

Emerging Infectious Diseases

A Public Health Response

One fall day in 1996, a little girl experienced diarrhea and stomach cramps and, within days, was in the hospital, kidneys failing, fighting futilely for her life. Laboratory tests showed that the cause was a deadly toxin-armed bacterium known as *Escherichia coli*, or *E. coli*, O157:H7—the same microbe that killed four children in 1993 and sickened hundreds of others after they ate undercooked hamburger from a fast-food chain. Since this virulent strain of *E. coli* was first identified in 1982, it has become one of the most feared food-related threats to the health of the American public.

With the little girl's death, health officials asked many questions: Where did the *E. coli* come from? Are others sick? Who will be sick tomorrow? Summoned to investigate, medical detectives from the state health department and the Centers for Disease Control and Prevention (CDC) questioned relatives and friends, pored over medical records, and investigated possible sources. They traced the child's infection to unpasteurized apple juice, a brand touted for its natural freshness.

Some might view a toddler's death from *E. coli*-contaminated apple juice as a disturbing but isolated incident. In reality, though, it is part of an ongoing life-and-death struggle in an invisible biological war. The enemy is a growing list of disease-causing microorganisms that are emerging or rebounding all over the world, some are appearing in new forms armed with new methods of attack. *E. coli* O157:H7 continues to strike in communities around the United States. For example, in June 1998 it infected 26 small children who played in a contaminated wading pool at a large water park in Georgia.



The Continuing Microbial Threat

Facing the Enemy

Only a few decades ago, a grateful public trusted that science had triumphed over infectious diseases by building a fortress of health protections. Antibiotics, vaccines, and aggressive public health campaigns had yielded a string of victories over old enemies like pneumonia, polio, and smallpox, and Americans were lulled into believing that microbial threats were a thing of the past. But the global spread of acquired immunodeficiency syndrome (AIDS), the resurgence of tuberculosis, and the appearance of new enemies like hantaviruses, Ebola virus, and deadly *E. coli* strains are reminders of the resilience and adaptability of our microbial adversaries. Within the last few years,

- A “bird flu” virus that had never before attacked humans began to kill people in Hong Kong.
- A new variant of a fatal brain disease, Creutzfeldt-Jakob disease, was identified in the United Kingdom, apparently transmitted by beef from animals with “mad cow disease.”
- *Staphylococcus* bacteria with reduced susceptibility to vancomycin, long the antibiotic of last resort, were seen for the first time.
- The country has been hit with several major multistate foodborne outbreaks, including those caused by parasites on raspberries, viruses on strawberries, and bacteria in produce, ground beef, cold cuts, and breakfast cereal.
- A new strain of tuberculosis that is resistant to many drugs, and occurs most often in people infected with human immunodeficiency virus (HIV), persists in New York City and some other large cities.

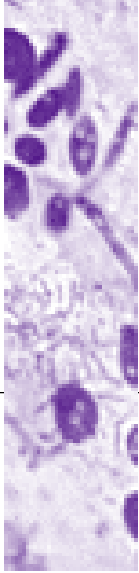


The emergence and reemergence of these and other disease agents have been fueled by

- Unprecedented worldwide population growth
- Increased international travel
- Increasing worldwide transport of animals and food products
- Changes in food processing and handling
- Changes in human behavior
- Human encroachment on wilderness habitats that are reservoirs for insects and animals that harbor infectious agents
- Microbial evolution and the development of resistance to antibiotics and other antimicrobial drugs

Whatever the cause, the resurgence of diseases attributed to newly emerging microbes poses a continuing challenge for the nation's public health and health-care systems. As pathogens strengthen their hold, broaden their reach, and pierce our defenses, our vulnerability is extending to the most mundane activities. Questions arise such as—Is my tap water safe to drink? Is the food I ordered in a restaurant safe to eat? Are my children likely to be bitten by disease-carrying insects or ticks while playing in the yard? Does my sex partner have an infection that might be passed on to me? Is it safe to vacation in a tropical country? Is the coughing person next to me on the subway or airplane spreading a deadly strain of influenza or tuberculosis?





CDC'S Plan for the New Millennium

Watch, Learn, Prepare, Act

The battle lines are drawn: new diseases are emerging and old diseases are regaining a foothold. This is happening not just in a faraway locale, but also in our own neighborhoods and homes. The enemy is invisible, furtive, and gaining in strength and numbers. As we approach the new millennium, we must be prepared for the unexpected today and for prolonged conflict tomorrow.

- We must enhance our watchfulness worldwide.
- We must prepare to fight diseases that we have never heard of while we learn to cope again with those we thought we had vanquished.
- We must keep our food, water, and blood supplies safe from contamination.
- We must develop new antibiotics and vaccines.
- We must combat drug-resistant illnesses.
- We must ensure that diseases carried by animals do not spread to people.
- We must protect the most vulnerable among us—children, pregnant women, the sick, the elderly, people without easy access to health care.
- We must be ready to act decisively in the event of a deliberate release of infectious microbes by terrorists or rogue nations.



In short, we must redouble our efforts to be vigilant, increase our understanding of microbes new and old, develop better weapons, and be prepared to respond with decisive action when needed.

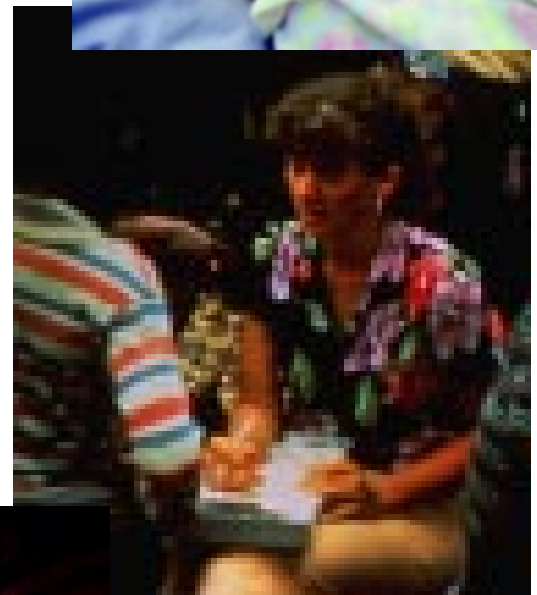
CDC—the nation's disease prevention agency—is dedicated to this mission. CDC's vision for the 21st century is of individuals, communities, and nations joined in a common effort to combat today's emerging infectious diseases and to prevent those of tomorrow. To realize this vision, CDC scientists have designed a plan to respond to microbial emergence and resurgence in the new millennium—*Preventing Emerging Infectious Diseases: A Strategy for the 21st Century*.

This plan is the second phase of an effort launched in 1994 with the publication of CDC's *Addressing Emerging Infectious Disease Threats: A Prevention Strategy for the United States*. The implementation of the 1994 strategy is well underway, and results are already evident. However, fulfilling CDC's vision of a safer world requires a long-term commitment and sustained effort. *Preventing Emerging Infectious Diseases: A Strategy for the 21st Century* describes CDC's next steps in the battle to prevent and control emerging infections. It takes into account the discoveries and challenges of the past few years and builds on new experiences, successes, and knowledge. Like the initial strategy, the plan is organized around four interdependent goals: **Surveillance and Response, Applied Research, Infrastructure and Training, and Prevention and Control.**

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How Disease Prevention Works

Surveillance systems at the state and national levels monitor emerging infections and detect outbreaks of disease. When surveillance data or other information uncovers a change in the occurrence or distribution of a disease, or when a new strain of a microbe becomes a health threat, specially trained public health workers investigate, assess the potential public health implications, and mount a rapid response. Through applied research, scientists ask and answer questions about the disease's causes, transmission, diagnosis, prevention, and control. A specialized infrastructure supports and equips public health workers and laboratories and links them in national and global communications networks. Training the next generation to fight emerging infectious diseases is a crucial component of public health. All of these efforts are ultimately directed toward disease prevention and control—the application of the most effective tools and technologies to strengthen personal and national defenses against infectious diseases.



Surveillance and Response

Watchfulness: Sizing Up Microbial Threats

In 1997, U.S. public health authorities received the long-dreaded alert: strains of the common, but potentially deadly, microbe *Staphylococcus aureus* had acquired the ability to partially withstand vancomycin, the antibiotic used when all other licensed drugs are ineffective. The discovery of the drug-resistant *Staphylococcus* strain in patients in Michigan and New Jersey came just 3 months after a similar resistant strain was found in an infant in Japan. Although the newly identified bacteria are not fully resistant to vancomycin, the possibility of a widespread untreatable infection marks a turn for the worse in the fight against infectious diseases and underscores the need for renewed attention to disease surveillance.

Surveillance means watchfulness: What is the threat? What caused it? Where is it appearing? How is it moving? Surveillance detects changes in disease occurrence and sounds the alarm for action. It provides the basis for timely public health decisions and timely responses.

Many of our most visible disease control successes have their basis in effective surveillance and response: tracing contaminated foods and prompting national warnings and recalls, identifying the most prevalent influenza virus

strains to make the best possible vaccine, monitoring the blood supply to keep it safe, tracking the proliferation of drug-resistant infections and instituting controls. To maintain these successes and to heighten our watchfulness to detect new threats, the country's surveillance and response systems—and the essential laboratory services on which they depend—need support and resources from all levels of government and the full cooperation of health-care networks and providers nationwide.

Throughout the United States, surveillance for foodborne diseases is a high priority. In the past, outbreaks of foodborne illness tended to be local events that were easily recognized. Now, however, outbreaks are often scattered over a wide geographic area—the consequence of regional or national distribution of food products. As part of the 1997 National Food Safety Initiative, the federal government is boosting its ability to track foodborne illnesses from coast to coast. In mid-1998, officials unveiled a new early warning system called PulseNet—a national network of laboratories that rapidly perform DNA “fingerprinting” on bacteria

samples from sick people and contaminated food. The network permits speedy comparison of fingerprint patterns through an electronic database at CDC. When patterns submitted from different sites are very similar, the computer alerts health agencies to a possible widespread outbreak so that further illnesses and deaths can be prevented.

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Applied Research

Knowledge: Discovering New Ways To Fight Disease

Asustained, forward-thinking applied research program enables scientists to uncover the weak links in the armor of emerging microbes, create novel ways to identify and fight microbial foes, and evaluate the preventive power of new approaches. For example, a growing body of evidence shows that emerging pathogens do more than cause acute infectious diseases. They can also be major contributors to chronic diseases traditionally associated with lifestyle and environment. Many stomach and duodenal ulcers—long thought to be due to stress and spicy food—are now known to result from infection with the bacterium *Helicobacter pylori*. Another bacterium, *Chlamydia pneumoniae*, may play a role in heart disease. Cancer of the cervix has been linked to infection with some types of human papillomavirus, and chronic liver disease and liver cancer are associated with chronic infection with hepatitis B and C viruses. Thus, some of the leading causes of death and disability may turn out to be to some degree infectious, and common infection-fighting drugs may help bring them under control.

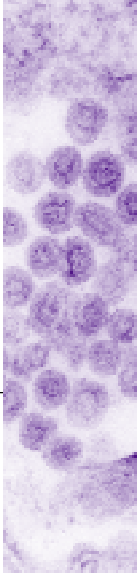
Research is also a crucial part of the response to new and reemerging diseases. In 1976, when a horrific tropical fever appeared out of nowhere in Sudan and Zaire (now the Democratic Republic of the Congo), no one knew what caused it, how it was spread, or how to control it. Researchers hurried to identify the cause of the epidemic, pinpoint its source, and halt its spread. The disease became known as Ebola hemorrhagic fever—“Ebola” after a nearby river and “hemorrhagic” because of the massive internal bleeding it often causes.

Because of the research conducted during and after this first outbreak, investigators were better prepared in 1995 when a major Ebola outbreak struck Zaire, in and around the city of Kikwit. By then, scientists knew that Ebola is caused by a virus spread by contact with body fluids. International teams of disease detectives used epidemiologic methods and laboratory tools to determine that the outbreak had been in progress at least 4 months before health authorities were alerted. Much of the ongoing transmission was occurring in hospitals, and the number of new cases dropped sharply after CDC, WHO, and their partners encouraged the use of barrier precautions, supplied protective clothing and disposable syringes, and disinfected health-care facilities.

While the 1995 outbreak was still going on, a research pathologist at CDC noticed that people who died of Ebola hemorrhagic fever had virus particles in their skin. Building on this finding, he and his colleagues developed a surveillance kit that lets health teams safely take diagnostic skin samples from people who have died from what appears to be Ebola. The samples can then be sent to laboratories for testing. CDC has provided kits to health-care facilities in the Kikwit area and has trained local staff to identify and test people with suspected Ebola. Prompt diagnosis of Ebola hemorrhagic fever will help provide early identification of outbreaks and allow control measures to be instituted as quickly as possible.



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Infrastructure and Training

Preparedness: Ready for Battle

Public health infrastructure and training support public health actions. Nations, states, and communities need strong infrastructures to sustain disease surveillance, research, and prevention activities and to prepare for the unexpected. They need modern laboratories that are equipped to recognize stealthy microbial agents like hepatitis C virus and *E. coli* O157:H7. They need people, equipment, and know-how to perform jobs as diverse as disease reporting, microbe identification, restaurant inspections, water-supply tests, vaccination campaigns, and public education. They need communications technologies to link scientists in national and global networks. They need training to teach laboratory researchers how to perform diagnostic tests and safely process deadly specimens, to instruct workers about new tools and techniques, and to prepare the next generation of scientists to confront emerging disease challenges.

The U.S. experience with rubella shows the importance of a strong public health infrastructure. Rubella (German measles) is an acute viral infection that is spread from person to person. Although the disease is usually mild, when a pregnant woman gets this infection, her baby can be born with severe birth defects, including heart defects, deafness, and mental retardation, and other outcomes of the condition known as congenital rubella syndrome (CRS).

Since a rubella vaccine was licensed in 1969, no major epidemics of rubella have occurred in the United States, and rubella infections have sharply decreased. Over the past few years, however, the epidemiology of rubella has changed, and it now occurs mainly in adults, rather than in children. Many of the affected adults come from countries without rubella vaccination programs. This shift

puts susceptible pregnant women and their fetuses at risk.

Since 1994, CDC has provided grants to all states to bolster the infrastructure for fighting vaccine-preventable diseases like rubella. North Carolina used its grant to strengthen disease monitoring and control. Thus, when an outbreak of rubella hit nine North

Carolina counties in 1997, a rubella surveillance system was already in place. The outbreak was detected early, and control measures were initiated without delay. No cases of CRS were reported in the months that followed.

Achievements like North Carolina's triumph over rubella are certainly impressive, but many health departments remain inadequately prepared for the fight against the new public health threats. Strengthening the public health infrastructure requires an ongoing and sizable investment in modernization and training to

boost local, state, national, and global disease-monitoring capacity and to augment outbreak-response expertise. Making these improvements is the only way to guarantee that the United States, and the world, are prepared with trained experts, well-equipped laboratories, and cutting-edge technology to combat emerging and reemerging microbes in the decades to come.

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Prevention and Control

Action: Protecting the Public

The culmination of all of these efforts is the prevention and control of infectious diseases. Disease prevention alerts people to the threats of new and reemerging diseases and teaches them how to protect themselves and their families. Disease control applies the most effective tools and technologies to combat infectious microbes.

The crusade against group B streptococcal infection illustrates the power of effective prevention and control. Scientists have known for a long time that 1 woman in 5 carries group B streptococcus bacteria in her body. The bacteria usually cause no symptoms. However, when transmitted from an infected pregnant woman to her newborn during childbirth, the bacteria can kill the baby—or leave a tiny survivor cruelly handicapped.

Until recently, most parents-to-be never learned about the possibility of this infection during their prenatal visits to the doctor's office. Unsuspecting new parents would typically be told about the disease only after delivery, when faced with a critically ill newborn. Although studies in the 1980s showed that giving antibiotics during childbirth to women at high risk can prevent group B strepto-

coccus infection in newborns, antibiotics were not routinely given, and thousands of U.S. babies continued to be stricken each year.

Why were these deadly but preventable infections still occurring? Surveys found that doctors were confused about recommendations to prevent group B streptococcal disease. CDC responded to this problem by joining with several partner organizations to develop and distribute new recommendations for disease prevention. As obstetricians adopted the new policies, the number of cases in newborns dropped—by more than 50% in some places—and the action saved thousands of babies from permanent disability, shielded thousands of parents from heartbreak, and saved the nation millions in medical costs. CDC is now working with community groups, health departments, and professional organizations to bring standardized prevention protocols to a wider audience.

These actions exemplify CDC's approach to disease prevention and control and the success that comes from translating the results of surveillance and research into practice. The nation can build on the strengths gained by investments in surveillance, research, infrastructure building, and training and apply them systematically to reducing illnesses and deaths from infectious diseases.



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Fighting Emerging Infections around the World

Infectious diseases remain the number one cause of death around the world, and the global upswing in new and reemerging microbes increases the danger to us all. The reality of that threat was dramatized recently by worldwide concern that a 1997 outbreak of avian influenza (“bird flu”) in Hong Kong might be the start of the next global pandemic.

Influenza is a wily adversary that routinely taxes the skills and resources of the public health community. Influenza is not caused by a single organism but by a group of related viruses that are constantly changing. Because the viruses vary so much from year to year, a new vaccine must be developed for each winter season.

Looming over the yearly routine of preparing for each flu season is the threat that a pandemic strain might emerge—a virulent new type of flu that can span the globe in months and decimate the world’s population—the kind that killed more than 20 million people in 1918–1919. Such a lethal virus can sweep the world without warning.

The recent influenza scare raised the specter of a possible global pandemic and jolted the world from any renewed complacency about infectious diseases. It also reminded us of the value and urgency of a strategy of national and international watchfulness, knowledge, preparedness, and action.

Scientists have done their best to build a sturdy defense against influenza. A worldwide detection system tracks the yearly changes in flu viruses. Timely global watchfulness pays off by giving manufacturers the lead time to prepare each year’s vaccine. The surveillance system worked well enough in 1997 to detect the new flu strain in Hong Kong that many feared might be the next worldwide killer.

Each year, scientists need to characterize the circulating flu strains early enough for vaccine to be created. They study thousands of virus samples from dozens of laboratories around the world to predict which types are likely to dominate the next flu season. From that knowledge, manufacturers can develop an appropriate vaccine. Laboratory research makes it possible to understand a new virus at its most basic level, develop tests to detect infected persons, and produce large quantities of effective vaccine quickly and safely.

Delivering influenza vaccine to people at high risk is a yearly public health priority. In the case of a potential pandemic, inoculating hundreds of millions of Americans would be a dizzying logistical feat—but possible within the parameters of state and national influenza preparedness plans. The challenge is to be ready.

Once a new strain actually strikes, the public health community is set into action—informing the public, educating medical workers, and vaccinating millions to meet the threat of an emerging influenza strain.

Pandemic flu is not the only threat facing us in the next millennium. An equivalent level of commitment and action is needed to thwart the full assemblage of emerging infectious diseases. The groundwork has already been laid, new tools are expanding our arsenal, and the challenges and opportunities of a new century await.



Partners in Disease Prevention and Control

Realizing CDC's vision of a safer world requires the sustained and coordinated work of many people and groups, from the highest levels of government and most respected research institutions to individual health-care providers, businesses, communities, and families.

In the national government, CDC has responsibility for disease surveillance and investigation of emerging threats. Other federal agencies share responsibilities for conducting research and activating control measures. State and local public health departments lead the effort to detect, prevent, and control emerging infectious diseases in their jurisdictions.

The campaign against infectious diseases also extends beyond public agencies. Laboratories test human samples for infectious agents and report results to health departments. Universities and research groups find and promote treatments, cures, and new methods for preventing infections. Health-care providers report notifiable diseases to public health authorities, take actions to check the spread of illness, and instruct patients on how to avoid infection. Pharmaceutical companies develop vaccines and antibiotics. Schools and child-care centers enforce immunization requirements and teach good health practices. Advocacy groups educate the public about diseases that threaten their neighborhoods and communities.

These groups often come together to tackle problems that require people and expertise beyond the resources of any one entity. One such challenge was



to halt the nationwide increase in babies born infected with HIV, the virus that causes AIDS. Before preventive treatments were available, 1,000 to 2,000 U.S. infants were born with HIV infection each year. In 1994, clinical trials sponsored by the National Institutes of Health (NIH) found that the anti-HIV drug zidovudine, given to HIV-infected mothers prenatally and at delivery and to their babies immediately after birth, could reduce the risk of mother-to-child (perinatal) HIV transmission by more than two-thirds. Zidovudine (also known as AZT or ZDV) was developed by industry scientists who built on the findings of researchers supported by NIH and private foundations. The drug was first licensed by the Food and Drug Administration (FDA) in 1987.

Based on the results of the clinical trials, the U.S. Public Health Service (PHS) issued guidelines in 1995 recommending HIV counseling and voluntary testing for all pregnant women and zidovudine therapy for those infected. A consortium of federal, state, and local health officials, AIDS service providers, and private physicians and researchers wrote the PHS guidelines. Putting them into action required the teamwork of public agencies, private institutions, and nonprofit organizations. Community representatives worked with health departments to meet local needs and link patients, doctors, counselors, scientists, activists, and public health workers. Public and private clinics, medical centers, and nonprofit sites provided counseling, testing, and treatment.

From 1992 through 1997, the number of babies in the United States with HIV/AIDS fell dramatically, by more than 40%. The public/private partnerships continue today and have expanded to include international groups, such as the Joint United Nations Programme on AIDS (UNAIDS).





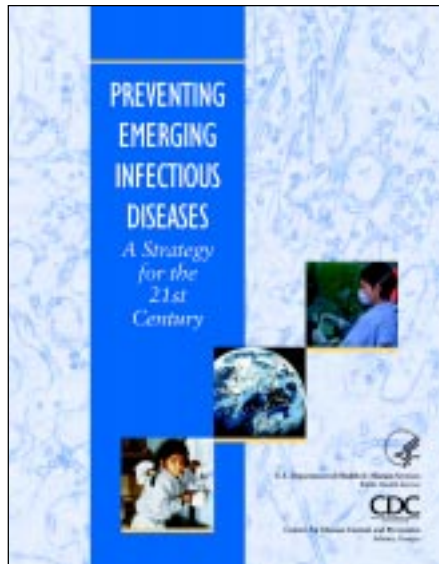
Entering the 21st Century

Armed for the New Millennium

Despite our best efforts to stop the onslaught of new and resurgent infections, infectious diseases probably will never be wholly subdued. Microbial pathogens are unpredictable, ever-changing, endlessly adaptable, and ready to ambush us any time our defenses falter. Therefore, we must be ready for whatever new threats arise.

CDC's publication, *Preventing Emerging Infectious Diseases: A Strategy for the 21st Century*, lays out the battle plan. The challenge for the nation is to respond with the resources and commitment needed to

- Maintain our watchfulness through surveillance
- Invigorate our knowledge through research
- Heighten our preparedness by strengthening public health systems
- Arm our communities, our nation, and the world for decisive preventive action against emerging and resurgent infectious diseases.



For additional copies of this booklet, or to obtain copies of CDC's plan, *Preventing Emerging Infectious Diseases: A Strategy for the 21st Century*, write to:

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