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Preventing Emerging Infectious Diseases As We Enter the 21st Century: CDC's Strategy

INFECTIOUS DISEASES ARE THE MAJOR CAUSE OF DEATH WORLDWIDE and among the leading causes of illness and death in the United States. Although public health measures such as improvements in sanitation, widespread vaccine coverage, and the use of antimicrobial agents have markedly reduced mortality from these diseases, most human infectious diseases continue to circulate. The importance of continued public health vigilance is illustrated by the resurgence of tuberculosis in the United States in the 1980s¹ and of diphtheria in the former Soviet Union in the 1990s.² Although we have no way of knowing when or where, new diseases will continue to emerge, carrying with them the threat of disastrous consequences.

In 1994, the Centers for Disease Control and Prevention (CDC) released *Addressing Emerging Infectious Diseases: A Prevention Strategy for the United States*.³ The implementation of this strategy is well underway. In September 1998, CDC issued an update, *Preventing Emerging Infectious Diseases: A Strategy for the 21st Century*,⁴ taking into account recent discoveries and public health developments such as:

The emergence of new threats and reemergence of old problems. Cases of new variant Creutzfeldt-Jakob disease, probably related to eating contaminated beef, were described in England in 1996, creating fears of a huge epidemic of this fatal neurologic condition.⁵ Reports in 1997 of cases of *Staphylococcus aureus* with reduced susceptibility to vancomycin in Japan and the United States raised the specter of a return to the pre-antibiotic era.⁶ The same year, an outbreak of avian influenza in Hong Kong—the first time an avian influenza virus had infected humans—raised concerns about a potential pandemic.⁷

New scientific findings and technologies. Scientists are increasingly recognizing that infectious agents are important contributors to many chronic conditions formerly thought to be lifestyle-related. *Helicobacter*

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pylori is now known to be the major cause of peptic ulcer disease;⁸ CDC and others have initiated efforts to educate health care providers and patients about the use of antibiotics to cure peptic ulcers. Evidence suggests that *Chlamydia pneumoniae* may contribute to the development of atherosclerosis,^{9,10} with consequences that include heart disease and stroke. Infection with *Mycoplasma* species may contribute to unexplained and complex illnesses such as various arthritic conditions.¹¹ The list of organisms suspected to contribute to chronic diseases is growing, raising the possibility that chronic conditions ranging from coronary artery disease to arthritis to cancer may some day be prevented by vaccines or treated with antimicrobial drugs.

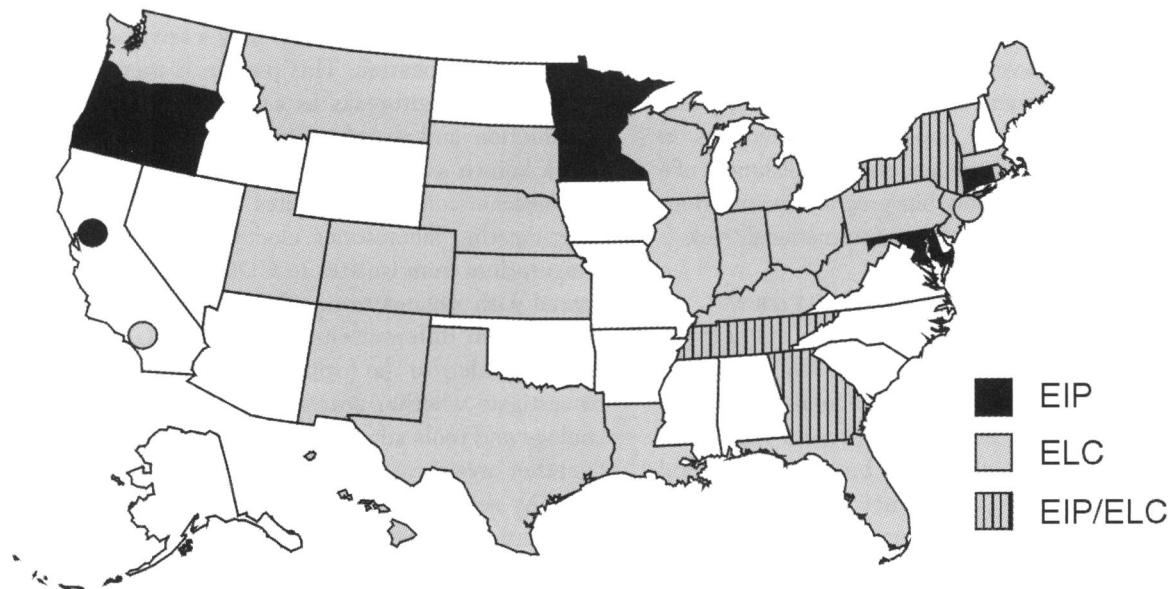
New government initiatives. The 1995 report of the Committee on International Science, Engineering, and Technology of the National Science and Technology Council¹² called for the US to work in partnership with other countries, the World Health Organization, and other international organizations to address the global problem of emerging infectious diseases. A 1996 Presidential Decision Directive called for greater coordination

among US government agencies to address infectious disease problems nationally and internationally.¹³ The 1997 National Food Safety Initiative called for a "farm-to-table" approach to reducing foodborne illness in this country.¹⁴ The Group of Eight industrialized nations and other international forums have also made surveillance of and response to emerging infectious diseases a high priority.

Changes in public health and health care delivery. As the public health landscape continues to change, state and local health departments struggle to find the resources to perform routine functions. CDC's 1994 strategy called for the development of the Epidemiology and Laboratory Capacity cooperative agreement program (see Figure). This program currently supports 30 state and local health departments. Particularly as the nation attempts to prepare for the possibility of bioterrorism, new demands are stressing the public health infrastructure.

Progress in achieving the 1994 goals and the need to build on these successes. The establishment of Emerging Infections Programs (EIPs) (see Figure) was a high priority of the 1994 plan. The eight EIPs conduct

Figure. State health departments with Epidemiology and Laboratory Capacity (ELC) and Emerging Infections Program (EIP) cooperative agreements as of December 1998



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active, population-based public health surveillance and cutting-edge research to answer key questions such as: What is the burden of foodborne and waterborne disease in the United States? What are the infectious causes of unexplained deaths and severe illnesses among young people in this country, and are these preventable? Is it cost-effective to provide prophylaxis to household contacts of patients with Group A streptococcal disease?

The EIPs also have the flexibility to respond quickly to public health crises. When new variant Creutzfeldt-Jakob disease was described in England, the EIPs (four at the time) rapidly mobilized to determine if this disease was a problem in the United States. Within weeks they reported that no cases had been detected among the population under surveillance.¹⁵

Other priorities in the 1994 plan that have been achieved include the establishment of physician-based networks to conduct surveillance for unusual diseases and syndromes; the development and implementation of guidelines for the prevention of opportunistic infections in immunosuppressed individuals; and the establishment of a public health laboratory fellowship program in infectious diseases, which now also includes an international track.

A STRATEGY FOR THE 21ST CENTURY

As infectious organisms have evolved, so too has CDC's plan to control them. The new plan focuses on nine "target areas," chosen because they represent significant human suffering and a substantial burden on societal resources: antimicrobial resistance; foodborne and waterborne diseases; diseases transmitted through blood transfusions or blood products; chronic diseases caused by infectious agents; vaccine development and use; diseases of people with impaired host defenses; diseases of pregnant women and newborns; and diseases of travelers, immigrants, and refugees.⁴ These nine target

areas are addressed by emphasizing four broad, intersecting goals:

Surveillance and response. The need to strengthen surveillance and response capacity has been an ongoing priority.^{1,16} In its 1992 report, *Emerging Infectious Diseases: Microbial Threats to Health in the United States*,¹⁷ the Institute of Medicine called for strengthening state and Federal surveillance efforts and recommended that the US take the lead in promoting a comprehensive global infectious disease surveillance system. CDC's updated plan addresses the need to integrate surveillance systems and to ensure that they are "coordinated, interconnected, comparable, and easy-to-use."¹⁸

The plan also discusses the importance of developing systems that can detect outbreaks that are geographically widespread, often with only a few cases of illness in any single location. This pattern is increasingly seen in foodborne outbreaks as a result of changes in food production and distribution practices. A national network known as PulseNet has been established to study *Escherichia coli* O157 isolates from patients and food. Participating laboratories electronically transmit DNA fingerprints from isolates to CDC, where they are compared with isolates from other locations. When fingerprints from different sites are identical, the computer sends an alert to the involved agencies, which can then investigate whether an outbreak is occurring. As technology and tools advance, this system is being extended to other organisms.

The new plan also emphasizes the importance of an international surveillance and response capacity and the need to identify unusual occurrences that may indicate a new disease or a bioterrorism incident.

Applied research. Applied research is essential for understanding emerging infectious diseases and how

to prevent and control them. A strength of many of CDC's research activities is that they combine laboratory and epidemiologic approaches. For example, nucleic acid-based fingerprinting methods have been used in diverse investigations, ranging from evaluating the likely countries of origin of measles cases in the United States¹⁹ to determining that the epidemic of HIV-1 among prostitutes in Thailand was not related to the epidemic among intravenous drug users.²⁰ Molecular subtyping will be critical in evaluating responses to HIV vaccines, development of which has for the most part focused on only a limited number of the many HIV subtypes.²¹ We anticipate that the number of molecular tools will continue to increase and that we will continue to identify new ways to apply this technology. Priorities described for applied research include improving tools for diagnosing and understanding emerging infectious diseases; identifying risk factors for infectious diseases, including infectious risk factors for chronic diseases; and developing and evaluating prevention and control strategies.

Infrastructure and training. The domestic public health infrastructure needs improvement, and the global needs are even more dramatic. Increasing numbers of complex outbreaks are testing the capacity of the US public health system. For example, a 1996 outbreak of cyclosporiasis lasted for well over a month and involved 14 states, the District of Columbia, and two Canadian provinces; the investigation reached as far as Guatemala.²² A similar outbreak in 1997 involved 13 states, the District of Columbia, and one Canadian province.²³ The international response to the occurrence of avian influenza in Hong Kong included significant assistance from at least six nations; CDC teams remained in Hong Kong for more than 60 days.

Another infrastructure issue of growing concern is the US capacity to detect and respond to potential acts of bioterrorism. The need to ensure that local, state, and Federal health agencies have certain core capacities—for example, that they can conduct surveillance and that they can mount an initial response—is addressed in the new strategy. In addition, the need for special capacities—for example, to identify organisms for which public health laboratories do not routinely test (for example, *Bacillus anthracis*, the causative agent of anthrax) or to have access to medications and vaccines (such as the smallpox vaccine) that are not provided as part of rou-

tine public health functions—is also being evaluated by CDC and others.

Prevention and control. All efforts are ultimately directed at prevention and control. CDC will work with many partners (including other government agencies, private industry, professional societies, nongovernmental organizations, and managed care organizations) to implement, support, and evaluate disease prevention activities in the US and internationally. Two new EIPs will be added and existing EIPs will be strengthened. Future priorities for the EIPs include the evaluation of new prevention strategies and the study of certain poorly understood syndromes, such as unexplained encephalitis, to learn more about their causes and how to prevent them. Another priority for CDC will be to conduct demonstration programs and develop, evaluate, and promote strategies that help health care providers and other individuals change behaviors that facilitate the transmission of diseases. For example, antimicrobial resistance is one of the most important emerging infectious disease issues in the United States today, with overprescribing of antibiotics a major contributor to this problem. CDC has recently initiated demonstration programs—one covering the entire state of Wisconsin and one in Cook County, Illinois—to assess the effectiveness of combining several strategies to reduce antimicrobial resistance.

WORKING TOGETHER TO ADDRESS EMERGING INFECTIOUS DISEASES

Preventing Emerging Infectious Diseases: A Strategy for the 21st Century was developed under the leadership of CDC's National Center for Infectious Diseases, with substantial input from CDC's National Center for HIV, STD, and TB Prevention; CDC's National Immunization Program; other components of CDC; and representatives of more than 50 organizations (including clinicians, researchers, state and local health officials, and many others). The battle against emerging infectious diseases will continue through our lifetimes and those of our children. It will require leadership from people in public health and clinical medicine, from private organizations and government, and from those who conduct research and carry out interventions in the field. We must communicate important prevention messages—the need for vaccinations, how to handle food safely, the importance of using antibiotics judiciously—to people

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throughout the world, who we hope will become our partners in this important undertaking. By joining together we can continue to reduce illness and death from infectious diseases in the United States and throughout the world. CDC looks forward to working

with its many partners in public health, health care delivery, research, and industry to implement the plan.

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References

1. Reichman LB. How to ensure the continued resurgence of tuberculosis. *Lancet* 1996;347:175-7.
2. Diphtheria epidemic—New Independent States of the former Soviet Union, 1990-1994. *MMWR Morb Mortal Wkly Rep* 1995;44:177-81.
3. Centers for Disease Control and Prevention (US). Addressing emerging infectious disease threats: a prevention strategy for the United States. Atlanta: Department of Health and Human Services; 1994.
4. Centers for Disease Control and Prevention (US). Preventing emerging infectious diseases: a strategy for the 21st century. Atlanta: Department of Health and Human Services (US); 1998.
5. World Health Organization consultation on public health issues related to bovine spongiform encephalopathy and the emergence of a new variant of Creutzfeldt-Jakob disease. *MMWR Morb Mortal Wkly Rep* 1996;45:295-6.
6. *Staphylococcus aureus* with reduced susceptibility to vancomycin—United States, 1997 [published erratum appears in *MMWR Morb Mortal Wkly Rep* 1997;46:851]. *MMWR Morb Mortal Wkly Rep* 1997;46:765-6.
7. Isolation of avian influenza A(H5N1) viruses from humans—Hong Kong, May-December 1997. *MMWR Morb Mortal Wkly Rep* 1997;46:1204-7.
8. Marshall BJ. *Helicobacter pylori*: the etiologic agent for peptic ulcer. *JAMA* 1995;274:1064-6.
9. Gupta S, Leatham EW, Carrington D, Mendall MA, Kaski JC, Camm AJ. Elevated *Chlamydia pneumoniae* antibodies, cardiovascular events, and azithromycin in male survivors of myocardial infarction. *Circulation* 1997;96:404-7.
10. Muhlestein JB, Anderson JL, Hammond EH, Zhao L, Trehan S, Schwobe EP, Carlquist JF. Infection with *Chlamydia pneumoniae* accelerates the development of atherosclerosis and treatment with azithromycin prevents it in a rabbit model. *Circulation* 1998;97:633-6.
11. Baseman JB, Tully JG. Mycoplasmas: sophisticated, reemerging, and burdened by their notoriety. *Emerg Infect Dis* 1997;3:21-32.
12. Working Group on Emerging and Re-emerging Infectious Diseases, Committee on International Science, Engineering, and Technology, National Science and Technology Council. Infectious disease—a global health threat. Washington: Government Printing Office; 1995.
13. Office of Science and Technology Policy, The White House (US). Fact sheet: addressing the threat of emerging infectious diseases. Washington: The White House; 1996 Jun 12.
14. Environmental Protection Agency (US), Department of Health and Human Services (US), Department of Agriculture (US). Food safety from farm to table: a national food-safety initiative. Washington: Government Printing Office; 1997 May.
15. Surveillance for Creutzfeldt-Jakob disease—United States. *MMWR Morb Mortal Wkly Rep* 1996;45:665-8.
16. Berkelman RL, Bryan RT, Osterholm MT, Leduc JW, Hughes JM. Infectious disease surveillance: a crumbling foundation. *Science* 1994;264:368-70.
17. Institute of Medicine. Emerging infections: microbial threats to health in the United States. Washington: National Academy Press; 1994.
18. Morris G, Snider D, Katz M. Intergrating public health information and surveillance systems. *J Public Health Management Practice* 1996;2:24-7.
19. Rota JS, Rota PA, Redd SB, Redd SC, Pattamadilok S, Bellini WJ. Genetic analysis of measles viruses isolated in the United States, 1995-1996. *J Infect Dis* 1998;177:204-8.
20. Hu DJ, Dondero TJ, Mastro TD, Gayle HD. Global and molecular epidemiology of HIV. In: Wormser GP, editor. *AIDS and other manifestations of HIV infection*. 3rd ed. Philadelphia: Lippincott-Raven Publishers; 1998.
21. Hu DJ, Dondero TJ, Rayfield MA, Richard GJ, Schochetman G, Jaffe H, et al. The emerging genetic diversity of HIV: the importance of global surveillance for diagnostics, research, and prevention. *JAMA* 1996;275:210-16.
22. Herwaldt BL, Ackers M-L, *Cyclospora* Working Group. An outbreak in 1996 of cyclosporiasis associated with imported raspberries. *N Engl J Med* 1997;336:1548-56.
23. Herwaldt B, Beach MJ, *Cyclospora* Working Group. The return of *Cyclospora* in 1997: another outbreak of cyclosporiasis in North America. *Ann Intern Med*. In press 1999. ■