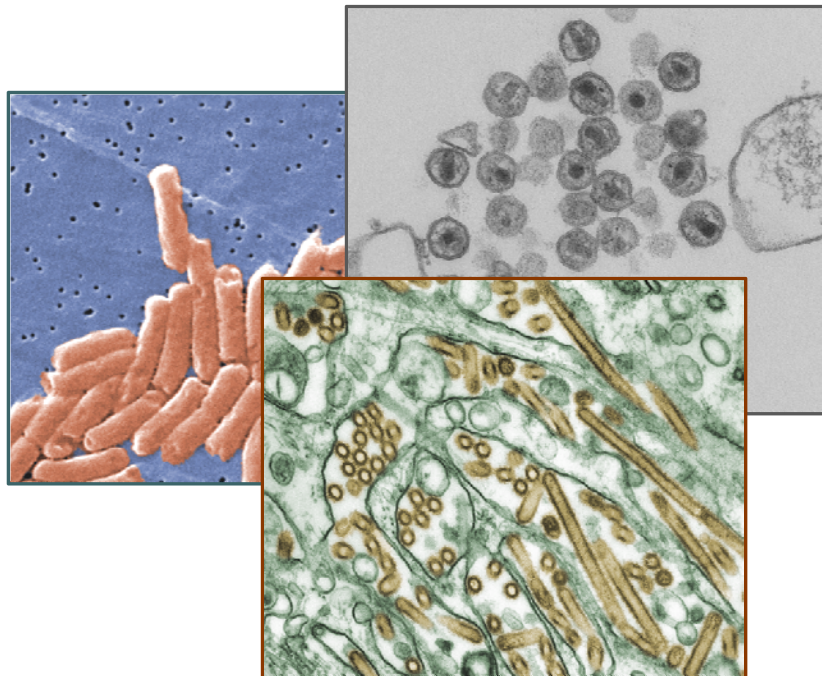


A CDC FRAMEWORK FOR PREVENTING INFECTIOUS DISEASES

*Sustaining the Essentials
and Innovating for the Future*



OCTOBER 2011

CENTERS FOR DISEASE CONTROL AND PREVENTION

Thomas R. Frieden, M.D., M.P.H., Director

Rima F. Khabbaz, M.D., Deputy Director for Infectious Diseases

OFFICE OF INFECTIOUS DISEASES

Rima F. Khabbaz, M.D., Director

INFLUENZA COORDINATION UNIT

Stephen C. Redd, M.D. (Rear Admiral, USPHS), Director

NATIONAL CENTER FOR EMERGING AND ZONOTIC INFECTIOUS DISEASES

Beth P. Bell, M.D., M.P.H., Director

NATIONAL CENTER FOR HIV/AIDS, VIRAL HEPATITIS, STD, AND TB PREVENTION

Kevin Fenton, M.D., Ph.D., Director

NATIONAL CENTER FOR IMMUNIZATION AND RESPIRATORY DISEASES

Anne Schuchat, M.D. (Rear Admiral, USPHS), Director

CENTER FOR GLOBAL HEALTH

Kevin M. De Cock, M.D., F.R.C.P., Director

Cover (clockwise from left): Salmonella sp. bacteria, HIV virions, and avian influenza A (H5N1) virions

Images on cover and on page 10 courtesy of CDC Public Health Image Library; image on page 25 courtesy of Margaret Ransbotham.

**A CDC FRAMEWORK FOR PREVENTING
INFECTIOUS DISEASES**

*Sustaining the Essentials
and Innovating for the Future*

OCTOBER 2011
Atlanta, Georgia

CONTENTS

Executive Summary	iii
Introduction	1
Elements and Priorities	8
Element 1. Strengthen public health fundamentals, including infectious disease surveillance, laboratory detection, and epidemiologic investigation	8
Element 2. Identify and implement high-impact public health interventions to reduce infectious diseases	14
Element 3. Develop and advance policies to prevent, detect, and control infectious diseases	20
Conclusion	25
References	26
 Boxes	
Box 1. Examples of infectious disease threats, unusual health events, and newly discovered pathogens, worldwide, 2000–2011	2
Box 2. Linkages between chronic and infectious diseases.....	4
Box 3. Infectious disease issues of special concern	6
(Also listed in Box 3.1 , page 16)	

EXECUTIVE SUMMARY

Infectious diseases are a leading cause of illness and death throughout the world. The enormous diversity of microbes combined with their ability to evolve and adapt to changing populations, environments, practices, and technologies creates ongoing threats to health and continually challenges our efforts to prevent and control infectious diseases.

A CDC Framework for Preventing Infectious Diseases: Sustaining the Essentials and Innovating for the Future—CDC’s ID Framework—was developed to provide a roadmap for improving our ability to prevent known infectious diseases and to recognize and control rare, highly dangerous, and newly emerging threats, through a strengthened, adaptable, and multi-purpose U.S. public health system. Although its primary purpose is to guide CDC’s infectious disease activities, the document is also designed to guide collective public health action at a time of resource constraints and difficult decisions, while advancing opportunities to improve the nation’s health through new ideas, partnerships, technical innovations, validated tools, and evidence-based policies.

The *ID Framework* outlines three critical elements in these efforts: **strong public health fundamentals**, including infectious disease surveillance, laboratory detection, and epidemiologic investigation; **high-impact interventions**; and **sound health policies**. The document also describes priority activities for achieving these essential components of public health, highlighting opportunities afforded through scientific and technological innovations, new partnerships, and the changing U.S. public health and healthcare systems.

Element 1. Strengthen public health fundamentals, including infectious disease surveillance, laboratory detection, and epidemiologic investigation

Strong public health fundamentals at the local, state, and national levels—including disease surveillance, laboratory detection, and epidemiologic investigation—are the bedrock of U.S. capacity to protect the public from infectious diseases and to save lives during outbreaks and other unusual health events. These three core activities create and sustain a flexible, multi-purpose U.S. public health system that reduces endemic diseases and is ready and able to respond to new threats. Priorities of **Element 1** include working with public health and healthcare partners to sustain and strengthen public health expertise and practice and to advance workforce development and training, ensuring that core capacities are not eroded.

- Modernize infectious disease surveillance to drive public health action
- Expand the role of public health and clinical laboratories in disease control and prevention
- Advance workforce development and training to sustain and strengthen public health practice

Element 2. Identify and implement high-impact public health interventions to reduce infectious diseases

Focused efforts to prevent and control high-burden infectious diseases can achieve dramatic results within a short time-frame, reducing disease burden and health inequities while saving lives and dollars. Priorities of **Element 2** include identifying and validating new tools for disease prevention

and control and accelerating the uptake and broad use of proven methods for decreasing illness and death from diseases and conditions of special concern.

- Identify and validate high-impact tools for disease reduction, including new vaccines; strategies and tools for infection control and treatment; and interventions to reduce disease transmitted by animals or insects
- Use proven tools and interventions to reduce high-burden infectious diseases, including vaccine-preventable diseases; healthcare-associated infections; HIV/AIDS; foodborne infections; and chronic viral hepatitis

Element 3. Develop and advance policies to prevent, detect, and control infectious diseases

Protecting the nation from infectious diseases requires sound, evidence-based health policies designed to ensure appropriate development and delivery of infectious diseases prevention measures; reduce health disparities and improve the health of vulnerable populations; and promote engagement with global partners to reduce cross-border disease spread and contain outbreaks at their source. To be most effective, these policies must reflect the best science and the best public health thinking, with broad input and consideration of varying perspectives to ensure recognition of the complex societal factors that affect the nation's health. Therefore, policy development should extend beyond the public health and healthcare communities to engage stakeholders and other partners across multiple sectors and specialties. Priorities of **Element 3** include ensuring the availability of sound scientific data to support policy development at CDC and partner organizations while working to advance established and new policies to reduce infectious diseases.

- Ensure the availability of sound scientific data to support the development of evidence-based and cost-effective policies
- Advance policies to improve prevention, detection, and control of infectious diseases to help integrate clinical infectious disease preventive practices into U.S. healthcare; increase community and individual engagement in disease prevention efforts; strengthen global capacity to detect and respond to outbreaks with the potential to cross borders; address microbial drug resistance; and promote "One Health" approaches to prevent emergence and spread of zoonotic diseases

Partnerships and implementation

Achieving CDC's vision of a strong, vigilant U.S. public health system—ready and able to prevent and control endemic diseases and respond to new and emerging threats— requires the sustained, coordinated, and complementary efforts of many individuals and groups. The *ID Framework* is designed to advance these efforts, optimally used in multiple capacities such as

- Working with state and local health departments to sustain and upgrade public health fundamentals and address priority infectious disease issues
- Coordinating with public health, healthcare, and other partners to increase actions and to formulate and advance policies that improve the nation's health
- Helping community leaders and businesses to improve local response readiness
- Educating the public about the interconnected efforts needed to prevent and control infectious diseases and their role in protecting health

INTRODUCTION

Infectious diseases are a leading cause of illness and death throughout the world. The enormous diversity of microbes combined with their ability to evolve and adapt to changing populations, environments, practices, and technologies creates ongoing threats to health and continually challenges our ability to prevent and control disease.

In low-income countries, the impact of infectious diseases is often devastating—decreasing survival rates, particularly among children, and impeding opportunities for economic growth and development. In more developed countries, infectious diseases also continue to present significant health and economic concerns. In the United States, examples of major infectious disease challenges include human immunodeficiency virus (HIV), which continues to newly infect approximately 50,000 Americans (and millions globally) each year; healthcare-associated infections (HAIs), a leading preventable cause of death; chronic viral infections, causing cancers of the liver and cervix; and drug-resistant pathogens, a major cause of severe and untreatable infections. Additional concerns include the emergence of new diseases such as the novel 2009 H1N1 influenza virus, the resurgence of “old” diseases in new locations, and local and multi-state outbreaks of foodborne diseases. Other recent examples include a resurgence of local dengue fever in Florida, a resurgence of pertussis in California that sickened infants too young to be vaccinated, and an outbreak of diarrheal disease caused by *Salmonella*-infected eggs sold throughout the country. These disease problems—endemic, new, and resurgent—cause immense suffering and death and impose enormous financial burdens on society.

A CDC Framework for Preventing Infectious Diseases: Sustaining the Essentials and Innovating for the Future—CDC’s ID Framework—was developed to provide a roadmap for improving our ability to prevent known infectious diseases and to recognize and control rare, highly dangerous, and newly emerging threats, through a strengthened, adaptable, and multi-purpose U.S. public health system.

The document was prepared by CDC’s Office of Infectious Diseases, Influenza Coordination Unit (ICU), and infectious disease national centers,* with assistance from other CDC organizational units† and input from other public and private sector experts and partner organizations. Although its primary purpose is to guide CDC’s infectious disease activities, the document is also designed to guide collective public health action at a time of resource constraints and difficult decisions, while advancing opportunities to improve the nation’s health through new ideas, partnerships, technical innovations, validated tools, and evidence-based policies.

Meeting challenges and pursuing opportunities in a new public health environment

Today’s infectious disease challenges are broader and more complex than they were in 1998, when CDC last issued a comprehensive

*The National Center for Emerging and Zoonotic Infectious Diseases; the National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention; and the National Center for Immunization and Respiratory Diseases.

†The Center for Global Health; the Office of Science, Epidemiology and Laboratory Services; the Office for State, Tribal, Local and Territorial Support; and the National Institute for Occupational Safety and Health.

Box 1. Examples of infectious disease threats, unusual health events, and newly discovered pathogens, worldwide, 2000–2011

- 2000 Outbreak of Rift Valley fever in Saudi Arabia and Yemen, representing the first reported cases of the disease outside the African continent
- 2000 First detection of carbapenem resistance among the common gram-negative bacteria *Enterobacteriaceae* (*Klebsiella pneumoniae*)
- 2001 Intentionally caused anthrax in the United States
- 2001 Identification in the Netherlands of a new virus, human metapneumovirus, among children with respiratory infections
- 2002 First detection of *Staphylococcus aureus* bacteria completely resistant to vancomycin
- 2002 Outbreak of multidrug-resistant *Salmonella* Newport in the United States
- 2002 Norovirus infection on cruise ships entering U.S. ports
- 2003 Global outbreak of severe acute respiratory syndrome (SARS) caused by a previously unknown coronavirus
- 2003 Identification of a new, hypervirulent strain of *Clostridium difficile* as the cause of hospital outbreaks of gastrointestinal illness in the United States and Canada
- 2003 Cases of monkeypox in the United States linked to exotic pets imported from Central Africa
- 2003 Re-emergence of avian influenza A (H5N1) in Southeast Asia, and outbreaks in Africa
- 2005 Marburg hemorrhagic fever outbreak in Angola
- 2005 Identification in Sweden of a new virus, human bocavirus, among children hospitalized with acute respiratory infections
- 2006 Rift Valley fever outbreak in Kenya
- 2007 Ebola hemorrhagic fever outbreak in the Democratic Republic of the Congo
- 2007 Outbreak of Nipah virus encephalitis in Bangladesh
- 2007 First detection in Italy of mosquito-borne transmission of chikungunya fever, previously detected only in parts of Africa and South and Southeast Asia
- 2007 Discovery in Thailand of a new human species of *Bartonella*, an insect-borne bacteria that multiples inside red blood cells causing fever, fatigue, muscle pain, headache, and rash
- 2007 Hemorrhagic fever outbreak in Uganda caused by a new strain of Ebola: Bundibugyo Ebola virus
- 2007 Outbreak of Marburg hemorrhagic fever in Uganda
- 2008 Ebola-like outbreak in Zambia due to a previously unknown virus: Lujo hemorrhagic fever virus
- 2008 Isolation in Australia of a new virus (transplant-associated arenavirus related to lymphocytic choriomeningitis virus) after three recipients of liver or kidney transplants from a single donor developed febrile illness and died
- 2008 Increasing outbreaks and international spread of carbapenem-resistant *Enterobacteriaceae*, and first detection of New Delhi metallo-beta-lactamase (NDM-1), a genetic element that can confer such resistance
- 2009–10 Locally transmitted dengue in Florida, representing the first cases acquired in the continental United States outside the Texas–Mexico border since 1945
- 2009–10 Influenza pandemic caused by a new influenza strain, influenza A (H1N1)
- 2010 Outbreaks of cholera in Haiti
- 2011 Outbreak of Shiga toxin-producing *Escherichia coli* O104:H4 (STEC O104:H4) infections in Germany
- 2011 Identification by an international team of researchers of a strain of gonorrhea (H041) resistant to all available antibiotics

plan to guide national efforts to prevent and control emerging infectious threats (1). Since then, new microbes or new forms of old ones have been discovered nearly every year, and infectious disease outbreaks triggering international responses have been reported on nearly every continent (Box 1). We have recent real-life examples of disease threats such as severe acute respiratory syndrome (SARS) and H5N1 and H1N1 influenza that emerged from animal reservoirs and clearly underscore the need and value of a “One Health” approach to disease prevention linking human, animal, and environmental health efforts.

While our changing, globalized world has provided increased opportunities for emergence and spread of infectious diseases, it has also brought significant advances for their control. Scientifically, we have a greater understanding of how microbes emerge, persist, develop resistance, and cause disease, including detailed knowledge of the molecular mechanisms that generate the endless flow of mutations and adaptations that make microbes difficult or impossible to “conquer.” In addition, new linkages between chronic diseases and infectious agents (Box 2) have been recognized, with some chronic diseases now prevented by vaccines or treated with antimicrobial drugs. Other advancements include increased opportunities for public health application of new technologies and innovations (e.g., molecular tools for diagnostics and epidemiology); health information technology (IT) tools—including electronic health records—for disease surveillance and health communications; and new vaccines and innovative approaches for preventing zoonotic and vectorborne diseases.

The *ID Framework* takes into account many of the scientific, demographic, technological, and economic developments currently modifying efforts to protect public health, challenging us

to re-think our processes and strategies and take advantage of new ways to prevent disease and improve health. Notable trends include an increased emphasis on disease prevention as a basic, cost-saving component of U.S. healthcare; greater individual awareness of public health issues; an aging, more susceptible population; increased public- and private-sector involvement in global health efforts; and greater recognition that the U.S. public health system is a critical part of national bioterrorism preparedness and response.

Today’s difficult economic environment has affected individuals, businesses, industries, and governments throughout the world. Budgetary and other constraints have, in turn, had a major impact on public health, requiring difficult decisions at the national, state, and local levels. Ensuring that these important decisions do not negatively affect human health because of weakened public health capacities will require broad and well-coordinated collaborative efforts to determine the best use of limited resources.

The ID Framework takes into account many of the scientific, demographic, technological, and economic developments currently modifying efforts to protect public health . . . Notable trends include an increased emphasis on disease prevention as a basic, cost-saving component of U.S. healthcare . . .

Box 2. Linkages between chronic and infectious diseases

Infectious disease can cause chronic diseases

- Infectious agents are linked to three of the six major causes of cancer death worldwide: hepatitis B and C viruses to hepatocellular carcinoma (liver cancer); human papillomavirus (HPV) to cervical cancer; and the bacteria *Helicobacter pylori* to gastric cancer.
- HIV, hepatitis viruses, and *Borrelia burgdorferi* (the tick-borne spirochete that causes Lyme disease) can cause persistent arthritis. Infections with *Neisseria gonorrhoeae* and *Chlamydia trachomatis* can also cause arthritis.
- *Tropheryma whipplei*, as well as *H. pylori*, can cause gastrointestinal disorders.
- Human T-cell lymphotropic viruses, *Mycobacterium tuberculosis*, West Nile virus, and *Treponema pallidum* (syphilis) can cause neurological disorders, especially in immunocompromised persons. Hepatitis C virus can cause depression and chronic fatigue.
- There is growing evidence linking certain infections with colon cancer and cardiovascular disease.

Some chronic diseases caused by infection can be prevented by vaccine or treated with antibiotics

- Hepatitis B virus infections and infection with the HPV strains that most commonly cause cancer are vaccine-preventable. Moreover, peptic ulcers caused by *H. pylori* can be treated with antibiotics.

Chronic conditions can increase the risk of severe illness or death from infection

- Healthcare-associated infections, including bloodstream infections and surgical site infections, are common killers of persons with conditions such as heart disease, cancer, stroke, and chronic lower respiratory disease.
- During the 2009–10 H1N1 influenza pandemic, pulmonary diseases such as asthma were found to increase the likelihood of severe illness or death from influenza. Other chronic disease risk factors for more severe H1N1 disease included neuromuscular conditions, diabetes, and obesity.

CDC's role

CDC works to protect and improve the health of people in the United States and abroad through the prevention and control of disease. As part of these efforts, CDC provides leadership and technical expertise to public health and healthcare communities in

- Conducting and facilitating the fundamental public health activities that protect populations and individuals from infectious diseases: disease surveillance, laboratory detection, and epidemiologic investigation
- Responding rapidly to outbreaks and unusual health events, at home and around the globe
- Increasing the understanding of infectious diseases, including factors contributing to transmission and disease progression.

When new diseases emerge or the cause of an outbreak is unknown, state and local health departments and foreign ministries of health often call upon CDC because of the agency's broad, collective knowledge of infectious threats.

CDC is also expanding its role in helping healthcare and community partners increase their focus on prevention to improve health and reduce health-related costs, in accordance with the 2010 Affordable Care Act and the *National Prevention Strategy* (2). These efforts include helping to monitor health outcomes, providing feedback on effective prevention practices, and offering support and guidance in establishing local prevention programs and improving outbreak response.

In addition to traditional public health partners, CDC collaborates with other federal agencies and many other partners such as animal health organizations, schools and businesses, and law enforcement and other emergency response agencies to prevent and respond to infectious disease threats. These organizations play critical roles in enhancing local capacity to respond to unusual health events, including the emergence of new diseases or emergence of known diseases into new areas, the intentional spread of disease by terrorists, and the prevention and control of infectious diseases that arise following natural disasters.

Partnerships and implementation

The fulfillment of CDC's vision of a strong, vigilant U.S. public health system—ready and able to prevent and control endemic diseases and respond to new and emerging threats—requires the sustained, coordinated, and complementary efforts of many individuals and groups. The *ID Framework* is designed to advance these efforts, optimally used in multiple capacities such as

- Working with state and local health departments to sustain and upgrade public health fundamentals and address infectious disease issues of special concern ([Box 3](#))
- Providing assistance to healthcare partners in their efforts to eliminate HAIs in hospitals and other healthcare venues
- Helping community leaders and businesses to improve local response readiness and promote community resilience during public health emergencies
- Coordinating with other federal agencies to formulate evidence-based policies that improve the nation's health
- Collaborating with partner organizations to increase public health actions and advance policies that promote health
- Educating the public about the interconnected efforts needed to prevent and control infectious diseases, empowering them to improve and protect their health and that of their families.

The fulfillment of CDC's vision of a strong, vigilant U.S. public health system—ready and able to prevent and control endemic diseases and respond to new and emerging threats—requires the sustained, coordinated, and complementary efforts of many individuals and groups.

Box 3. Infectious disease issues of special concern

Antimicrobial resistance

Antimicrobials are critical, life-saving tools, yet their use contributes to a significant challenge in infection control: drug-resistant pathogens. Patients infected with drug-resistant microbes are more likely to require hospitalization, remain in the hospital longer, and have a poor prognosis. In the United States, antibiotic-resistant infections are responsible for an estimated \$20 billion in excess healthcare costs, \$35 billion in societal costs, and 8 million additional hospital days. Combating antimicrobial resistance requires a multi-faceted approach involving the efforts of patients, healthcare providers, industry, policy makers, and the public. CDC provides expertise in monitoring the effectiveness of current antibiotics and the emergence of resistant strains and works to advance broad collaborations to ensure appropriate use of antimicrobials in communities and healthcare settings. These efforts include providing leadership in the development and implementation of the [2011 public health action plan to combat antimicrobial resistance](#), which coordinates the activities of federal agencies for more effective and efficient actions to address this emerging threat.

Chronic viral hepatitis

An estimated 1.4 million persons in the United States are chronically infected with hepatitis B virus and 2.7–3.9 million with hepatitis C virus. Many of these people have “silent” infections and do not know that they are infected, increasing their risk for cirrhosis or liver cancer and for unknowingly transmitting infection. In 2011, HHS released a [viral hepatitis action plan](#) designed to improve prevention, increase identification and linkage to care among infected persons, and improve coordination of federal and partner efforts to reduce viral hepatitis. CDC is helping to lead and advance many of the actions described in the plan, including expanded educational campaigns to increase awareness of viral hepatitis, of risk factors and the need for testing, and of new treatment advances.

Food safety

An estimated 48 million foodborne illnesses occur in the United States each year, resulting in 128,000 hospitalizations and 3,000 deaths, with factors such as today’s global food supply and mass processing contributing to these events. Among its prevention activities, CDC tracks and investigates foodborne diseases in collaboration with state and local health departments and other partners, working to rapidly identify their sources and contain their spread. Vital to these efforts are CDC-supported national networks of federal, state, and local laboratories that can detect and identify clusters of foodborne illness. CDC is also working to help advance the 2011 Food Safety Modernization Act—important legislation calling for new safety standards, expanded inspections and compliance, improved import safety, and increased surveillance of foodborne illness.

Healthcare-associated infections

HAIs are a leading preventable cause of illness and death in the United States, affecting approximately 5% of all hospitalized patients and resulting in significant healthcare costs. Demonstrated successes by CDC and public health partners in using concerted infection control practices to reduce HAIs have contributed to a number of healthcare quality improvement efforts, including increased roles for state health departments in HAI prevention. An example of these successes is the approximate 58% decline in central line-associated bloodstream infections from 2001–2009, which saved an estimated 27,000 lives and \$1.8 billion in medical costs. CDC is working to sustain and advance these HAI prevention efforts and helping to change HAIs from inevitable aspects of healthcare to rare, unacceptable events.

HIV/AIDS

Despite major advances in prevention and treatment, HIV infection remains a significant national and global public health challenge. In the United States, more than 1 million persons are living with HIV. An estimated one-fifth of these individuals are unaware of their infection, precluding access to life-saving treatment and important

prevention information to protect their partners. HIV prevention saves lives and healthcare costs: from 1991–2006, HIV prevention efforts averted an estimated 350,000 U.S. infections, saving \$125 billion in medical care costs. CDC is committed to advancing the [National HIV/AIDS Strategy for the United States](#), with primary goals of 1) reducing HIV incidence; 2) increasing access to care and improving health outcomes for persons with HIV infection; and 3) reducing HIV-related health disparities.

Respiratory infections

Acute respiratory infections such as pneumonia and influenza are the leading infectious cause of death in the United States and globally, responsible for an estimated 3.5 million deaths worldwide each year. As experience with the 2003 global outbreak of severe acute respiratory syndrome (SARS) and the 2009 H1N1 influenza pandemic demonstrated, these infections can spread rapidly. Tuberculosis also remains a significant global health threat, with unrecognized infections and drug-resistant strains complicating control efforts. The emergence of highly transmissible novel influenza viruses also remains a global concern and a primary focus of prevention efforts for CDC and public health partners throughout the world.

Safe water

An estimated 2.5 billion people (half of the developing world and more than one-third of the world's population) lack access to safe water and adequate sanitation. Diarrheal diseases are the second leading infectious cause of morbidity and mortality worldwide, with particular impact on growth, development, and survival among children. Lack of these basic needs also impedes socio-economic progress for many developing countries, perpetuating a cycle of poverty and disease. CDC's global water, sanitation, and hygiene (WASH) program provides expertise and interventions aimed at saving lives and reducing illness by improving global access to healthy and safe water, adequate sanitation, and improved hygiene, with particular efforts targeted toward reducing diarrheal disease in children. These efforts also include outbreak response, such as those undertaken in response to the large outbreaks of cholera in Haiti following the country's 2010 earthquake. Domestically, CDC works with state and local health departments to conduct infectious disease surveillance and other prevention activities associated with drinking water and recreational water.

Vaccine-preventable diseases

Vaccines are our most effective and cost-saving tools for disease prevention, preventing untold suffering and saving tens of thousands of lives and billions of dollars in healthcare costs each year. CDC works to reduce vaccine-preventable diseases, helping to ensure broad immunization coverage and the availability of recommended vaccines for children affected by inability to pay; identifying and responding to outbreaks of vaccine-preventable diseases; and monitoring the impact and safety of vaccines and communicating their efficacy and public health significance. These efforts help advance the [2010 National Vaccine Plan](#), the nation's roadmap for vaccine research and immunization coverage. On the international level, CDC works with public and private partners to reduce vaccine-preventable diseases worldwide, including intensive efforts to complete the eradication of polio; introduce new, life-saving vaccines; and identify strategies to help strengthen immunization systems in developing countries.

Zoonotic and vectorborne diseases

An estimated 75% of emerging infections are zoonotic, i.e., they emerged from animal populations to infect and then spread among humans. Examples include HIV, Ebola virus, H5N1 and H1N1 influenza viruses, and the SARS coronavirus. Diseases transmitted by vectors such as mosquitoes also remain major concerns, posing challenges not only in tropical areas but throughout the world, with diseases such as Japanese encephalitis, West Nile virus infection, and dengue fever resurging or appearing in new areas. Lyme disease, spread by infected ticks, is among the top 10 notifiable diseases reported to CDC. CDC works with domestic and global partners in developing and advancing new approaches to improving zoonotic and vector-borne disease prevention and control and helping to advance a "One-Health" approach that links human, animal, and environmental health experts in these efforts.

ELEMENTS AND PRIORITIES

ELEMENT 1

Strengthen public health fundamentals, including infectious disease surveillance, laboratory detection, and epidemiologic investigation

Strong public health fundamentals at the local, state, and national levels—including disease surveillance, laboratory detection, and epidemiologic investigation—are the bedrock of U.S. capacity to protect the public from infectious diseases and to save lives during outbreaks and other unusual health events. These three core activities create and sustain a flexible, multi-purpose U.S. public health system that reduces endemic diseases and is ready and able to respond to new threats.

Because of the unpredictability of infectious diseases, any weaknesses in these public health fundamentals can have far-reaching consequences. For example, the dramatic declines in the incidence of tuberculosis (TB) that began in the mid-20th century led to a dismantling of most state and local TB control programs, leaving many communities unprepared for the rise in TB cases that began in the mid-1980s. Largely associated with the emerging epidemic of HIV/AIDS and the increase in drug-resistant strains, the TB resurgence continued for nearly a decade and only began to decline in the early 1990s after aggressive action was taken to rebuild local disease control programs (3). Broad efforts to rebuild the nation’s infectious disease infrastructure were undertaken in the 1990s, and further enhancements were made in the 2000s through investments in emergency preparedness.

Priorities

Priorities include working with public health and healthcare partners to sustain and strengthen public health expertise and practice and to advance workforce development and training, ensuring that core capacities are not eroded due to economic or other constraints. An important component of these activities is documenting and communicating the value, effectiveness, and impact of core public health activities.

Activities to modernize infectious disease capacities nationwide also support ongoing efforts to improve performance of state and local health departments (e.g., [national voluntary accreditation](#) activities); to instill a culture of continuous program improvement across all activities; and to help build staff capacity for implementing, monitoring, and evaluating disease prevention and control programs.

Priority1A. Modernize infectious disease surveillance to drive public health action

The collection and analysis of disease information provides *data for action*—essential information for reducing disease and controlling outbreaks. Infectious disease surveillance data help to identify areas and populations at increased risk for infection, improving our ability to direct and prioritize public health interventions. Surveillance data are also required to monitor the effectiveness, timeliness, and cost-effectiveness of current prevention and control efforts and to identify gaps and new prevention strategies.

CDC and public health partners are working with the healthcare community—including clinicians, hospitals, clinical laboratories, healthcare organizations, and provider-based sentinel networks—to modernize infectious disease surveillance at the federal, state, and local levels. The aim is to increase the quality and reduce the costs of public health and healthcare, taking full advantage of IT tools, electronic networks, and other advancements that make disease surveillance faster, more sensitive, and less expensive—reducing illness and saving lives. As an example, electronically collected and transmitted data from the Gonococcal Isolate Surveillance Project (GISP), a CDC-supported surveillance system that monitors antimicrobial susceptibilities in *Neisseria gonorrhoeae* isolates obtained at dozens of sexually transmitted disease (STD) clinics in the United States, led to changes in treatment guidelines in 2007 after showing high levels of fluoroquinolone resistance (4). More recently, data from GISP have identified decreasing cephalosporin susceptibility among gonococcal isolates (5)—critical information for healthcare providers and health departments.

Key activities to modernize infectious disease surveillance include

- Improving collection and communication of timely, accurate, and complete surveillance data to drive effective public health action
- Advancing meaningful public health use of electronic health records for infectious disease surveillance and other health purposes (e.g., monitoring immunization coverage, safety, and effectiveness)
- Strengthening laboratory-based disease surveillance nationwide by advancing partnerships, policies and incentives, and training that enhance capacity of clinical laboratories to test for microbes of public health concern, including drug-resistant microbes
- Intensifying surveillance for unusual health events, including emerging zoonotic and vectorborne diseases and intentionally caused outbreaks, through strategies such as
 - Integrating public health data with animal health data (e.g., from the U.S. Department of Agriculture [USDA]) and intelligence data (e.g., from the Department of Homeland Security [DHS]), as described in the *National Biosurveillance Strategy for Human Health* (6)
 - Analyzing health data on travelers from multiple sources (e.g., GeoSentinel, HealthMap)
- Using evolving health IT tools to provide rapid feedback and alerts to hospitals, clinicians, patients, and public health practitioners, based on timely and accurate surveillance data, e.g.,
 - Providing feedback to hospital administrators and public health officials on the efficacy (and cost-effectiveness) of infectious disease prevention practices (e.g., for the prevention of HAIs and drug resistance)
 - Alerting physicians to local epidemics and communicating prevention and treatment updates
 - Alerting patients at risk for severe infection during local infectious disease outbreaks and communicating information to protect their health.

CDC and public health partners are working with the healthcare community . . . to modernize infectious disease surveillance at the federal, state, and local levels. The aim is to increase the quality and reduce the costs of public health and healthcare, taking full advantage of IT tools, electronic networks, and other advancements that make disease surveillance faster, more sensitive, and less expensive—reducing illness and saving lives.

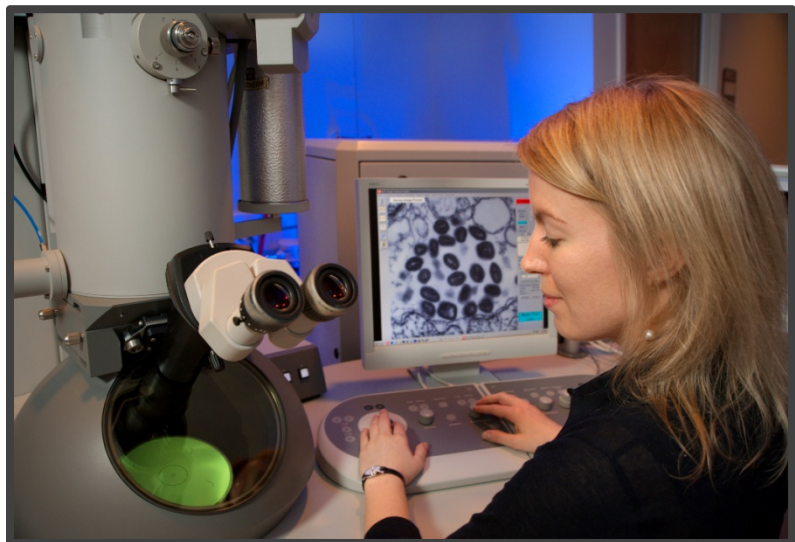
Priority 1B. Expand the role of public health and clinical laboratories in disease control and prevention

Diagnostic testing to detect and characterize infectious pathogens is an integral component of day-to-day responsibilities at public health and clinical laboratories and the essential means of identifying the causative agents of outbreaks. When those agents are rare or unknown, states and localities often work with CDC's infectious disease laboratories, which serve as a national and global diagnostic reference center for all infectious threats, including rare zoonotic viruses, drug-resistant bacteria, and potential bioterror agents.

Public health laboratory scientists also work with epidemiologists to monitor endemic diseases and measure progress in disease prevention and control; assist healthcare partners and clinical laboratories by conducting testing to facilitate treatment; and collaborate with other researchers to investigate disease pathology and progression.

CDC works with the Association of Public Health Laboratories (APHL), the American Society for Microbiology (ASM), and many other partners to enhance and upgrade laboratory detection capacities. Essential in these efforts are well-integrated and highly capable laboratory networks such as the Laboratory Response Network (LRN), a network of laboratories assembled to rapidly respond to acts of chemical or biological terrorism, emerging infectious diseases, and other public health emergencies; and PulseNet, a national and global network of public health and food regulatory agency laboratories that identifies and links foodborne disease outbreaks. As an example of these enhanced laboratory capacities, a new DNA fingerprinting technique (the Multiple-Locus Variable-Number Tandem Repeat Analysis) developed by PulseNet is helping public health laboratories and the USDA Food Safety Inspection Service (FSIS) to differentiate among strains of *Escherichia coli* O157:H7 and *Salmonella* and to pinpoint the source of local and multistate foodborne outbreaks.

Diagnostic testing to detect and characterize infectious pathogens is an integral component of day-to-day responsibilities at public health and clinical laboratories and the essential means of identifying the causative agents of outbreaks.



Key activities to expand laboratory detection and reporting include the following:

- Developing, validating, and disseminating diagnostic innovations, e.g.,
 - Accurate, multi-pathogen and point-of-care tests that can rapidly identify or rule out pathogens during field investigations as well as during clinical care
 - Rapid methods to detect, measure, and monitor antimicrobial resistance and ensure proper selection of antibiotics
 - New tools and assays for detecting and characterizing emerging threats, e.g., techniques for
 - rapid identification of potential bioterror agents
 - environmental sampling of microbes in water, air, and soil
 - genotypic surveillance of foodborne, waterborne, and enteric microbes and vaccine-preventable diseases
 - identification of new and reemerging threats (e.g., pathogen discovery, zoonotic and vectorborne infections)
 - New tools for scaling up laboratory activities during emergencies (e.g., automated, high-throughput diagnostic testing and DNA sequencing)
 - Tools and techniques for analyzing large amounts of protein or nucleic acid data (e.g., proteomic and genomic profiling tools along with bioinformatics analysis and information management tools) to advance pathogen identification and typing, host response, disease treatment, and vaccine development
- Improving information flow among clinicians, clinical labs, public health labs, and CDC, e.g.,
 - Implementing automatic electronic laboratory reporting of notifiable diseases from clinical laboratories to state health departments and CDC
 - Implementing electronic mechanisms for exchange of public health information—including laboratory orders and test results—between diagnostic laboratories (both public and private)
- Conducting long-range planning to ensure continued capacity at CDC to serve as a national and global reference center for all infectious diseases
- Developing strategies to help strengthen public health laboratory capacity through high-efficiency operating models and improved testing platforms and informatics capabilities
- Developing new and advancing existing standards and protocols for safe and rapid transfer of patient specimens to clinical and public health laboratories.

Priority 1C. Improve capacity for epidemiologic investigations and public health response

CDC and state and local health departments are working with partners in healthcare, government, emergency response, animal health, community development, and other areas to improve capacity for epidemiologic investigations and public health response. Included in these efforts are routine epidemiologic activities such as investigations of cases, clusters, and outbreaks of known and unusual diseases, including nationally notifiable diseases that are reported to CDC by state health departments. These daily activities improve knowledge of disease risk factors and control measures and also help epidemiologists hone the skills needed during emergencies. For example, during the 2009–2010 H1N1 pandemic, state and local health authorities and their healthcare partners

strengthened existing laboratory-based surveillance mechanisms and used their basic knowledge of influenza and respiratory disease to provide real-time guidance about the novel influenza virus to healthcare providers and members of the public.

Key activities to improve epidemiologic investigations and public health response include

- Developing innovative tools for outbreak investigations—incorporating new technologies such as bioinformatics, portable digital devices, and high-performance computing to improve information exchange across jurisdictions. Examples include
 - IT tools for linking, integrating, and displaying real-time epidemiologic, diagnostic, and clinical case-data, including geographical case-coding tools for monitoring disease spread
 - Applications in cell phones and other mobile devices for gathering public health data during outbreaks
 - Mathematical modeling tools for evaluating the likelihood and location of disease spread from animals to humans during animal outbreaks and for assessing the projected impact of an emerging outbreak or pandemic
- Developing pre-event investigative performance measures and protocols (e.g., protocols for collecting data on risk factors, disease severity, and other clinical information) for use during outbreak investigations
- Using lessons learned from outbreak responses (e.g., the 2009 H1N1 pandemic response) to strengthen overall preparedness, including distribution and use of emergency medical countermeasures (e.g., pharmaceuticals stored in the Strategic National Stockpile) and diagnostics development
- Coordinating across CDC and with external partners to facilitate collaborative efforts for rapid response to infectious disease outbreaks of unknown etiology
- Partnering with DHS to enhance state and local bioterrorism prevention and response capacity through improved cooperation and data-sharing between local public health and law enforcement groups.

Priority 1D. Advance workforce development and training to sustain and strengthen public health practice

The nation's health depends on a public health workforce that is well trained, prepared, and able to address new and emerging threats. However, many state and local public health departments are understaffed and lack basic capacities for responding to crises (7–10). Critical areas for trained public health workers include disease surveillance, epidemiologic investigation, and laboratory detection; meaningful public health use of electronic networks and health IT tools; and use of new tools and channels for public health communications, including risk communication.

CDC works with APHL, the Association of State and Territorial Health Officials (ASTHO), the Council of State and Territorial Epidemiologists (CSTE), the National Association of County and City Health Officials (NACCHO), and many other partners to assist health departments in setting and meeting goals for workforce development and training. Fulfillment of these goals is advanced through proven capacity-building programs such as the Epidemiology and Laboratory Capacity for Infectious Diseases Cooperative Agreement ([ELC](#)) and the Emerging Infections Programs ([EIP](#)), as

well as targeted epidemiology and laboratory training programs. Examples of current training programs include the following:

- ***Epidemic Intelligence Service (EIS)***, the nation’s training program for applied epidemiology, including conducting disease surveillance and preventing, investigating, and controlling outbreaks. In addition to CDC assignments, EIS trainees are assigned to state and local health departments to assist with routine public health research activities and to provide assistance during large or complex public health emergencies.
- ***Public Health Laboratory Research Fellowships***, which provide training in laboratory detection, microbial characterization, and infectious disease research to public health laboratorians. Fellowships are conducted in collaboration with partner organizations including [APHL](#) and [ASM](#).
- ***CDC/CSTE Applied Epidemiology Fellowship Program***, which trains recent graduates in the expanding field of applied epidemiology. Established in collaboration with the Association of Schools of Public Health (ASPH) and the Health Resources and Services Administration (HRSA), the fellowship works to provide a high quality training experience and to secure long-term career placement for fellows at the state or local level.
- ***Public Health Associate Program***, which provides recent college graduates with broad, hands-on experience in the day-to-day operations of state, tribal, local, and territorial public health departments, helping to train public health leaders of the future.

Other key activities to advance workforce development and training include

- Expanding access to high-quality public health e-learning products and training
- Providing guidance and training for public health workers on integrating IT health tools into all aspects of public health practice and “e-health,” including disease surveillance and reporting, molecular diagnostics, molecular epidemiology, and emergency response
- Assisting public health departments in transitioning to expanded roles in healthcare quality assurance, assessment, and policy development (e.g., training public health workers to serve as liaisons between health departments and hospitals to advance prevention through healthcare)
- Engaging partners to extend the reach of public health messages through the use of new communication tools and channels, e.g., working with
 - Medical/nursing schools and professional organizations to craft public health messages for use by healthcare providers
 - Behavioral scientists to develop public health campaigns designed to promote social norms and behaviors that prevent disease transmission
 - Community leaders to develop communication strategies for reaching vulnerable populations.

Critical areas for trained public health workers include disease surveillance, epidemiologic investigation, and laboratory detection; meaningful public health use of electronic networks and health IT tools; and use of new tools and channels for public health communications, including risk communication.

ELEMENT 2

Identify and implement high-impact public health interventions to reduce infectious diseases

Focused efforts to prevent and control high-burden infectious diseases can achieve dramatic results within a short time-frame, reducing disease burden and health inequities while saving lives and reducing healthcare costs.

Priorities

Priorities include identifying and validating new tools for disease prevention and control and accelerating the uptake and broad use of proven methods for decreasing illness and death from diseases and conditions of special concern ([Box 3](#)).

Priority 2A. Identify and validate high-impact tools for disease reduction

A strong public health system requires innovative, validated, and cost-saving tools for disease prevention and control that build on new ideas, technologies, partnerships, and other opportunities. Examples include new vaccines, targeted strategies and tools for infection control and treatment, and innovative approaches to reduce zoonotic and vectorborne diseases.

- **New vaccines**

The public health power of vaccines is clearly illustrated by the introduction and use of two recent vaccines. The pneumococcal conjugate vaccine, introduced in 2000, had prevented more than 13,000 U.S. deaths by 2008 (11). More recently, a new rotavirus vaccine, introduced in 2006, has been shown to prevent approximately 40,000–60,000 U.S. hospitalizations each year (12).

Laboratory studies and clinical trials to develop new vaccines are supported by the National Institutes of Health (NIH) and other public and private partners. As new vaccines are developed and approved, CDC works to advance their introduction and use, monitor their safety, and evaluate their impact on disease burden.

- **Strategies and tools for infection control and treatment**

Infection control. Identification of and adherence to infection control measures is essential for preventing development and spread of antimicrobial resistance; reducing HAIs; and decreasing transmission of communicable diseases, especially influenza and other respiratory infections, including non-vaccine-preventable respiratory infections. Strategies and tools for preventing antimicrobial resistance (*see also Priority 3B, Address microbial drug resistance*) and HAIs include the establishment of health department- and healthcare-facility-based prevention collaboratives to implement recommended practices and promote judicious use of antibiotics. Specific measures target ventilator-associated pneumonias and infections with *Clostridium difficile*, multi-drug-resistant *Klebsiella pneumoniae*, and other gram-negative bacteria. Other innovative prevention approaches under investigation focus on the environment as a reservoir for healthcare-associated pathogens and include use of ultraviolet light and other modalities to reduce transmissions.

Outside of healthcare settings, efforts are focused on strengthening individual and community-based infection control measures (e.g., hand-washing, respiratory hygiene, and other non-pharmaceutical interventions such as self-isolation/quarantine), particularly during outbreaks. Additional activities include evaluating and optimizing the use of broader community mitigation tools such as school closings and public event cancellations.

Treatment. Working with partners to develop and disseminate clinical guidance is critical for preventing increased severity and further spread of infectious diseases. During the 2009–2010 H1N1 influenza pandemic, CDC provided guidance on the use of antivirals in populations at increased risk for severe disease, including pregnant women and persons with chronic conditions such as diabetes, lung disease, and neuromuscular disorders. These recommendations were shown to improve outcomes among these populations: for example, early treatment of pregnant women with antiviral medications was associated with fewer admissions to an intensive care unit and fewer deaths.

In addition, during the 2010 outbreak of dengue fever in Puerto Rico, public health authorities provided guidance on clinical management of dengue fever and dengue hemorrhagic fever. Although no antiviral drug therapy is currently available for dengue fever, good medical management can reduce the related fatality rate to less than 1% (13). CDC also worked with Haitian and international partners to provide clinical guidance for rapidly evaluating and treating cholera patients and controlling disease spread in Haiti following the epidemic that began months after the devastating earthquake in January 2010.

New strategies to improve clinical management of STDs include ensuring prompt treatment of the partners of patients diagnosed with chlamydia or gonorrhea by promoting [Expedited Partners Therapy](#). Other new clinical interventions aimed at reducing high-burden diseases include the establishment of [TB Regional Training and Medical Consultation Centers](#) to optimize TB treatment and reduce the development of drug resistance. Additional strategies include advancing efforts to enable co-treatment of frequently associated conditions such as HIV, STDs, and TB—approaches that can also help reduce health disparities.

- **Interventions to reduce disease transmitted by animals or insects**

Zoonotic and vectorborne diseases are the primary source of emerging infections, requiring multi-disciplinary partnerships and innovative approaches for their prevention and control (*see also Priority 3B, Promote One Health approaches . . .*). Recent efforts include the development of promising human vaccines against dengue and malaria, expanded use of insecticide-treated bed nets and indoor walls in malaria endemic areas, and the use of tick-control interventions among deer carrying ticks that transmit Lyme disease.

For vectorborne disease control, resistance to pesticides is an ongoing challenge affected by usage, vector biology, and environmental changes (14). Improved approaches to insect control are underway, including a new class of insecticides derived from the bark of the Alaskan yellow cedar tree. Potential applications include prevention of mosquito-borne diseases like dengue fever and malaria; tickborne diseases like Lyme disease, ehrlichiosis, and Rocky Mountain Spotted Fever; and diseases caused by tickborne potential bioterror agents (e.g., babesiosis, tularemia, Q fever). New efforts designed to avoid pesticide resistance are also under

investigation, including altering the capacity of mosquitos to host malaria parasites or other human pathogens.

Improved diagnostics (*Priority 1B*) are also essential for controlling zoonotic and vectorborne diseases. CDC is helping to develop and validate field-friendly diagnostic tests that can rapidly identify zoonotic diseases in humans and animals (e.g., plague, tularemia, anthrax, and monkeypox), expediting the delivery of treatment and prevention interventions.

Priority 2B. Use proven tools and interventions to reduce high-burden infectious diseases

CDC has initiated a series of targeted efforts that use known, effective strategies to achieve measurable results within a short period of time against diseases and conditions with high population impact. Termed *Winnable Battles*, these efforts target select domestic and global infectious diseases along with known causes of major chronic diseases and other health concerns. For domestic infectious diseases, these efforts include strategies to reduce HIV infections, HAIs, and foodborne diseases. These *Winnable Battle* actions and other priority infectious disease activities (**Boxes 3 and 3.1**) involve national strategies and multi-level partnerships to reduce illness and death from high-burden diseases, taking advantage of proven tools, scientific expertise, and field experience. Examples of these efforts include the following:

- **Vaccine-preventable diseases**

Vaccines are our most effective and cost-saving tools for disease prevention. For each annual U.S. birth cohort vaccinated against 13 diseases in accordance with the recommended schedule from the Advisory Committee on Immunization Practices (ACIP), approximately 42,000 lives are saved, 20 million cases of disease are prevented, \$13.6 billion in direct costs are saved, and \$68.9 billion in direct plus indirect (societal) costs are saved.‡ Advancing the use of vaccines—including helping to ensure broad coverage, monitoring the impact and safety of vaccines, and communicating their efficacy and public health significance—is an important component of CDC’s infectious disease prevention efforts.

Box 3.1 Infectious disease issues of special concern

- Antimicrobial resistance
- Chronic viral hepatitis
- Food safety
- Healthcare-associated infections
- HIV/AIDS
- Respiratory infections
- Safe water
- Vaccine-preventable diseases
- Zoonotic and vectorborne diseases

‡ Preliminary results of updated analysis from Zhou F, Santoli J, Messonnier M, Yusuf H, Shefer A, Chu S, Rodewald L, Harpaz R. Economic evaluation of the 7-vaccine routine childhood immunization schedule in the United States, 2001. *Arch Pediatr Adolesc Med* 2005;159:1136-1144.

As part of these efforts, CDC oversees the Vaccines for Children ([VFC](#)) program, working with federal partners, industry, and state and local health departments to help enable access to recommended vaccines for financially vulnerable children.

Ongoing efforts to modernize the national infrastructure for vaccine delivery are supported by the Prevention and Public Health Fund of the 2010 Affordable Care Act. Particular aims are to expand access to childhood vaccines, especially in medically underserved communities, and to expand access to vaccines recommended for adolescents and adults, including vaccines against seasonal influenza, pneumococcal infections, pertussis, human papillomavirus (HPV), hepatitis B virus, and bacterial meningitis. In addition, these funds are supporting efforts to evaluate the introduction of new vaccines on disease burden—a key factor in understanding return on public health investments.

Other improvements include upgrading state-level immunization registries to make them interoperable with electronic health records and integrate them into the Vaccine Tracking System ([VTrcks](#)), CDC's new IT system developed as part of the agency's large-scale efforts to improve processes and systems for managing publicly funded vaccine ordering and distribution. Another aim is to develop reimbursement policies that allow public health departments to bill private insurance companies for vaccinations given to insured populations.

Internationally, CDC works with ministries of health, the World Health Organization (WHO), the U.S. Agency for International Development (USAID), the GAVI Alliance, the Gates Foundation, and many other partners to reduce vaccine-preventable diseases, including intensive efforts to complete the eradication of polio; to introduce new, life-saving vaccines (e.g., meningococcal A and *Streptococcus pneumoniae* conjugates, rotavirus, HPV); and to identify strategies to help strengthen immunization systems in developing countries. These and other activities are included in the *CDC Global Immunization Strategic Framework, 2011–2015 (15)*, which outlines goals, strategies, and success measures for effectively meeting priority global immunization challenges in the near future.

- **Healthcare-associated infections**

HAIs are a leading cause of preventable death in the United States. At any given time, approximately 1 in 20 patients receiving treatment in U.S. hospitals has an HAI. HAIs are often the secondary cause of death among people with heart disease, cancer, stroke, and chronic lower respiratory disease.

In 2002, approximately 1.7 million HAIs and nearly 100,000 associated deaths occurred in U.S. hospitals (16). Demonstrated successes by CDC and public health partners over the past decade in using concerted infection control practices to reduce HAIs have led to a number of healthcare quality initiatives and campaigns, including the HHS *Action Plan to Prevent Healthcare-Associated Infections (17)* and expanded use of public health measures to reduce HAIs. Examples of these tools and incentives include

- Evidence-based guidelines developed by the Healthcare Infection Control Practices Advisory Committee ([HICPAC](#)) with CDC and partners
- HAI infection control “[toolkits](#)” for hospitals and healthcare personnel

- Efforts to link adherence to CDC infection control guidelines with financial incentives offered from the Centers for Medicare and Medicaid Services (CMS) to improve healthcare quality as part of the 2010 Affordable Care Act
- The National Healthcare Safety Network ([NHSN](#)), which enables healthcare facilities, state health departments, and HHS to monitor HAIs and track successes and areas for improvement.

Also as part of these efforts, state health departments are working with state hospital associations and quality-improvement organizations to expand their roles in HAI prevention. Reflecting this national movement toward greater accountability on the use of proven practices to prevent HAIs, all 50 states and the District of Columbia now have state HAI prevention plans.

- **HIV/AIDS**

Despite major advances in prevention and treatment, HIV infection remains a significant national and global public health challenge. CDC estimates that approximately 1.2 million persons in the United States were living with HIV at the end of 2008, and each year more than 56,000 are newly infected (18,19). Although expanded HIV testing efforts have helped both to increase the proportion of infected persons who are aware of their infection and to decrease the number of persons with late diagnoses, approximately 20% of U.S. persons living with HIV remain unaware of their infection and nearly one-third of HIV diagnoses still occur late in the course of infection (20). Early identification of HIV infection can enable access to life-saving treatment, help reduce further transmission, and decrease medical costs. It is estimated that HIV prevention efforts in the United States averted 350,000 infections from 1991–2006, saving \$125 billion in medical care costs (21). CDC works with public and private partners to promote testing to identify infected persons and link them to care and prevention services. Innovative strategies to reach higher risk populations include targeted testing efforts, programs designed to help infected persons avoid passing their infection to their partners, and community-based efforts such as syringe services programs designed to reduce HIV transmission among injection drug users. Government-wide efforts are underway to implement the *National HIV/AIDS Strategy for the United States*, (22) with primary goals of 1) reducing HIV incidence; 2) increasing access to care for persons with HIV infection; and 3) reducing HIV-related health disparities.

Global estimates indicate that 33.3 million persons were living with HIV infection at the end of 2009 (23). CDC serves as a key U.S. government agency in supporting the implementation of the U.S. Global Health Initiative ([GHI](#)) through the President’s Emergency Plan for AIDS Relief ([PEPFAR](#)), with expanded focus on improving the health of women and children, including reducing maternal-to-child transmission of HIV. As part of these efforts, CDC works with ministries of health and other partners throughout the world to improve local capacity to prevent and reduce the impact of HIV infection.

Promising new ways of preventing and treating HIV, including pre- and post-exposure prophylaxis, are under evaluation. As evidence on the effectiveness of new interventions moves forward, CDC will ensure prompt and effective translation of research findings into sound public health practice.

- **Foodborne infections**

Each year in the United States, foodborne pathogens cause an estimated 48 million illnesses, 128,000 hospitalizations, and 3,000 deaths (24,25). While approximately 1,000 U.S. foodborne disease outbreaks are reported annually (26), most foodborne illnesses do not occur as part of recognized outbreaks. Recent foodborne disease surveillance data indicate relative declines in incidence from 1996–2010 for infections associated with many key foodborne pathogens; however, the rate of *Salmonella* infections—the most common foodborne infection reported—has remained unchanged (27). In the United States, *Salmonella* infections sicken an estimated 1 million persons and result in an estimated \$365 million in direct medical costs each year. Among its prevention activities, CDC tracks and investigates foodborne diseases in collaboration with state and local health departments and other partners, working to rapidly identify their sources and contain their spread. Vital to these efforts are extensive foodborne illness surveillance systems, such as the following:

- ***Foodborne Diseases Active Surveillance Network (FoodNet)***, operated by the Emerging Infections Program, which conducts active surveillance for foodborne diseases
- ***National Antimicrobial Resistance Monitoring System (NARMS)***, a collaboration among CDC, USDA/FSIS, and the U.S. Food and Drug Administration's (FDA) Center for Veterinary Medicine to monitor drug-resistant pathogens in food animals that might be transmitted to humans
- ***PulseNET***, a national network of public health laboratories that performs DNA "fingerprinting" on foodborne bacteria to detect outbreaks caused by contamination of centrally processed food products that are shipped to stores or restaurants in many different locations
- ***Outbreak Response Team***, which investigates local and multistate outbreaks of foodborne, waterborne, and enteric diseases.

CDC also receives data on nationally notifiable conditions—including foodborne illnesses such as botulism, hepatitis A, salmonellosis, and shigellosis—on a weekly basis through the National Notifiable Diseases Surveillance System ([NNDSS](#)).

In addition, CDC is working to advance the [2011 Food Safety Modernization Act](#)—important legislation calling for new safety standards, expanded inspections and compliance, improved import safety, and increased surveillance of foodborne illness. Increased efforts are being directed toward improving coordination and data sharing with public health partners and the public; expanding surveillance networks; and enhancing epidemiologic and laboratory tools for detecting and investigating outbreaks and identifying sources of foodborne illnesses.

Internationally, CDC continues to help strengthen and implement tools for early detection and response to foodborne disease outbreaks, including [PulseNet International](#) and the [Global Food Infections Network](#). CDC also participates in the [WHO Initiative to Estimate the Global Burden of Foodborne Disease](#), which generates data that nations can use to set food safety priorities and standards that enhance the safety of the global food supply.

- **Chronic viral hepatitis**

Chronic infection with hepatitis B virus (HBV) and hepatitis C virus (HCV) is a silent epidemic in the United States, involving approximately 0.8–1.4 million persons infected with HBV (28) and an estimated 2.7–3.9 million persons with HCV infection (29). Many persons infected with HBV or HCV are unaware of their infection, placing them at risk for developing cirrhosis or liver cancer and unknowingly transmitting infection. A safe and effective vaccine against HBV has been available for nearly three decades, and universal vaccination against HBV among children, begun 1991, has led to substantial declines among younger age groups. No vaccine against HCV is available. While rates of HCV declined in the United States from 1992–2005 and have since plateaued, several states have reported increases in cases of HCV infection among adolescents and young adults, with injection drug use the most common risk factor (30).

In January 2010, the Institute of Medicine (IOM) issued a report on prevention and control of hepatitis in the United States (31). The report outlined a series of recommendations for improving surveillance, public and healthcare provider knowledge, immunizations and other prevention services, and healthcare related to viral hepatitis. In response to the IOM report, HHS developed a comprehensive action plan (32) designed to improve prevention of viral hepatitis and related disease, to increase identification and linkage to care among infected persons, and to improve coordination of federal and partner efforts to reduce viral hepatitis. CDC is helping to lead many of the actions described in the plan, including improving education for patients, healthcare providers, and the public; expanding testing; enhancing surveillance activities; and promoting interventions to reduce cases associated with drug use, lapses in infection control, and perinatal transmission.

On a global level, approximately 350–370 million persons are infected with HBV, and 130–170 million are living with HCV (33,34). CDC works with ministries of health, WHO, GAVI, and other international partners to prevent new cases, including introducing and advancing HBV vaccines as part of childhood immunization regimens.

ELEMENT 3 **Develop and advance policies to prevent, detect, and control infectious diseases**

Protecting the nation from infectious diseases requires sound, evidence-based health policies designed to

- Ensure appropriate development and delivery of infectious disease prevention measures
- Reduce health disparities and improve the health of vulnerable populations
- Promote engagement with global partners to reduce cross-border disease spread and contain outbreaks at their source

To be most effective, these policies must reflect the best science and the best public health thinking, with broad input and consideration of varying perspectives to ensure recognition of the complex societal factors that affect the nation’s health—the [social determinants of health](#). Therefore, policy development should extend beyond the public health and healthcare communities to engage stakeholders and other partners across multiple sectors and specialties.

Priorities

Priorities include ensuring the availability of sound scientific data to support policy development at CDC and partner organizations while working to advance established and new policies to reduce infectious diseases.

CDC consults with individuals and institutions across the nation to advance policy development by reviewing emerging problems, addressing gaps in scientific knowledge, and identifying new opportunities for policy solutions. Once policies are formulated and in place, CDC works with public health and healthcare partners to facilitate implementation and evaluate outcomes.

Priority 3A. Ensure the availability of sound scientific data to support the development of evidence-based and cost-effective policies

The availability of accurate, timely, and useful data is essential to inform national, state, and other policies on infectious disease control and prevention. Examples include national regulations to prevent U.S. importation and spread of TB and other quarantinable conditions, quality assurance for clinical laboratory testing, oversight of research laboratories working with disease agents and toxins that could potentially be used for bioweapons, and industry regulations to improve the safety of food and water. Organizations such as The Joint Commission and the U.S. Preventive Services Task Force (which also contributes to [The Guide to Community Preventive Services](#)) also rely on strong scientific data and public health recommendations to enhance healthcare quality. Similarly, public health recommendations developed by ACIP are based on the best available scientific data, and are, in turn, used by states and other policy makers to formulate immunization policies for schools, daycare facilities, and other educational and care settings.

Actions to support the development of effective, evidence-based policies for infectious disease prevention and control include

- Assessing the national burdens of high-mortality infectious diseases (e.g., respiratory diseases, HIV infection)
- Identifying public health activities with high return on investments, including those directed toward high-risk populations
- Developing strategies for sustaining and expanding public/private collaborations to improve healthcare quality (e.g., based on proven practices outlined in guidelines to reduce HAIs)
- Creating predictive models for disease emergence (e.g., vectorborne and zoonotic diseases), disease spread, outbreak response, and disease elimination (e.g., HBV, TB, congenital syphilis)
- Monitoring rates of and risk factors for foodborne illness to inform food safety policy and regulatory action
- Monitoring the effectiveness of strategies to reduce behaviors that increase individual risk for infectious diseases (e.g., through the [Behavioral Risk Factor Surveillance System](#)).

Protecting the nation from infectious diseases requires sound, evidence-based health policies . . . To be most effective, these policies must reflect the best science and the best public health thinking, with broad input and consideration of varying perspectives to ensure recognition of the complex societal factors that affect the nation's health . . .

Priority 3B. Advance policies to improve prevention, detection, and control of infectious diseases

Effective implementation of evidence-based health policies can prevent illness and disease spread, enhance healthcare quality, promote health equity, and reduce healthcare costs. Efforts are needed to advance new and ongoing policies that achieve the following:

- **Help integrate clinical infectious disease preventive practices into U.S. healthcare**

CDC and state and local health departments are advancing policies and practices that increase healthcare quality and reduce healthcare costs, in accordance with the 2010 Affordable Care Act. These efforts require sustained public health outreach to healthcare providers, hospitals, clinical laboratories, and healthcare organizations.

Activities that help make disease prevention a standardized, routine part of healthcare include

- Healthcare delivery policies that encourage early detection and treatment of diseases to prevent further transmission and the development of more severe disease
- Healthcare–facility policies and practices designed to prevent infections and adverse events related to healthcare, including those related to blood transfusions and organ and tissue transplants
- IT policies that optimize secure exchange of health information and advance public health goals, including meaningful public health use of electronic health records and electronic laboratory reporting
- Occupational safety policies and practices that protect both patients and healthcare workers (e.g., improving influenza vaccination rates among hospital personnel)
- Medical reimbursement policies that provide incentives for preventive services (e.g., vaccination and prevention counseling) and preventive practices (e.g., infection control).

- **Increase community and individual engagement in disease prevention efforts**

Public health efforts to prevent and control disease depend on engagement and action of communities and individuals. Community-based partnerships underpin public health activities for both routine disease prevention and outbreak response—enabling broad access to medical services and public health information and reaching underserved rural and urban areas. Public participation in infectious disease prevention efforts is also vital, often serving as the primary step in reducing disease spread. The impact of such participation can be improved through targeted dissemination of practical health information to particular groups and populations with increased risk for acquiring or transmitting infections. Examples include making travelers' health information available to the 35 million Americans who travel internationally every year; disseminating specific risk reduction information to persons at high risk for diseases such as HIV and chronic viral hepatitis; and ensuring that affected families understand how to help implement community mitigation activities such as self-quarantine during outbreaks.

Efforts to increase community and individual action to prevent infectious disease include policies and initiatives designed to enhance

- Availability of public health information through new communication channels, including use of mobile devices to enable individual awareness
- Community resilience during outbreaks and unusual public health events
- Delivery of preventive services to vulnerable and marginalized populations, with particular focus on strategies to reduce health disparities
- Utilization of clinical and preventive services by persons with or at risk for infectious diseases, including efforts to reduce stigma associated with certain infections
- Judicious use of antibiotics through messages targeted to patients, parents, and healthcare providers
- Understanding of the benefits of vaccination and the risks and dangers of vaccine-preventable diseases
- Health literacy and understanding of social practices and behaviors that facilitate or prevent disease spread.

Community-based partnerships underpin public health activities for both routine disease prevention and outbreak response. . . Public participation in infectious disease prevention efforts is also vital, often serving as the primary step in reducing disease spread.

- **Strengthen global capacity to detect and respond to outbreaks with the potential to cross borders**

Threats to global health security—health events that can harm not only individuals but society as a whole—include bioterrorist acts; industrial or laboratory accidents; and outbreaks of new, drug-resistant, or highly dangerous infectious diseases. Ensuring early detection and response to these threats requires global cooperation.

The 2005 International Health Regulations (IHR) provide a legal and political framework for detecting and containing outbreaks of international concern (35). Under the 2005 IHR, all WHO member states (nearly 200 nations) are required to maintain or develop core capacities for disease surveillance, reporting, and response capacity, with industrialized nations providing technical support to less developed nations. Implementation of the 2005 IHR is designed to improve the capacity of all countries to detect, assess, report, and respond to public health threats.

CDC works to advance the 2005 IHR and other global health policies in collaboration with other U.S. and international partners by supporting and expanding

- Bilateral and multilateral initiatives to detect and control emerging threats, including drug-resistant diseases, influenza pandemics, and bioterrorist events§
- Global and regional infectious disease surveillance networks, such as WHO's Global Outbreak Alert and Response Network ([GOARN](#))

§U.S. efforts to support international preparedness and response to bioterrorist events and pandemics are described in the *National Strategy to Counter Biological Threats* (http://www.whitehouse.gov/sites/default/files/National_Strategy_for_Counteracting_BioThreats.pdf).

- Public health responses to infections from dangerous high-consequence pathogens (e.g., Ebola virus and other pathogens causing viral hemorrhagic fever)
- Responses to outbreaks of infectious diseases that follow natural disasters such as floods, tsunamis, and hurricanes.

- **Address microbial drug resistance**

Antimicrobial drugs have saved lives, eased the suffering of millions of people, and contributed to major gains in life expectancy. However, the emergence of resistance in bacteria, viruses, parasites, and fungi is undermining those gains, eliminating the availability of effective treatments for many infectious diseases. In the United States, antibiotic-resistant infections are responsible for an estimated \$20 billion in excess healthcare costs, \$35 billion in societal costs, and 8 million additional hospital days (36,37).

Current issues that underscore the dangers of drug-resistant diseases include

- Emergence in healthcare settings of gram-negative bacteria like *E. coli* and *K. pneumoniae* that are resistant to antibiotics of last resort (carbapenams)
- International spread of extremely drug-resistant TB
- Increasing gonococcal resistance to available antibiotics
- Increases in drug-resistant *Acinetobacter baumannii* infections among U.S. military personnel (38)
- Increasing number of hospital outbreaks involving drug-resistant *C. difficile* (39).

Combating antimicrobial resistance requires a multi-pronged, multi-sector approach that includes developing and advancing policies and programs designed to

- Reduce the prevalence of resistant infections
- Improve surveillance for emerging antimicrobial resistance problems in human and animal settings, such as through efforts to enhance laboratory sharing of resistance patterns
- Prolong the useful life of antimicrobial drugs through judicious use, taking into account both human and veterinary use
- Encourage development of new antimicrobial drugs
- Promote development and optimal use of vaccines
- Improve laboratory capacities and diagnostics aimed at detecting and characterizing new or emerging organisms resistant to antimicrobials.

Domestic partners in these efforts include state and local health departments, other federal agencies, universities, the Infectious Diseases Society of America (IDSA) and other professional organizations, pharmaceutical and biotechnology companies, healthcare delivery organizations, insurers, agricultural producers, consumer groups, and members of the public. International partners include WHO and the [EU-US Trans Atlantic Task Force on Antimicrobial Resistance](#).

- **Promote One Health approaches to prevent emergence and spread of zoonotic diseases**

The recognition that most new human pathogens emerge from animal reservoirs (40,41) has given rise to a One Health approach to disease prevention that links human, animal, and environmental health. One Health approaches typically aim to prevent or control zoonotic diseases—diseases caused by microbes that infect both humans and animals.

The elimination of canine rabies in the United States in 2004 after decades of intensive surveillance, laboratory advancements, and vaccination efforts on the part of human and veterinary science communities is a prime example of successful One Health collaborations, providing a model for improved understanding and control of emerging zoonoses and offering potential for developing countries, where canine rabies continues to cause tens of thousands of deaths each year.

One Health policies and actions can facilitate early detection of new diseases that emerge from animal and insect reservoirs and also offer potential means for improving food safety and preventing the emergence of antimicrobial resistance. Examples include policies that support interdisciplinary collaborations and communications on all aspects of healthcare for humans and animals, in accordance with the goals of the [One Health Initiative](#). Other One Health policy goals include



- Active participation of agricultural and veterinary partners in integrated analysis of animal health and human health data to identify new threats
- Improved linkages between veterinary experts and state and local epidemiologists (e.g., via the [Environmental Health Specialist Network](#))
- Strategies that reduce the risk of importing infectious diseases into the United States via animals and cargo.

In addition to domestic partners in these efforts, CDC also works with USAID, the Food and Agricultural Organization (FAO), the World Organization for Animal Health (OIE), and other international partners to promote worldwide One Health planning and cooperation.

CONCLUSION

CDC's *ID Framework* seeks to mobilize partners and actions to sustain and advance the fundamental infectious disease surveillance, laboratory, and epidemiologic capacities that support our nation's public health system, recognizing current challenges facing federal, state, and local agencies while realizing vast opportunities for innovative work. Effective and expansive partnerships working to implement proven practices and to identify and evaluate new public health strategies remain our best means of achieving these goals—protecting health and saving lives.

REFERENCES

1. CDC. Preventing emerging infectious diseases: A strategy for the 21st century. U.S. Department of Health and Human Services, Public Health Service, 1998.
2. National Prevention Council. National prevention strategy. U.S. Department of Health and Human Services, Office of the Surgeon General, 2011. Available at <http://www.healthcare.gov/center/councils/npphpc/strategy/report.pdf>.
3. CDC. A strategic plan for the elimination of tuberculosis in the United States. MMWR 1989;38(No. S-3):1–25. Available at <http://www.cdc.gov/mmwr/preview/mmwrhtml/00001375.htm>.
4. CDC. Update to CDC's sexually transmitted diseases treatment guidelines, 2006: Fluoroquinolones no longer recommended for treatment of gonococcal infections. MMWR 2007;56:332–336. Available at <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5614a3.htm>.
5. CDC. Cephalosporin susceptibility among *Neisseria gonorrhoeae* isolates—United States, 2000–2010. MMWR 2011;60:873–877. Available at http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6026a2.htm?s_cid=mm6026a2_w.
6. CDC. National biosurveillance strategy for human health. Version 2.0, February 2010. Available at http://www.cdc.gov/osels/pdf/NBSHH_v2.pdf.
7. Trust for America's Health. Ready or not? Protecting the public's health from disease, disasters, and bioterrorism, 2010. Available at <http://healthyamericans.org/assets/files/TFAH2010ReadyorNot%20FINAL.pdf>.
8. The Council of State and Territorial Epidemiologists Epidemiology Capacity Assessment (ECA) Workgroup. 2009 national assessment of epidemiology capacity: Findings and recommendations. Available at <http://www.cste.org/dnn/Portals/0/2009EpidemiologyCapacityAssessmentReport.pdf>.
9. Association of State and Territorial Health Officials. Impact of budget cuts on state and territorial public health services. Fact Sheet, December 2010. Available at <http://www.astho.org/Display/AssetDisplay.aspx?id=5511>.
10. National Association of County and City Health Officials. Local health department job losses and program cuts: 2008–2010. Survey Findings, March 2011. Available at <http://www.naccho.org/topics/infrastructure/lhdbudget/loader.cfm?csModule=security/getfile&PageID=181468>.
11. Pilishvili T, Lexau C, Farley MM, et al. Sustained reductions in invasive pneumococcal disease in the era of conjugate vaccine. J Infect Dis 2010;201:32–41.
12. Tate JE, Cortese MM, Payne DC, et al. Uptake, impact, and effectiveness of rotavirus vaccination in the United States. Pediatr Infect Dis J 2011;30:S56–S60.
13. World Health Organization and the Special Programme for Research and Training in Tropical Diseases. Dengue guidelines for diagnosis, treatment, prevention and control. New edition, 2009. A joint publication of the World Health Organization (WHO) and the Special Programme for Research and Training in Tropical Diseases (TDR). World Health Organization, 2009. Available at http://whqlibdoc.who.int/publications/2009/9789241547871_eng.pdf
14. Rosenberg R, Beard CB. Vector-borne infections. Emerg Infect Dis 2011 May. Available at <http://wwwnc.cdc.gov/eid/article/17/5/pdfs/11-0310.pdf>.
15. CDC. CDC global immunization strategic framework, 2011–2015. Available at <http://www.cdc.gov/ncird/div/gid/GID-strat-framework.html>.
16. Klevens RM, Edwards J, Richards C, et al. Estimating health care-associated infections and deaths in U.S. hospitals, 2002. Public Health Rep 2007;122:160–166.
17. U.S. Department of Health and Human Services. Action plan to prevent healthcare-associated infections. June 2009. Available at http://www.hhs.gov/ash/initiatives/hai/actionplan/hhs_hai_action_plan_final_06222009.pdf.
18. CDC. HIV surveillance—United States, 1981–2008. MMWR 2011;60:689–693. Available at http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6021a2.htm?s_cid=mm6021a2_w.
19. Hall HI, Song R, Rhodes P, et al. Estimation of HIV incidence in the United States. JAMA 2008;300:520–529.
20. CDC. Vital signs: HIV testing and diagnosis among adults—United States, 2001–2009. MMWR 2010;59:1550–1555. Available at http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5947a3.htm?s_cid=mm5947a3_w.
21. Farnham PG, Holtgrave DR, Sanson SL, Hall HI. Medical costs averted by HIV prevention efforts in the United States, 1991–2006. J Acquir Immune Defic Syndr 2010;54:565–567.

22. Office of National AIDS Policy. National HIV/AIDS strategy for the United States. July 2010. Available at <http://www.whitehouse.gov/sites/default/files/uploads/NHAS.pdf>.
23. Joint United Nations Programme on HIV/AIDS. Global report: UNAIDS report on the global AIDS epidemic 2010. UNAIDS, 2010. Available at http://www.unaids.org/globalreport/global_report.htm.
24. Scallan E, Hoekstra RM, Angulo FJ, et al. Foodborne illness acquired in the United States—major pathogens. *Emerg Infect Dis* 2011 Jan. Available at <http://www.cdc.gov/EID/content/17/1/7.htm>.
25. Scallan E, Griffin PM, Angulo FJ, Tauxe RV, Hoekstra RM. Foodborne illness acquired in the United States—unspecified agents. *Emerg Infect Dis* 2011 Jan. Available at <http://www.cdc.gov/EID/content/17/1/16.htm>.
26. CDC. Surveillance for foodborne disease outbreaks—United States, 2007. *MMWR* 2010;59:973–979. Available at http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5931a1.htm?s_cid=mm5931a1_w.
27. CDC. Vital signs: Incidence and trends of infection with pathogens transmitted commonly through food—Foodborne Diseases Active Surveillance Network, 10 U.S. sites, 1996–2010. *MMWR* 2011;60:749–755. Available at http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6022a5.htm?s_cid=mm6022a5_w.
28. CDC. Disease burden from viral hepatitis A, B, and C in the United States. U.S. Department of Health and Human Services, CDC, 2008. Available at http://www.cdc.gov/hepatitis/PDFs/disease_burden.pdf.
29. Armstrong GL, Wasley A, Simard EP, McQuillan GM, Kuhnert WL, Alter MJ. The prevalence of hepatitis C virus infection in the United States, 1999 through 2002. *Ann Intern Med* 2006;144:705–714.
30. CDC. Hepatitis C virus infection among adolescents and young adults—Massachusetts, 2002–2009. *MMWR* 2011;60:537–541. Available at http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6017a2.htm?s_cid=mm6017a2_w.
31. Institute of Medicine. Hepatitis and liver cancer: A national strategy for prevention and control of hepatitis B and C. Washington, DC: The National Academies Press, 2010.
32. U.S. Department of Health and Human Services. Combatting the silent epidemic of viral hepatitis: Action plan for the prevention, care & treatment of viral hepatitis. 2011. Available at http://www.hhs.gov/ash/initiatives/hepatitis/actionplan_viralhepatitis2011.pdf.
33. Goldstein ST, Zhou F, Hadler SC, Bell BP, Mast EE, Margolis HS. A mathematical model to estimate global hepatitis B disease burden and vaccination impact. *Int J Epidemiol* 2005;34:1329–1339.
34. Perz JF, Armstrong GL, Farrington LA, Hutin YJ, Bell BP. The contribution of hepatitis B virus and hepatitis C virus infections to cirrhosis and primary liver cancer worldwide. *J Hepatol* 2006;45:529–538.
35. World Health Organization. International health regulations (2005)—2nd edition. 2008. Available at <http://www.who.int/ihr/9789241596664/en/index.html>.
36. Roberts RR, Hota B, Ahmad I, et al. Hospital and societal costs of antimicrobial-resistant infections in a Chicago teaching hospital: Implications for antibiotic stewardship. *Clin Infect Dis* 2009;49:1175–1184.
37. Antibiotic-resistant infections cost the U.S. healthcare system in excess of \$20 billion annually. PRNewswire, United Business Media, October 19, 2009. Available at <http://www.prnewswire.com/news-releases/antibiotic-resistant-infections-cost-the-us-healthcare-system-in-excess-of-20-billion-annually-64727562.html>.
38. CDC. *Acinetobacter baumannii* infections among patients at military medical facilities treating injured U.S. service members, 2002–2004. *MMWR* 2004;53:1063–1066. Available at <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5345a1.htm>.
39. CDC. Severe *Clostridium difficile*-associated disease in populations previously at low risk—four states, 2005. *MMWR* 2005;54:1201–1205. Available at <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5447a1.htm>.
40. Jones KE, Patel NG, Levy MA, Storeygard A, Balk D, Gittleman JL, Daszak P. Global trends in emerging infectious diseases. *Nature* 2008;451:990–993.
41. Taylor LH, Latham SM, Woolhouse ME. Risk factors for human disease emergence. *Philos Trans R Soc Lond B Biol Sci* 2001;356:983–989.