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Preface

The spectrum of infectious disease is changing rapidly in conjunction with dramatic changes in our society and environment. Worldwide, there is explosive population growth with expanding poverty and urban migration; international travel is increasing; and technology is rapidly changing—all of which affect our risk of exposure to the infectious agents with which we share our environment. Despite historical predictions to the contrary, we remain vulnerable to a wide array of new and resurgent infectious diseases.

The President's Health Security Act of 1993 addresses the need for universal health care coverage as well as the need to enhance community-based public health strategies. As our nation proceeds with health care reform, we must identify those public health priorities that need to be addressed at the community level as well as those that can be addressed by individual patient care providers. Preventing infectious diseases must be a high priority in a reformed health care system and requires close cooperation between clinicians and public health professionals.

Our vulnerability to emerging infections was dramatically demonstrated in 1993. A once obscure intestinal parasite, *Cryptosporidium*, caused the largest waterborne disease outbreak ever recognized in this country; an emerging bacterial pathogen, *Escherichia coli* O157:H7, caused a multi-state foodborne outbreak of severe bloody diarrhea and kidney failure; and a previously unknown hantavirus, producing an often fatal lung infection, was linked to exposure to infected rodents.

In recent years, our antimicrobial drugs have become less effective against many infectious agents, and experts in infectious diseases are concerned about the possibility of a "post-antibiotic era." At the same time, our ability to detect, contain, and prevent emerging infectious diseases is in jeopardy.

Since 1987, the National Academy of Science's Institute of Medicine has published three reports, each of which documents, from different perspectives, the urgent need to improve our ability to identify infectious disease threats and respond to them effectively. To meet this urgent need, we must improve the public health infrastructure at the local, state, and federal levels and recognize that the health of the American people is inextricably linked to the health of people in other nations; infectious diseases can and do spread rapidly around the globe; and global surveillance for emerging infections is vital to public health.

In partnership with local and state public health officials, other federal agencies, medical and public health professional associations, infectious disease experts from academia and clinical practice, and international and public service organizations, the Centers for Disease Control and Prevention (CDC) has developed a plan that addresses the priorities set forth in the three Institute of Medicine reports and *Healthy People 2000* and serves as a guide for CDC to work in collaboration with its partners in safeguarding this nation from the threat of emerging infectious diseases.

Development of this plan began in December 1992 at a meeting of the Board of Scientific Counselors of CDC's National Center for Infectious Diseases. Guidance was subsequently obtained at a meeting of infectious disease and public health experts in Atlanta in March 1993 and at a meeting of state and territorial public health epidemiologists, laboratory directors, and veterinarians in Minneapolis in June 1993. Drafts of this plan have also been reviewed by leaders of numerous medical, scientific, and public health organizations. The assistance obtained throughout this process has been invaluable in ensuring that the plan reflects the public health concerns of a large number of medical and public health experts.

Plan implementation will require long-term collaborations and partnerships with clinicians, microbiologists, public agencies, universities, private industry, and communities. As the Nation's Prevention Agency, CDC looks forward to working with its many partners to address the challenges of emerging infectious disease threats.

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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*

Once expected to be eliminated as a public health problem, infectious diseases remain the leading cause of death worldwide. Dramatic changes in society, technology, and the environment together with the diminished effectiveness of certain approaches to disease control have propelled this nation and the rest of the world into a new era; the spectrum of infectious diseases is expanding and many infectious diseases once thought conquered are increasing.

To effectively address emerging infectious diseases, the Centers for Disease Control and Prevention (CDC) has developed a strategic plan emphasizing surveillance, applied research, and prevention activities critical to maintaining a strong defense against infectious diseases that affect, or threaten to affect, the public's health. The goals of this plan are as follows:

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

Both individual health care coverage and core public health functions are needed to maintain health at the community level. Implementation of this plan will be a critical step toward ensuring health security for all Americans.

The Concept of Emergence

Emerging infectious diseases are diseases of infectious origin whose incidence in humans has increased within the past two decades or threatens to increase in the near future.[1]

Many factors, or combinations of factors, can contribute to disease emergence. Newly emergent infectious diseases may result from changes or evolution of existing organisms; known diseases may spread to new geographic areas or new human populations; or previously unrecognized infections may appear in persons living or working in areas undergoing ecologic changes, such as deforestation or reforestation, that increase their exposure to insects, animals, or environmental sources that may harbor new or unusual infectious agents.[2-5]

Reemergence of infectious diseases may occur because of the development of antimicrobial resistance in existing agents (e.g., gonorrhea, malaria, pneumococcal disease) or breakdowns in public health measures for previously controlled infections (e.g., cholera, tuberculosis [TB], pertussis).

The Threat of Emerging Infections

In the United States and elsewhere, infectious diseases increasingly threaten public health and contribute significantly to the escalating costs of health care. As society, technology, and the environment change, pathogens evolve or spread, and the spectrum of infectious diseases expands.

Emerging infections, such as acquired immunodeficiency syndrome (AIDS) and TB, vividly illustrate that no nation can be complacent regarding human vulnerability to the microorganisms with which we share our environment. Since the early 1970s, the U.S. public health system has been challenged by many newly identified pathogens and syndromes, such as Lyme disease, Legionnaires' disease, toxic shock syndrome, human immunodeficiency virus/AIDS, hepatitis C virus, cryptosporidiosis, and, most recently, hantavirus.

In addition, the incidence of many diseases widely presumed to be under control—such as cholera, dengue, yellow fever (YF), and TB—has increased in many areas or spread to new regions or populations throughout the world. As a consequence of widespread use and misuse of antimicrobial drugs, this country also faces the emergence of drug-resistant pathogens. Even drugs used in the treatment of common bacterial infections are becoming increasingly ineffective, resulting in prolonged illnesses, higher mortality rates, and higher health care costs.

Emerging infections are particularly serious in persons with lowered immunity, such as those infected with HIV and those receiving medications for cancer or organ transplantation, whose numbers are increasing. Others who may be disproportionately affected by emerging infections include the elderly; persons living in institutional settings, such as hospitals and nursing homes; and those with inadequate access to health care, such as the homeless, migrant farm workers, and others of low socioeconomic status.

The number of children attending child care facilities has increased dramatically in the past decade as mothers of young children have increasingly entered the workforce. These children, now numbering over 11 million, are at a markedly increased risk for enteric infections, such as hepatitis A, giardiasis, and cryptosporidiosis; respiratory illnesses; and middle ear infections. Additionally, many of these illnesses are carried home and transmitted to other members of a household.

Examples of Emerging Infectious Diseases, United States, 1993

- *E. coli* O157:H7 disease
- Cryptosporidiosis
- Coccidioidomycosis
- Multidrug-resistant pneumococcal disease
- Vancomycin-resistant enterococcal infections
- Influenza A/Beijing/32/92
- Hantavirus infections

Examples of Emerging Infectious Diseases, Outside the United States, 1993

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

Emerging infections transmitted by contaminated foods and public water supplies place entire communities at risk. Early in 1993, hamburgers contaminated with the bacterial pathogen *Escherichia coli* O157:H7 and served at a fast-food restaurant chain caused a multi-state outbreak of hemorrhagic colitis (bloody diarrhea) and serious kidney disease, resulting in the deaths of at least four children. 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.

Lack of surveillance and limited availability of appropriate diagnostic tests interfere with public health efforts to prevent and control outbreaks. Both *E. coli* O157:H7 and *Cryptosporidium* were first recognized as significant human pathogens in the early l980s, but neither has received adequate public health attention.

Exposure to certain animals is also placing Americans at risk for emerging infectious diseases. Hantavirus pulmonary syndrome (HPS), first detected in the southwestern United States in 1993, has been linked to exposure to infected rodents in over a dozen states. More than 50 cases have been detected and more than half of those infected have died.

Once considered "exotic," tropical infectious diseases are having an increasing effect on the American public. Although the true impact is unknown, several recent examples include severe illness and at least one death due to cholera among international airline passengers arriving in California; malaria in residents of southern California and immigrants in North Carolina; fever and heart failure in New York and Canada among patients who received blood transfusions contaminated with the bloodborne parasite that causes Chagas disease in Latin America; and a newly described form of the parasitic blood and bone marrow infection, leishmaniasis, in troops returning from the Persian Gulf conflict.

From a historical perspective, cholera, smallpox, and plague are examples of infectious diseases that spread globally with devastating impact, often occurring during periods of rapid economic change or population growth.[5] In modern times, travel and commerce have fostered the worldwide spread of HIV/AIDS and influenza as well as the reemergence of cholera as a global health threat. As Nobel Laureate Dr. Joshua Lederberg has stated, "The microbe that felled one child in a distant continent yesterday can reach yours today and seed a global pandemic tomorrow." Clearly, emerging infections can affect people everywhere, regardless of lifestyle, cultural or ethnic background, or socioeconomic status.

The public health infrastructure of this country is poorly prepared for the emerging disease problems of a rapidly changing world. Current systems that monitor infectious diseases domestically and internationally are inadequate to confront the present and future challenges of emerging infections. Many foodborne and waterborne disease outbreaks go unrecognized or are detected late; the magnitude of the problem of antimicrobial drug resistance is unknown; and global surveillance is fragmentary.

Surveillance of infectious diseases in the United States is heavily dependent upon voluntary collaboration between CDC and state and local health departments, which in turn depend on physician-initiated reporting of a limited number of specific, recognized infectious diseases. Reporting is generally incomplete.

Results from a recent survey by the Council of State and Territorial Epidemiologists illustrate the inadequacy of existing infectious disease surveillance by documenting the limited number of professional positions dedicated to infectious disease surveillance in most states. For example, in 12 of the 50 states surveyed, no professional position is dedicated to surveillance of foodborne and waterborne diseases. Funding for communicable disease surveillance is largely confined to diseases for which public health crises have already developed; over 95% of funds allocated to states for infectious disease surveillance are targeted to four disease categories (TB, HIV/AIDS, sexually transmitted diseases, and selected vaccine-preventable diseases).[6] No federal resources are provided to state and local health departments to support the national notifiable disease system. Likewise, the ability of state public health laboratories to support the surveillance, diagnosis, and control of infectious diseases has diminished.

Timely recognition of emerging infections requires early warning systems to detect these diseases, so that they can be quickly investigated and controlled before they become major public health crises. Prompt detection of these new threats requires careful monitoring by effective surveillance systems, a thorough understanding of trends in incidence and distribution of known infectious agents, and good communication among clinicians, medical laboratories, and public health systems.

The ability to detect what is new or reemerging depends on the capacity to identify and track the routine as well as the unusual. Like radar or "early warning" systems that detect threats to national security, surveillance with appropriate laboratory support is critical to an effective defense against these diseases. They are the most important tools for determining which infectious diseases are emerging, causing serious public health problems, or receding.

Effective surveillance also provides a basis for evaluating the outcome of both public health and personal medical care programs. Surveillance information can ensure the use of the most efficacious and cost-effective approaches to preventive, as well as curative, health care. Whatever shape health care reform takes in this country, surveillance will be key to the meaningful evaluation of new programs.

In addition to comprehensive and innovative surveillance systems, effective preparation for emerging infectious diseases requires sound foundations in professional expertise, laboratory support, and research capability. These foundations support 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 for most infectious diseases.

As highlighted in three recent reports by expert committees convened by the National Academy of Science's Institute of Medicine (IOM), the ability of the U.S. public health system and our health professionals to deal with emerging infectious disease problems is in jeopardy.[1,7,8] The earliest of these reports, "The U.S. Capacity to Address Tropical Infectious Disease Problems,"[7] published in 1987, documented our poor state of readiness to recognize, treat, or control infectious disease threats emanating from the tropics—regions which have yielded such microbial threats as Lassa fever and Ebola viruses, chloroquine-resistant malaria, and penicillin-resistant gonorrhea. The second IOM report, "The Future of Public Health," published in 1988, concluded that the U.S. public health system is in disarray. It emphasized that U.S. approach to public health has too often been crisis driven, an approach that is costly because it blocks our ability to institute cost-saving preventive strategies.[8]

The third IOM report, "Emerging Infections, Microbial Threats to Health in the United States," published in 1992, emphasized the ongoing threat to domestic and global health from emerging infectious diseases.[1] The report provided specific recommendations for CDC, the National Institutes of Health, the Food and Drug Administration, the Department of Defense, and other state and federal 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, significant improvements are needed in public health systems, program design, and infrastructure. Toward this end and the achievement of 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, international organizations, health care providers, medical laboratory personnel, and others.

CDC's plan, "A Prevention Strategy for the United States," contains four critical goals that address, in a broader context, specific IOM recommendations for revitalizing our nation's ability to identify, contain, and most importantly, prevent illness from emerging infectious diseases (Table, page 6).

- **Goal I (Surveillance)** emphasizes the improvement and expansion of infectious disease surveillance in the United States and internationally. Included under this goal are 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 various sites across the United States. 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. Other objectives emphasize improved detection and monitoring of trends of antimicrobial resistance in institutional as well as community settings; expansion of field investigations and epidemic response capabilities; detection and prevention of foodborne and waterborne infections; 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 the emergence or prevention of new infections; better characterizing the public health and economic impact 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 identifying new pathogens and the expanded use of molecular epidemiology in investigating emerging diseases. Priorities also include improving rapid response capability and contingency plans for the emergence of new strains of known pathogens, and conducting vaccine efficacy studies to support the President's Childhood Immunization Initiative. An additional priority is the reestablishment of CDC extramural programs to promote effective partnerships with public agencies, universities, and private industry and to support 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 plans for expanded dissemination of CDC's *Morbidity and Mortality Weekly Report*), as well as other important public health information sources. Another priority is the creation of an accessible and comprehensive U.S. infectious disease database that increases awareness of infectious diseases and promotes public health action. The database will contain information on such topics as antimicrobial resistance, foodborne and waterborne disease outbreaks, travelers' health, antimicrobial drug availability, vaccine preventable diseases, and vaccine guidelines. Other activities address the development and implementation of guidelines for preventing emerging infectious diseases and the provision of prevention information.

- **Goal IV (Infrastructure)** deals with issues relating to local, state, and federal infrastructures, 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—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. Also proposed are plans for expanding facilities for maintaining specimen banks of etiologic agents and clinical specimens.

This plan reflects CDC's commitment to meet the challenge of important emerging public health problems. The need to proceed rapidly is made more urgent by a number of diseases that pose an immediate danger: methicillin-resistant *Staphylococcus aureus*, a common cause of hospital infections, may be developing resistance to vancomycin; penicillin resistance is spreading in *Streptococcus pneumoniae*; cholera will

likely be introduced into the Caribbean islands from the current pandemic in Latin America, and the new strain, *Vibrio cholerae* O139, is spreading throughout southern Asia; changing food industry practices, dietary choices of the American people, and globalization of food supplies will bring new challenges to providing a diet safe from pathogens such as *Salmonella* sp. and *E. coli* O157:H7; and ongoing investigations of HPS document that the geographic distribution of this infection is much broader than the desert Southwest. These infectious disease problems demonstrate the urgency for expeditiously implementing this plan.

The goals and activities in this plan are consistent with the goals set forth in recently proposed plans for health care reform. Examples of issues in infectious disease emergence that are particularly relevant to these plans include prolonged hospitalizations caused by hospital-acquired infections; increased morbidity and treatment costs resulting from antimicrobial resistance; and excessive burdens placed on public and private health care facilities due to community-wide outbreaks of foodborne and waterborne infections.

Some of the activities listed in this document are already in the planning stages and will be implemented soon. Most will require additional funds and personnel. Specific details of many of the proposed activities need further development in full cooperation with other federal agencies, state and local health authorities, academic institutions, professional societies, private industry, and others. With this document as a guide and a first step, implementation will be based on public health needs and resource availability. This process will be approached in stages, as a long-term endeavor with sustainable impact and emphasis on extramural programs (Table).

This strategy is based upon the premise that it is far less costly, in both human suffering and economic terms, to anticipate and prevent infectious diseases than to react with expensive treatment or containment measures to unanticipated public health crises. Implementation of this plan does not guarantee that a microorganism will not cause disaster. However, investments in surveillance, laboratory research and training, epidemiologic investigations, and integration with prevention and control efforts will ensure that we are better prepared to respond to emerging infectious disease threats and to lessen their impact. It is crucial that emerging infectious diseases be addressed and that the basic tenets of prevention-oriented public health policy form an integral component of our nation's efforts to safeguard health in our communities.

Table. Implementation: High Priorities for 1994–1996

Goal I: Surveillance

- Strengthen notifiable disease surveillance at the state and local levels.
- 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.
- 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 sites for a global consortium to promote the detection, monitoring, and investigation of infections emerging internationally that could affect the health of Americans.

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.

Summary of Goals and Objectives

Goal I: ***Surveillance***
Detect, promptly investigate, and monitor emerging pathogens, the diseases they cause, and the factors influencing their emergence.

Objectives:

A. Expand and coordinate surveillance systems for the early detection, tracking, and evaluation of emerging infections in the United States.

B. Develop more effective international surveillance networks for the anticipation, recognition, control, and prevention of emerging infectious diseases.

C. Improve surveillance and rapid laboratory identification to ensure early detection of antimicrobial resistance.

D. Strengthen and integrate programs to monitor and prevent emerging infections associated with food/water, new technology, and environmental sources.

E. 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:

A. Expand epidemiologic and prevention effectiveness research.

B. Improve laboratory and epidemiologic techniques for the rapid identification of new pathogens and syndromes.

C. Ensure timely development, appropriate use, and availability of diagnostic tests and reagents.

D. Augment rapid response capabilities for vaccine 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:

A. Use diverse communication methods for wider and more effective delivery of critical public health messages.

B. 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:

A. Ensure the ready availability of the professional expertise and support personnel needed to better understand, monitor, and control emerging infections.

B. Make available state-of-the-art physical resources (laboratory space, training facilities, equipment) needed to safely and effectively support the preceding goals and objectives.