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

Executive Summary

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
and Prevention (CDC)
Atlanta, Georgia 30333



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Centers for Disease Control and Prevention David Satcher, M.D., Ph.D.
Director

The material in this report was prepared for publication by:

National Center for Infectious Diseases James M. Hughes, M.D.
Director

The production of this report as an *MMWR* serial publication was coordinated in:

Epidemiology Program Office Barbara R. Holloway, M.P.H.
Acting Director

Richard A. Goodman, M.D., M.P.H.
Editor, MMWR Series

Scientific Information and Communications Program

Recommendations and Reports Suzanne M. Hewitt, M.P.A.
Managing Editor

Nadine W. Martin
Project Editor

Rachel J. Wilson
Writer-Editor

Phillip C. Bourque
Peter M. Jenkins
Visual Information Specialists

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The following CDC staff members prepared this report:

Ralph T. Bryan, M.D.
Robert W. Pinner, M.D.
Robert P. Gaynes, M.D.
C. J. Peters, M.D.
Judith R. Aguilar
Ruth L. Berkelman, M.D.
National Center for Infectious Diseases

In consultation with:

Epidemiology Program Office
Barbara R. Holloway, M.P.H., Acting Director
International Health Program Office
Joe H. Davis, M.D., M.P.H., Director
National Center for Chronic Disease Prevention and Health Promotion
Virginia S. Bales, M.P.H., Acting Director
National Center for Environmental Health
Stephen B. Thacker, M.D., M.Sc., Acting Director
National Center for Health Statistics
Manning Feinleib, M.D., Dr.P.H., Director
National Center for Injury Prevention and Control
Mark L. Rosenberg, M.D., M.P.P., Director
National Center for Prevention Services
Alan R. Hinman, M.D., M.P.H., Director
National Immunization Program
Walter A. Orenstein, M.D., Director
National Institute for Occupational Safety and Health
Linda Rosenstock, M.D., M.P.H., Director
Public Health Practice Program Office
Edward L. Baker, M.D., M.P.H., Director

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

Executive Summary

Ingenuity, knowledge, and organization alter but cannot cancel humanity's vulnerability to invasion by parasitic forms of life. Infectious disease which antedated the emergence of humankind will last as long as humanity itself, and will surely remain, as it has been hitherto, one of the fundamental parameters and determinants of human history.

— William H. McNeill in *Plagues and Peoples*, 1976

Summary

The spectrum of infectious disease is changing rapidly in conjunction with dramatic societal and environmental changes. Worldwide, explosive population growth with expanding poverty and urban migration is occurring; international travel and commerce are increasing; and technology is rapidly changing—all of which affect the risk of exposure to infectious agents.

*Recent examples of important emerging infectious diseases include prolonged diarrheal illness due to waterborne *Cryptosporidium*, hemorrhagic colitis and renal failure from foodborne *Escherichia coli* O157:H7, pneumonia and middle-ear infections caused by drug-resistant pneumococci, and rodentborne hantavirus pulmonary syndrome. These diseases as well as resurgent diseases (e.g., tuberculosis and cholera) illustrate human vulnerability to microorganisms in the environment. Three recent reports by the Institute of Medicine document the need to address emerging infectious disease threats.*

In partnership with representatives from health departments, other federal agencies, medical and public health professional associations, and international organizations, CDC has developed a strategic plan to address emerging infectious disease threats. The plan contains four goals that emphasize surveillance, applied research, prevention and control, and public health infrastructure. To ensure sustainability, plan implementation will be approached in stages, as a long-term endeavor with emphasis on extramural programs. As health-care reform proceeds, priority should be given to strengthening partnerships between health-care providers, microbiologists, and public health professionals to detect and control emerging infectious diseases.

INTRODUCTION

Once expected to be eliminated as a public health problem, infectious diseases remain the leading cause of death and disability-adjusted life years (DALYs) worldwide (1) and are among the leading causes of death in the United States (2). Dramatic changes in society, technology, and the environment, together with the diminished effectiveness of certain approaches to disease control, usher in an era wherein the spectrum of infectious diseases is expanding, and many infectious diseases once thought to be controlled are increasing (Box 1).

The term "emerging infectious diseases" refers to diseases of infectious origin whose incidence in humans has either increased within the past two decades or threatens to increase in the near future (3). To effectively address emerging infectious diseases, CDC has developed a strategic plan emphasizing surveillance, research, and prevention activities necessary to maintain a strong defense against infectious diseases that affect, or threaten to affect, the public's health.

The goals of this plan address priorities for surveillance, applied research, prevention and control, and public health infrastructure, respectively:

- Goal I.** Detect, promptly investigate, and monitor emerging pathogens, the diseases they cause, and the factors influencing their emergence.
- Goal II.** Integrate laboratory science and epidemiology to optimize public health practice.
- Goal III.** Enhance communication of public health information about emerging diseases and ensure prompt implementation of prevention strategies.
- Goal IV.** Strengthen local, state, and federal public health infrastructures to support surveillance and implement prevention and control programs.

BOX 1. Examples of emerging infectious diseases, 1993

Diseases in the United States

- Coccidioidomycosis
- Cryptosporidiosis
- Drug-resistant pneumococcal disease
- *Escherichia coli* O157:H7 disease
- Hantavirus pulmonary syndrome
- Influenza A/Beijing/32/92
- Vancomycin-resistant enterococcal infections

Diseases outside the United States

- Cholera, Latin America
- Dengue, Costa Rica
- Diphtheria, Russia
- *E. coli* O157:H7, South Africa and Swaziland
- Multidrug-resistant *Shigella dysenteriae*, Burundi
- Rift Valley fever, Egypt
- *Vibrio cholerae* O139, Asia
- Yellow fever, Kenya

BACKGROUND

The Concept of Emergence

Many factors or combinations of factors can contribute to disease emergence. Newly emergent infectious diseases may result from changes in or evolution of existing organisms; known diseases may spread to new geographic areas or human populations; or previously unrecognized infections may appear in persons living or working in areas undergoing ecologic changes (e.g., deforestation or reforestation) that increase human exposure to insects, animals, or environmental sources that may harbor new or unusual infectious agents (Table 1) (4–7).

Infectious diseases may reemerge because of either the development of antimicrobial resistance in existing agents (e.g., gonorrhea, malaria, pneumococci) or breakdowns in public health measures for previously controlled infections (e.g., cholera, tuberculosis, and pertussis) (3).

The Burden of Infectious Diseases

In the United States and elsewhere, infectious diseases increasingly threaten public health and contribute substantially to the escalating costs of health care. For example, childhood ear infections are the leading cause of patient visits to pediatricians, and the incidence of visits for these infections increased 150% during 1975–1990 (8). In addition, infectious agents may be causing diseases previously considered noninfectious: *Helicobacter pylori* has a well-established association with peptic ulcer disease and gastritis (9); sexually transmitted human papillomavirus is associated with cervical cancer (10); and infection with hepatitis C virus—now recognized as a leading cause of chronic liver disease and cirrhosis in the United States—occurs in an estimated 150,000 persons annually (11). *Chlamydia* infections have long been implicated in infertility and, more recently, have been tentatively associated with coronary artery

TABLE 1. Factors contributing to emergence of infectious diseases*

| Categories | Specific examples |
|---------------------------------|--|
| Societal events | Economic impoverishment; war or civil conflict; population growth and migration; urban decay |
| Health care | New medical devices; organ or tissue transplantation; drugs causing immunosuppression; widespread use of antibiotics |
| Food production | Globalization of food supplies; changes in food processing, packaging, and preparation |
| Human behavior | Sexual behavior; drug use; travel; diet; outdoor recreation; use of day care facilities |
| Environmental changes | Deforestation/reforestation; changes in water ecosystems; flood/drought; famine; global warming |
| Public health infrastructure | Curtailment or reduction of prevention programs; inadequate communicable disease surveillance; lack of trained personnel (e.g., epidemiologists, laboratory scientists, and vector and rodent control specialists) |
| Microbial adaptation and change | Changes in virulence and toxin production; development of drug resistance; microbes as cofactors in chronic diseases |

* Adapted from reference 3.

disease (12), and rodentborne hantaviruses may play a role in hypertensive renal disease (13).

Infectious diseases account for 25% of all visits to physicians each year, and antimicrobial agents are the second most frequently prescribed class of drugs in the United States. (14,15). Direct and indirect costs of infectious diseases (e.g., economic losses and days of disability) may exceed an estimated \$120 billion. Such approximations, however, most likely underestimate the burden of infectious diseases. For example, the *International Classification of Diseases* (ICD-9) distributes infectious diseases across several categories, obscuring their public health impact (e.g., the classification of endocarditis among cardiovascular diseases and the classification of meningitis and middle-ear infections among diseases of the nervous system and sense organs, respectively).

The Threat of Emerging Infections

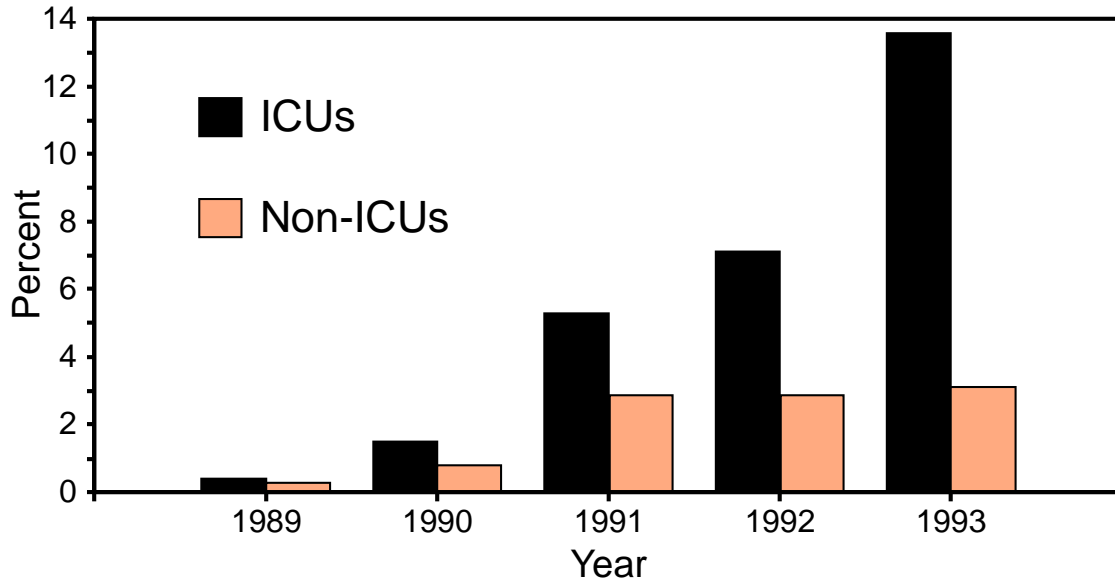
As a consequence of changes in society, technology, and the environment, pathogens evolve or spread, and the spectrum of infectious diseases expands. Emerging infections, such as human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS), illustrate that no nation can be complacent regarding human vulnerability to microorganisms in the environment. Since the early 1970s, the U.S. public health system has been challenged by other newly identified pathogens and syndromes, such as Legionnaires' disease, Lyme disease, toxic shock syndrome, hepatitis C virus, and, most recently, hantavirus pulmonary syndrome (16–23). Moreover, the incidence of many diseases widely presumed to be under control—such as cholera (24), dengue (25), yellow fever (26), and tuberculosis (TB) (27,28)—has increased in many areas or spread to new regions or populations throughout the world. Because of widespread use and misuse of antimicrobial drugs, their effectiveness in treating common bacterial infections is diminishing, resulting in prolonged illnesses, higher mortality rates, and higher health-care costs (Figure 1) (29–35).

Emerging infections are particularly serious in persons with lowered immunity, such as those infected with HIV and those receiving immunosuppressive therapy for cancer or organ transplantation—populations whose numbers are increasing (Figure 2). Other groups that may be disproportionately affected by emerging infections include the elderly; persons being cared for in institutional settings, such as hospitals and nursing homes; and persons with inadequate access to health care, such as the homeless, migrant farm workers, and others of low socioeconomic status.

The number of children attending day care facilities has increased in the past decade as more mothers of young children have entered the work force. These children, now numbering more than 11 million, are at a substantially increased risk for enteric infections, such as hepatitis A, giardiasis, and cryptosporidiosis; acute respiratory illnesses; and middle-ear infections. Also, children who become infected can infect other members of a household (36).

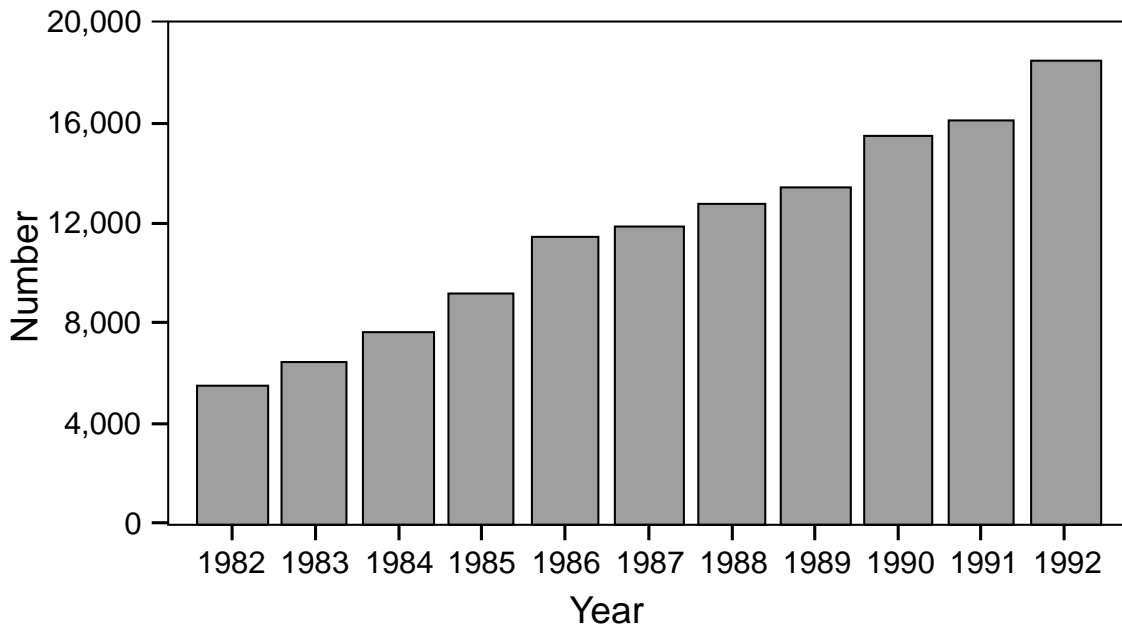
Emerging infections transmitted by contaminated public water supplies place entire communities at risk. In the spring of 1993, contamination of a municipal water supply with the intestinal parasite *Cryptosporidium* caused the largest recognized outbreak of waterborne illness in the history of the United States; an estimated 403,000 persons in Milwaukee, Wisconsin, had prolonged diarrhea, and approximately 4,400 persons required hospitalization (personal communication, Jeffrey P. Davis, commu-

FIGURE 1. Percentage of nosocomial enterococci reported as resistant to vancomycin isolated from infections in patients in intensive-care units (ICUs) and non-ICUs, by year — National Nosocomial Infections Surveillance system, 1989–March 31, 1993*



*Treatment options for patients with nosocomial infections associated with vancomycin-resistant enterococci are limited, often to unproven combinations of antimicrobials or experimental compounds.

FIGURE 2. Number of organ transplants — United States, 1982–1992



Source: United Network for Organ Sharing, Scientific Registry Data, July 23, 1993.

nicable disease epidemiologist, Wisconsin). Large segments of populations may also be exposed to emerging infections through contaminated food products. For example, in 1993, hamburgers contaminated with the bacterial pathogen *Escherichia coli* O157:H7 and served at a fast-food restaurant chain caused a multistate outbreak of hemorrhagic colitis (bloody diarrhea) and serious kidney disease, resulting in the deaths of at least four children (37,38).

Limitations in both surveillance and the availability of appropriate diagnostic tests constrain public health efforts to prevent and control outbreaks. Both *E. coli* O157:H7 and *Cryptosporidium* were first recognized as important human pathogens in the early 1980s, but neither has received adequate public health attention (Figure 3).

Exposure to certain animals also poses a risk for emerging infectious diseases. Hantavirus pulmonary syndrome, first recognized in the southwestern United States in 1993, has been linked to exposure to infected rodents in more than a dozen states. More than 60 cases have been detected; of those, more than half have died (Figure 4) (20-23).

Once considered "exotic," tropical infectious diseases are having an increasing effect on the U.S. public. Recent examples include severe illness and at least one death due to cholera among international airline passengers arriving in California (39); malaria among residents of southern California and immigrants in North Carolina (40,41); fever and heart failure in New York and Canada among patients who received blood transfusions contaminated with the bloodborne parasite (*Trypanosoma cruzi*) that causes Chagas' disease in Latin America (42,43); and a newly described form of leishmaniasis among troops returning from the Persian Gulf conflict (44,45).

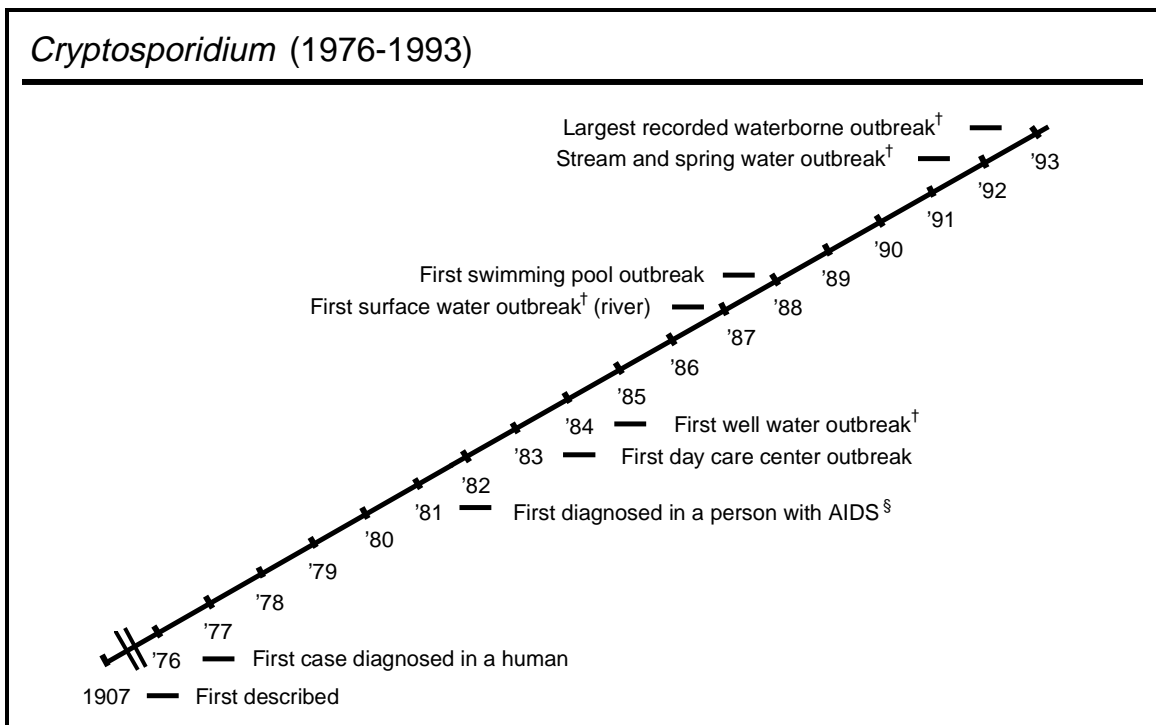
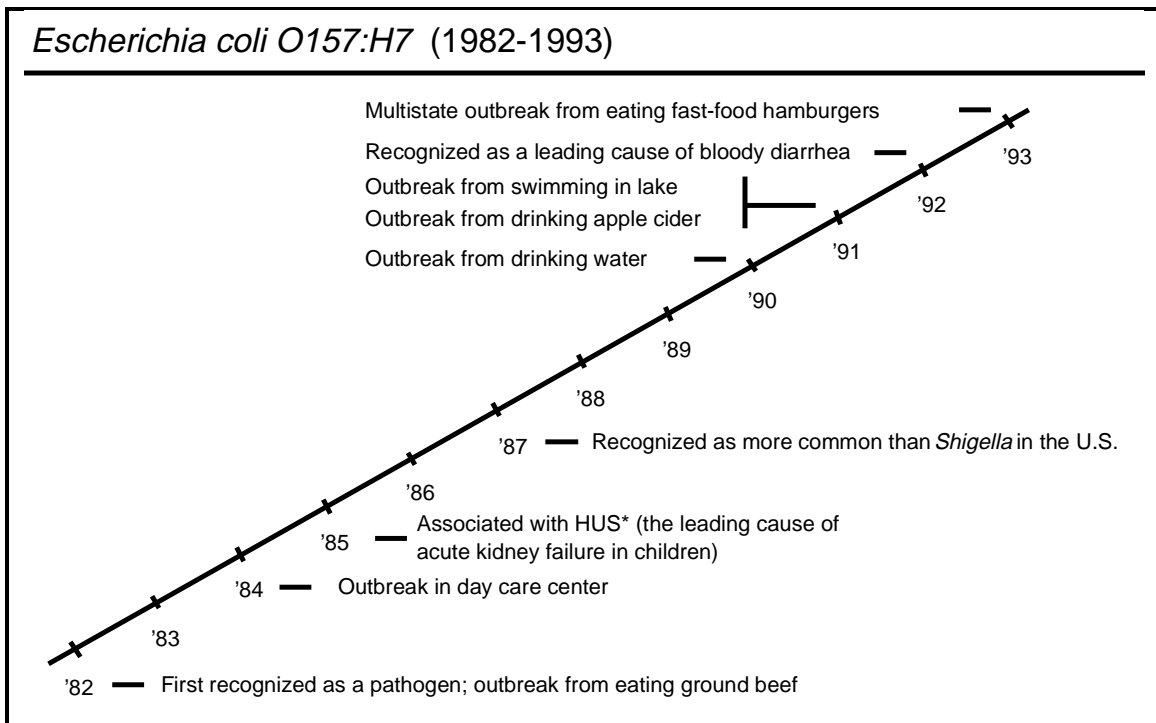
From a historical perspective, cholera, smallpox, and plague are examples of infectious diseases that spread globally with devastating impact, often during periods of rapid economic change or population growth (7). Today, travel and commerce have fostered the worldwide spread of pathogens such as HIV/AIDS and influenza, as well as the reemergence of cholera as a global health threat—consistent with a perspective that "the microbe that felled one child in a distant continent yesterday can reach yours today and seed a global pandemic tomorrow" (46). These examples underscore the fact that emerging infections can affect persons in geographically widespread areas, regardless of factors such as lifestyle, cultural or ethnic background, or socioeconomic status.

Preparing to Confront Emerging Infections

The public health infrastructure is insufficiently prepared to confront today's emerging disease problems. Domestic surveillance systems for most infectious diseases are inadequate and global surveillance is fragmentary at best. For example, foodborne and waterborne disease outbreaks may be either unrecognized or detected late, and the magnitude of the problem of antimicrobial drug resistance is unknown.

Surveillance of infectious diseases in the United States depends on voluntary collaboration between CDC and state and local health departments, which depend on reporting by health-care professionals of a limited number of specific, recognized infectious diseases. Reporting is generally incomplete. Results of a recent survey conducted by the Council of State and Territorial Epidemiologists underscore the inadequacy of existing infectious disease surveillance by documenting the limited number of professional positions dedicated to infectious disease surveillance in most

FIGURE 3. Emergence of foodborne and waterborne pathogens — United States



* Hemolytic uremic syndrome.

† Involved municipal water supplies.

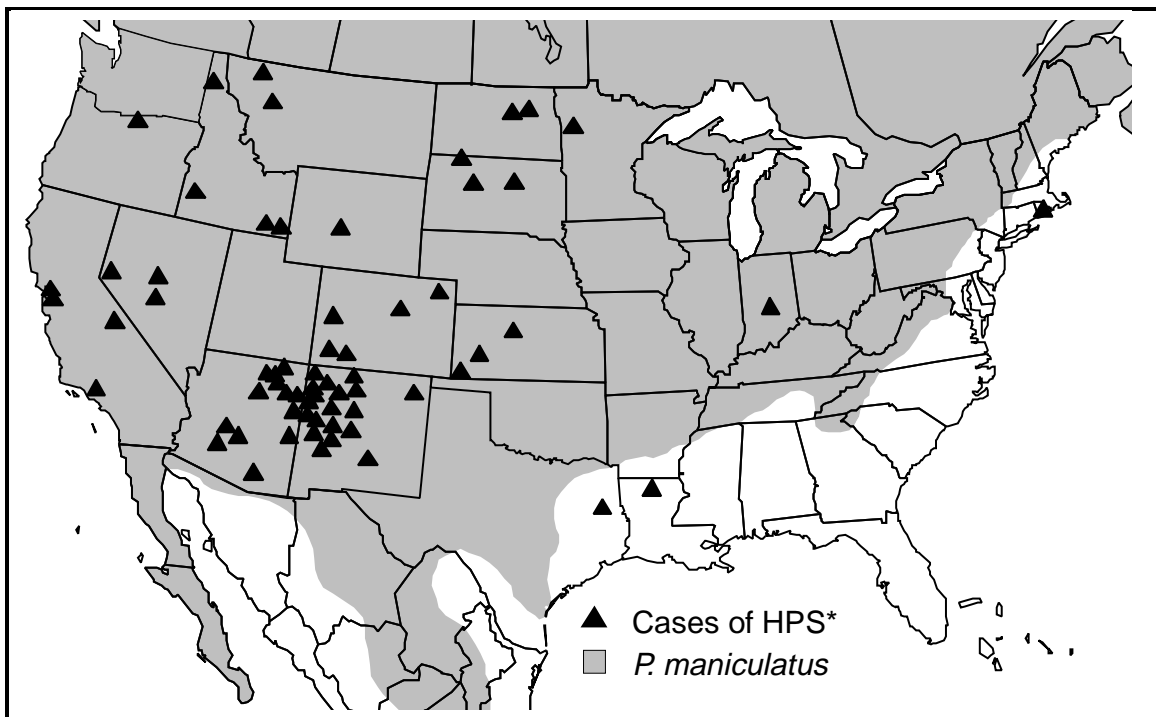
§ Acquired immunodeficiency syndrome.

states. For example, in 12 of the 50 states surveyed, no professional position is dedicated to surveillance of foodborne and waterborne diseases. Funding for infectious disease surveillance is restricted primarily to diseases for which public health crises have already developed. In 1992, more than 95% of federal funds allocated to states for infectious disease surveillance were targeted to four disease categories (i.e., TB, HIV/AIDS, sexually transmitted diseases [STDs], and selected vaccine-preventable diseases) (personal communication, M. Osterholm, Council of State and Territorial Epidemiologists survey on surveillance). However, no federal resources are provided to state and local health departments to support the national notifiable disease system. In addition, the ability of state public health laboratories to support the surveillance and control of infectious diseases has diminished (47).

Timely recognition of emerging infections requires early warning systems to detect such problems so they may be promptly investigated and controlled before they evolve into public health crises. Prompt detection of these new threats depends on careful monitoring by effective surveillance systems; on a thorough understanding of trends in incidence and distribution of known infectious agents; and on effective communication among clinicians, clinical laboratory personnel, and public health professionals.

The ability to detect what is new or reemerging depends on the capacity to identify and track both the routine and the unusual. Like radar or "early warning" systems that detect threats to national security, surveillance with appropriate laboratory support is a critical element in the effective defense against these diseases. Surveillance systems

FIGURE 4. Distribution of *Peromyscus maniculatus* and number of recognized cases of hantavirus pulmonary syndrome, selected geographic regions, as of March 23, 1994



*Hantavirus pulmonary syndrome.

are the most important tools for determining which infectious diseases are emerging or receding.

Effective surveillance also provides a basis for evaluating the outcome of both public health and personal medical-care programs. Surveillance information is essential to ensure the use of the most efficacious and cost-effective approaches to preventive, as well as curative, health care. Regardless of the direction of health-care reform, surveillance will be critical to the meaningful evaluation of new prevention programs.

In addition to comprehensive and innovative surveillance systems, effective preparation for detecting, preventing, and controlling emerging infectious diseases requires sound foundations in professional expertise, laboratory support, and research capability to strengthen the infrastructure needed to address the ongoing, but often changing, threats from emerging infections. Despite the continued emergence of such threats, support for applied research and control efforts has declined over the past decade.

Three recent reports by expert committees convened by the National Academy of Science's Institute of Medicine (IOM) have indicated that the ability of the U.S. public health system and health professionals to address emerging infectious disease problems is in jeopardy (3,48,49). The earliest of these reports, "The U.S. Capacity to Address Tropical Infectious Disease Problems" (48), documented the inadequate state of readiness to recognize, treat, or control infectious disease threats emanating from the tropics—regions that have yielded microbial threats such as Lassa fever and Ebola viruses, chloroquine-resistant malaria, and penicillin-resistant gonorrhea. The second report, "The Future of Public Health," concluded that the U.S. public health system is in disarray. This report emphasized that the U.S. approach to public health has too often been crisis driven, an approach that is costly because it constrains the institution of cost-saving preventive strategies (49).

The third IOM report, "Emerging Infections, Microbial Threats to Health in the United States," emphasized the ongoing threat to domestic and global health from emerging infectious diseases (3). The report provided specific recommendations for CDC, the National Institutes of Health, the Food and Drug Administration, the Department of Defense, and other federal and state agencies for addressing microbial threats to health in the United States and elsewhere. This report emphasized a critical leadership role for CDC in a national and global effort to detect and control emerging infectious disease threats.

THE CDC PREVENTION STRATEGY

To effectively detect and prevent emerging infections, improvements are needed in public health systems, program design, and infrastructure. To accomplish these improvements and to achieve the objectives of *Healthy People 2000*, CDC has developed a strategy to address these microbial threats. Because meeting the broad challenge of emerging infections requires interaction, cooperation, and coordination among a wide range of public and private organizations, the development of this strategy has taken place in partnership with state and local health departments, other federal agencies, academic institutions, health-care providers, medical laboratory personnel, and international organizations.

The prevention strategy outlined in this document contains four critical goals that address, in a broader context, specific IOM recommendations for revitalizing the ability to identify, contain, and, most importantly, prevent illness from emerging infectious diseases (Box 2).

Goal I (Surveillance) emphasizes the improvement and expansion of surveillance capabilities for infectious diseases in the United States and internationally. This goal includes plans for strengthening local and state public health programs for infectious disease surveillance, establishing provider-based sentinel surveillance networks, and creating population-based Emerging Infections Epidemiology and Prevention Centers at different sites throughout the United States (Table 2). Also included are plans for a global consortium of closely linked epidemiology/biomedical research centers to promote the detection, monitoring, and investigation of emerging infections (Box 3). Other objectives emphasize improved detection and monitoring of trends in antimicrobial resistance in both institutional and community settings; expansion of field investigations and epidemic response capabilities; prevention of foodborne and waterborne infectious diseases and improved knowledge of the distribution of animal reservoirs and vectors associated with human infectious diseases.

Goal II (Applied Research) focuses on applied research and the integration of laboratory science and epidemiology with public health practice. Emphasis is placed on determining how behavioral factors influence exposure to new infections; better characterizing the health burden of both well-established and emerging infections; and evaluating the effectiveness and economic benefit of strategies to prevent emerging infectious diseases. An additional focus is the development and application of improved laboratory techniques for the identification of new pathogens and the expanded use of molecular epidemiologic techniques in investigating emerging diseases. Supporting the national Childhood Immunization Initiative by conducting vaccine efficacy studies and improving rapid response capabilities for vaccine development and delivery is also a priority. A final focus is the reestablishment of CDC extramural programs to promote effective partnerships with public agencies, universities, and private industry and to support applied research in surveillance, epidemiology, and prevention of emerging infections.

Goal III (Prevention and Control) addresses enhanced communication of public health information and the implementation of prevention strategies for emerging infections. Highlighted under this goal are proposals for expanded dissemination of the *MMWR*, as well as other important public health information sources. Another priority is the creation of an accessible and comprehensive infectious disease database for the United States that increases awareness of infectious diseases and promotes public health action. The database will contain current information on topics such as antimicrobial resistance, foodborne and waterborne disease outbreaks, travelers' health, antimicrobial drug availability, vaccine-preventable diseases, and vaccine guidelines. This goal also addresses the development and implementation of guidelines for preventing emerging infectious diseases and the provision of critical prevention materials.

BOX 2. Summary of goals and objectives for preventing illness from emerging infectious diseases**Goal I: Surveillance**

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

Objectives:

- Expand and coordinate surveillance systems for the early detection, tracking, and evaluation of emerging infections in the United States.
- Develop more effective international surveillance networks for the anticipation, recognition, control, and prevention of emerging infectious diseases.
- Improve surveillance and rapid laboratory identification to ensure early detection of antimicrobial resistance.
- Strengthen and integrate programs to monitor and prevent emerging infections associated with food/water, new technology, and environmental sources.
- Strengthen and integrate programs to monitor, control, and prevent emerging vector-borne and zoonotic diseases.

Goal II: Applied Research

Integrate laboratory science and epidemiology to optimize public health practice.

Objectives:

- Expand epidemiologic and prevention effectiveness research.
- Improve laboratory and epidemiologic techniques for the rapid identification of new pathogens and syndromes.
- Ensure timely development, appropriate use, and availability of diagnostic tests and reagents.
- Augment rapid response capabilities for vaccine production and delivery and expand evaluation of vaccine efficacy and the cost effectiveness of vaccination programs.

Goal III: Prevention and Control

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

Objectives:

- Use diverse communication methods for wider and more effective delivery of critical public health messages.
- Establish the mechanisms and partnerships needed to ensure the rapid and effective development and implementation of prevention measures.

Goal IV: Infrastructure

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

Objectives:

- Ensure the ready availability of the professional expertise and support personnel needed to better understand, monitor, and control emerging infections.
- Make available state-of-the-art physical resources (e.g., laboratory space, training facilities, and equipment) needed to safely and effectively support the preceding goals and objectives.

Goal IV (Infrastructure) deals with issues relating to local, state, and federal infrastructure, particularly personnel and physical resources. Points of emphasis include maintaining expertise in rare or unusual infectious diseases and establishing training programs that emphasize the diagnosis of infectious diseases. A public health laboratory fellowship in infectious diseases is proposed. Also emphasized is the need for state-of-the-art physical resources such as laboratory space, training facilities, and equipment. Laboratory capabilities must be maintained in a manner that optimizes flexibility and "surge capacity" so that unanticipated public health threats can be adequately, efficiently, and safely addressed. Plans for expanding facilities for maintaining specimen banks of etiologic agents and clinical specimens are also a priority.

IMPLEMENTATION

This plan reflects CDC's commitment to meet the urgent public health challenge of important emerging infectious diseases. The need to proceed rapidly is made more urgent for many reasons. Many diseases pose an immediate danger. For example, methicillin-resistant *Staphylococcus aureus*, a common cause of hospital infections, may potentially develop resistance to vancomycin (29,50); penicillin resistance is spreading in *Streptococcus pneumoniae* (29,31,51); the potential exists for extension of the current cholera epidemic in Latin America to the Caribbean Islands (24); and *Vibrio cholerae* O139, a new strain for which existing cholera vaccines are ineffective and prior infection with *V. cholerae* O1 affords no protection, is spreading throughout

TABLE 2. Potential projects for Emerging Infections Epidemiology and Prevention Centers, United States

| Potential center locations | Center Projects | | | | | |
|----------------------------|--|---|---|--|---|--|
| | Unexplained deaths of possible infectious etiology in young adults | Foodborne disease surveillance and prevention | Prevention of opportunistic infections in HIV-* infected inner-city populations | Drug resistance in nursing homes and day care facilities | Febrile and diarrheal illness in migrant farm workers | Etiologic agents of community-acquired pneumonia |
| Northeast | X | X | X | | | |
| Mid-Atlantic | X | X | X | X | | X |
| Southeast | X | X | X | | X | |
| South | X | X | X | | X | X |
| Midwest | X | X | | X | X | |
| Southwest | X | X | | X | | X |
| West | X | X | X | X | X | |
| Northwest | X | X | | X | X | X |
| U.S. Pacific Islands | X | X | | | | X |
| U.S. Caribbean Islands | X | X | X | | | |

* Human immunodeficiency virus.

southern Asia (Figure 5) (52,53). Changing food-industry practices, dietary choices, and globalization of food supplies will bring new challenges to provide a diet safe from pathogens such as *Salmonella sp.* and *E. coli* O157:H7 (37,38,54–57). Ongoing investigations of hantavirus pulmonary syndrome document that the geographic distribution of this infection goes beyond the desert Southwest (23). These infectious disease problems emphasize the necessity of expeditiously implementing this plan through a balanced intramural and extramural effort.

The implementation of the goals and objectives in this plan is relevant to health-care reform. Examples of relevant issues include prolonged hospitalizations caused by hospital-acquired infections; increased morbidity and treatment costs resulting from antimicrobial drug resistance; and excessive burdens placed on public and private health-care delivery facilities because of community-wide outbreaks of food-borne and waterborne infections.

Some of the activities listed in this document are already in the planning stages and will be implemented soon. Many of the proposed activities need further development

BOX 3. Examples of potential members of a global consortium of epidemiology/ biomedical research programs/ centers

Existing networks

- CDC Field Epidemiology Training Programs
- International Clinical Epidemiology Network
- International Office of Epizootics Worldwide Information System
- Pan American Health Organization-CDC Dengue Surveillance Laboratory Network
- Pan American Health Organization Polio Eradication Laboratory Surveillance Network
- World Health Organization Arbovirus and Hemorrhagic Fever Collaborating Centers
- World Health Organization Global Influenza Surveillance Network

Existing research facilities

- Caribbean Epidemiology Centre, Trinidad
- CDC: National Center for Infectious Diseases Field Stations (Côte d'Ivoire, Guatemala, Puerto Rico, Kenya, Sierra Leone, and Thailand)
- Department of Defense: U.S. Army Research Facilities (Brazil, Kenya, Thailand) and U.S. Naval Research Facilities (Egypt, Indonesia, Peru, Philippines)
- Food and Agriculture Organization Reference Centers (Argentina, Brazil, Colombia, Czech Republic, France, Germany, Hungary, Kenya, Panama, Senegal, Spain, Sri Lanka, Thailand, United Kingdom, Uruguay, and the United States)
- French Scientific Research Institute (e.g., Senegal, Congo, Côte d'Ivoire)
- Instituto de Nutrición para Centroamérica y Panamá, Guatemala
- International Center for Diarrhoeal Disease Research, Bangladesh
- National Institutes of Health, National Institute of Allergy and Infectious Diseases-supported facilities (Brazil, Colombia, Israel, Mali, Mexico, Philippines, Sudan, Uganda, Venezuela, and Zimbabwe)
- Pasteur Institutes (e.g., Algeria, Central African Republic, French Guiana, Iran, Madagascar, Morocco, New Caledonia, Senegal, and Vietnam)

in full cooperation with other federal agencies, state and local health authorities, academic institutions, professional societies, private industry, and others. With this document serving as both a guide and a first step, implementation will be based on public health priorities and resource availability. This process will be approached in stages, as a long-term endeavor with sustainable impact and emphasis on extramural programs (Box 4).

The strategy of this plan is based on repeated experience demonstrating that it is less costly to anticipate and prevent infectious disease threats than to react with expensive treatment or containment measures to public health crises. Public health policy and practice that combine investments in surveillance, laboratory research and training, and epidemiologic investigations with prevention and control efforts will reduce the impact of emerging infectious disease threats, in terms of both human suffering and economic losses.

BOX 4. Implementation: high priorities for 1994–1996

Goal I: Surveillance

- Strengthen notifiable disease surveillance at state and local levels.
- Establish two physician-based Sentinel Surveillance Networks to detect and monitor emerging diseases, such as unexplained adult respiratory distress syndrome, drug-resistant pneumococcal disease, and childhood illnesses characterized by fever and rash.
- Establish four population-based Emerging Infections Epidemiology and Prevention Centers to conduct focused epidemiology/prevention projects emphasizing foodborne and waterborne infectious diseases and potentially vaccine-preventable diseases.
- Strengthen and link four existing research facilities/networks for a global consortium to promote the detection, monitoring, and investigation of infections emerging internationally that could affect the health of U.S. residents.

Goal II: Applied Research

- Reestablish an extramural 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.
- Initiate prevention effectiveness studies to assess the impact of food preparation guidelines on the incidence of foodborne infections such as *E. coli* O157:H7 and *Salmonella enteritidis*.

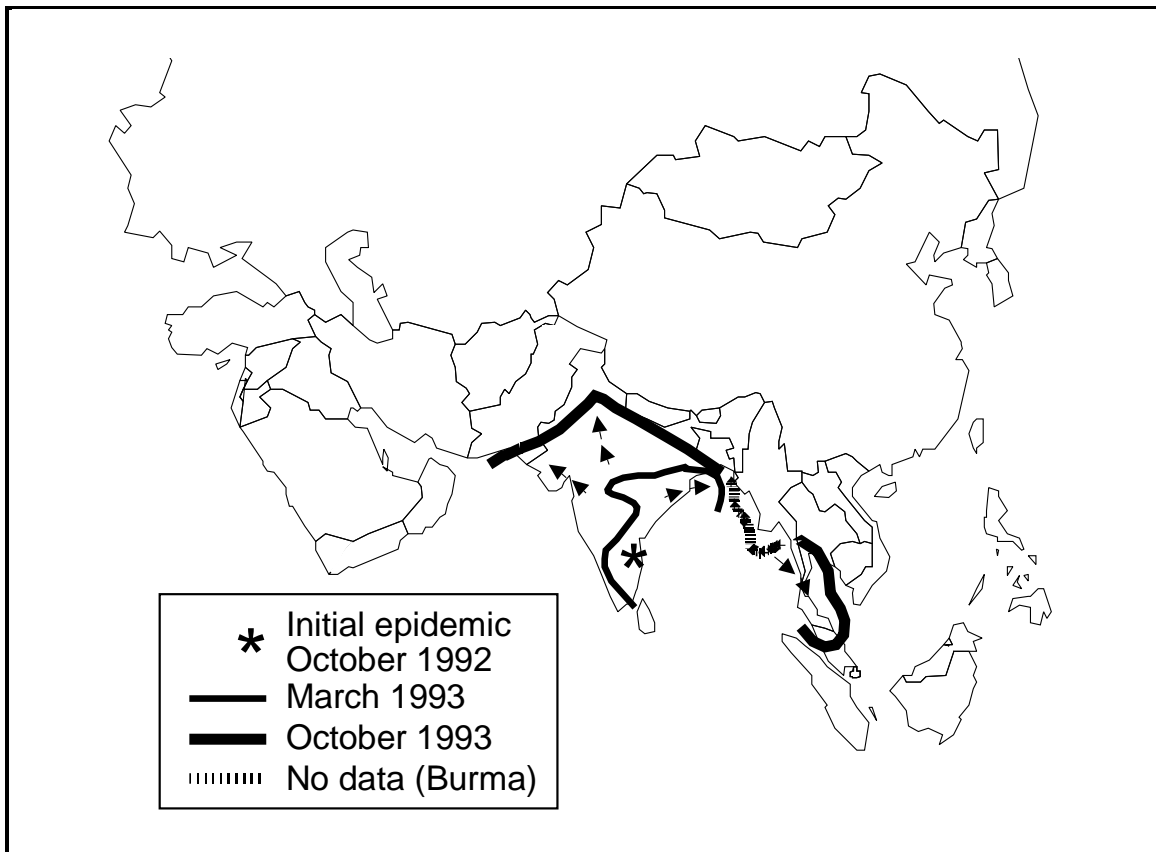
Goal III: Prevention and Control

- Develop additional means to deliver laboratory and public health information informing health professionals about emerging infections and antimicrobial drug resistance.
- Develop and implement guidelines for the prevention of opportunistic infections in immunosuppressed persons.

Goal IV: Infrastructure

- Provide state-of-the-art training in diagnostic evaluation and testing for medical laboratory personnel to ensure the diagnosis and surveillance of emerging infections.
- Establish a public health laboratory fellowship in infectious diseases that will train medical microbiologists in public health approaches to diagnosis and molecular epidemiology.

FIGURE 5. Migratory path of *Vibrio cholerae* O139 (Bengal) — Asia, 1992–1993



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