

PREVENTING EMERGING INFECTIOUS DISEASES

*A Strategy
for the
21st
Century*



U.S. Department of Health & Human Services
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CDC
CENTERS FOR DISEASE CONTROL
AND PREVENTION

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Cover background: Electron micrograph of avian influenza virus (H5N1), a newly discovered and virulent strain of influenza that infected humans in Hong Kong in 1997.

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Centers for Disease Control and Prevention

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PREFACE

In 1994, CDC launched the first phase of a nationwide effort to revitalize national capacity to protect the public from infectious diseases. The effort focused on four goals: improving disease surveillance and outbreak response; supporting research to understand and combat emerging infectious threats; preventing infectious diseases by implementing disease control programs and communicating public health information; and rebuilding the infectious disease-control component of the public health infrastructure.

As a nation, we have made progress in all four areas. The first line of defense for public health—our network of state and local health departments—has been strengthened, and as a nation we have become better prepared to address new diseases as they arise. We have developed new tools for detecting and controlling infectious diseases. New programmatic efforts have incorporated the latest theories and techniques to help people change behaviors that favor the spread of infectious diseases. These achievements were made possible by the hard work and dedication of colleagues in local, state, and federal government; in universities; in private industry; and in many nongovernmental organizations and professional societies. CDC has

also begun to address emerging disease issues at the global level, working in partnership with foreign governments, the World Health Organization, and other organizations and agencies.

At the same time, however, we have witnessed the appearance of new and unforeseen disease threats, such as a virulent strain of avian influenza that attacks humans, a human variant of “mad cow disease,” and new drug-resistant forms of *Staphylococcus aureus*. The emergence of these threats reminds us that we must not become complacent. We must never underestimate the power, destructiveness, and endless adaptability of infectious microbes.

As we face the new millennium, we must renew our commitment to the prevention and control of infectious diseases, recognizing that the battle between humans and microbes will continue long past our lifetimes and those of our children.

This document, *Preventing Emerging Infectious Diseases: A Strategy for the 21st Century*, describes CDC’s plan to combat infectious diseases over the next 5 years. We look forward to working with our many partners throughout the nation and the world as we implement this plan.

Jeffrey P. Koplan, M.D., M.P.H.

Director

Centers for Disease Control and Prevention

EXECUTIVE SUMMARY

Pathogenic microbes can be resilient, dangerous foes. Although it is impossible to predict their individual emergence in time and place, we can be confident that new microbial diseases will emerge.

—*Institute of Medicine, Emerging Infections: Microbial Threats to Health, 1992*

Infectious diseases are a continuing menace to all people, regardless of age, gender, lifestyle, ethnic background, and socioeconomic status. They cause suffering and death, and impose an enormous financial burden on society. Although some diseases have been conquered by modern advances, such as antibiotics and vaccines, new ones are constantly emerging (such as AIDS, Lyme disease, and hantavirus pulmonary syndrome), while others reemerge in drug-resistant forms (such as malaria, tuberculosis, and bacterial pneumonias).

Because we do not know what new diseases will arise, we must always be prepared for the unexpected. For example, in 1997, an avian strain of influenza that had never before attacked humans began to kill previously healthy people in Hong Kong. This crisis raised the specter of an influenza pandemic similar to the one that killed 20 million people in 1918. Also in 1997, strains of *Staphylococcus aureus* with diminished susceptibility to vancomycin were reported in Japan and the United States. If we are unable to replace drugs like vancomycin as they lose their effectiveness—and to limit the emergence and spread of resistance—some diseases may become untreatable, as they were in the preantibiotic era. In addition, the recent discovery that a strain of the virus that causes HIV/AIDS has been circulating at least since 1959¹ illustrates the furtive way in which emerging infectious agents can insinuate themselves into human populations and remain undetected for years before emerging explosively as public health problems. Each of these examples reminds us that we are barely one step ahead of the microbes and underscores our need for a strong and vigilant public health system.

CDC'S PLAN: PREVENTING EMERGING INFECTIOUS DISEASES

This plan has been prepared under the leadership of CDC's National Center for Infectious Diseases (NCID) with significant input from other major CDC programs and centers involved in addressing emerging infectious disease issues. These include the National Center for HIV, STD, and TB Prevention (NCHSTP) and the National Immunization Program (NIP). Other parts of CDC that support infectious disease prevention and control include CDC's Office of Global Health (OGH), Epidemiology Program Office (EPO), Public Health Practice Program Office (PHPPPO), and the National Institute for Occupational Safety and Health (NIOSH). In addition, CDC has worked with many experts and institutions throughout the United States and abroad to develop this plan.

The fulfillment of CDC's vision will require the sustained and coordinated efforts of many individuals and organizations. As CDC carries out this plan, it will coordinate with state and local health departments (e.g., on surveillance of infectious diseases), academic centers and other federal agencies (e.g., on research agendas), health care providers and health care networks (e.g., on development and dissemination of guidelines), international organizations (e.g., on outbreak responses overseas), and other partners.

GOALS AND OBJECTIVES FOR PREVENTING EMERGING INFECTIOUS DISEASES

Because *Preventing Emerging Infectious Diseases* is a sequel to CDC's 1994 plan, its objectives and activities are organized under the same four goals described in the first plan, although in a different order. The goals are **Surveillance and Response, Applied Research, Infrastructure and Training, and Prevention and Control.**

Public health surveillance is the ongoing, systematic collection, analysis, interpretation, and dissemination of health data, including information on clinical diagnoses, laboratory-based diagnoses, specific syndromes, health-related behaviors, and other indicators related to health outcomes. Epidemiologists use these data to detect outbreaks; characterize disease transmission patterns by time, place, and person; evaluate prevention and control programs; and project future health care needs. For **Goal I: Surveillance and Response**, the objectives call for strengthening infectious disease surveillance and response in the United States and internationally, as well as improving methods for gathering and evaluating surveillance data. They also emphasize that surveillance data are critical not only for detecting outbreaks, but also for improving public health practice and medical treatment.

Research is essential for understanding emerging infectious diseases and how to prevent and control them. For **Goal II: Applied Research**, the objectives include improving tools for identifying and understanding emerging infectious diseases; determining risk factors for infectious diseases, as well as infectious risk factors for chronic diseases; and conducting research to develop and evaluate prevention and control strategies.

The public health infrastructure is the underlying foundation that supports the planning, delivery, and evaluation of public health activities and practices. For **Goal III: Infrastructure and Training**, the objectives and activities focus on enhancing epidemiologic and laboratory capacity in the United States and internationally. In the United

States, this requires improving CDC's ability to communicate electronically with its partners and strengthening CDC's capacity to serve as a reference center for diagnosis of infectious diseases and drug-resistance testing. The objectives and activities also address the need to enhance the nation's capacity to respond to outbreaks, including those caused by bioterrorism, and to provide training opportunities to ensure that today's workers and future generations are able to respond to emerging threats.

All of CDC's efforts are ultimately directed at the implementation of **Goal IV: Prevention and Control.** CDC will work with many partners (including other government agencies, professional societies, private industry, nongovernmental organizations, and managed care organizations) to implement, support, and evaluate disease prevention in the United States and internationally. As part of this effort, CDC will conduct demonstration programs and will develop, evaluate, and promote strategies that help health care providers and other individuals change behaviors that facilitate disease transmission.

Target Areas

Preventing Emerging Infectious Diseases targets certain categories of emerging infectious disease problems and particular groups of people who are at special risk. Collectively, these cause great suffering and represent a tremendous burden on society. Addressing infectious disease issues in these target areas will be a high priority during the implementation of this plan.

Antimicrobial Resistance. The emergence of drug resistance in bacteria, parasites, viruses, and fungi is swiftly reversing advances of the previous 50 years. As we approach the 21st century, many important drug choices for the treatment of common infections are becoming increasingly limited and expensive and, in some cases, nonexistent.

Foodborne and Waterborne Diseases. Changes in food processing and distribution are resulting in

more multistate outbreaks of foodborne infections. In addition, a new group of waterborne pathogens has emerged that is unaffected by routine disinfection methods.

Vectorborne and Zoonotic Diseases. Many emerging or reemerging diseases are acquired from animals or are transmitted by arthropods. Environmental changes can affect the incidence of these diseases by altering the habitats of disease vectors.

Diseases Transmitted Through Blood Transfusions or Blood Products. Improvements in donor screening, serologic testing, and transfusion practices have made the U.S. supply one of the safest in the world, despite its size and complexity. However, because blood is a human tissue, it is a natural vehicle for transmission of infectious agents. Therefore, continued vigilance is needed to ensure the safety of the U.S. blood supply.

Chronic Diseases Caused by Infectious Agents. Several chronic diseases once attributed to lifestyle or environmental factors (such as some forms of cancer, heart disease, and ulcers) might be caused by or intensified by infectious agents. This new knowledge raises the possibility that certain chronic diseases may someday be treated with antimicrobial drugs or prevented by vaccines.

Vaccine Development and Use. Childhood diseases such as diphtheria, tetanus, polio, measles, mumps, rubella, and *Haemophilus influenzae* type b meningitis have been virtually eliminated in the United States through universal vaccination. However, additional vaccines are needed to prevent diseases that represent a great societal burden in the United States or internationally, such as HIV/AIDS, dengue fever, hepatitis C, and malaria.

Diseases of People with Impaired Host Defenses. People whose normal host defenses against infection have been impaired by illness or medical treatment or as a result of age are more likely to become ill with a variety of infectious diseases. Infections that occur with increased frequency or severity in such people are often called opportunistic infections (OIs). Health care providers and sci-

entists must be ready to identify and investigate each new OI as it appears, and to learn how to diagnose, treat, control, and prevent it.

Diseases of Pregnant Women and Newborns. Asymptomatic infections in a pregnant woman can increase an infant's risk of prematurity, low birthweight, long-term disability, or death. In addition, infections may be silently transmitted from mother to child during pregnancy, delivery, or breast feeding. Effective and accessible prenatal care is essential to the prevention of infection in pregnant women and newborn babies.

Diseases of Travelers, Immigrants, and Refugees. People who cross international boundaries—such as tourists, workers, immigrants, and refugees—may be at increased risk of contracting infectious diseases and may also disseminate diseases to new places. International air travel has increased substantially in recent years, and more travelers are visiting remote locations where they may be exposed to infectious agents that are uncommon in their native countries.

ANTICIPATED OUTCOMES

Achievement of the objectives described in this plan will improve our ability to understand, detect, control, and prevent infectious diseases. The outcome will be a stronger, more flexible U.S. public health infrastructure well-prepared to respond to well-known disease problems and to address the unexpected, whether it is an influenza pandemic, a disease caused by an unknown organism, or a bioterrorist attack.

Implementation of this plan will produce the following results:

- A nationwide network for surveillance and response will ensure the prompt identification of emerging infectious diseases. State and local health departments will have the equipment and trained personnel needed to serve as the front line public health response to infectious disease threats.

- Intensive population-based surveillance and research programs in at least 10 areas of the United States will generate data to identify new threats to public health and help guide responses to emerging infectious diseases.
- Health departments will rapidly detect and investigate outbreaks of foodborne illnesses using sophisticated epidemiologic and laboratory techniques. Early detection will facilitate rapid implementation of control measures and the prevention of illness and death.
- Countries in all regions of the world will participate in a global system for surveillance and response that includes surveillance for infectious agents that are resistant to antimicrobial drugs. This effort will be undertaken in partnership with the World Health Organization and other organizations and agencies around the world.
- Enhancement of the public health infrastructure will help prepare the United States to respond to bioterrorist incidents.
- Improved diagnostic testing methods will be developed for new, reemerging, and drug-resistant pathogens.
- A better understanding of risk factors for the development of infection and disease will provide new opportunities for disease prevention.
- A better understanding of relationships between infectious agents and some chronic diseases will lead to new strategies for preventing and treating chronic diseases.
- New strategies will be designed to reduce insect vector populations and control animal populations that serve as reservoirs for human diseases.
- Diagnostic and reference reagents will be available for use by public health laboratories. CDC will have enhanced capacity to serve as the national reference center for diagnosis of infectious diseases and for drug-resistance testing.
- The next generation of epidemiologists and laboratorians will be trained and prepared to respond to emerging infectious disease threats.
- Implementation of prevention guidelines will result in decreased death and disability due to nosocomial infections, opportunistic infections, antimicrobial resistance, and infections in newborns.
- Cooperative efforts among managed care organizations, health care facilities, state and local health departments, and CDC will improve treatment and prevention of infectious diseases.
- Deaths from vaccine-preventable diseases will be significantly reduced in the United States and abroad.
- Community-based demonstration programs will help identify cost-effective approaches to addressing emerging infectious disease problems.

INTRODUCTION

Infectious diseases are a continuing menace to all people, regardless of age, gender, lifestyle, ethnic background, and socioeconomic status (see Box 1). They cause suffering and death and impose an enormous financial burden on society (see Box 2). Although some diseases have been conquered by modern advances, such as antibiotics and vaccines, new ones are constantly emerging (such as HIV/AIDS, Legionnaires' disease, Lyme disease, and hantavirus pulmonary syndrome), while others reemerge in drug-resistant forms (such as malaria, tuberculosis, and bacterial pneumonias).

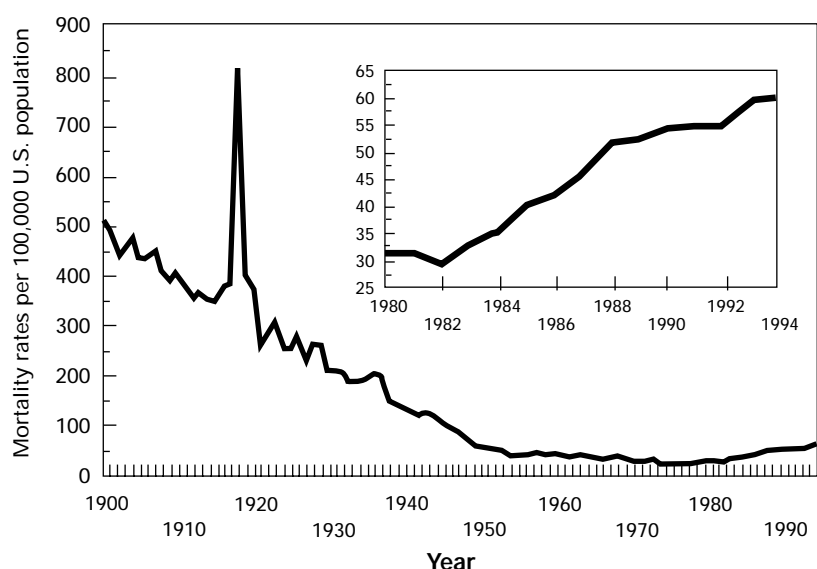
Because we do not know what new diseases will arise, we must always be prepared for the unexpected. For example, in 1997, an avian strain of influenza that had never before attacked humans began to kill previously healthy people in Hong Kong. This crisis raised the specter of an influenza

pandemic similar to the one that killed 20 million people in 1918. Also in 1997, strains of *Staphylococcus aureus* with diminished susceptibility to vancomycin were reported in Japan and the United States. If we are unable to replace drugs like vancomycin as they lose their effectiveness—and to limit the emergence and spread of resistance—some diseases may become untreatable, as they were in the preantibiotic era. In addition, the recent discovery that a strain of the virus that causes HIV/AIDS has been circulating at least since 1959¹ illustrates the furtive way in which emerging infectious agents can insinuate themselves into human populations and remain undetected for years before emerging explosively as public health problems. Each of these examples reminds us that we are barely one step ahead of the microbes and underscores our need for a strong and vigilant public health system.

Box 1 Trends in Deaths Caused by Infectious Diseases in the United States, 1900–1994

Infectious disease mortality in the United States decreased markedly during most of the 20th century. However, between 1980 and 1992, the death rate from infectious diseases increased 58% (including only those people for whom the primary cause of death was an infectious disease).² The sharp increase in infectious disease deaths in 1918 and 1919 was caused by the influenza pandemic, which killed more than 20 million people worldwide and over 500,000 people in the United States.³ This episode illustrates the volatility of infectious disease death rates.

Source: National Center for Health Statistics, CDC, Vital Statistics of the United States, Mortality. Washington, DC: Public Health Service.



This document, *Preventing Emerging Infectious Diseases: A Strategy for the 21st Century*, describes a strategy for moving toward the fulfillment of CDC's vision of a world in which we join in a common effort to combat today's emerging infectious diseases and prevent those of tomorrow. It represents the second phase of the effort launched in

1994 with the publication of CDC's *Addressing Emerging Infectious Disease Threats: A Prevention Strategy for the United States*.⁴ This strategy was developed in collaboration with experts and professional organizations and societies throughout the United States and abroad.

Box 2 Economic Costs for Patient Care from Infectious Diseases, United States

The direct and indirect costs of infectious diseases continue to be tremendous. The following are some examples of the cost per case for several infectious diseases:

- The lifetime, discounted, direct* medical cost of treating a person infected with HIV is estimated to be \$96,000.^{5,6} The lifetime, discounted direct medical costs of treating a child infected with HIV since birth were estimated by one study to be about \$161,000⁷; a second study calculated a higher, but undiscounted, figure of \$408,000.⁸ None of these estimates includes the financial impact of multidrug therapy with protease inhibitors, which costs more than \$10,000 per person per year and is now widely used.⁹
- When a patient on a medical ward acquires an infection, treatment costs an average of \$2,100 in additional hospital charges (1992 dollars). Blood-stream infections (bacteremia) cause the patient to stay in the hospital an average of 7 additional days and result in an average of \$3,517 in additional hospital charges per infected patient.¹⁰
- Recent outbreaks of cryptosporidiosis in several cities in the United States have cost an average of \$330 per case-patient in direct medical costs and lost productivity. The most severe cases, which require hospitalization, cost more than 10 times the average.¹¹
- Most cases of Lyme disease that are diagnosed in the early stages of the illness incur about \$74 in direct medical treatment costs. However, if diagnosis and treatment do not occur in a timely manner, complications can result that cost from \$2,228 to \$6,724 per patient in direct medical costs in the first year alone.¹²
- In the United States, human papillomaviruses (HPV) are associated with 82% of the 15,000 cases and 4,600 deaths due to cervical cancer each year. They are also associated with more than one million precancerous lesions of varying severity.¹³⁻¹⁵ The direct medical cost of treating a patient with cervical cancer is \$9,200 to \$13,360, while surgery to remove a precancerous lesion costs from \$1,100 to \$4,360.¹⁶

*Direct medical costs include physician and clinic staff charges, medications, devices and appliances, and diagnostic tests. Direct nonmedical costs include transportation to health care facility and care provided by families. Indirect costs include lost wages and time spent being ill or caring for ill persons, whereas intangible costs include apprehension, grief, pain, changes in social functioning, and psychological consequences.

BACKGROUND

The “End” of Infectious Diseases

In the years following World War II, it was widely believed that humans were winning the centuries-long war against infectious microbes. Life-threatening bacterial diseases such as tuberculosis and typhoid fever could be treated by antibiotics. Dreaded diseases of childhood such as polio, whooping cough, and diphtheria could be conquered through vaccination. Coupled with earlier improvements in urban sanitation and water quality, vaccines and antibiotics dramatically lowered the incidence of infectious diseases. Thus, it became possible to imagine a world in which infectious pathogens would no longer prey upon humanity.

However, this optimism was premature. As early as the 1950s, penicillin began to lose its power to cure infections caused by *Staphylococcus aureus*, a common bacterium that can cause serious illness. In 1957 and 1968, new strains of influenza emerged in China and spread rapidly around the globe, and in the 1970s there was a resurgence of sexually transmitted diseases. Also during the 1970s, several new diseases were identified in the United States and elsewhere, including Legionnaires’ disease, Lyme disease, toxic shock syndrome, and Ebola hemorrhagic fever. During the 1980s, as state and local support for infectious disease surveillance declined,¹⁷ our attitude of complacency towards infectious disease threats was further shaken by the appearance of acquired immunodeficiency syndrome (AIDS) and the reemergence of tuberculosis (including multidrug-resistant strains), which spread quickly through U.S. cities.

A New Consensus:

The Institute of Medicine Report

By the early 1990s, health experts no longer believed that the threat of infectious diseases was receding in the United States or elsewhere. Growing concern about the threat of emerging infectious diseases was cogently expressed in a 1992 report

issued by the Institute of Medicine (IOM) of the National Academy of Sciences. The report, *Emerging Infections: Microbial Threats to Health in the United States*, emphasized the intimate links between U.S. health and international health.¹⁸ It described the major factors that contribute to disease emergence, including societal changes and the ability of microbes to evolve and adapt (see Box 3). It concluded that emerging infectious diseases are a major threat to U.S. health, and it challenged the U.S. government to take action.

Box 3 What Are Emerging Infectious Diseases and Why Are They Emerging?

As defined in the 1992 Institute of Medicine report, emerging infectious diseases include diseases whose incidence in humans has increased within the past two decades or threatens to increase in the near future.¹⁸ Modern demographic and environmental conditions that favor the spread of infectious diseases include

- Global travel.
- Globalization of the food supply and centralized processing of food.
- Population growth and increased urbanization and crowding.
- Population movements due to civil wars, famines, and other man-made or natural disasters.
- Irrigation, deforestation, and reforestation projects that alter the habitats of disease-carrying insects and animals.
- Human behaviors, such as intravenous drug use and risky sexual behavior.
- Increased use of antimicrobial agents and pesticides, hastening the development of resistance.
- Increased human contact with tropical rain forests and other wilderness habitats that are reservoirs for insects and animals that harbor unknown infectious agents.

CDC's Response

In 1994, CDC answered the challenge from the Institute of Medicine by launching a national effort to revitalize the U.S. capacity to protect the public from infectious diseases. This effort was described in *Addressing Emerging Infectious Disease Threats: A Prevention Strategy for the United States*.⁴ As funds became available, CDC implemented the strategy incrementally, with the help of many partners.

By fiscal year 1997, funds were available to implement about one-third of the recommended programs and activities, with a focus on improving surveillance, conducting applied research,

rebuilding the public health infrastructure, and enhancing prevention of emerging infectious diseases. These activities were accomplished in partnership with federal, state, and local agencies; universities; private industry; foreign governments; the World Health Organization (WHO); and many nongovernmental organizations. Examples of the impact of public health actions that address emerging infectious disease threats are listed in Boxes 4 and 5. The implementation of the 10 highest priority items from *Addressing Emerging Infectious Disease Threats* is described in the Appendix (see page 53).

Box 4 Examples of the Impact of Prevention Activities To Reduce Morbidity and Mortality due to Emerging Infectious Diseases

In recent years, prevention efforts in the United States by CDC and other groups have led to

- Reduction in the number of nosocomial (health care-associated) outbreaks of multidrug-resistant tuberculosis from 9 between 1990 and 1993 to none in 1996 and 1997, due to the implementation of tuberculosis control measures in hospitals.¹⁹
- Reduction in HIV/AIDS mortality by 23% from 1995 to 1996, associated with declines in the incidence of HIV/AIDS-related opportunistic infections.²⁰
- Reduction in cases of group B streptococcal disease (GBS) by over 40% between 1993 and 1995²¹ in communities that implemented CDC's GBS guidelines.²² The reduction in GBS cases was maintained through 1997.²³ (See also Box 20.)
- Reduction in cases of bacterial meningitis among children under 5 years old by 87% between 1986 and 1995 due to vaccination against *Haemophilus influenzae* type b, the leading cause of bacterial meningitis in children.²⁴
- Reduction in the incidence of hepatitis B infection by more than 60% from 1985 to 1996, due in part to changes in high risk behaviors and increased immunization.²⁵
- Reduction in the incidence of invasive listeriosis by 44% between 1989 and 1993, associated with increased food industry efforts, aggressive food monitoring policies, and the dissemination of dietary guidelines to consumers at special risk (for example, pregnant women, the elderly, and immunocompromised people).²⁶ The reduction in listeriosis cases was maintained between 1993 and 1996.²³
- Reduction in the incidence of hepatitis C infection by more than 80% from 1989 to 1996, due in part to changes in high risk behaviors and improved screening of the blood supply.²⁷

Box 5 Disasters Averted: Disease Control in Action

When public health efforts are successful, fewer cases of disease occur, and small outbreaks are stopped before they can become large ones. Because it can be difficult to measure the absence of a problem, the success of disease control programs can be difficult to assess. Here are examples of some potentially devastating outbreaks that were controlled by rapid public health action.

Hepatitis C virus transmitted through a contaminated medical product

In 1994, CDC assisted in the investigation of an outbreak of hepatitis C virus that was transmitted through contaminated immunoglobulin intravenously administered to people with immunodeficiency disorders. In collaboration with the Food and Drug Administration (FDA), CDC traced the infection to multiple lots of immunoglobulin that were marketed by a single manufacturer.²⁸ The manufacturer rapidly issued a voluntary worldwide recall of its intravenous immunoglobulin preparations. The U.S. Public Health Service subsequently issued recommendations for screening and counseling patients who had received the contaminated product. To prevent future outbreaks, FDA now requires specific procedures to inactivate viruses in such products.

Escherichia coli O157:H7 transmitted by hamburger meat

In 1997, the Colorado Department of Public Health and Environment detected a small cluster of cases of *E. coli* O157:H7 infection using DNA fingerprinting techniques²⁹ (see Boxes 26 and 27). Each of the ill people had eaten the same brand of frozen hamburger patty. Twenty-five million pounds of ground beef were recalled, and a potential nationwide outbreak was averted.

Salmonella Agona transmitted by an internationally distributed snack food

Between October 1994 and January 1995, Israeli health officials noted an increased incidence of salmonellosis caused by *Salmonella* Agona. In February 1995, British officials reported a small outbreak of *S. Agona* infection associated with eating a snack food manufactured in Israel. Epidemiologic studies showed that the outbreaks in Israel and the United Kingdom were related.³⁰ Working with state health departments, CDC identified 10 people in the United States who had also become ill after eating the suspect snack food, and FDA was able to culture *S. Agona* from unopened packages. A food hazard warning was issued, and the product was recalled in several countries, resulting in the prevention of thousands of potential cases of salmonellosis.

Ebola hemorrhagic fever virus transmitted by contact with body fluids

An outbreak of Ebola hemorrhagic fever killed 240 people in and around the city of Kikwit in the Democratic Republic of Congo (then Zaire) between January and August 1995 (see Box 44). Epidemiologic investigation indicated that much of the ongoing transmission was occurring in hospitals. The number of new cases dropped sharply after CDC and its partners helped disinfect the hospitals and supplied the staff members with protective clothing and disposable syringes.³¹ In addition, aggressive case-finding and prompt dissemination of health information to the local population lessened disease spread outside of hospitals.

Hepatitis A virus transmitted by frozen strawberries

An outbreak of hepatitis A among children in several U.S. states in March and April 1997 was traced to the consumption of frozen strawberries distributed through a USDA-sponsored school lunch program. Working together, FDA, CDC, USDA, and the health departments of the affected states determined that the strawberries had been processed and packed by a company in California, which voluntarily recalled the implicated product lots.³² CDC subsequently notified state health departments about the possible benefits of administering immunoglobulin to children who may have eaten contaminated strawberries. Due to prompt attention by state and local health departments, CDC, and other federal agencies, the extent of the outbreak was limited.

Tuberculosis in New York City

More than 3,800 cases of tuberculosis (TB) were reported in New York City in 1992, the peak year of the recent epidemic. Beginning that year, the New York City Department of Health began a program of Directly Observed Therapy (DOT) to ensure that all TB patients complete their prescribed courses of antibiotic treatment. Since then, cases have fallen steadily each year. In 1997, only 1,730 cases were reported. Moreover, between 1992 and 1997, cases of multidrug-resistant tuberculosis decreased from 441 to 53. The New York City DOT program is considered a model program by the World Health Organization.

THE SECOND PHASE OF CDC'S STRATEGY

The effort to rebuild U.S. capacity to combat infectious diseases is well under way. However, the fulfillment of CDC's vision of a safer world in the next millennium requires a long-term commitment and sustained effort. This document, *Preventing Emerging Infectious Diseases: A Strategy for the 21st Cen-*

ture, describes the second phase of CDC's strategy, taking into account the new discoveries and challenges of the past 4 years and building on the experience, success, and knowledge gained from implementing the 1994 plan (see Box 6).

Box 6 Why Does CDC's Emerging Infections Plan Need To Be Updated?

Several new developments have contributed to CDC's decision to amend and update its emerging infectious diseases plan, in addition to progress in implementing the highest priorities in the 1994 plan. These include

Emerging Threats

- A new variant of a fatal neurologic illness, Creutzfeldt-Jakob disease, in the United Kingdom, possibly transmitted by ingestion of beef from animals afflicted with "mad cow disease."
- A new and virulent strain of influenza in Hong Kong.
- *Staphylococcus aureus* with reduced susceptibility to vancomycin in the United States and Japan.
- A new strain of multidrug-resistant tuberculosis, now endemic in New York City and New York State.

Scientific Findings

- Evidence that many infectious microbes cause or contribute to the development of some chronic diseases.
- Discovery of many human genes that influence susceptibility to infection, severity of infection, and responsiveness to vaccination or treatment.³³
- Further discoveries about what appears to be a new type of transmissible agent, the prion, which appears to be responsible for certain neurologic diseases, including Creutzfeld-Jakob disease.³⁴

Tools and Technologies

- Electronic communications linking public health institutions in most areas of the world.

- Innovations in biotechnology that make it easier to identify and track microbes.

Changes in Health Care Delivery

- Increased participation in managed care plans in the United States, creating new opportunities and challenges for disease prevention, surveillance, control, and research.
- Shortened hospital stays for some conditions, making it necessary to develop ways to monitor patient outcomes that appear after the patient has left the hospital.
- Growth of home health care,³⁵ requiring new public health partnerships and new methods for assessing the impact of treatments and measuring the occurrence of health care-related infections in home health care settings.

Public and Policy Issues

- Books, films, and media reports about the dangers of emerging infectious diseases, resulting in increased public awareness.
- Government reports and commitments, such as the 1995 National Science and Technology Council report (see Box 7),³⁶ the 1996 Presidential Decision Directive on Emerging Infectious Diseases,³⁷ and the 1997 National Food Safety Initiative.³⁸

CDC's Role

CDC—the nation's prevention agency—is dedicated to the prevention and control of disease and the promotion of health. The agency grew out of efforts to control malaria in the United States, and today retains a critical role in addressing infectious disease threats. CDC is known for

- Working with state health departments and others to conduct surveillance to identify disease problems.
- Responding rapidly to outbreaks of disease.
- Providing knowledge and tools for prevention.
- Combining its strengths in epidemiology and laboratory sciences to solve problems that cannot be solved by either discipline alone.
- Providing global assistance to prevent disease.

CDC Components Involved with Infectious Diseases

This plan has been prepared under the leadership of CDC's National Center for Infectious Diseases (NCID) with significant input from other major CDC programs and centers involved in addressing emerging infectious disease issues. These include the National Center for HIV, STD, and TB Prevention (NCHSTP) and the National Immunization Program (NIP). NCHSTP is responsible for developing, assessing, and disseminating programs to prevent and control HIV/AIDS, tuberculosis, and sexually transmitted diseases within the United States and its territories. NCHSTP also plays a leadership role in many international control efforts, often working in collaboration with WHO, the U.S. Agency for International Development, and other global partners. The National Immunization Program (NIP) provides leadership for immunization activities at the federal, state, and local levels, and collaborates with WHO, the United Nations Children's Fund (UNICEF), and other organizations in the worldwide eradication of polio and other international immunization programs. Other parts

of CDC that support infectious disease prevention and control include CDC's Office of Global Health (OGH), Epidemiology Program Office (EPO), Public Health Practice Program Office (PHPPO), and National Institute for Occupational Safety and Health (NIOSH).

Partnerships

The fulfillment of CDC's vision of a safer world requires the sustained, coordinated, and complementary efforts of many individuals and organizations. For example, many U.S. agencies play important roles in combating emerging infectious diseases, often in cooperation with each other (see Box 7). Other important players include private citizens, health care providers, companies, and laboratories. Examples of special contributions by pharmaceutical companies include the donation by Merck & Co. of ivermectin for worldwide treat-

Box 7 A U.S. Government Task Force on Emerging Infectious Diseases

In 1996 the Committee on International Science, Engineering, and Technology (CISSET) of the National Science and Technology Council formed an Emerging Infectious Disease Task Force charged with implementing the recommendations of the 1995 CISSET policy report³⁶ and the provisions of the 1996 Presidential Decision Directive on Emerging Diseases.³⁷ The members of the Task Force, which is chaired by CDC and the White House Office of Science and Technology Policy, also includes the

National Institutes of Health
 Food and Drug Administration
 U.S. Agency for International Development
 U.S. Department of Defense
 U.S. Department of Agriculture
 National Oceanic and Atmospheric Administration,
 Department of Commerce
 National Aeronautics and Space Agency
 U.S. Department of State

ment of onchocerciasis (river blindness) and by SmithKline Beecham of albendazole for worldwide elimination of lymphatic filariasis (a major global cause of disability from lymphedema and elephantiasis). A nonprofit organization, Rotary International, has made major contributions to polio eradication efforts. As CDC carries out this plan, it will coordinate with state and local health departments (for example, on surveillance of infectious diseases), academic centers and other federal agencies (for example, on research agendas), health care providers and health care networks (for example, on development and dissemination of guidelines), international organizations (for example, on outbreak responses overseas), and many other partners.

Goals for Preventing Emerging Infectious Diseases

Preventing Emerging Infectious Diseases: A Strategy for the 21st Century describes steps that we can take over the next 5 years to help create a world in which people are better protected from infectious diseases. Because this document is an update of the 1994 plan, its activities are organized under the same four goals described in the first plan: **Surveillance and Response**, **Applied Research**, **Infrastructure and Training**, and **Prevention and Control**.

The four goals are interdependent. **Surveillance** systems monitor emerging infectious pathogens and outbreaks of disease. A **response** is mounted when surveillance data or other information indicates a change in the incidence or distribution of an infectious disease, or when a new or variant strain of a pathogen has become a health threat. Through **applied research**, scientists answer questions about the etiology, transmission, diagnosis, prevention, and control of emerging infectious diseases. Research, surveillance, and response all depend on the public health **infrastructure** that supports, trains, and equips public health workers, and links them in national and global networks. **Training** the next generation of public health scientists is a crucial component of the public health infrastructure. All of CDC's efforts are ultimately directed at imple-

menting the fourth goal, **prevention and control**, which receives increased emphasis in this plan. In many instances, CDC acts as a catalyst, developing and evaluating prevention and control strategies that can be implemented by others.

An outline of the goals and objectives in *Preventing Emerging Infectious Diseases* appears on page 14.

Target Areas

To accomplish these goals and objectives, *Preventing Emerging Infectious Diseases* targets certain categories of emerging infectious disease problems and particular groups of people who are at special risk. Addressing infectious disease problems in these target areas will be a high priority as we implement this plan.

Emerging Disease Issues

- Antimicrobial Resistance
- Foodborne and Waterborne Diseases
- Vectorborne and Zoonotic Diseases
- Diseases Transmitted Through Blood Transfusions or Blood Products
- Chronic Diseases Caused by Infectious Agents
- Vaccine Development and Use

Populations of Special Concern

- People with Impaired Host Defenses
- Pregnant Women and Newborns
- Travelers, Immigrants, and Refugees

Antimicrobial Resistance. Antimicrobial drugs have saved the lives of millions of people. However, the emergence of drug resistance in bacteria, parasites, viruses, and fungi is swiftly reversing miracles of the previous 50 years. As we approach the 21st century, many important drug choices for the treatment of common infections are becoming increasingly limited and expensive and, in some cases, nonexistent.³⁹ A 1995 U.S. government report estimated that the emergence of antimicrobial resistance among six common bacteria in hospitals adds approximately \$661 million per year in hospital charges.⁴⁰ (This estimate is an underestimate

because it does not include indirect costs, such as costs of lost days of work.)

Foodborne and Waterborne Diseases. Each year, millions of people get sick from foodborne diseases in the United States and thousands die.⁴¹ Changes in how food is processed and distributed have resulted in more multistate outbreaks in the United States (see Box 8). CDC is a major participant in the National Food Safety Initiative, which was created in 1997 to address food safety problems in the United States.

Waterborne microbes are also an important threat to the water supplies of many U.S. cities.⁴² A new group of pathogens has emerged that is unaffected by routine disinfection. Of the waterborne outbreaks reported to CDC during 1993 and 1994, more than half of those for which a specific patho-

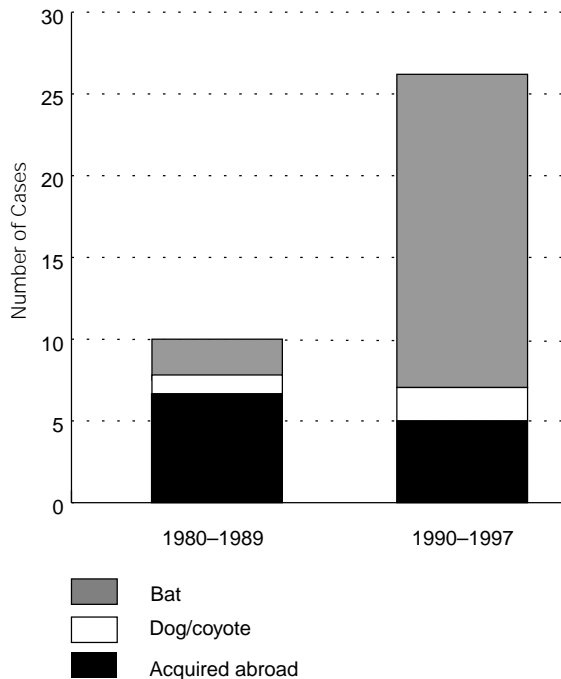
gen could be identified were caused by a chlorine-resistant microbe.⁴³

Vectorborne and Zoonotic Diseases. Many diseases emerging or reemerging today are acquired from animals (see Box 9) or are transmitted by arthropods. Animal-borne pathogens are important not only because of the illnesses they cause, but also because new human diseases can arise from animal reservoirs. For example, pandemic strains of influenza can emerge from avian and swine reservoirs,⁴⁴ and many experts believe that HIV evolved from a virus carried by a nonhuman primate. Changes in the environment—including climate changes and ecological changes due to engineering projects like dam-building—can also have profound effects on rates of vectorborne and zoonotic diseases.

Box 8 Examples of Multistate Foodborne Outbreaks in the United States, 1994–1997

Year	Organism	Number of States	Food Source
1994	<i>Shigella flexneri</i>	2	Green onions, probably contaminated in Mexico.
1994	<i>Listeria monocytogenes</i>	3	Milk, contaminated after pasteurization and shipped interstate.
1995	<i>Salmonella</i> Enteritidis	41	Ice cream premix hauled in trucks that had previously carried raw eggs.
1996	<i>Cyclospora cayetanensis</i>	20	Raspberries from Guatemala, mode of contamination unclear. Cases were also reported in the District of Columbia and two Canadian provinces.
1996	<i>Escherichia coli</i> O157:H7	3	Unpasteurized apple juice, probably contaminated during harvest.
1996	Norwalk virus	5	Oysters, contaminated before harvest.
1997	<i>Salmonella</i> Infantis	2	Alfalfa sprouts, probably contaminated during sprouting.
1997	<i>C. cayetanensis</i>	18	Raspberries imported from Guatemala, mesclun lettuce, and products containing basil. Cases were also reported in the District of Columbia and two Canadian provinces.
1997	Hepatitis A	4	Strawberries from Mexico distributed through the USDA Commodity Program for use in school lunches (see Box 5).

Box 9 Emergence of Bat-associated Rabies in Humans in the United States



The number of cases of rabies diagnosed in humans in the United States has increased significantly since 1990. Most of the increase is associated with rabies strains found in bats, even though bats account for less than 10% of the approximately 7,000–9,500 cases of animal rabies reported in the United States each year. Partly because most people who die from bat-associated rabies have no history of a bat bite or a bite from another animal, the disease is frequently misdiagnosed. Often, the correct diagnosis is not made until after death, when an autopsy is performed. Although nearly 40 different species of bats are found north of Mexico, most human fatalities are due to variant rabies viruses associated with a single bat species.⁴⁵

Diseases Transmitted Through Blood Transfusions or Blood Products. Improvements in donor screening, serologic testing, and transfusion practices have made the U.S. supply one of the safest in the world, despite its size and complexity. However, because blood is a human tissue, it is a natural vehicle for transmission of infectious agents (see Box 10). Dur-

Box 10 Bacterial Contamination of Blood and Blood Products

Since 1985, there have been 21 reported episodes of transfusion of red blood cell units contaminated with the bacterial pathogen *Yersinia enterocolitica*, leading to 12 deaths.⁴⁶ Studies indicate that the rate of contamination of blood products by other bacterial pathogens also may be significant.⁴⁷ In 1997, CDC entered into a cooperative agreement with national blood collection and distribution agencies to determine the frequency of transfusion reactions associated with bacterial contamination of blood products.

Currently, the nation's blood supply is not routinely screened for bacterial contamination. The new study will be a critical step in addressing this issue and will increase clinicians' awareness of bacterial contamination as a cause of transfusion reactions.

ing the 1980s, HIV was transmitted through clotting factor and blood transfusions, and during the 1990s, hepatitis C virus was transmitted via intravenous immunoglobulin (see Box 5). Although research on artificial blood substitutes is under way, it is unlikely that they will be available in the near future. Therefore, continued vigilance is required to ensure the safety of the U.S. blood supply.

Chronic Diseases Caused by Infectious Agents. Several chronic diseases once attributed to lifestyle or environmental factors (such as some forms of cancer, diabetes, heart disease, and ulcers) are actually caused by or intensified by an infectious agent (see Box 11). For example, the majority of peptic ulcers—long thought to be due to stress and diet—are now known to be caused by the bacterium *Helicobacter pylori*, and recent data indicate that *Chlamydia pneumoniae* infection may contribute to coronary artery disease (see Box 29). Findings like these raise the possibility that some chronic conditions, including cancer and heart disease, may someday be treated with antimicrobial drugs or prevented by vaccines. Over the next 5 years, CDC

will play a major role in assessing new research findings, encouraging and conducting further research where needed, and disseminating information to physicians and other health care providers.

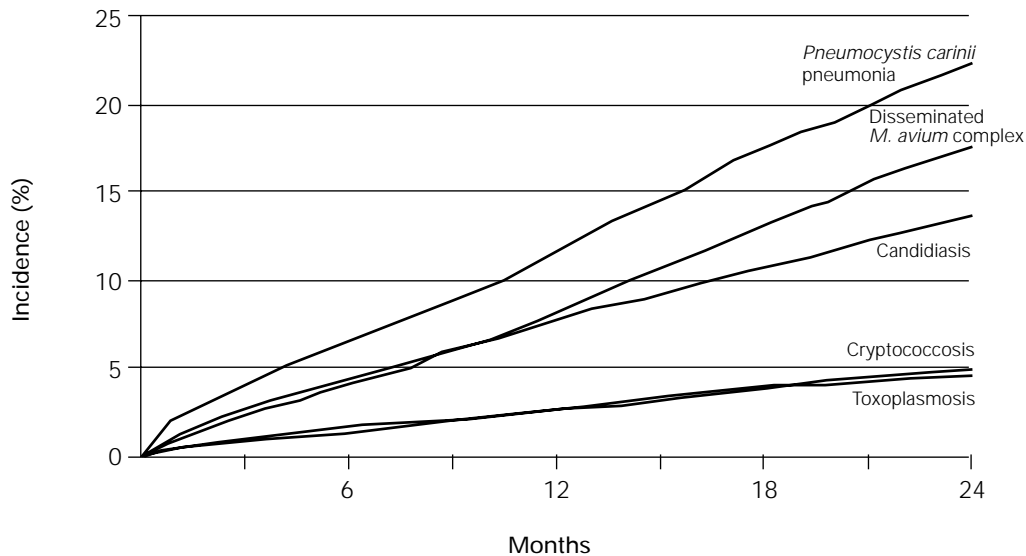
Vaccine Development and Use. Childhood diseases such as diphtheria, tetanus, polio, measles, mumps, rubella, and *Haemophilus influenzae* type b meningitis have been virtually eliminated in the United States through universal vaccination.⁴⁸ Moreover, smallpox has been eradicated worldwide, and polio may be globally eradicated by the year 2000. However, although several new vaccines are currently undergoing clinical evaluation (for example, against Lyme disease, rotavirus gastroenteritis, and invasive pneumococcal disease), no effective vaccines exist for many other new or reemerging diseases (for example, HIV/AIDS, dengue, hepatitis C, and malaria). CDC and its partners are working to develop new vaccines and to evaluate their immunogenicity, efficacy, and safety. In the United States, increasing vaccination rates in adults (for example, those at risk for complications of influenza or pneumococcal pneumonia)—as well as in children—is a high priority for CDC. In addition, CDC participates in implementation of programs to prevent and control vaccine-preventable diseases internationally (see Box 34).

Diseases of People with Impaired Host Defenses. People whose normal host defenses against infection have been impaired by illness or medical treatment or as a result of age are more likely to become ill with a variety of infectious diseases. Infections that occur with increased frequency or severity in such people are often called opportunistic infections (OIs) (see Box 12). Over the past two decades, the most significant emergence of OIs worldwide has been in persons infected with HIV. Other populations at risk include recipients of bone marrow and solid organ transplants; patients receiving chemotherapy, chronic corticosteroid therapy, or other immunosuppressive drugs; patients suffering from burns and traumatic injuries; diabetics; patients on renal dialysis; patients with indwelling medical devices; newborn infants; and

Box 11 Infectious Agents That Cause or Contribute to Neoplastic Diseases in Humans

Epstein-Barr virus	Nasopharyngeal carcinoma (undifferentiated) Burkitt's lymphoma Posttransplant lymphoproliferative disease B-cell lymphoma
<i>Helicobacter pylori</i>	Gastric carcinoma Mucosa-associated lymphoid tissue lymphoma
Hepatitis B virus	Hepatocellular carcinoma
Hepatitis C virus	Hepatocellular carcinoma
Human herpesvirus-8	Kaposi's sarcoma
Human immunodeficiency virus	Lymphoma
Human papillomavirus	Cervical carcinoma
Human T-cell leukemia virus	Adult T-cell leukemia
Liver flukes	Cholangiocarcinoma
<i>Schistosoma haematobium</i>	Bladder carcinoma

Box 12 Incidence of Opportunistic Infections (OIs) in HIV-Positive Adults with Depressed CD4 Lymphocyte Counts



As this graph shows, the incidence of OIs is high when an HIV-infected adult becomes severely immunosuppressed (that is, has a CD4 lymphocyte count that is less than 200 cells/ μ L). *Pneumocystis carinii* and disseminated *Mycobacterium avium* complex infections are the most commonly diagnosed OIs in this population. Data are from CDC's Adult and Adolescent Spectrum of Disease Project, which consists of medical record reviews of HIV-infected persons 13 years of age and older who receive care at more than 100 medical facilities in 11 cities in the United States and Puerto Rico.

Source: CDC Adult and Adolescent Spectrum of Disease Project, 1992-1996.

the elderly. Health care providers and scientists must be ready to identify and investigate each new OI as it appears and to learn how to diagnose, treat, control, and prevent it.

Diseases of Pregnant Women and Newborns. When a pregnant woman acquires an infection, the health of both the woman and her fetus may be endangered. Asymptomatic infections in a pregnant woman can increase an infant's risk of prematurity, low birthweight, long-term disability, or death.

Some infections may be silently transmitted from mother to child during pregnancy, delivery, or breast feeding, causing illness or death. Adverse outcomes from many of these infections can be prevented by prenatal care. Unfortunately, access to, and utilization of, prenatal care is low in some communities. Because of limited access to care and other factors, some racial and ethnic minorities experience high rates of maternal infections and related complications (see Box 13).

Box 13 Infectious Diseases and the Black-White Mortality Gap

African Americans have higher rates of some infectious diseases than other American ethnic groups. Reasons for these higher rates are only partially understood, but include differences in access to care and lower average socioeconomic status. During the early 1990s, African Americans had an infectious disease death rate of 46 per 100,000, 36% higher than the rate for the population as a whole.⁴⁹ In the 1980s, African American infants had the highest early and late neonatal death rate due to infectious diseases of any group (33.8 and 41.7 per 100,000 live births, respectively) and a postneonatal infection death rate (96.4 per 100,000 live births), second only to American Indians and Alaska Natives.⁵⁰

CDC is committed to ensuring improved public health services for underserved communities, including ethnic and racial minorities who experience a disproportionate burden of illness and death from infectious diseases. CDC is also committed to ensuring the elimination of racial and ethnic disparities in health outcomes to the greatest extent possible.

Diseases of Travelers, Immigrants, and Refugees. People who cross international boundaries—such as tourists, business people and other workers, immigrants, and refugees—may be at increased risk of contracting infectious diseases, and may also disseminate diseases to new places. International air travel has increased substantially in recent years, and more Americans than ever before are visiting remote and tropical locations. Tourists or workers may be exposed to infectious agents against which they have no immunity because the agents are uncommon in their native countries. Immigrants may come from nations where diseases like tuberculosis are endemic, and refugees may come from situations where crowding and malnutrition create ideal conditions for the spread of diseases such as cholera, malaria, measles, and varicella.

SUMMARY OF THE GOALS AND OBJECTIVES

The implementation of the objectives and activities described in this plan will help us realize CDC's vision of a world in which all available tools are used to combat today's diseases and prevent those of tomorrow. Many of the activities build on existing efforts or are in the planning stages. Others represent new efforts. All require partnerships and a sustained commitment by federal, state, and local health agencies.

Goal I: Surveillance and Response

Detect, investigate, and monitor emerging pathogens, the diseases they cause, and the factors influencing their emergence, and respond to problems as they are identified.

Objectives:

- A. Strengthen infectious disease surveillance and response.
- B. Improve methods for gathering and evaluating surveillance data.
- C. Assure the use of surveillance data to improve public health practice and medical treatment.
- D. Strengthen global capacity to monitor and respond to emerging infectious diseases.

Goal II: Applied Research

Integrate laboratory science and epidemiology to optimize public health practice.

Objectives:

- A. Develop, evaluate, and disseminate tools for identifying and understanding emerging infectious diseases.
- B. Identify the behaviors, environments, and host factors that put people at increased risk for infectious diseases and their sequelae.
- C. Conduct research to develop and evaluate prevention and control strategies in the nine target areas.

Goal III: Infrastructure and Training

Strengthen public health infrastructures to support surveillance and research and to implement prevention and control programs.

Objectives:

- A. Enhance epidemiologic and laboratory capacity.
- B. Improve CDC's ability to communicate electronically with state and local health departments, U.S. quarantine stations, health care professionals, and others.
- C. Enhance the nation's capacity to respond to complex infectious disease threats in the United States and internationally, including outbreaks that may result from bioterrorism.
- D. Provide training opportunities in infectious disease epidemiology and diagnosis in the United States and throughout the world.

Goal IV: Prevention and Control

Ensure prompt implementation of prevention strategies and enhance communication of public health information about emerging diseases.

Objectives:

- A. Implement, support, and evaluate programs for the prevention and control of emerging infectious diseases.
- B. Develop, evaluate, and promote strategies to help health care providers and other individuals change behaviors that facilitate disease transmission.
- C. Support and promote disease control and prevention internationally.

CDC'S PLAN:

Preventing

Emerging

Infectious

Diseases:

A Strategy

for the

21st Century

GOAL I: SURVEILLANCE AND RESPONSE

Detect, investigate, and monitor emerging pathogens, the diseases they cause, and the factors influencing their emergence, and respond to problems as they are identified.

OBJECTIVE I-A.

Strengthen infectious disease surveillance and response.

Public health surveillance is the ongoing, systematic collection, analysis, interpretation, and dissemination of health data, including information on clinical diagnoses, laboratory-based diagnoses, specific syndromes, health-related behaviors, and use of products related to health (for example, sales of antimicrobial drugs). Epidemiologists use these data to detect outbreaks; characterize disease transmission patterns by time, place, and person; evaluate prevention and control programs; and project future health care needs. Our nationwide system of surveillance requires involvement and resources from all levels of government, as well as a reversal of the trend towards decreasing state and local support for disease surveillance, which began in the 1980s (see page 3).

CDC's 1994 plan identified three complementary programs to help rebuild the U.S. public health infrastructure for surveillance and response to infectious diseases: the Epidemiology and Laboratory Capacity (ELC) program, the Emerging Infections Programs (EIPs), and provider-based sentinel networks. These programs have enabled health departments to identify and respond to public health problems, as well as realize important research contributions. In addition to expansion of these programs, other surveillance systems are needed that address special health problems not covered by routine surveillance.

ACTIVITIES:

i. Extend the ELC program to all state, territorial, and large local health departments. The goal of the ELC program is to help large health departments develop the core capacity to meet the infectious disease threats of the future. ELC support provides health departments with the technical tools, training, and financial resources to maintain surveillance for infectious diseases of public health importance, provide laboratory services, and investigate outbreaks. Between September 1995 and September 1998, CDC entered into ELC agreements with 30 states and localities (see Box 14). By 2002, CDC plans to involve all 50 state health departments, as well as many territorial and large local health agencies. Specific activities undertaken through the ELC program include developing innovative systems for early detection and investigation of outbreaks, tracking antimicrobial resistance, and ensuring electronic reporting of surveillance data.

ii. Strengthen the EIP network by increasing its demographic and geographic representativeness and enhancing its laboratory and epidemiologic capacity. The EIPs (see Box 14) conduct population-based surveillance and research that go beyond the routine functions of local health departments to address important issues in infectious diseases and public health. These programs involve partnerships among state health departments, academic centers, and CDC. In addition to conducting surveillance, the EIP network participates in emergency outbreak responses and addresses new problems whenever they arise (see Box 15).

EIP activities of the past few years have included investigations of meningococcal and streptococcal diseases. In addition, the EIPs have established surveillance for unexplained deaths and severe illnesses in previously healthy people less than 50 years old in an attempt to determine which known infectious diseases are not being recognized and to identify new infectious agents that can cause severe diseases or death.

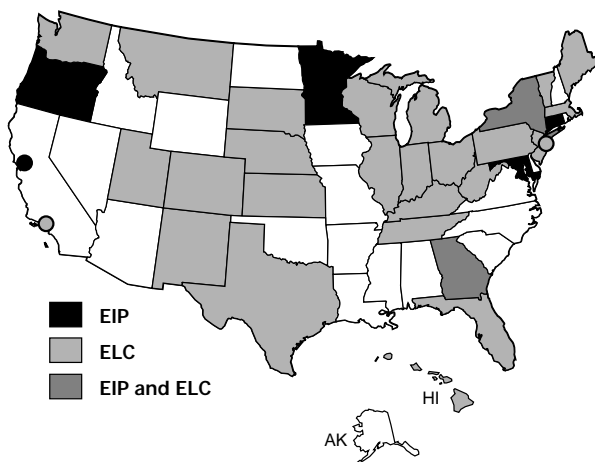
In 1996, the Foodborne Diseases Active Surveillance Network (FoodNet) was created within the EIP sites in collaboration with CDC, the Food and Drug Administration, and the U.S. Department of Agriculture (see Box 16). This program includes active surveillance for diseases caused by foodborne pathogens, case-control studies to identify risk factors for acquiring foodborne illness, and surveys to assess medical and laboratory practices related to the diagnosis and treatment of foodborne illness.

Over the next 5 years, three additional EIP sites will be added, and existing sites will be strengthened. EIP priorities for 1998-2002 include deter-

mining the burden of foodborne and waterborne diseases in the United States, increasing vaccination against invasive pneumococcal disease in adults, and evaluating programs to prevent group B streptococcal disease and retard the emergence and transmission of antibiotic resistance. The EIPs will also evaluate certain disease syndromes of unknown origin, such as unexplained encephalitis, to learn more about their causes and how to prevent them.

iii. Use the existing provider-based sentinel networks to monitor syndromes and diseases, and establish at least one additional network. The 1994 plan called for the establishment of provider-based sentinel networks to study conditions that are not covered by health department surveillance and that

Box 14 Epidemiology and Laboratory Capacity (ELC) and Emerging Infections Programs (EIP) Cooperative Agreements



This map shows the locations of health departments with ELC and EIP cooperative agreements as of September 1998.

Box 15 The EIPs Help Determine if Variant Creutzfeldt-Jakob Disease Is Occurring in the United States

On March 20, 1996, an expert advisory committee to the government of the United Kingdom announced that several people had died from what appeared to be a new variant of Creutzfeldt-Jakob disease (CJD), a fatal neurologic illness. The committee believed that a transmissible agent that causes bovine spongiform encephalopathy (BSE, commonly known as "mad cow disease") had spread from cattle to humans through the consumption of contaminated beef. The possibility was raised that these deaths could represent the beginning of a human epidemic of variant CJD. The cause of BSE is believed to be a prion, a proteinaceous infectious particle without nucleic acid that causes disease by inducing changes in the folding of a previously normal brain protein.

The EIP network instituted active surveillance for the new variant of CJD in the United States. By comparing the results of labor-intensive active surveillance (which included canvassing pathologists, neuropathologists, and neurologists) with less intensive methods, the EIPs showed that analysis of death certificate data was a reasonably effective way to monitor CJD. On August 9, 1996, CDC announced that no cases had been detected at any of the U.S. surveillance sites.

are likely to be seen by specific kinds of health providers. In 1996 and 1997, three provider-based sentinel networks were established:

Emergency Department Sentinel Network for Emerging Infections (EMERGENCY ID NET) is a network of academically affiliated emergency medicine centers that operate emergency departments at 11 hospitals in large U.S. cities. The network monitors a number of syndromes, including bloody diarrhea, illnesses that follow exposure to animals, illness in immigrants and travelers, hemolytic uremic syndrome following infection with *Escherichia coli* O157:H7, and first-

time seizures that are not associated with head trauma or cancer (a possible indication of neurocysticercosis).

Infectious Diseases Society of America Emerging Infections Network (IDSA EIN) is a network of over 500 infectious disease practitioners. The network surveys its members regularly on topical issues in clinical infectious diseases. It also enhances communications and health education among its members, collaborates in research projects, and provides assistance in casefinding during outbreak investigations. Its membership represents a ready source of infectious disease expertise for CDC and state health departments to draw on during outbreaks or when unusual illnesses occur.

Sentinel Network of Travel Medicine Clinics (GeoSentinel) is composed of 22 travel medicine clinics located in the United States and other countries. The network monitors temporal and geographic trends of infectious diseases among travelers, immigrants, and refugees seen in these clinics. The data are analyzed by CDC and can be used to develop travel advisories and recommendations for health care providers. In the future, GeoSentinel may help track the spread of diseases from place to place when outbreaks occur.

CDC will also continue to strengthen other provider-based networks, such as the National Nosocomial Infections Surveillance System, a national source of data on hospital-related infections.

iv. Develop or improve infectious disease surveillance in the nine target areas (see page 8). Surveillance for many of the issues of concern in the target areas will be conducted through the mechanisms described under previous activities in this plan. However, in some cases, special systems will be needed (see Box 17).

Box 16 FoodNet: Enhancing Food Safety in the United States

The Foodborne Diseases Active Surveillance Network (FoodNet) and other surveillance systems provide CDC with high-quality data on many types of foodborne and waterborne illnesses, including enteric illnesses caused by bacteria, parasites, and viruses, and hemolytic uremic syndrome due to *Escherichia coli* O157:H7. FoodNet also contributes to the development of long-term strategies for preventing outbreaks and is helping evaluate the burden of waterborne diseases in the United States.

FoodNet conducts investigations of foodborne infections and evaluates the effectiveness of prevention and control programs. In 1996, its first year of operation, FoodNet determined that *Campylobacter* is the most frequently identified foodborne pathogen in the United States. In 1997 it completed multistate case-control studies on two other bacterial foodborne microbes, *Salmonella* and *E. coli* O157:H7. The studies confirmed that regional variations in the incidence of *E. coli* O157:H7 infections reflect real differences in local infection rates rather than variations in diagnostic testing.

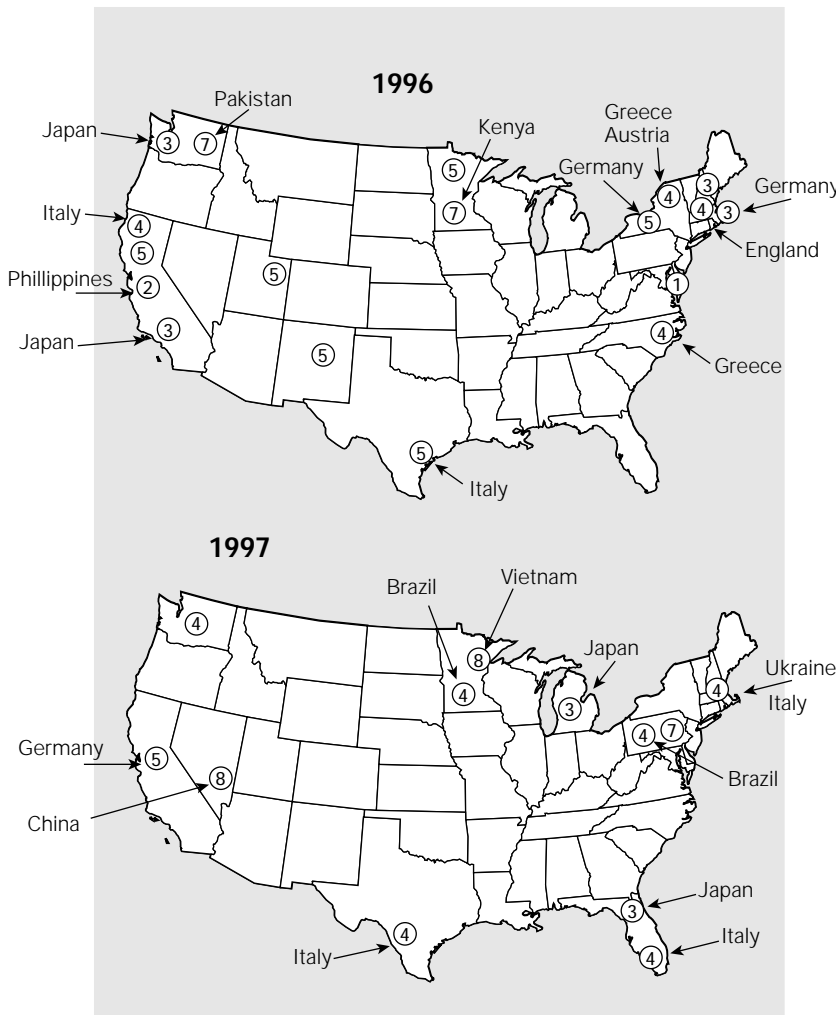
In 1996, FoodNet helped identify outbreaks of *E. coli* O157:H7 due to contaminated apple cider and lettuce. As a consequence of these and other investigations, apple juice manufacturers are now asked to record on the product label whether their juice is pasteurized. In addition, the lettuce industry has begun to consider steps that will make lettuce safer to eat.

v. Develop new approaches to improve recognition of rare events. Many emerging diseases are identified by astute clinicians or laboratorians. For example, in 1993, a physician with the U.S. Indian Health Service reported the unusual occurrence of two deaths from sudden respiratory failure in previously healthy young adults. Through the combined efforts of health departments in New Mexico, Arizona, Colorado, and Utah, the Indian Health

Service, and CDC, an additional 17 cases were quickly identified. Within 3 weeks, the cause of this syndrome was identified as a hantavirus—an agent not previously known to cause respiratory problems.

CDC will explore new approaches for the rapid identification of unusual events, including diseases of unknown etiology and diseases caused by the deliberate release of pathogenic agents by a terrorist or as a weapon of war.

Box 17 Use of Molecular Epidemiology To Document the Interruption of Indigenous Transmission of Measles in the United States



The number of measles cases in the United States continues to be low. Although several outbreaks were reported in 1996 and 1997, molecular epidemiologic studies indicated that they were most likely caused by importation of measles from outside the country, most frequently from western Europe and Japan.⁵¹ When an outbreak of measles occurs in the United States, an index case (a “first” case to which each of the other cases in the outbreak can be traced) is identified, and the strain of measles virus is isolated and sequenced to determine its country of origin. The maps indicate the origin (when known) of viruses responsible for measles outbreaks in the United States in 1996 and 1997. The numbers correspond to the genetic group of the measles virus isolated.

Over the last 5 years, millions of doses of measles vaccine have been distributed worldwide, and concerted efforts by the Pan American Health Organization have contributed to the unprecedented decline in measles cases in the Americas. In 1994 and 1995, few (if any) cases of measles were imported into the United States from Latin America. These successes have convinced many health experts to support worldwide measles control efforts as a first step towards the global eradication of measles.

OBJECTIVE I-B.**Improve methods for gathering and evaluating surveillance data.**

ACTIVITIES:

i. Integrate public health information and surveillance systems. CDC is helping to increase communication among information systems and to discourage duplication of data collection, storage, and transmission. This effort involves integrating surveillance systems at CDC and working with federal, state, and local partners to help define system specifications that will allow more efficient sharing of data. Surveillance systems should be designed to take advantage of data that are already in electronic form (for example, from clinical laboratories). CDC is working with individual state health departments to develop model systems for integrating surveillance at the state level through the Information Network for Public Health Officials (INPHO) program, which is partially supported by the Robert W. Woodruff Foundation.

ii. Use integrated health care delivery systems to enhance traditional public health surveillance. To respond to changes in health care delivery, CDC and health departments are developing new partnerships and new ways of conducting surveillance. For example, CDC and health departments are working closely with managed care organizations and hospitals to use computerized medical records for surveillance and research, while addressing issues related to confidentiality. In addition, CDC is working with health care organizations to ensure that infectious disease data are included in efforts to evaluate and improve health care quality. CDC will also work with home health care providers to adapt existing methods of hospital disease surveillance to home health care settings. An early priority will be to establish a surveillance system for bloodstream infections in home care patients.

iii. Use new tools to improve surveillance. Molecular fingerprinting, for example, has provided new approaches for disease surveillance and outbreak investigation. Molecular fingerprinting of microbes is similar to the DNA fingerprinting used by forensic scientists to identify criminals who have left bloodstains or strands of hair at the scene of a crime. Fingerprinting techniques can distinguish among strains or isolates of bacteria, fungi, viruses, or parasites. Methods used for fingerprinting include comparing the genetic sequences of organisms and comparing the sizes of nucleic acid fragments produced after digestion with special enzymes. For viruses, it is more common to sequence portions of the genome in order to compare different strains.

Public health workers use molecular fingerprinting and sequencing to identify epidemics that might otherwise go undetected and to trace outbreaks to particular sources, such as water supplies, food shipments, or infected animals or people. When people become ill from vaccine-preventable diseases, these tools are used to determine whether the illness is caused by the microbial strains used in vaccines or by wild-type strains (see Box 18). Scientists are using these techniques to determine the reason for recent increases in vaccine-preventable diseases such as pertussis (whooping cough) and rubella (German measles) among adults. CDC also uses molecular analysis to guide the annual selection of strains that are included in each year's influenza vaccine. In addition, molecular sequence analysis has been useful in studying unusual cases of HIV transmission and in tracking the spread of HIV throughout the world.

CDC will continue to work with state health departments to create real-time, on-line capacity to compare strains of *E. coli* O157:H7 and *Salmonella* (see Box 19), so that when an outbreak occurs in the United States, neighboring states can use subtyping methods to decide whether they need to implement coordinated prevention and control measures. CDC also supports regional laboratories that are establishing a national database of

Box 18 Pertussis in the United States and Abroad

Pertussis, or whooping cough, is a vaccine-preventable bacterial disease that can cause fatalities, especially in children less than 1 year old. After whole-cell pertussis vaccines were introduced in the mid 1940s, the incidence of this disease in the United States declined dramatically. However, since 1980 the incidence has been rising. In 1996, 7,796 cases occurred—the highest annual number reported since 1967. Although infants and young children continue to have the highest rates of pertussis, those rates have not increased since 1993. On the other hand, the incidence among adolescents and adults has increased substantially.⁵²

An evaluation of the U.S. pertussis vaccination program by CDC concluded that it is still highly effective for young children.⁵³ However, immunity diminishes in many adolescents and adults, and no vaccine is licensed for those age groups. In addition, some portion of the increase in adolescent and adult cases may be due to improved recognition and reporting. CDC continues to advise that all children receive the currently recom-

mended 5-dose regimen of pertussis vaccinations. Protection for adolescents and adults is achieved through early diagnosis and treatment and through prompt prophylaxis for those who have been in contact with infected people.

An increasing incidence of pertussis is a concern in certain other countries as well, although the reasons for the resurgence may not be the same as in the United States. Large outbreaks have occurred in the Netherlands and Canada, mostly affecting infants and children, many of whom have been vaccinated. A molecular analysis suggests that the strains of pertussis currently in circulation in the Netherlands are different from those that were observed in the past.⁵⁴ Another study concluded that pertussis strains isolated during recent outbreaks in Canada are different from current whole-cell vaccine strains.⁵⁵ One hypothesis under evaluation is that new strains of pertussis may have evolved that are not affected by the vaccines used in the Netherlands and Canada.

molecular fingerprints of *Mycobacterium tuberculosis* isolates.

Other tools that can increase the usefulness of surveillance include geographic information systems (see page 28) and computer programs that detect subtle variations in patterns of surveillance data that may indicate disease outbreaks.

OBJECTIVE I-C.

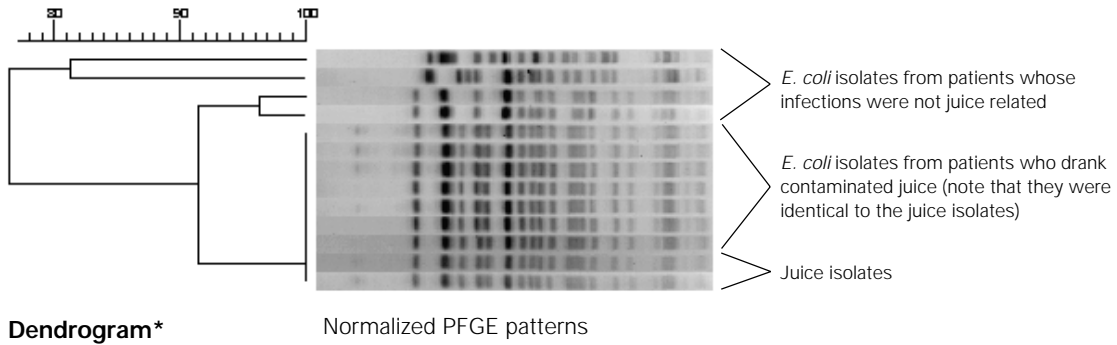
Ensure the use of surveillance data to improve public health practice and medical treatment.

Surveillance data provide the basis for public health action. These data are used to evaluate disease control interventions, identify disease risk factors, and improve clinical practice, as well as to detect outbreaks.

ACTIVITIES:

i. Use surveillance data to analyze questions of public health importance. Surveillance data can be used to identify risk factors for new diseases and to evaluate prevention guidelines for known ones. For example, surveillance data gathered by the EIPs on group B streptococcal (GBS) infections have been used to evaluate the guidelines for diagnosis and treatment of GBS infection during pregnancy (see Box 20). Data gathered by the EIPs on *Streptococcus pneumoniae* infections have been used to evaluate clinical outcomes associated with drug-resistant infections and to model the cost-effectiveness of vaccinating the elderly against this organism. CDC is currently using surveillance data as one means of assessing the effectiveness of routine HIV counseling and testing of pregnant women for reducing perinatal transmission of HIV. Through December 1997, data indicate a continuing decrease in the numbers of U.S. children with perinatally transmitted HIV infection (see Box 21).

Box 19 Using Subtyping Data To Identify Outbreaks



* Vertical line at 100% represents isolates that are indistinguishable from each other. Lines farther away from 100% on the dendrogram indicate isolates have similarities to the outbreak isolates but are not a perfect match.

Pulsed-field gel electrophoresis (PFGE) is a method of molecular fingerprinting. The picture shows the relationships among PFGE patterns of *Escherichia coli* O157:H7 isolates from Washington State. The PFGE patterns of the two isolates from apple juice are identical to the patterns of isolates from patients who drank the contaminated juice, but different from those from patients whose infections were not juice-related. This technology has been used to identify outbreaks of foodborne illnesses, especially those that involve clusters of cases that are too geographically or temporally scattered to come to public health attention through usual methods of surveillance.

In partnership with state health departments and the Association of Public Health Laboratories (APHL), CDC is creating a molecular subtyping network called PulseNet, which is based on DNA fingerprinting of bacteria that cause foodborne diseases. The project is being implemented for *Escherichia coli* O157:H7 and will soon be extended to include *Salmonella* Typhimurium and other foodborne pathogens. All participants will use standardized equipment and protocols, and a centralized database

of DNA patterns ("DNA fingerprints") will be stored on a computer server at CDC. Through the participation of the U.S. Department of Agriculture (USDA) and the Food and Drug Administration (FDA), the database will include fingerprints derived from contaminated foods as well as from clinical isolates.

When outbreaks occur, participating laboratories will submit DNA fingerprints such as the ones shown in the picture for comparison with those in the database. A fingerprint analysis can be completed at a local laboratory in 24 hours, and electronic patterns can be matched by computer within a few minutes. If a submitted pattern matches a pattern on the server, the submitting laboratory will be able to download epidemiologic data associated with the *E. coli* strain that exhibits that pattern. If the submitted pattern is not an exact match, information on the closest matches will be provided. If the same DNA pattern is submitted by two or more participating laboratories within a short time, the CDC server will warn each participating laboratory that a multistate outbreak may be in progress.

Over the next 5 years, CDC will use surveillance data from many sources to assess the impact of programs to promote high levels of vaccine coverage in children, adolescents, and adults and interventions to prevent the spread of antimicrobial resistance in hospitals and communities. Surveillance data may also be helpful in assessing health care-associated outcomes (such as infections) in people undergoing outpatient surgery or being discharged after shortened hospital stays. Such data will also be used to evaluate the effectiveness of strategies for preventing infections in people with impaired host defenses and to assess the effectiveness of postexposure prophylaxis for health care workers with inadvertent occupational exposure to such infections as hepatitis B and HIV (see Box 22). Should irradiation of food come into wide use, surveillance data will be used to help evaluate the effectiveness of this intervention (see Box 31). Be-

sides using surveillance data at the national level for the development and evaluation of prevention strategies, CDC will provide information that local health departments can use in the practice of public health.

ii. Facilitate access to surveillance data that can be used in clinical practice. One way to disseminate this kind of information is through the Internet. For example, since 1995, rates of nosocomial infections associated with catheters and other invasive devices in intensive care unit patients and rates of antimicrobial resistance in hospitalized patients have been published semiannually on the Internet and in the medical literature.⁵⁶ Hospitals can use these data to assess their infection control strategies.

Box 20 Surveillance Data Show Reduction in Group B Streptococcal Disease

During the 1970s, group B *Streptococcus* (GBS) became the leading cause of sepsis and meningitis among newborns throughout the United States, leading to death in approximately 50% of the infants infected. During the 1980s, improved recognition and treatment reduced the case-fatality rate to about 10%. However, an estimated 8,000 cases of serious neonatal infection continued to occur each year.

During the 1990s, working in partnership with organizations of health professionals and community-based groups, CDC issued guidelines that recommended antibiotic treatment during delivery for women at risk of transmitting GBS infection to their newborns. A study by CDC concluded that up to 79% of the GBS infections that occurred in 1995 were potentially preventable. Moreover, the data indicated that, although the incidence of neonatal GBS infections has declined up to 43% in some areas, no change has occurred in others.²¹

CDC has recommended that GBS prevention activities be integrated into all obstetric care programs. It has also begun an evaluation of the barriers that impede the implementation of effective control measures.

Box 21 Surveillance To Evaluate Prevention of Perinatal HIV Transmission

Each year, over 6,000 HIV-infected women give birth in the United States,⁵⁷ where perinatal transmission accounts for virtually all new HIV infections in infants. Before interventions were available, HIV infection had become a leading cause of death in children aged 1-4 years. In 1994, a clinical trial found that zidovudine, given to mothers prenatally and at delivery and to their babies immediately after birth, could reduce the risk of perinatal transmission of HIV by 66%.⁵⁸ (In the absence of zidovudine treatment, around 25% of newborns were infected.) Subsequently, the U.S. Public Health Service issued guidelines recommending HIV counseling and voluntary testing for all pregnant women and zidovudine therapy for those infected.

Surveillance data indicate that the guidelines have had a significant impact. Since implementation of the guidelines began, the incidence of pediatric AIDS has been reduced over 40%. In addition, rates of HIV testing of pregnant women have improved significantly, and maternal and newborn zidovudine therapy has been well accepted.⁵⁹ Nevertheless, more HIV infections in newborns could be prevented. Studies are underway to evaluate the relative contributions of a number of potential factors (for example, lack of prenatal care, poor provider adherence to the guidelines, poor patient adherence to therapy, and zidovudine resistance) to the continuing problem of pediatric HIV infection.

Box 22 The HIV Postexposure Prophylaxis Registry

Exposures to bloodborne pathogens pose a serious occupational threat to health care workers. Between 500,000 and one million needlestick injuries occur annually in the United States, and about 1% of them may involve an HIV-infected source.

As of December 1997, CDC had received reports of 54 documented cases and 132 possible cases of occupationally acquired HIV infection among health care workers in the United States. Although postexposure treatment with antiretroviral agents is an important component of the prevention of occupationally acquired HIV infection, little information exists on the use and toxicity of antiretroviral drugs (with the exception of zidovudine) for the prevention of HIV in people exposed to the virus.

The HIV Postexposure Prophylaxis (PEP) Registry is designed to evaluate the use of antiretroviral drugs in health care workers who receive PEP for occupational HIV exposure. By collecting information on the worker's exposure, antiretroviral therapy, symptoms, and laboratory findings, this registry will help clarify the safety of PEP. The registry began in October 1996, and 279 health care workers were enrolled as of February 1998. Overall, 77% of health care workers who undergo PEP experience some symptoms due to the treatment. CDC publicized the registry by distributing thousands of educational packets and brochures to health care workers.

OBJECTIVE I-D.

Strengthen global capacity to monitor and respond to emerging infectious diseases.

Because of the ease and frequency of modern travel, it is no longer possible to protect the health of U.S. citizens without addressing infectious disease problems that are occurring elsewhere in the world. As stated in the 1996 Presidential Decision Directive on Emerging Infectious Diseases, the United States is committed to working with international partners to promote an inclusive, global network for surveillance and response to infectious diseases.³⁷

ACTIVITIES:

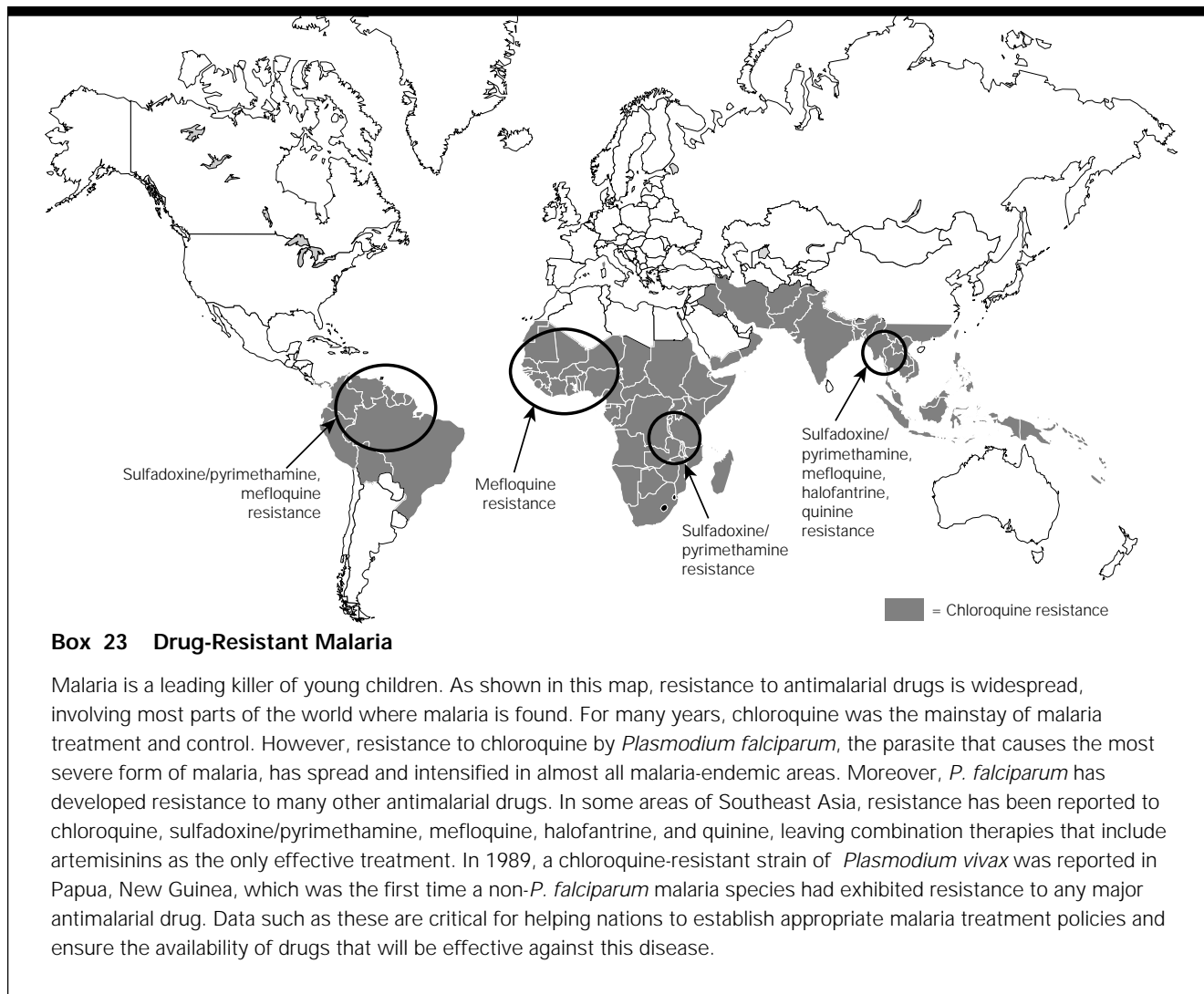
i. In partnership with other U.S. agencies, national governments, WHO, the World Bank, other international organizations, and the CISET Emerging Infectious Disease Task Force (see page 7), work to strengthen global surveillance and response to emerging infectious diseases. This will involve improving global communications, expanding disease surveillance, and preparing protocols for detecting and responding to outbreaks of emerging infectious diseases. It is especially important that disease surveillance be enhanced in developing nations, where emerging diseases may go undetected for long periods.

Early warning systems to detect drug-resistant pathogens can help limit the spread of antimicrobial resistance and enable local governments and health care providers to improve patient care and public health. As part of this effort, CDC will also continue to work with other agencies and nations to expand laboratory capability, assist in training public health professionals, and expand international surveillance for antimicrobial resistance. CDC will also build on existing international collaborations to monitor new strains of HIV to protect the U.S. blood supply and to contribute to ongoing efforts to develop a vaccine against HIV.

ii. Assist global surveillance and response efforts through increased support of CDC-based WHO Collaborating Centers. CDC sponsors 46 WHO Collaborating Centers, 32 of which are related to infectious disease epidemiology, laboratory diagnosis, research, training, and control. They are part of a global network of more than 1,000 infectious disease collaborating centers worldwide that addresses such issues as reference diagnostic work on foodborne diseases, respiratory diseases, botulism, malaria, measles, meningitis, arthropod-borne diseases, rickettsial diseases, and special viral pathogens (such as hantavirus and other viruses that cause hemorrhagic fevers).

iii. Help monitor conditions that favor the emergence or spread of infectious diseases. CDC will establish liaisons with international organizations that provide medical treatment to refugees and other displaced people, and track population movements that may be associated with epidemic diseases. CDC will also help monitor infectious diseases in areas altered by development projects that change the habitats of vectors and animals that carry human pathogens, and the agency will participate in international efforts to address environ-

mental and climatic phenomena that may influence the emergence of infectious pathogens. To help control the emergence and spread of drug-resistant microbes, CDC will work with other nations to address policies related to prescription practices, patient compliance with drug regimens, and other behavioral issues (see Box 23). CDC will also help focus attention on policies that allow antimicrobial agents to be sold without prescription on the open market.



GOAL II: APPLIED RESEARCH

Integrate laboratory science and epidemiology to optimize public health practice.

OBJECTIVE II-A.

Develop, evaluate, and disseminate tools for identifying and understanding emerging infectious diseases.

ACTIVITIES:

i. Develop, evaluate, and disseminate testing methods for infectious agents. Diagnostic tests are essential to disease surveillance and outbreak response, as well as to clinical management of patients with infectious diseases. Sensitive, specific, rapid, and inexpensive testing methods are lacking for many emerging infectious organisms. For some organisms, existing testing methods cannot distinguish between past and current infections. For others (such as HIV and malaria parasites), “point-of-care” methods are needed to provide test results while the patient is still at the clinic or office. Moreover, many methods are too expensive for routine use in developing countries or not rugged enough for large-scale studies in the field. Improved methods of detecting antimicrobial resistance in clinical settings are also needed.

CDC will continue to encourage intramural and extramural research to develop diagnostic testing methods (see Box 24), particularly for “orphan” diseases—those for which the market for diagnostic testing is not great enough to stimulate research and development by private industry.

Box 24 Advances in Diagnosis of *Chlamydia trachomatis* Infections

Chlamydia trachomatis is responsible for about 4 million new infections every year in the United States. Although most genital chlamydial infections in women (and up to half of those in men) are asymptomatic, they can have significant consequences, such as infertility in women. However, many people remain unaware that they are infected and unknowingly pass the infection on to their sexual partners. Obtaining cervical and urethral specimens for traditional diagnostic testing requires intrusive procedures that may not be acceptable to asymptomatic people. However, new methods have been developed that rely on DNA amplification techniques that can detect microbial nucleic acids in urine samples. These noninvasive tests provide new opportunities for outreach and screening of asymptomatic people. This is particularly important for adolescents, who are at highest risk for infection and for serious complications due to untreated infections.

Multicenter evaluations of these new methods indicate that they are far more sensitive than traditional assays. CDC has contributed to the evaluation and support of these methods by providing reference diagnostic services to laboratories across the country and by overseeing a national *Chlamydia* laboratory committee in collaboration with the Association of Public Health Laboratories. CDC’s guidelines on the use of nucleic acid amplification methods for the detection of *Chlamydia trachomatis* and *Neisseria gonorrhoeae* infections are scheduled for publication in 1999.

Nucleic acid amplification methods for chlamydia infections are used in large-scale screening projects such as the federally funded National Program for Prevention of Infertility due to Sexually Transmitted Diseases. This program was created through a collaboration between CDC and the Office of Population Affairs, U.S. Department of Health and Human Services. Through this program, all states can provide screening and treatment services in family planning clinics and sexually transmitted disease clinics. In some places, screening services have been expanded to nonclinical settings such as schools and youth detention centers.

Box 25 Evaluating Diagnostic Test Kits for Lyme Disease

Lyme disease is the most common vectorborne disease in the United States, and the number of Lyme disease cases has been steadily increasing. In 1990, more than 20 commercial test kits were available for serologic diagnosis of Lyme disease in humans. However, an evaluation by CDC rated each of them as poor, unstandardized, and unreliable. Thus, treatment recommendations and public health policy decisions were being based on faulty data.

Working with the Association of Public Health Laboratories (APHL), the U.S. Food and Drug Administration (FDA), the U.S. National Institutes of Health (NIH), the Council of State and Territorial Epidemiologists (CSTE), university researchers, and test kit manufacturers, CDC standardized an enzyme-linked immunosorbent assay (ELISA) and a Western blot (WB) assay for the diagnosis of Lyme disease. CDC also cosponsored a national meeting which recommended a two-step approach involving both ELISA and WB. The two-step method has been widely adopted as the standard for clinical testing and research, and it is now being evaluated in the clinical setting.

The number of commercially available diagnostic test kits is expected to increase markedly in the near future. CDC will continue to work with the Food and Drug Administration and others to ensure that commercially manufactured test kits are evaluated and to make recommendations about their use (see Box 25).

ii. Develop, evaluate, and implement approaches for identifying factors that influence the risk of infection and disease. New tools for studying infection and disease are being developed at a rapid rate. These include new methods for modeling risk factor data and new laboratory tools (see Box 18). In addition, special tools for the collection and analysis of risk factor data, such as geographic information systems (GIS) and remote sensing technologies, are being developed; the potential applications of these new technologies are still being explored (see Box 26).

Box 26 Using Geographic Data To Understand Disease

New tools that facilitate the collection and analysis of spatial data include global positioning systems (GPS), which are hand-held units that pinpoint locations by longitude, latitude, and altitude; geographic information systems (GIS), which use a set of locations provided by GPS to create detailed computer maps; and satellite-derived remotely sensed (RS) data.

At the CDC research station in western Kenya, scientists are using GPS to map 7,500 households, rivers, roads, and medical facilities within a 75-square-mile area. By linking the map to an epidemiologic database, the GIS program provides information on how many cases of malaria occurred at each household, whether the malaria strains were drug-resistant, whether mosquito breeding grounds were present, and whether children died. Epidemiologists plan to use this map to answer questions that could not easily be answered before: Does proximity to mosquito breeding grounds increase childhood mortality? Does proximity to a medical facility decrease childhood mortality? Is drug resistance spreading in a predictable pattern? Public health officials can also use the map to target intensive vector control measures to households that harbor large numbers of mosquitoes.

RS data systems provide information on climate, soil types, and distribution of plant life and bodies of water. By examining a series of RS pictures taken every few months and superimposed on GIS maps, epidemiologists can study the relationship between environmental changes and the incidence of disease. For example, scientists at CDC, the Indian Health Service, and Johns Hopkins University are using RS and GPS to map cases of hantavirus pulmonary syndrome, an often-fatal respiratory disease carried by rodents. The maps incorporate information on rainfall, vegetation, and rodent populations. Scientists are using these data to identify environmental conditions that are associated with increased risk of human disease. These studies may lead to the development of methods for predicting environmental conditions that might result in outbreaks of animalborne and insectborne diseases, so that prevention measures can be taken.

OBJECTIVE II-B.

Identify the behaviors, environments, and host factors that put people at increased risk for infectious diseases and their sequelae.

ACTIVITIES:

i. Identify factors that influence the risk of developing infectious diseases. The identification of disease risk factors (see Box 27) has been a concern of public health officials since earliest times. For example, in the first century B.C., the Roman people were warned against locating farms near marshy places because of the risk of the disease now known as malaria.⁶⁰ In modern times, the range of risk factors under study has increased. New areas of risk factor research include the relationship between health care practices and infection rates (see Box 28); the relationship between changes in the environment (such as climate change) and the incidence and distribution of diseases; and the impact of people's genetic makeup on their susceptibility to disease and response to treatment. Other important risk factors include some that have been traditionally studied as risk factors for chronic diseases, such as smoking, which may increase rates of pneumonia and Legionnaires' disease, and exposure to second-hand smoke, which can increase susceptibility to ear infections in children.⁶¹

When programs to prevent or control specific diseases are in progress, risk factor research is critical for understanding why cases continue to occur and how to prevent them. For example, routine rubella immunization protects children and adults born in the United States from German measles, which can cause birth defects when it infects preg-

nant women. In contrast, high rates of rubella among adults from Latin America have highlighted the need not only to improve immunization rates among Hispanic populations in the United States, but also to encourage other countries to implement rubella immunization programs.

Risk factor research conducted by CDC involves close collaboration between laboratory scientists and epidemiologists, who use the results to design new prevention and treatment strategies and evaluate their effectiveness.

ii. Assess the role of infectious agents in causing or exacerbating chronic diseases and syndromes for which the causative agents are unknown. As described on pages 10–11 and in Box 29, several chronic diseases once thought to be caused by lifestyle or environmental factors are actually caused or intensified by infectious agents. These findings have profound implications for the treatment and prevention of chronic diseases. CDC will play a major role in assessing new research findings, encouraging and conducting further research where needed, and disseminating information to physicians and other health care providers. CDC will also help translate new research findings into prevention strategies; for example, CDC will continue to inform people that antibiotics should be used to treat peptic ulcer disease.

In addition, CDC will support research on illnesses for which the responsible agent is unknown, but thought to be infectious. For example, in a recent research study at 10 large hospitals, no infectious agent was identified in stool samples from over 90% of patients being evaluated for diarrhea with routine diagnostic procedures.⁶²

Box 27 Examples of New Risk Factors and Sources for Infection Identified by CDC Investigations, 1994–1998

Outbreak investigations provide some of the most important opportunities for identifying risk factors for disease. The investigations described below were conducted in collaboration with many partners in state and local health departments, other federal agencies, and other organizations. Foodborne outbreaks are described in Box 8.

Year	Location	Problem	Finding	Implications
1994	United States	Hepatitis C ²⁸	Strong association with particular lots of intravenous (IV) immunoglobulin from one company.	Led to requirement for viral inactivation steps and new testing procedures to ensure safety of IV and intramuscular (IM) immunoglobulin products.
1994	Rhode Island	Bloodstream infections (BSIs) ⁶³	BSIs associated with use of needleless inoculation devices. Findings led to CDC recommendations on the use and management of needleless devices.	First outbreak to link these devices with adverse outcomes in patients.
1995	Democratic Republic of Congo	Ebola infection ⁶⁴	Transmission linked to direct contact with ill patients.	No evidence of airborne transmission. Led to updating of policies for managing patients with viral hemorrhagic fever in the United States.
1996	Indiana	Vancomycin-resistant enterococci ⁶⁵	Illness linked to prior use of antibiotics. Implementation of control measures reduced transmission.	Highlighted rapid spread of this strain in the United States. Also showed feasibility and effectiveness of control measures to reduce the spread of antibiotic-resistant organisms in hospitals.
1997-98	New York	HIV	Cluster of cases of HIV infection in women who had sexual contact with one HIV-positive man.	HIV detection and prevention programs need to be strengthened in rural communities.

Box 28 Bloodstream Infections in ICU and Home Health Care Patients

Since 1993, CDC has investigated three outbreaks of bloodstream infection (BSI) among patients in intensive care units (ICUs) that were associated with decreases in nurse-to-patient ratios.^{66,67} In each of these outbreaks, rates of BSI increased when the number of health care workers per patient decreased or when the level of training of those workers decreased. The epidemiologic relationship between nursing staff numbers and training levels and the rates of BSIs remained significant even after controlling for other factors.

Since that time, CDC has also investigated three outbreaks of BSIs among patients receiving home infusion therapy.^{63,68,69} Risk factors for these outbreaks include practices related to care of the intravenous line, the use of particular types of intravenous devices, and socioeconomic factors. Interventions that involve teaching and training home health care providers and families of home care patients are being evaluated.

iii. Investigate the risk from poorly understood infectious agents of potential public health importance. As our arsenal of diagnostic testing methods has improved, so has the number of organisms we can identify in human, animal, and environmental samples. However, our ever-more-sensitive tests sometimes detect microbes that are not necessarily pathogenic (for example, hepatitis G). In other cases, an organism has been associated with a specific illness, but its role in causing or exacerbating the illness remains unclear (for example, human herpesvirus-8 and Kaposi's sarcoma).

The transplantation of animal organs into human beings is being tested in the United States and elsewhere as a therapeutic procedure for certain

Box 29 Role of *Chlamydia pneumoniae* Infection in Coronary Artery Disease and Atherosclerosis

Chlamydia pneumoniae is a common bacterium that infects more than 50% of people at some point in their lives.⁷⁰ It causes about 10% of all pneumonias and may play a role in the pathology of acute asthma and chronic bronchitis.^{70,71} Current research suggests that *C. pneumoniae* may also contribute to heart attacks, strokes, and claudication from atherosclerosis, a painful condition in which circulation to the legs or other parts of the body is inadequate.

Chlamydia pneumoniae has been found in the atherosclerotic lesions of coronary arteries, carotid arteries, the aorta, smaller cerebral vessels, and larger peripheral arteries.⁷²⁻⁷⁵ In laboratory cultures and in animal models, infection with this organism can produce the same types of inflammatory processes found in diseased arteries of the heart.^{76,77} In addition, studies have demonstrated rising or elevated levels of antibodies to this bacterium in some men during the months just preceding a heart attack.⁷⁸ Two recent small studies indicate that antibiotics given during or after a first heart attack may decrease the risk of a second cardiac problem.^{79,80} This finding raises the possibility that antibiotics may have a role in the treatment of cardiovascular illnesses. Further collaboration is needed among clinicians, epidemiologists, and laboratory scientists to define the role of *C. pneumoniae* in heart and vascular disease and to design new treatments and prevention strategies.

life-threatening illnesses. However, many scientists fear that infectious agents carried by transplanted organs (and not known to infect humans) may be capable of causing disease under the special conditions of transplantation (see Box 30). The use of animal tissue or other products in humans may also facilitate the transmission of zoonoses.

Box 30 Xenotransplantation

More than 50,000 people who need organ transplants die every year while waiting for a compatible organ. Because of the growing demand for, and the shortage of, human organs, transplant centers are turning to nonhuman animals. For example, doctors are experimenting with implants of fetal pig neuronal tissues to treat people who have Parkinson's disease, and with implants of pig liver cells to maintain liver function in people with catastrophic liver failure until a human liver can be found. However, medical experts are concerned that some animal organs and tissues may harbor persistent viruses that might infect humans, and that these viruses could cause uncontrollable human epidemics. This fear is underscored by the possibility that the HIV pandemic may have been caused by the transmission of a virus from monkeys to humans.

CDC is working with other Public Health Service agencies to draft guidelines for preventing the transmission of infectious agents during xenotransplantation, to monitor patients who receive xenotransplants, and to develop diagnostic assays for viruses that may be present in xenografts from pigs and baboons. CDC also supports the establishment of a national registry of xenotransplantation recipients, the creation of a repository for specimens from source animals and human recipients, and the development of a National Xenotransplantation Advisory Committee.

OBJECTIVE II-C.

Conduct research to develop and evaluate prevention and control strategies in the nine target areas.

CDC will continue to support and encourage research to create tools for the prevention and control of infectious diseases, including the development of drugs and vaccines, methods for disinfecting food and water, and behavioral interventions to prevent transmission. Another priority is to determine how best to implement and promote strategies for prevention and control of infectious diseases.

ACTIVITIES:

i. Work with partners in government, industry, and other sectors to develop and evaluate vaccines and products for immunotherapy, such as immunoglobulins. The National Institutes of Health, CDC, and their partners are helping develop state-of-the-art formulations, (such as DNA vaccines, live-vector vaccines, conjugate vaccines, and multicomponent vaccines) for the prevention of such diverse diseases as tuberculosis, Lyme disease, malaria, HIV/AIDS, dengue hemorrhagic fever, and influenza. Priorities in vaccine research include the following: identifying characteristics of the immune response that provide protection against particular diseases (in individuals with intact immune systems as well as in individuals who are immunocompromised); determining which components of a microbe are most effective at eliciting protective immune responses in humans; developing improved model systems for the evaluation of new vaccines; and participating in field evaluations of new vaccines. In addition, CDC will continue to conduct research related to the development of immunoglobulins that can be used to prevent or treat emerging infectious diseases.

CDC will also continue to work closely with FDA to expand existing mechanisms for ensuring vaccine safety and efficacy, such as providing an adequate cold chain, developing heat-stable vaccines, testing vaccine preparations for the presence of adventitious agents when required, and developing adjuvants that are safe for human use.

ii. In collaboration with other organizations, support research to develop and evaluate new antimicrobial drugs and prophylactic agents, as well as methods to control disease vectors and reservoirs. For many diseases that are not vaccine-preventable, drug therapy is crucial. For some diseases (for example, Ebola hemorrhagic fever and cryptosporidiosis), there is currently no effective drug therapy. For other diseases, more effective, less toxic, and cheaper drugs are sorely needed. For still others, new drugs are needed because of microbial

resistance to existing medications. For example, certain strains of enterococci are no longer sensitive to any commercially available antibiotic.

Controlling vectorborne and zoonotic diseases requires both pharmacologic treatment and vector control using insecticides, molluscicides, or rodenticides. Genetic modifications that decrease an insect's ability to transmit disease may become important public health tools in the future.

CDC's priorities in drug and pesticide development include

- Working with industry to encourage the development of new antimicrobial agents.
- Supporting efficacy trials of new drugs and treatments in the United States and internationally.
- Developing strategies to reduce insect vector populations.
- Developing and evaluating methods to control animal populations that serve as reservoirs for human diseases.

iii. Support research to develop new methods of disinfection. Disinfection procedures are important for a wide range of products. CDC priorities include assessing new methods for sterilization of food (see Box 31) and reducing contamination of water, assessing methods for the inactivation of pathogens in blood and blood products, and promoting the development and increased use of synthetic blood products produced by recombinant DNA techniques. In the developing world, a method for providing safe drinking water that includes disinfection and safe storage appears promising in evaluations in homes, marketplaces, and clinics; this system has the potential to greatly reduce transmission of waterborne diseases.⁸¹

CDC will also continue to study the role of the hospital environment in facilitating the spread of infections and to identify new ways of preventing these infections. CDC efforts include the following:

Box 31 Pasteurization of Solid Foods

In the United States, heat pasteurization is used routinely to kill pathogens in milk and certain other liquid foods. Over the past few years, however, outbreaks associated with uncooked or undercooked food have stimulated interest in using terminal treatment methods on solid foods as well. In the future, pasteurizing technologies for solid foods may solve public health problems that cannot be remedied by improving human or animal sanitation, or through other measures that are currently in use. Such problems include bacterial and parasitic contamination of fresh berries and contamination of fresh poultry by *Campylobacter* and *Salmonella*.

At the present time, gamma irradiation is the best studied of the potential cold pasteurization techniques. It has been approved by the FDA for use on fruits and vegetables, spices, chicken, and red meat. Research is also underway on other pasteurization methods, including techniques that rely on pulsed energy and bright light.

Because pasteurization does not destroy all microorganisms and because contamination can occur after pasteurization, good food processing and handling practices will still be necessary, even when the use of irradiated food becomes more widespread.

- Learning how bacteria interact with environmental surfaces and medical devices, using scanning electron microscopy and other tools.
- Determining how to control biofilms on medical devices and tubing, and in water systems in medical settings. (Biofilms are coatings that develop inside water distribution systems, such as water lines in dental equipment, which can harbor infectious organisms.)
- Assessing new methods for disinfection and reuse of dialysis equipment.
- Determining whether microbes are developing resistance to environmental disinfectants.
- Assessing new approaches to filtering air and otherwise reducing the spread of airborne organisms.

iv. Support social science and behavioral research to develop better prevention programs. Most factors associated with disease emergence depend on human behavior. Thus, designing disease prevention strategies requires an understanding of the behavior of patients, families, and health care workers. CDC has a key role in conducting social and behavioral research to identify the attitudes, perceptions, and expectations that motivate patients and health care providers to comply with guidelines or treatment. Behavioral research is also needed to develop better communication messages and channels to facilitate the implementation of community- and hospital-based prevention programs (see Box 32). For example, CDC is using focus groups and other research to identify barriers to the appropriate use of antibiotics by physicians and parents. CDC will also evaluate the impact of interventions aimed at changing beliefs and behaviors that promote disease transmission or impede medical treatment, and will assess the relative roles of guidelines, public education, formulary controls, and other methods in improving public health.

Box 32 Project Respect

The correct and consistent use of male condoms (or, if male condoms cannot be used, female condoms) during sexual intercourse is highly effective in preventing HIV infection, as well as other sexually transmitted diseases (STDs).

Between 1993 and 1995, in partnership with several other organizations, CDC conducted Project Respect—a randomized trial of alternative approaches to counseling people who visit STD clinics on how to prevent HIV and other STDs. One group received simple educational messages, while others received intensive counseling that focused on the particulars of the client's personal situation. After 6 months, people who received client-centered counseling were significantly more likely to use condoms 100% of the time and had significantly fewer new STDs. At 12 months, rates of condom use were similar in the two groups but the reduced rate of new STDs persisted among people who received client-centered counseling.⁸² CDC and other Project Respect investigators are translating these research findings into prevention programs that can be delivered in other clinical settings.

GOAL III: INFRASTRUCTURE AND TRAINING

Strengthen public health infrastructures to support surveillance and research and to implement prevention and control programs.

OBJECTIVE III-A.

Enhance epidemiologic and laboratory capacity.

The public health infrastructure is the underlying foundation that supports the planning, delivery, and evaluation of public health activities and practices. CDC's ongoing effort to rebuild the U.S. public health infrastructure that addresses infectious diseases requires a significant investment in modernization and training. Several critical issues are addressed in the objectives that follow.

The need for adequate physical facilities at CDC—including insectories and animal facilities, as well as laboratories and equipment—is addressed in other documents and plans. Many state and local health agencies also require improved physical facilities.

ACTIVITIES:

i. Define core public health functions and capacities needed for monitoring the spread of microbes and responding to infectious disease outbreaks, and provide personnel in state and large local health departments with essential equipment and training. Working with partners in state and local health departments, CDC has begun a process to identify the essential functions and core requirements that a state health department must have to protect its population against infectious disease threats, as well as ways to assess how well those functions are performed. For example, each state and large local health agency must have sufficient diagnostic proficiency to serve as a local infectious disease refer-

ence laboratory, a role that is likely to become more important as more laboratory services are privatized or affected by regionalization. Another core requirement is that adequate epidemiologic staff are available to investigate outbreaks, and that they work closely with laboratory staff and have appropriate tools (for example, computer equipment and compatible software) to facilitate effective interactions. In addition, state and local health departments of all sizes need access to surveillance information on the populations they serve, access to laboratory services, and access to additional assistance during emergencies.

CDC has developed specific programs, such as the Epidemiology and Laboratory Capacity (ELC) Program (see page 17), to address some core capacity needs, particularly of state and large local health departments. However, resources are needed from all levels of government to ensure that in all communities there is a strong local public health presence that serves as the first line of defense against emerging infectious diseases. State and local health departments should consider developing emerging infectious diseases plans that address local priorities.

ii. Strengthen CDC's capacity to serve as the national and international reference laboratory for diagnosis of infectious diseases and for drug-resistance testing. CDC is one of the few institutions in the world that maintains a comprehensive diagnostic facility with the capacity to detect almost all known infectious microbes. The staff at CDC includes experts in bacterial, viral, fungal, rickettsial, and parasitic diseases, as well as in diseases caused by environmental toxins. CDC's diagnostic laboratories play an essential and sometimes unique

role in determining the cause of outbreaks of emerging infectious diseases. State and local health departments, as well as health ministries in other countries, depend on CDC's ability to assist with difficult diagnoses, especially when the cause of an outbreak is unknown, or when clinical samples are so hazardous that they must be handled under the most stringent biocontainment conditions (see Box 33). CDC also plays a key role in ensuring that an adequate supply of diagnostic reagents is available for public health use.

iii. Promote the development and production of diagnostic and reference reagents for use by public health laboratories. In past years, CDC maintained

extensive supplies of pathogen-specific antibodies and other serologic reagents that were standardized and quality-controlled. These reagents were critical for use in research, diagnosis, and for typing pathogens during outbreaks. However, supplies of many reagents are now at dangerously low levels and some have been exhausted. Sustained efforts will be required to ensure that they remain available.

iv. Work with state health departments to standardize new diagnostic techniques and facilitate their use throughout the United States. CDC helped standardize techniques for fingerprinting strains of *Escherichia coli* (see Box 18) and is working on

Box 33 Using Molecular Pathology To Diagnose a Fatal Disease of Unknown Cause

During October 1995, 13 people died of respiratory failure in a rural area of northwestern Nicaragua, and hundreds more reported sudden attacks of chills, headache, and musculoskeletal pain. These symptoms were compatible with diagnoses of dengue hemorrhagic fever and dengue fever, two forms of disease caused by dengue virus, which is endemic to much of Central and South America. However, all blood tests for dengue were negative.

The mystery was solved at CDC by pathologists who use molecular and immunologic probes, such as DNA sequences and antibodies, to diagnose diseases. The pathologists tested autopsy tissues for a wide variety of microbes known to cause lung disease and hemorrhagic fevers, ruling out numerous viral, bacterial, and parasitic agents. Eventually, they improvised a new immunohistochemical test for *Leptospira*, a bacterial pathogen of animals and humans that in humans usually causes kidney and liver disease. Although this microorganism is not generally associated with lung disease, the scientists were aware that in the 1980s respiratory symptoms had been reported in cases of leptospirosis in Korea and China.^{83,84} The autopsy tissues turned out to be positive for *Leptospira*, and the results were later confirmed by additional assays.

Leptospirosis had not been considered a plausible diagnosis by attending physicians, who were not familiar with cases of leptospirosis with prominent

respiratory symptoms. Moreover, the only laboratory test available at the time that distinguished between past and current infections—the microscopic agglutination test (MAT)—required a comparison between acute-phase and convalescent-phase serum specimens, which were not available from the patients with pulmonary hemorrhage, who died within a few days. (The doctors had not ordered MAT on samples from patients without hemorrhage because they did not suspect leptospirosis in those patients either.) Without the immunohistochemical test, which unequivocally demonstrated the presence of leptospires, the outbreak might have gone undiagnosed for several months or remained indefinitely as a “mysterious febrile illness of unknown etiology.” Instead, the diagnosis was made in time to save several patients from dying of respiratory failure by administering intravenous antibiotics.

At the request of the Ministry of Health of Nicaragua, CDC provided recommendations for disease prevention as well as treatment. They advised people to keep rodents and domestic animals out of their homes and to avoid water or mud that might be contaminated with infected animal urine. The recommendations were also used in a public health education program to prevent further outbreaks during the next rainy season. CDC is planning to evaluate additional approaches to preventing leptospirosis in high risk settings.

methods for many other organisms, for example, for detection and characterization of Norwalk-like viruses and for tracking strains of *Bordetella pertussis* (the causative agent of whooping cough) (see page 22).

v. Clarify the role of regional facilities in the United States in specialized diagnosis and strain typing. For some types of laboratory testing, it may be impractical to develop diagnostic capacity in every state or to concentrate all resources at CDC. For that reason, CDC will continue to investigate ways to develop regional laboratory capacity for certain tests. For example, CDC has established the National Tuberculosis Genotyping and Surveillance Network, which includes seven regional laboratories that use standardized subtyping methods to track strains of drug-resistant tuberculosis.

vi. Assist other U.S. agencies, international organizations, and other nations in building global capacity for disease surveillance and response. Like the United States, many countries are trying to improve their national capacities for disease surveillance, prevention, and control. CDC will continue to build on efforts to improve health communications at the international level, including projects initiated by the World Bank, WHO, the U.S. Agency for International Development, the Asian-Pacific Economic Cooperation, and the Transatlantic Agenda with the European Union. CDC will also work to strengthen public health management training capacity in developing countries and provide technical assistance in the collection of vital data (such as data from death certificates), in epidemiology, and in laboratory sciences (see Box 34).

Box 34 World Health Organization (WHO) Global Polio Laboratory Network



Ascertaining whether a disease is still present in a given area (and, therefore, that further prevention efforts are needed) is a critical part of any disease eradication effort (see Box 45). The WHO Global Polio Laboratory Network uses molecular techniques to determine whether wild-type polio is circulating in areas undergoing eradication efforts. CDC began training Laboratory Network virologists in 1986, soon after the Pan American Health Organization (PAHO) declared its goal of eradicating polio from the Americas by 1990. CDC will continue to train Network virologists for several more years, as new methods are developed to meet the stringent surveillance criteria necessary to obtain certification of global polio eradication.

OBJECTIVE III-B.

Improve CDC's ability to communicate electronically with state and local health departments, U.S. quarantine stations, health care professionals, and others.

The prompt detection of domestic outbreaks depends on the flow of reliable surveillance data from physicians, hospitals, clinical laboratories, and epidemiologists to state and local health departments and CDC. CDC will continue to play a leadership role in promoting electronic reporting of laboratory data for use in public health surveillance and rapid response to outbreaks.

Electronic communication will also improve laboratory diagnosis by linking CDC laboratories with special diagnostic expertise to state and local laboratories. This will be especially important during outbreak investigations. CDC is also making use of the Internet to disseminate guidelines and other information, as well as to provide consultations and training.

ACTIVITIES:

- i. Ensure that every state, territorial, and large local health department has access to compatible software, hardware, and training required for participation in integrated networks for surveillance and response, as well as for access to guidelines and other essential resources.** Ideally, every state and local health department should have electronic access to surveillance information, as well as the capacity to share information on a regular basis with other state and local health departments and with CDC.
- ii. Improve management of medical screening data on refugees and monitor illnesses detected in immigrants and travelers at U.S. ports of entry.** In

partnership with the Council of State and Territorial Epidemiologists (CSTE), CDC will enhance the current information system for providing data on health problems of immigrants and refugees for use by state health departments, health care providers, and others who need medical screening information. Enhancements will include a follow-up program to monitor the outcome of selected diseases identified in immigrants and refugees.

OBJECTIVE III-C.

Enhance the nation's capacity to respond to complex infectious disease threats in the United States and internationally, including outbreaks that may result from bioterrorism.

A strong and flexible public health infrastructure is the best defense against any disease outbreak, including a pandemic or a terrorist attack. Many of the objectives and activities in this plan help build such an infrastructure.

ACTIVITIES:

- i. Work with state and local health departments, other federal agencies, organizations of first responders (such as firemen and emergency medical workers), and international partners to develop plans for responding to complex outbreaks, including those caused by the deliberate release of toxins or infectious organisms.** A national plan has been developed to respond to an influenza pandemic (see Box 35), and additional efforts are needed to prepare for other potentially devastating outbreaks. These plans need to address issues that range from establishing secure lines for communication to ensuring that first responders know how to protect themselves from deadly agents.

Box 35 The National Plan for Pandemic Influenza

New strains of influenza viruses can emerge unpredictably and spread rapidly and pervasively through susceptible populations, sometimes causing pandemics (worldwide epidemics). This is due in large part to two features of the influenza virus: its ability to exchange genetic information between strains and its ability to occasionally “jump” species barriers between mammalian and avian hosts.

Experts agree that future pandemics of influenza are likely, if not inevitable. In the United States alone, preliminary estimates indicate that an influenza pandemic would cause between 88,000–227,000 deaths and that the economic impact would range from \$71–\$166 billion.⁸⁵ The sudden and unpredictable emergence of pandemic influenza (see Box 1), and its potential to cause severe health and social consequences, are reasons why we need a national plan to protect the public against pandemic influenza.

CDC is an active member of the interagency Group on Influenza Pandemic Preparedness and Emergency Response (GRIPE), which developed the national influenza plan. If an influenza pandemic occurs, CDC's “mission control” responsibilities would include

- Confirming the cause and scope of the threat.
- Establishing a communication network for prompt dissemination of information to public health officials, health care providers, and the general public.
- Developing and testing candidate vaccines.
- Implementing vaccine purchase and distribution.
- Monitoring adverse events after vaccination.
- Disseminating information and coordinating education campaigns through the national media.
- Communicating and coordinating activities with other countries.
- Evaluating the effectiveness of the national effort.

In late 1997, a new and virulent strain of influenza (strain H5N1) was detected in Hong Kong through the World Health Organization's (WHO's) global influenza surveillance network. Because this strain—which normally infects birds—had never before been known to infect humans, a worldwide alert was issued through WHO and other national and international networks, and many of the activities described in the national influenza plan, including enhanced surveillance and a search for candidate vaccines, were initiated.

ii. Enhance national “surge” capacity for responding to outbreaks of unusual size, duration, and severity. In recent years, CDC and other organizations have responded to increasing numbers of infectious disease emergencies that require large numbers of personnel over long periods of time (such as the outbreaks of Ebola hemorrhagic fever in Africa and the multistate outbreaks of cyclosporiasis in the United States). CDC plans to implement the recommendations developed through a planning process that include

- Establishing emergency mechanisms that provide CDC with extra resources, including extra personnel, during complex outbreaks.
- Maintaining CDC's expertise in infectious diseases, including rare diseases that have the capacity to cause high rates of illness and death.
- Ensuring that CDC has adequate scientific and support staff (in both numbers and expertise) for responding to outbreaks.
- Ensuring that emergency procurement procedures are in place and that medical supplies and field equipment are ready for immediate shipment at all times.
- Establishing a computer system dedicated to gathering epidemiologic and laboratory data during outbreaks. This database should be accessible to all those involved in the outbreak response.

In the event of a terrorist attack, some additional resources and procedures may be required. For example, expertise may be needed in the diagnosis and treatment of certain diseases rarely seen in the United States (for example, anthrax, botulism, and brucellosis) that might be caused by biological weapons. CDC must also be prepared to mobilize extra staff; coordinate closely with federal security agencies; and procure specialized diagnostic tests, drugs, and vaccines.

State and local health departments also need surge capacity for outbreaks. Mechanisms for

sharing state and federal staff and other resources during emergencies will be evaluated.

iii. Assist FDA, WHO, private industry, other governments, and international organizations to ensure that emergency medical supplies, including drugs, vaccines, diagnostics, and antisera, are available during outbreaks. CDC is working with FDA and the Ciset Emerging Infectious Disease Task Force to engage WHO and the U.S. pharmaceutical industry in developing a procedures manual for obtaining medical supplies during health emergencies. Through WHO, pharmaceutical companies from other nations will also participate in this effort.

OBJECTIVE III-D.

Provide training opportunities in infectious disease epidemiology and diagnosis in the United States and throughout the world.

CDC's 1994 plan emphasized the need for additional training opportunities to ensure that we are well-prepared to respond to emerging infectious disease threats. Between 1994 and 1997, CDC began to identify and fill some of those gaps in training (see the Appendix), but more remains to be done.

ACTIVITIES:

i. Ensure the continued training of epidemiologists in problems related to emerging infectious diseases. Graduates of programs such as CDC's Epidemic Intelligence Service (EIS) perform key roles in federal government, in state and local health departments, and in health care settings. Today's epidemiologists must be trained in the use of modern molecular, statistical, and geographical tools.

ii. Increase the number of laboratory scientists trained in infectious diseases through the Emerging Infectious Diseases (EID) Laboratory Fellow-

ship Program and add a track for international students. The EID Laboratory Fellowship Program trains microbiologists in public health approaches to diagnosis and molecular epidemiology. Its goal is to train laboratory scientists to become leaders in public health laboratories, especially at the state and local levels.

iii. Maintain and expand other CDC training programs in emerging infectious diseases and develop new programs as needed. These include the CDC Summer Fellows Program for infectious diseases, which provides opportunities to minority students in historically black colleges and universities (HBCU), Hispanic-serving health professions schools (HSHPS), and American Indian and Alaska Native medical students. Other CDC programs include the Public Health Summer Fellows and Project Imhotep, which provide additional opportunities for HBCU and HSHPS students. CDC also provides research training through postdoctoral fellowships awarded by the American Society for Microbiology. In addition, CDC provides distance learning opportunities to infectious disease specialists and public health practitioners through the Public Health Training Network and the National Laboratory Training Network.

CDC will provide additional opportunities for professional training through preventive medicine residencies, prevention effectiveness internships, public health informatics fellowships, genetics fellowships, public health prevention specialist fellowships, and programs in such disciplines as behavioral sciences and health education.

iv. Help medical and public health professionals keep up to date with new tools, techniques, and issues. This includes

- Educating and training clinical laboratorians in the diagnosis of emerging pathogens.
- Working with U.S. schools of public health, nursing, medicine, and veterinary sciences to update curricula to include courses on the prevention and control of emerging infectious diseases.

- Helping to ensure coverage of emerging infectious diseases in continuing medical education efforts and other training for professionals.
- Incorporating training for local and state health department personnel into CDC-supported programs, such as the Emerging Infections Programs.

v. Expand CDC's efforts to train counterparts in developing countries in the use of epidemiologic and laboratory methods for combating emerging infectious diseases. Some of these efforts involve formal programs, like CDC's Field Epidemiology Training Programs (FETPs), which are based in

15 countries throughout the world, and CDC's Sustainable Management Development Program, which has graduates in 39 countries. The goal of the FETPs is to develop highly trained in-country epidemiologists who can address local public health problems. Another formal program is the joint CDC-NIH effort to provide epidemiologic training at NIH-sponsored emerging infections research programs overseas. CDC also participates in training programs sponsored by nongovernmental organizations, such as the Rockefeller Foundation's Schools of Public Health Without Walls.

GOAL IV: PREVENTION AND CONTROL

Ensure prompt implementation of prevention strategies and enhance communication of public health information about emerging diseases.

OBJECTIVE IV-A.

Implement, support, and evaluate programs for the prevention and control of emerging infectious diseases.

Preventing emerging infectious diseases is a multidisciplinary and multifaceted endeavor. It requires the resources and expertise of many groups of people in both the public and private sectors.

ACTIVITIES:

i. Expand existing community-based control programs. CDC works with many partners to conduct broad-based community programs for controlling certain diseases, such as dengue fever and dengue hemorrhagic fever in Puerto Rico (see Box 36) and malaria in Kenya and other African nations. CDC is also working to expand domestic HIV prevention efforts through the HIV Prevention Community Planning Project, which targets public resources toward programs for groups at highest risk of HIV infection and ensures that HIV prevention activities reflect the needs and preferences of local communities. Other programs supported by CDC focus on specific problems in more limited settings, such as control of infectious diseases in hospitals.

Box 36 Prevention and Control of Dengue Hemorrhagic Fever

Dengue (or "break-bone") fever is an acute illness characterized by the abrupt onset of fever, rash, headache, and pain in the muscles, joints, and eyes. Although dengue epidemics can be explosive, fatalities are rare, except when the illness develops into dengue hemorrhagic fever (DHF), which can lead to shock and death.

After many years of infrequent dengue outbreaks in the Americas, there has been a dramatic resurgence of epidemic dengue fever and, for the first time, the emergence of DHF. The increased incidence of dengue and the emergence of DHF is associated with the reinfestation of most Latin American countries by *Aedes aegypti*, the principal mosquito vector of dengue viruses.⁸⁶ This mosquito was eradicated from most of the American tropics in the 1940s, 1950s, and 1960s, as part of the effort to prevent urban epidemics of yellow fever.

A program for prevention and control of epidemic dengue and DHF in Puerto Rico was begun in 1985. The program had five components: 1) active, laboratory-based surveillance, 2) emergency vector control, 3) education of the medical community, 4) emergency hospitalization, and 5) community-based mosquito control. The program was developed in partnership with the Puerto Rico Department of Health and Rotary International and emphasized community participation and community ownership.

The program on dengue has had a global impact. It has been used as a model to develop the Pan American Health Organization's *Dengue and Dengue Hemorrhagic Fever in the Americas: Guidelines for Prevention and Control* and the *WHO Global Strategy for Prevention and Control of Dengue Hemorrhagic Fever*. CDC has recently received a grant from the Foundation of Rotary International to initiate pilot dengue prevention projects in the Philippines and Colombia. If successful, the pilot projects may be the first component of a Rotary-supported global program on prevention and control of dengue and DHF.

ii. Develop and support new community-based demonstration programs in the target areas. CDC will continue to develop community-based demonstration projects and evaluate their sustainability. In the United States, new demonstration projects would be especially helpful in the following areas:

- Programs to prevent the development and spread of antimicrobial resistance.
- Programs to promote the prevention of foodborne and waterborne diseases.
- Integrated pest management to prevent vectorborne diseases.
- Health education and prenatal care programs to prevent perinatal infections.
- Programs to prevent HIV transmission through treatment and prevention of other sexually transmitted diseases

iii. Evaluate the impact and cost-effectiveness of alternative approaches to reducing infectious diseases. For example, CDC will evaluate the cost-effectiveness of different ways to reduce the development and spread of antimicrobial resistance, respond to outbreaks of diseases like group A meningococcal infection, improve vaccination rates, and vaccinate people against Lyme disease. Health interventions involving animals and the environment also need assessment. CDC will identify the most cost-effective approaches for controlling rabies in animals and reducing food contamination on farms.

iv. Increase the use of vaccines to prevent and control emerging infectious diseases (see Box 37). Through the Vaccines for Children Program and other efforts, CDC is working to ensure that all U.S. children get routine childhood vaccinations. CDC is also helping to implement the Adult Immunization Action Plan, which, among other priorities, aims to increase vaccine coverage among adults at risk for influenza and pneumococcal pneumonia—major causes of hospitalization and death among the elderly and people with chronic lung disease. Other groups targeted for vaccina-

Box 37 Diphtheria in the United States

A number of diseases have become extremely rare in the United States because of universal vaccination among children and adults. One example is diphtheria, a bacterial infection characterized by the development of a membrane in the throat that can sometimes obstruct the airway and cause the infected person to suffocate. In the prevaccine era, diphtheria was a major killer of children in both industrialized and agrarian countries. The most severe cases were caused by bacterial strains that secrete a toxin that damages heart muscle and nervous tissue.

Although only a few cases of diphtheria are reported annually, CDC continues to conduct surveillance for diphtheria and other vaccine-preventable illnesses, to guard against the ever-present possibility of their reemergence. Whenever a new case of diphtheria is detected in the United States, CDC and its collaborators isolate the causative organism and use molecular fingerprinting to trace its origin. An isolated case of diphtheria might be imported from a country that lacks an effective vaccination program (as did Russia and the newly independent states of the former Soviet Union in the early 1990s). Or it might occur when a new strain of bacteria evolves that is unaffected by the diphtheria vaccine now in use.

Most of the diphtheria cases reported in the United States since 1988 have been imported from other countries, suggesting that endemic strains of diphtheria were disappearing from North America. However, in 1996, researchers isolated strains of toxigenic *Corynebacterium diphtheriae* from throat swabs and blood samples obtained from several members of a small community in South Dakota who had mild or asymptomatic infections. Molecular analysis of the bacterial strains suggested that they were endemic, rather than imported.⁸⁷ Similar investigations in Canada revealed the persistent circulation of toxigenic strains of diphtheria in other small communities.⁸⁸

CDC is investigating why *C. diphtheriae* is still present in the South Dakota community. Although the resurgence may be due to a low local rate of vaccination, it is also possible that subclinical foci of disease exist in many other U.S. communities. In view of these uncertainties—and the resurgence of diphtheria in Russia and Eastern Europe—CDC recommends that all Americans receive a diphtheria booster every 10 years to prolong the beneficial effects of the vaccine administered in childhood.

tion include health care workers who are at risk for contracting hepatitis B and travelers who are at risk for diseases like hepatitis A or yellow fever.

v. Work with health care providers, hospitals, managed care organizations, and others to improve patient outcomes related to infectious diseases. CDC will promote the incorporation of performance indicators that measure the effectiveness of disease control measures into hospital and managed care organization reporting systems (for example, the Health Plan Employer Data and Information Set [HEDIS] and the Indicator Monitoring System [IMS]). Feedback from such indicators can be used to modify health care practices. CDC will also encourage the use of hospital-based computer systems to provide physicians with feedback on the success or failure of the antibiotic treatments they administer.

vi. Work with private industry, government agencies, and others to develop systems that promote prompt identification of infectious disease problems and rapid implementation of control measures. Whenever there are safe and cost-effective steps consumers can take to protect themselves from a contaminated product implicated in an outbreak, CDC must ensure public notification. This often involves working with other federal agencies, such as the Food and Drug Administration and the Environmental Protection Agency, state and local health departments, private industry, consumer groups, and others. CDC will help develop electronic networks to disseminate information on outbreaks due to contaminated health care-related products (for example, blood products, like intravenous albumin). In addition, CDC will work with private industry to improve record keeping on commercial food distribution so that shipments of contaminated food can be traced back to their sources.

vii. Work with personnel at U.S. ports of entry and with the travel industry to prevent the importation of infectious diseases and reduce illness in U.S. travelers when they are abroad and after they return home. CDC is responsible for identifying ill passengers on airplanes and cruise ships entering the United States, in collaboration with airplane and ships' crews. Medical staff at ports of entry must be provided with up-to-date case definitions for syndromes and specific diseases they need to be alert for, and airport personnel must have contingency plans for dealing with highly contagious international passengers. CDC must also continue to work with the travel industry to ensure that travelers from the United States take appropriate precautions when they visit other parts of the world.

OBJECTIVE IV-B.

Develop, evaluate, and promote strategies to help health care providers and other individuals change behaviors that facilitate disease transmission.

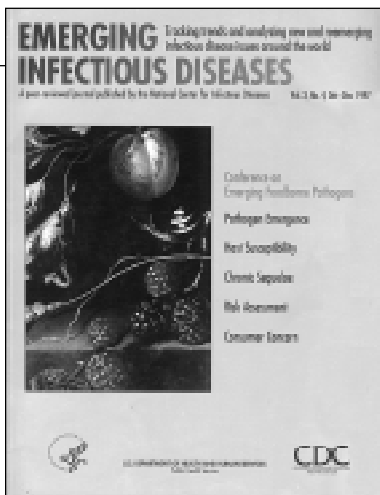
ACTIVITIES:

i. Work with other organizations to communicate disease prevention information to professionals and the public. CDC will continue to serve as a source of scientific information on emerging infectious diseases (see Boxes 38–40). It will make increased use of the Internet to ensure that this information is widely disseminated.

The importance of partners in developing and disseminating public health information is illustrated in a new CDC effort to address the problem of hepatitis C, an emerging infectious disease that affects an estimated 3.9 million persons in the United States. This campaign will involve professional organizations, private industry, public health agencies, and many others. Key messages include the following: those at risk need to be tested and counseled and those infected need appropriate medical evaluation and treatment.

Box 38 The EID Journal

Emerging Infectious Diseases (EID), a peer-reviewed journal, was established in January 1995 to enhance communication of public health information about emerging infections among professionals in infectious diseases and related sciences. The quarterly journal tracks disease trends, analyzes new and reemerging infectious diseases, and disseminates information around the world. In May 1997, the journal's home page was accessed over 18,000 times. More than 7,000 subscribers receive the journal by e-mail, and the print version is distributed to 19,000 public health professionals in the United States and abroad. A Spanish translation of the journal is also available electronically. EID is indexed in Index Medicus/Medline, Current Contents, and other electronic databases.



ii. Work with other organizations to develop and implement programs to improve public health practices in the target areas. Human behaviors are major factors in the spread of infectious diseases. CDC will emphasize programs that change behaviors by influencing individuals (for example, by promoting hand washing) and organizations (for example, by promoting formulary restrictions in hospitals and managed care organizations to reduce the use of antimicrobial drugs). In many cases, a combination of approaches will be employed.

Box 39 Using the Internet To Help Control an Outbreak of Hantavirus Pulmonary Syndrome

Hantavirus pulmonary syndrome (HPS), which is carried by rodents, is a lung disease that was first identified during a 1993 outbreak in the southwestern United States. People who become infected often die within days because of severe pulmonary hemorrhage. To prevent and control future outbreaks, CDC has developed educational materials that use text, images, animation, and video to explain how the disease can be treated and how individuals can avoid infection. These materials are available on CDC's Internet website on a page called "All About Hantavirus" (www.CDC.gov/ncidod/diseases/hanta/hps/index.htm).

In 1997, during an HPS outbreak in Chile, local health care workers used information from this website to mount a multimedia prevention campaign. They designed posters and radio and TV announcements that explained how people could protect themselves and their families from HPS. The announcements offered advice on how to keep rodents out of homes and work places and described special precautions for workers who are regularly exposed to rodents. The announcements also urged people in the affected area who experienced flu-like symptoms to get immediate medical attention.

By the time an epidemiologic team from CDC arrived in the outbreak area, the campaign was already well under way. Knowing that the public had access to prevention information, the CDC team was able to concentrate its efforts on the epidemiologic investigation. Although the number of HPS cases that were avoided by preventive action cannot be counted, it is likely that many lives were saved by the rapid actions of the Chileans.

iii. Develop, implement, and evaluate disease prevention guidelines that can be used by the public, health care providers, and health care systems. One way in which CDC furthers its mission is by providing guidelines on how to prevent specific diseases or disease problems (see Boxes 40 and 41). The development of disease prevention guidelines is a multistep process that begins with field research on risk factors, transmission patterns, and the

Box 40 Preventing Infection in Immunocompromised People Through Dissemination of Information

CDC helps people who have impaired immune systems avoid infection by providing them and their health care providers with up-to-date information on disease prevention. For example, pamphlets developed by CDC explain how HIV/AIDS patients can lessen their risk of developing *Pneumocystis carinii* pneumonia by taking prophylactic medications and avoid contracting zoonotic infections from pets.

CDC has also developed educational material on the prevention of infection due to the waterborne parasite *Cryptosporidium*, which may cause life-threatening intestinal problems in people with impaired immune systems. CDC recommends that people with HIV/AIDS who wish to reduce their risk consider boiling or filtering their tap water or using bottled water, and use caution when in contact with recreational water (for example, swimming pools and water parks). CDC is also working with manufacturers and the Food and Drug Administration to improve labeling so that consumers can identify filters, bottled water, and other products that can help reduce their risk of contracting cryptosporidiosis.

Box 41 USPHS/IDSA Guidelines for the Prevention of Opportunistic Infections in Persons Infected with HIV

CDC issued the USPHS/IDSA *Guidelines for the Prevention of Opportunistic Infections in Persons Infected with Human Immunodeficiency Virus* in 1995, in association with other U.S. Public Health Service (USPHS) agencies, the Infectious Diseases Society of America (IDSA), and numerous other organizations, health care providers, and patient advocates. The guidelines address 17 categories of opportunistic infections. They include information on how to prevent exposure to specific opportunistic pathogens, how to use chemoprophylaxis or vaccination to prevent disease, and how to prevent disease recurrence. They also address issues of concern to HIV-infected children and pregnant women.

The USPHS/IDSA guidelines were endorsed by numerous organizations and disseminated widely, providing a new standard of care for HIV-infected people. The guidelines were updated and republished in 1997.

effectiveness and cost-effectiveness of different prevention strategies.

In developing guidelines, CDC relies on the expertise and experience of many different groups and integrates many different kinds of data into easily understood documents that guide clinical and public health practice. Once completed, prevention guidelines are implemented in partnership with physicians, professional societies, nongovernmental organizations, and others. Thereafter, field research is used to confirm that the guidelines are effective in reducing the incidence of disease. Guidelines are updated periodically to incorporate new information as it becomes available.

CDC is developing new methods for disseminating guidelines. For example, CDC has published *CDC Prevention Guidelines: A Guide to Action*⁸⁹ in CD-ROM format. CDC will make a special effort to work with managed care organizations to

adapt, implement, and assess the effectiveness of these guidelines. In addition, CDC is supporting an independent, nonfederal task force that is developing a *Guide to Community Preventive Services*, which will provide recommendations on population-based interventions and methods for their delivery based on the best available evidence.

Over the next 5 years, guidelines will be developed for such topics as the prevention of opportunistic infections in bone marrow transplant recipients, and will be updated in such areas as infection control in hospitals and health care settings, reduction of occupational exposure to infectious agents in health care settings, and medical screening of immigrants and refugees. When possible, new guidelines will be integrated into existing ones so that they are easier to implement. When appropriate, they will be disseminated and updated via the Internet (in addition to other channels). For example, guidelines already exist for many diseases that affect pregnant women and newborns. Integrating new information on the prevention of such

Box 42 HICPAC Guidelines

The Hospital Infection Control Practices Advisory Committee (HICPAC) was established by CDC in 1991. Its publications represent the official recommendations of CDC and the U.S. Department of Health and Human Services on hospital infection control practices and strategies for the surveillance, prevention, and control of hospital-acquired infections.

HICPAC has issued guidelines to help health care providers improve the quality of their services. These include

- Immunization of Health-Care Workers (issued jointly with the Advisory Committee on Immunization Practices) (1997)
- Guidelines for Infection Control in Healthcare Personnel (1997)
- Guidelines for Prevention of Intravascular Device-Related Infections (1996)
- Guidelines for Isolation Precautions in Hospitals (1996)
- Recommendations for Preventing the Spread of Vancomycin Resistance (1995)
- Guidelines for Prevention of Nosocomial Pneumonia (1994)

diseases as group B streptococcal disease into existing guidelines will make it easier for practitioners to take an integrated approach to prevention.

iv. Work with school boards, departments of education, and others to incorporate information about prevention of infectious diseases into elementary and secondary school education. The agreement described on page 56 to address foodborne diseases involves the U.S. Department of Education, and plans are being developed to provide health information to adolescents through broad educational programs.

OBJECTIVE IV-C.**Support and promote disease control and prevention internationally.**

CDC is working with organizations in the United States and throughout the world to provide leadership and technical assistance for the global prevention and control of emerging infectious diseases. Some of this work is conducted through the CISET Emerging Infectious Disease Task Force.

ACTIVITIES:

i. Work with foreign governments, WHO, the U.S.–European Union Task Force on Communicable Diseases, other international partners, and the CISET Emerging Infectious Disease Task Force to promote global programs for the prevention and control of infectious diseases. CDC will continue its efforts to establish systematic antimicrobial resistance monitoring throughout the world to support control efforts and will help draft a set of international standards for antibiotic resistance monitoring. CDC will also train foreign nationals and help ensure that they have adequate equipment and reagents for monitoring drug-resistant pathogens. CDC will continue to support quality assurance efforts in laboratories that participate in WHO's WHONET surveillance system and its program for Antimicrobial Resistance Monitoring (ARM), as well as continue to participate in WHO's ongoing surveillance project for drug-resistant tuberculosis.

CDC will continue to contribute to global efforts to eradicate polio and other diseases that may soon be slated for eradication or elimination (see page 49) and to respond to diseases and outbreaks of international concern. CDC will also continue to work with WHO's Expanded Program on Immunization (EPI) to conduct surveillance for vaccine-preventable diseases and will help assess the possibility of integrating selected vaccines (such as yellow fever and Japanese encephalitis) into national and regional components of EPI. Vaccines against *Haemophilus influenzae* type b (Hib) have

almost eliminated this cause of meningitis in industrialized countries, and CDC is working with other partners (including WHO, the U.S. Agency for International Development [USAID], and the Children's Vaccine Initiative) to promote childhood vaccination against Hib in developing countries.

ii. Provide technical assistance and transfer cost-effective technologies to other countries, using governmental and nongovernmental channels. For example, CDC is helping address blood safety in Kenya and Guatemala (focusing on HIV and Chagas' disease, respectively) and is promoting inexpensive environmental control measures to prevent nosocomial tuberculosis transmission in countries with a high prevalence of HIV infection. At its field site in Botswana, CDC is learning how to improve tuberculosis control strategies in communities with high HIV prevalence. Lessons learned are being shared with other African countries. CDC is also developing diagnostic reference protocols suitable for use in developing countries that have limited resources. CDC will continue to work with WHO and others to develop disease control guidelines for use in developing countries where diagnoses are difficult to confirm because of the lack of laboratory facilities.

iii. Participate in bilateral and multilateral initiatives to improve global infectious disease prevention and control. Over the past few years, several bilateral and multilateral groups have put emerging infectious diseases on their agendas (see Box 43). CDC staff will continue to participate in interagency delegations that promote international action to combat emerging infectious diseases.

iv. Work with WHO and other partners to complete the revision of International Health Regulations. The International Health Regulations require reporting of outbreaks of certain diseases (such as plague, yellow fever, and cholera) that require international attention because they can rapidly spread from country to country. The next revision of the regulations is proposed to emphasize disease syndrome reporting rather than specific diseases.

Box 43 International Agendas That Address Emerging Infectious Diseases

Emerging infectious diseases are a topic of discussion at many high-level international meetings. Many governments view emerging infections as an economic issue as well as a public health issue, because healthy people are more productive and more able to contribute to their countries' economies. Moreover, outbreaks can impede economic development by interfering with tourism and trade.

Emerging infectious diseases are on the agenda of the

- Asian-Pacific Economic Cooperation (APEC)
- Common Agenda with Japan
- U.S.-Russia Commission on Economic and Technological Cooperation
- U.S.-South Africa Binational Commission
- Group of Eight Industrialized Nations
- Transatlantic Agenda with the European Union
- U.S.-Mexico Binational Agreement

v. Work with developing countries to sustain health care improvements and surveillance efforts after outbreaks. In addition to helping to control outbreaks, CDC provides affected populations with tools to address infectious disease problems that may arise in the future. This often involves maintaining a relationship with health authorities and medical professionals in the affected area. For example, since the Ebola fever outbreak in the Democratic Republic of Congo in May 1995, CDC representatives have helped the local community maintain improvements in hospital infrastructure and hospital nursing practices. In coordination with WHO, they have remained involved in ongoing efforts to develop long-term surveillance of hemorrhagic fever outbreaks in the region (see Box 44). After the 1994 plague outbreak in India, CDC scientists participated in WHO-supported courses to train Indian health professionals in the diagnosis, epidemiology, and microbiology of plague.

Box 44 Skin Biopsy Surveillance for Ebola

A 1995 outbreak of Ebola hemorrhagic fever—one of the deadliest viral diseases known—in and around the city of Kikwit in the Democratic Republic of Congo (then Zaire) did not receive international attention until several months had passed and several hospital workers died (see also Box 5). Part of the delay was caused by difficulty in diagnosing Ebola fever, which requires immediate testing of highly infectious tissues.

While the outbreak was still in progress, scientists at CDC began developing a method for the detection of Ebola virus antigens in formalin-treated skin specimens from fatal cases. Formalin fixing renders specimens noninfectious, and the fixed skin does not require immediate testing, cold storage, or special shipping procedures. After the outbreak was over, CDC developed Ebola virus surveillance kits to enable health workers to safely obtain and fix skin necropsy samples. The fixed specimens could then be shipped to CDC for testing. The kits were provided to health care facilities in the Kikwit area. Using a manual developed at CDC, the local health workers were trained to identify suspected Ebola cases and to isolate patients suffering from hemorrhagic fevers.

CDC is distributing the training manuals and test kits widely, as well as developing new assays for the diagnosis of other hemorrhagic fevers. Prompt diagnosis of hemorrhagic fevers in Africa will help provide early warning of outbreaks and allow control measures to be instituted promptly.

vi. Continue to work toward the global eradication of polio and Guinea worm disease and the eradication or elimination of other infectious diseases. The effort to eradicate smallpox is perhaps the single best example of using global cooperation to address a public health problem. Its success stimulated other efforts to eliminate infectious diseases. Projects to eradicate polio and Guinea worm disease are under way (see Box 45), and global momentum is building to eradicate measles, a leading cause of death in developing countries. Other diseases that may be proposed for future eradication programs include *Haemophilus influenzae* type b, filariasis, onchocerciasis, rubella, and hepatitis B.

Box 45 Eradication Efforts

Polio Eradication

The effort to eradicate polio in the Americas, which was initiated by the Pan American Health Organization in 1985, led to the elimination of polio in the Western Hemisphere by 1991. Since 1988, the global effort has been led by WHO, in partnership with an international coalition that includes CDC, Rotary International, the United Nations Children's Fund (UNICEF), and the governments of many countries. The Americas were certified by WHO as polio-free in 1994. By 1996, only 3,977 cases of polio were detected worldwide, which is an 89% decrease since the effort began.⁹⁰ Polio is targeted for worldwide eradication by the year 2000.

CDC has contributed to the eradication campaign by helping plan the global strategy; developing laboratory techniques for detecting and characterizing vaccine and wild-type strains of poliovirus; improving surveillance and vaccine delivery; training health workers (including laboratorians and epidemiologists); supporting the WHO Global Polio Laboratory Network (see Box 34); and providing vaccines and technical advice to national and regional eradication programs.

Guinea Worm Disease Eradication

The eradication of Guinea worm disease (also called dracunculiasis) depends mainly on environmental and behavioral interventions that reduce exposure to contaminated water, rather than on vaccination. The Guinea Worm Eradication Program has been so successful that the illness has been referred to as a "submerging" disease. At the current rate of progress, dracunculiasis may be eliminated before polio. The leaders of this effort include the Carter Center's Global 2000 Program, UNICEF, WHO, and CDC.

CDC became formally involved in the eradication effort in 1984—after several years of providing assistance—when a WHO Collaborating Center for Research, Training, and Eradication of Guinea Worm was established at CDC's National Center for Infectious Diseases. CDC mapped the distribution of dracunculiasis and conducted research to improve its diagnosis, treatment, control, and prevention. Since 1986, the number of cases of Guinea worm has decreased by 95%.^{91,92} CDC continues to send expert consultants to endemic countries to promote training and to provide support to national eradication programs.

The underserved areas of developing countries that present the greatest challenges for disease eradication are often the same areas where surveillance and response to emerging diseases are most difficult. Therefore, infrastructure developed for disease eradication programs is an extremely impor-

tant byproduct of disease eradication campaigns. Eradication programs provide valuable training opportunities for epidemiologists, public health advisors, and village health workers. Furthermore, as diseases are conquered, the resources used to address them can be applied to new threats.

ANTICIPATED OUTCOMES

Achievement of the objectives described in this plan will improve our ability to understand, detect, control, and prevent infectious diseases. The outcome will be a stronger, more flexible U.S. public health infrastructure well-prepared to respond to well-known disease problems and to address the unexpected, whether it be an influenza pandemic, a disease caused by an unknown organism, or a bioterrorist attack.

Implementation of this plan will produce the following results:

- A nationwide network for surveillance and response will ensure the prompt identification of emerging infectious diseases. State and local health departments will have the equipment and trained personnel needed to provide the front line public health response to infectious disease threats.
- Intensive population-based surveillance and research programs in at least 10 areas of the United States will generate data to identify new threats to public health and help guide responses to emerging infectious diseases.
- Health departments will rapidly detect and investigate outbreaks of foodborne illnesses using sophisticated epidemiologic and laboratory techniques. Early detection will facilitate the rapid implementation of control measures and the prevention of illness and death.
- Countries in all regions of the world will participate in a global system for surveillance and response that includes surveillance for infectious agents that are resistant to antimicrobial drugs. This effort will be undertaken in partnership with the World Health Organization and organizations and agencies around the world.
- Enhancement of the public health infrastructure will help prepare the United States to respond to bioterrorist incidents.
- Improved diagnostic testing methods will be developed for new, reemerging, and drug-resistant pathogens.
- A better understanding of risk factors for the development of infection and disease will provide new opportunities for disease prevention.
- A better understanding of relationships between infectious agents and some chronic diseases will lead to new strategies for preventing and treating chronic diseases.
- New strategies will be designed to reduce insect vector populations and control animal populations that serve as reservoirs for human diseases.
- Diagnostic and reference reagents will be available for use by public health laboratories. CDC will have enhanced capacity to serve as the national reference center for diagnosis of infectious diseases and for drug-resistance testing.
- The next generation of epidemiologists and laboratorians will be trained and prepared to respond to emerging infectious disease threats.
- Implementation of prevention guidelines will result in decreased death and disability due to emerging infectious diseases.
- Cooperative efforts among managed care organizations, health care facilities, state and local health departments, and CDC will improve treatment and prevention of infectious diseases.
- Deaths from vaccine-preventable diseases will be significantly reduced in the United States and abroad.
- Community-based demonstration programs will help identify cost-effective approaches to addressing emerging infectious disease problems.

APPENDIX

Implementation of

High Priority Activities from

*Addressing Emerging
Infectious Disease Threats:
A Prevention Strategy for the
United States*

1994–1997

In the 1994 plan, *Addressing Emerging Infectious Disease Threats: A Prevention Strategy for the United States*, CDC outlined 10 priority activities for the first years of the effort to combat emerging infectious diseases. This appendix describes the progress made in implementing those 10 activities. Additional CDC achievements in the area of emerging infectious diseases have been summarized elsewhere.^{93,94}

Goal I: Surveillance and Response

Detect, investigate, and monitor emerging pathogens, the diseases they cause, and the factors influencing their emergence.

PRIORITY I:

Strengthen notifiable disease surveillance at the state and local levels.

Implementation:

- 1995 Created the Epidemiologic and Laboratory Capacity (ELC) Cooperative Agreement Program to help states and large local and territorial health departments develop the core capacity to meet infectious disease threats (see page 17).
- 1995 Entered into ELC agreements with Colorado, Florida, Georgia, Kansas, Los Angeles County, Massachusetts, New Jersey, New York City, Washington State, and West Virginia.
- 1996 Entered into ELC agreements with Hawaii, Louisiana, Maine, New York State, and Pennsylvania.
- 1997 Entered into ELC agreements with Illinois, Michigan, Ohio, Tennessee, Utah, Vermont, and Wisconsin.
- 1997 Entered into a cooperative agreement with the Council of State and Territorial Epidemiologists (CSTE) to enhance state health departments' capacities to respond to outbreaks of unusual size, duration, or severity.

PRIORITY 2:

Establish two physician-based sentinel surveillance networks to detect and monitor emerging diseases, such as unexplained adult respiratory distress syndrome, multidrug-resistant pneumococcal disease, and childhood illnesses characterized by fever and rash.

Implementation:

- 1995 Established the Emergency Department Sentinel Network for Emerging Infections (EMERGEncy ID NET) (see page 19). The network is coordinated by the Olive View-UCLA Education and Research Institute.
- 1996 Established the Infectious Disease Society of America Emerging Infections Network (IDSA EIN), which includes over 500 infectious disease specialists practicing in 47 states, the District of Columbia, and Puerto Rico (see page 19). This network is coordinated by the Veterans Administration Medical Center in Portland, Oregon.
- 1996 Established the Sentinel Network of Travel Medicine Clinics (GeoSentinel), in collaboration with the International Society of Travel Medicine (see page 19). GeoSentinel is composed of 22 travel medicine clinics, located in the United States and other countries.
- 1996–1997 Established seven to eight sentinel surveillance projects per year to investigate such diseases as pneumonia, hepatitis, influenza, nosocomial infections, catheter-related infections, LaCrosse encephalitis, recurrent respiratory papillomatosis, Creutzfeldt-Jakob disease, and infections due to vancomycin-resistant enterococci, acyclovir-resistant genital herpes, and respiratory syncytial virus.

PRIORITY 3:

Establish four population-based Emerging Infections Epidemiology and Prevention Centers to conduct focused epidemiology and prevention projects emphasizing foodborne and waterborne infectious diseases and diseases that are vaccine preventable.

Implementation:

- 1995 Created the Emerging Infections Programs (EIPs) (see pages 17–18).
- 1995 Entered into EIP agreements with California, Connecticut, Minnesota, and Oregon.
- 1996 Entered into an EIP agreement with Georgia.
- 1996 Created the Foodborne Disease Active Surveillance Network (FoodNet), in collaboration with the EIP network, the U.S. Food and Drug Administration, and the U.S. Department of Agriculture, to monitor the burden and determine the causes of foodborne diseases in the United States (see page 19).
- 1997 Entered into EIP agreements with New York State and Maryland.

PRIORITY 4:

Strengthen and link four existing sites for a global consortium to promote the detection, monitoring, and investigation of infections emerging internationally that could affect the health of Americans.

Implementation:

- 1994 Helped form the National Science and Technology Council's interagency Working Group on Emerging and Re-emerging Infectious Diseases, Committee on International Science, Engineering and Technology (CISSET), chaired by the Director, CDC.
- 1995 Supported the development and passage of the 1995 World Health Assembly resolution that formed the basis for the WHO program on emerging diseases and led to the establishment of the Division of Emerging and Other Communicable Diseases

Surveillance and Control (WHO/EMC).

- 1995 Assigned CDC staff to the WHO subregional office in Harare, Zimbabwe, to implement a program to improve preparedness for, and response to, epidemic diarrheal diseases in southern Africa.
- 1995–1997 Participated in interagency emerging infectious disease activities initiated under the following bilateral and multilateral forums:
- The Asian-Pacific Economic Cooperation (APEC)
 - The Common Agenda with Japan
 - The U.S.-Russia Commission on Economic and Technological Cooperation
 - The U.S.-South Africa Binational Commission
 - The Group of Eight Industrialized Nations
 - The Transatlantic Agenda with the European Union
 - U.S.-Mexico Binational Agreement
- 1996 Helped form the interagency CISSET Emerging Infectious Disease Task Force (cochaired by CDC and the White House Office of Science and Technology Policy) to implement the National Science and Technology Council report, *Infectious Disease—A Global Health Threat*³⁶ and the 1996 Presidential Decision Directive on Emerging Infectious Diseases.³⁷
- 1996–1997 Conducted an exchange of scientists with Vietnam and prepared a feasibility study for establishing a field station there.
- 1996–1997 Enhanced the CDC field stations in Kenya and Guatemala.
- 1996–1997 Provided funds to enhance surveillance and response capacities at 23 WHO Collaborating Centers based at CDC that address emerging infectious disease issues covered in this plan (see page 25).
- 1996–1997 Strengthened global surveillance for influenza by increasing the number of influenza

surveillance sites in China from 6 to 12, training laboratorians from 14 countries in Latin America and the Caribbean, and providing resources for enhanced influenza surveillance in Russia.

- 1997 Assigned an epidemiologist to work at the Naval Medical Research Unit No. 3 (NAMRU-3) in Cairo.

Goal II: Applied Research

Integrate laboratory science and epidemiology to optimize public health practice.

PRIORITY 1:

Reestablish an extramural research program to support emerging infectious disease prevention and control activities, such as evaluating the role of prescribing practices in the development of antimicrobial drug-resistant pathogens.

Implementation:

- 1996 Created extramural grant programs to support research on tickborne diseases and on preventing the spread of antimicrobial resistance.
- 1997 Created extramural grant programs to support research on heterosexual and household transmission of hepatitis C virus infection; the development of diagnostics for certain parasitic, bacterial, and sexually transmitted diseases; and the development of algorithms for the diagnosis and treatment of diarrheal diseases. A contract was established to evaluate the utility of human papillomavirus testing in screening protocols for cervical disease.
- 1996–1997 Provided support for a variety of collaborative projects with academic institutions, through cooperative agreements with the Minority Health Professionals Foundation, the Association of Schools of Public Health, and the Association of Teachers of Preventive Medicine. The projects included studies of bleeding disorders, respiratory ill-

nesses in day care, and enteric infections in a rural minority community.

PRIORITY 2:

*Assess the impact of food preparation guidelines on the incidence of foodborne infections such as *E. coli* O157:H7 and *Salmonella* Enteritidis.*

Implementation:

- 1996–1997 Conducted surveys at FoodNet sites to assess factors related to ascertainment of foodborne and waterborne illnesses. Questions under study included the following: Which diagnostic tests are ordered for patients with enteric illnesses? Which laboratory tests are performed when a health-care provider sends a stool sample to a clinical laboratory?
- 1996–1997 Conducted case-control studies of *E. coli* O157 and *Salmonella* infections at five FoodNet sites to investigate the role of food-handling practices and other behavioral factors in the transmission of foodborne diseases.
- 1997 Established a memorandum of understanding with the Food and Drug Administration, the U.S. Department of Agriculture, the U.S. Department of Education, and the Partnership for Food Safety Education (which includes representatives of the food industry) to develop a program for public education in food safety.

Goal III: Prevention and Control

Enhance communication of public health information about emerging diseases and ensure prompt implementation of prevention strategies.

Priority 1:

Develop additional means to deliver laboratory and public health information on emerging infections and antimicrobial resistance.

Implementation:

- 1994 Established biweekly national teleconferences to share expertise on the prevention and control of cryptosporidiosis outbreaks, under the auspices of the CDC Working Group on Waterborne Cryptosporidiosis.
- 1995 Created new outlets for the dissemination of public health information, including
- A new scientific journal called *Emerging Infectious Diseases*.
 - On-line dissemination of surveillance data via the CDC Internet home page.
 - Slide sets with technical notes on emerging infectious diseases for use by public health professionals.
- 1995–1997 Supported a series of forums on emerging infectious diseases conducted by the Institute of Medicine of the National Academy of Sciences, as well as several other conferences and scientific meetings on emerging infections.
- 1995–1997 Sponsored teleconferences for health professionals on such topics as hantavirus pulmonary syndrome, *E. coli* O157, vancomycin-resistant enterococci, and management of pneumococcal pneumonia.
- 1996 Developed a National Infectious Disease Prevention Training Plan in conjunction with the Association of State and Territorial Directors of Health Promotion and Public Education (ASTDHPPE).
- 1996–1997 With the French agencies ORSTOM (Office de la Recherche Scientifique et Technique Outre-mer) and CNRS (Centre National de la Recherche Scientifique), as well as several other partners, CDC developed and sponsored the 1996 and 1997 International Workshops on Molecular Epidemiology and Evolutionary Genetics in Infectious Diseases.
- 1996–1997 Implemented a wide range of health education projects, including an Internet-based laboratory training program on drug-resistant gonorrhea and a program to educate pet owners about prevention of reptile-associated salmonellosis. CDC also created exhibits on dengue for a children's museum in Puerto Rico and conducted focus group research to develop a manual on infectious disease prevention issues for caretakers of older adults.
- 1997 Strengthened national education efforts on hepatitis-related liver disease (with an initial emphasis on infection with hepatitis C virus) by supporting efforts of private organizations, producing a teleconference, and providing training and educational materials.
- 1997 Created a public education campaign to improve communication between the public and physicians concerning *Helicobacter pylori* and ulcers.
- 1997 Published *The CAUSE: Careful Antibiotic Use to Prevent Resistance*, a newsletter for clinicians, public health workers, and others.
- 1997 Published *Cryptosporidium and Water: A Public Health Handbook* and conducted a teleconference on this topic for state and local health authorities, water utility workers, and others.
- 1997 Planned the International Conference on Emerging Infectious Diseases, held in Atlanta, Georgia, in March 1998.

PRIORITY 2:

Develop and implement guidelines for the prevention of opportunistic infections in immunosuppressed persons.

Implementation:

- 1995 Published *Guidelines for the Prevention of Opportunistic Infections in HIV-Infected Persons* by the U.S. Public Health Service and the Infectious Diseases Society of America. These guidelines were published in CDC's *Morbidity and Mortality Weekly Report (MMWR)* and other medical journals and newsletters, and are available on the Internet.
- 1996 Initiated work on guidelines for the prevention of opportunistic infections in bone marrow transplant recipients.
- 1997 Updated the 1995 *Guidelines for the Prevention of Opportunistic Infections in HIV-Infected Persons* and published them in the *MMWR* and other medical journals.

Goal IV: Infrastructure and Training

Strengthen local, state, and federal public health infrastructures to support surveillance and implement prevention and control programs.

Priority 1:

Provide state-of-the-art training in diagnostic evaluation and testing for medical laboratory personnel to ensure the diagnosis and surveillance of emerging infections.

Implementation:

- 1995–1996 Transferred rapid diagnostic techniques for diagnosis of hantavirus pulmonary syndrome and arboviral diseases (such as LaCrosse encephalitis, St. Louis encephalitis, and Venezuelan equine encephalitis) to state and local health departments.

- 1995–1997 Supported projects to improve diagnostic capacity at state and major metropolitan area health departments, through ELC agreements, EIPs, and other cooperative agreements. For example, funds were provided to eight states in 1996 and five states in 1997 through ELC agreements to implement standardized DNA fingerprinting of *E. coli* O157:H7 in state public health laboratories.
- 1995–1997 Supported intramural projects to improve diagnostic capacity at CDC's National Center for Infectious Diseases, providing laboratorians with advanced training, and purchasing state-of-the-art laboratory equipment and computer tools.
- 1996 Supported 75 new full-time positions at the National Center for Infectious Diseases, including laboratory scientists and technicians.
- 1996 Worked with the Pan American Health Organization to provide training in the diagnosis of influenza, dengue, and dengue hemorrhagic fever to support active surveillance for these diseases in the Americas.

Priority 2:

Establish a public health laboratory fellowship in infectious diseases that will train medical microbiologists in public health approaches to diagnosis and molecular epidemiology.

- 1995 Created the Emerging Infectious Diseases Laboratory Fellowship Program through a cooperative agreement with the Association of Public Health Laboratories (APHL) (see page 40). Of the 18 fellows who completed the program as of February 1998, two entered Ph.D. degree programs, two entered master's degree programs, six accepted positions at CDC laboratories, five accepted positions at state public health laboratories, one accepted a position with a clinical microbiology laboratory, and one accepted a fellowship with the U.S. Department of Agriculture.

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ACRONYMS

AIDS	acquired immunodeficiency syndrome
APEC	Asian-Pacific Economic Cooperation
APHL	Association of Public Health Laboratories
ARM	Antimicrobial Resistance Monitoring
ASTDHPPE	Association of State and Territorial Directors of Health Promotion and Public Health Education
BSE	bovine spongiform encephalopathy
BSIs	bloodstream infections
CDC	Centers for Disease Control and Prevention
CISET	Committee on International Science, Engineering, and Technology
CJD	Creutzfeldt-Jakob disease
CNRS	Centre National de la Recherche Scientifique
CSTE	Council of State and Territorial Epidemiologists
DNA	deoxyribonucleic acid
DOT	Directly Observed Therapy
EID	emerging infectious diseases
EIPs	Emerging Infections Programs
EIS	Epidemic Intelligence Service
ELC	Epidemiology and Laboratory Capacity Program
ELISA	enzyme-linked immunosorbent assay
EMC	Division of Emerging and Other Communicable Diseases Surveillance and Control
EMERGENCY	
ID NET	Emergency Department Sentinel Network for Emerging Infections
EPI	Expanded Program on Immunization
EPO	Epidemiology Program Office
FDA	Food and Drug Administration
FETPs	Field Epidemiology Training Programs
FoodNet	Active Foodborne Disease Surveillance Network
GBS	group B streptococcal disease
GeoSentinel	Sentinel Network of Travel Medicine Clinics
GIS	geographic information system
GPS	global positioning system
GrIPPE	Group on Influenza Pandemic Preparedness and Emergency Response
HBCU	historically black colleges and universities
HEDIS	Health Plan Employer Data and Information Set
HHV-8	human herpesvirus-8
Hib	<i>Haemophilus influenzae</i> type b
HICPAC	Hospital Infection Control Practices Advisory Committee
HPS	hantavirus pulmonary syndrome

HPV	human papillomaviruses
HSHPS	Hispanic-serving health professions schools
IDSA	Infectious Diseases Society of America
IDSA EIN	Infectious Diseases Society of America Emerging Infections Network
IMS	Indicator Monitoring System
INPHO	Information Network for Public Health Officials
IOM	Institute of Medicine
MAT	microscopic agglutination test
MMWR	<i>Morbidity and Mortality Weekly Report</i>
NAMRU-3	Naval Medical Research Unit No. 3 in Cairo
NCHSTP	National Center for HIV, STD, and TB Prevention
NCID	National Center for Infectious Diseases
NIH	National Institutes of Health
NIOSH	National Institute for Occupational Safety and Health
NIP	National Immunization Program
OGH	Office of Global Health
OI	opportunistic infection
ORSTOM	Office de la Recherche Scientifique et Technique Outre-mer
PAHO	Pan American Health Organization
PEP	postexposure prophylaxis
PFGE	pulsed-field gel electrophoresis
PHPPO	Public Health Practice Program Office
RS	remotely sensed
STDs	sexually transmitted diseases
TB	tuberculosis
UNICEF	United Nations Children's Fund
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
USPHS	U.S. Public Health Service
WB	Western blot
WHO	World Health Organization