, Q fever, Lassa fever, Rift Valley fever, and other viral hemorrhagic fevers.

These specialized NCEZID scientists are vital in helping CDC and its partners prepare by developing diagnostic tests and updated guidance for clinicians, laboratories, public health officials, and the public. All of this would be critically important to saving lives during a large-scale public health emergency caused by bioterrorists.

2. We oversee work in CDC's high-containment labs (HCL). Many of the dangerous pathogens that could cause major outbreaks or be used in bioterrorism are securely handled in HCL labs (*see p. 10*). The biosafety level (BSL)-3 lab handles pathogens that could cause serious illness, but could be treated. Pathogens that are even more deadly and for which no vaccine or treatment is available require containment in the most secure facility, the BSL-4 lab.

3. We manage the Laboratory Response Network (LRN). The LRN is a unique network of more than 130 laboratories established in collaboration with the Federal Bureau of Investigation and the Association of Public Health Laboratories to respond to bioterrorism, chemical terrorism, and other public health emergencies. The network includes state and local public health laboratories, as well as veterinary, agriculture, military, law enforcement, and water- and food-testing labs. When an emergency strikes, the LRN quickly mobilizes as it did during the anthrax investigation of 2001 and in 2014 for the Ebola outbreak.

Bioterrorism has the potential to quickly kill millions of people.

IMAGE (LEFT): NCEZID scientists suiting up before they enter the BSL-4 laboratory.

Photo: Jim Gathany

NCEZID Working Around The World

TARGETING INFECTIOUS DISEASE AROUND THE WORLD

NCEZID scientists are in the forefront of global outbreak response, reducing the spread of diseases that cross borders, because as the Ebola and Zika epidemics have demonstrated, an outbreak overseas is only a plane ride away. Our scientists also strengthen health security in the United States by focusing on pathogens (like anthrax or plague) that could be intentionally spread by bioterrorists.

What we're doing:

- **Lead major outbreak responses**, providing the technical expertise and workforce for major outbreaks like cholera, Ebola, and Zika.
  - 500+ NCEZID staff deployed to Zika response
  - 1,000+ NCEZID staff deployed to West Africa for Ebola response
- During the 2014 Ebola outbreak, NCEZID worked with Sierra Leone to fast-track development of a national program to **decrease the spread of Ebola in healthcare facilities**. The program's success led Sierra Leone to add trained infection prevention staff to 25 government hospitals and 14 districts, ensuring that infection prevention and control remain a priority in healthcare.
- We've **developed many new tests** with partners that have helped us respond faster to outbreaks of emerging infectious diseases including Zika, Ebola, yellow fever, dengue, and plague.
- Our **ePathology** service lets our pathology experts share a microscope with scientists across the globe and provide real-time consultation for urgent cases or rarely seen pathogens.
- Strengthen **public health systems** to prevent global spread of disease, including robust surveillance systems to pick up diseases, disease detectives who can trace the source of the outbreak, and responsive and effective laboratories that provide confirmation.
- Reduce illness and death among **US travelers**, expatriates, and other globally mobile populations.

NCEZID epidemiologist greets children in a northern Tanzania village during a cholera outbreak rapid response.

An outbreak of infectious disease is always just a plane ride away.

BACK COVER:
Aspergillus fumigatus (fungus)

Photo: Jim Gathany

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