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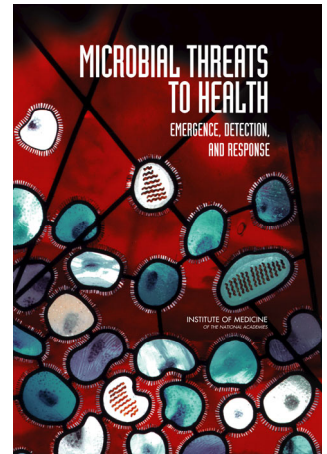
Shaping the Future for Health

MICROBIAL THREATS TO HEALTH: EMERGENCE, DETECTION, AND RESPONSE

Infectious diseases continue to be a serious burden around the world, in developing and industrialized countries alike. Whether naturally occurring or intentionally inflicted, infections can cause illness, disability, and death in individuals while disrupting whole populations, economies, and governments. And because national borders offer trivial impediment to such threats, especially in the highly interconnected and readily traversed “global village” of our time, one nation’s problem soon becomes every nation’s problem. The United States has shown leadership in the past by strengthening its own and others’ capacities to deal with infectious diseases, but the present reality nevertheless is that public health and medical communities are inadequately prepared. We must do more to improve our ability to prevent, detect, and control emerging—as well as resurging—microbial threats to health.

In 1992, the Institute of Medicine (IOM) published a landmark report, *Emerging Infections: Microbial Threats to Health in the United States*, offering the consensus of a wide-ranging group of specialists that America needed a wake-up call. The report maintained that infectious diseases were a tangible threat to our security and that we might soon regret the comfort and complacency that had overtaken us with the advent of wonder drugs and vaccines. That study was a stimulus for numerous other studies and policy actions, many of them in response to the harsh realities of the spread of HIV/AIDS, the emergence of new or previously unrecognized diseases, the resurgence of old diseases, and the looming failure of scientific research and technological innovation in antimicrobial drugs to keep up with the constant evolution of microbial resistance.

The present report is the successor to the 1992 IOM document, and it observes that a decade later the impact of infectious diseases on the United States has only increased. Illnesses unknown in this country only a few years ago, such as West Nile encephalitis and hantavirus pulmonary syndrome, have emerged to kill hundreds of Americans—and the long-term consequences for survivors of



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these illnesses are as yet unknown. Meanwhile, *known* diseases that were thought to be virtually eradicated in the United States, such as measles, pertussis, and malaria, still reappear, occasionally in epidemic proportions. Moreover, gains made against sexually transmitted diseases have recently slowed or reversed in certain population groups.

Compounding the danger posed by these infectious diseases are other important trends: the continuing increase in antimicrobial resistance, which has become pervasive not only in the United States but worldwide; the country's diminished capacity to recognize and respond to microbial threats—particularly those originating elsewhere; and the intentional use of biological agents to do harm.

Thus conclude the report's authors, the Committee on Emerging Microbial Threats to Health in the 21st Century, who were charged by IOM in 2001 to: review the current state of knowledge on the emergence of infectious diseases; assess the capacity of the United States to detect and respond to microbial threats to health; and identify potential challenges and opportunities for public health actions, both global and domestic, to strengthen capabilities in prevention, detection, and response.

In other words, the committee's assignment was to set forth the principal factors involved in the threats' emergence, take stock of existing measures for dealing with them, and specify what further investments of fiscal and political capital are needed. The committee's subsequent conclusions and recommendations are summarized below.

FACTORS IN EMERGENCE

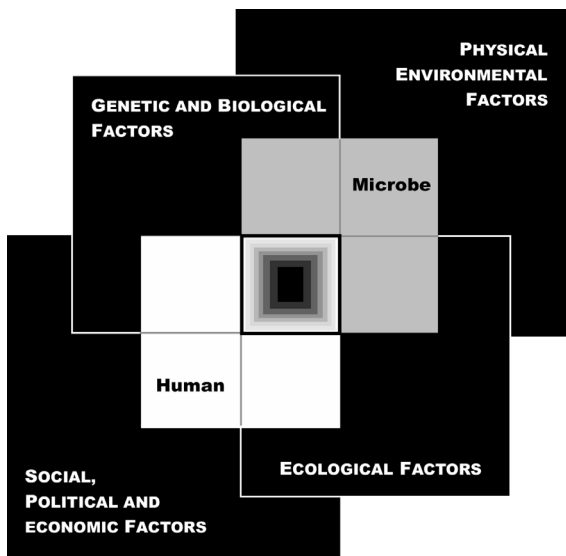
Thirteen individual factors—some reflecting the ways of nature, most of them reflecting our ways of life—account for new or enhanced microbial threats. Any of these factors alone can trigger problems, but their convergence creates especially high-risk environments where infectious diseases may readily emerge, or re-emerge, afflicting individuals and societies alike while posing particular challenges for the medical and public health communities that must face these situations at the front lines. It's conceivable, in fact, that in certain places microbial "perfect storms" could occur—convergences of several factors—and unlike meteorological perfect storms, the events would not be on the order of once-in-a-century, but frequent.

The individual factors in emergence examined in this report are these:

Microbial Adaptation and Change. The tremendous evolutionary potential of microbes makes them adept at developing resistance to even the most potent drug therapies and complicates attempts at creating effective vaccines.

Human Vulnerability. Susceptibility to infection can result when normal defense mechanisms are impaired by causes such as genetically inherited traits and

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The Convergence Model.
 At the center of the model is a box representing the convergence of factors leading to the emergence of an infectious disease. The interior of the box is a gradient flowing from white to black; the white outer edges represent what is known about the factors in emergence, and the black center represents the unknown (similar to the theoretical construct of the “black box” with its unknown constituents and means of operation). Interlocking with the center box are the two focal players in a microbial threat to health—the human and the microbe. The microbe–host interaction is influenced by the interlocking domains of the determinants of the emergence of infection: genetic and biological factors; physical environmental factors; ecological factors; and social, political, and economic factors.

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Climate and Weather. Climate can directly affect disease transmission through its impacts on the replication, movement, and evolution of microbes and vectors; climate can also operate indirectly through its effects on ecology and human behavior.

Changing Ecosystems. Altered environments have immense influence on the transmission of microbial agents, whether waterborne, airborne, foodborne, or vector-borne.

Economic Development and Land Use. Commercial activities can have intended or unintended impacts on the environment. For example, new or previously unknown infectious diseases have emerged from the increased human contact with animal reservoirs that resulted from changing land-use patterns.

Human Demographics And Behavior. Infectious diseases can result from individuals’ activities that involve exposure to microbial pathogens or simply from the increased probability of infectious disease as populations grow and people come into closer contact.

Technology and Industry. Advances in medical technologies, such as blood transfusions and organ transplants, have created new pathways for the spread of certain infections. Meanwhile, the use of antibiotics in food-product animals has heightened antimicrobial resistance.

International Travel and Commerce. The rapid and virtually unrestricted transport of humans, animals, foods, and other goods can lead to the broad dissemination of pathogens and their vectors throughout the world.

Breakdown of Public Health Measures. In many places, the lack of basics such as potable water or sanitation contributes to infectious diseases. But similar effects can also occur elsewhere from inadequate vaccine supplies, low immunization rates, or a paucity of expertise—say, in vector control.

Poverty and Social Inequality. Mortality from infectious diseases is closely correlated with global inequities in income. Economic trends affect not only the individuals at risk but also the structure and availability of public health institutions necessary to reduce risks.

War and Famine. Displacement caused by war and the fairly consistent sequelae of malnutrition from famine can contribute significantly to the emergence and spread of infectious diseases.

Lack of Political Will. It is not only the governments in the regions of highest disease prevalence that must commit themselves, but also the leaders of affluent regions that ultimately share the same global microbial landscape.

Intent To Harm. The world today is vulnerable to the threat of deliberate biological attacks that can cause large numbers of deaths and widespread social disruption. The likelihood of such events, in fact, is high, and public health systems and health care providers must be prepared to address them.

DETECTION AND RESPONSE: ADDRESSING THE THREATS

Who should do what, and why, to reduce the rising infectious disease rates prompted by the above emergence factors both singly and in combination? The committee responded with an array of conclusions and recommendations for specific actions, actors, and coordinators to fortify or replace current policies and infrastructural elements that the committee deemed inadequate.

Among the committee's most prominent recommendations are the following two, based on the inevitability that an effective national response to infectious diseases, given their highly transportable nature, must be a global response:

The United States should seek to enhance the global capacity for response to infectious disease threats, focusing in particular on threats in the developing world. Efforts should be coordinated by key international agencies such as the World Health Organization (WHO); based in appropriate U.S. federal agencies (the Centers for Disease Control and Prevention [CDC], the Department of Defense [DOD], the National Institutes of Health [NIH], the Agency for International Development [USAID], and the Department of Agriculture [USDA], for example); and include collaboration with private-sector organizations and foundations. Investments should take the form of financial and technical assistance, operational research, en-

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hanced surveillance, and efforts to share both knowledge and best public health practices across national boundaries.

The United States should take a leadership role in promoting the implementation of a comprehensive system of surveillance for global infectious diseases that builds on the current global capacity of infectious disease monitoring. To this end, CDC should enhance its regional infectious disease surveillance; DOD should expand and increase in number its Global Emerging Infections Surveillance overseas program sites; and NIH should increase its global surveillance research. In addition, CDC, DOD, and NIH should intensify their efforts to develop and arrange for distribution of laboratory diagnostic reagents needed for global surveillance, transferring technology to other nations where feasible to ensure self-sufficiency and sustainable surveillance capacity. Overseas activities should be coordinated by a single federal agency such as CDC. Sustainable progress and ultimate success in these efforts will require health agencies to broaden partnerships to include nonhealth agencies and institutions such as the World Bank.

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Another of the committee's main recommendations stresses the need to bolster the U.S. public health infrastructure, which has suffered from years of neglect:

U.S. federal, state, and local governments should direct the appropriate resources to rebuild and sustain the public health capacity necessary to respond to microbial threats to health, both naturally occurring and intentional. Expanded prevention and control measures must be executed by an adequately trained and competent workforce. Examples of such measures include surveillance; laboratory capacity; epidemiological, statistical, and communication skills; and systems to ensure the rapid utility and sharing of information.

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The committee directly aims a recommendation—involving the critical need for vaccine development, production, and deployment—to the highest levels in government, which at present are “neither addressing all of these challenges at a sufficiently high level nor providing adequate resources”:

The U.S. Secretary of Health and Human Services should ensure the formulation and implementation of a national vaccine strategy for protecting the U.S. population from endemic and emerging microbial threats. Only by focusing leadership, authority, and accountability at the cabinet level can the federal government meet its national responsibility for ensuring an innovative and adequately funded research base for existing and emerging diseases as well as an ample supply of vaccines. In that spirit, the Secretary of HHS should work closely with other relevant federal agencies, Congress, industry, academia, and the public health community.

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To avert an imminent crisis resulting from microbial agents' increasing resistance to available antimicrobial drugs, the committee recommends procedures to alert infectious disease control stakeholders to the problem and more finely target the use of antimicrobials. It also advises action on one major source of the problem:

FDA should ban the use of antimicrobials for growth promotion in animals if those classes of antimicrobials are also used in humans.

CDC, FDA, professional health organizations, academia, health care delivery systems, and industry should expand efforts to decrease the inappropriate use of antimicrobials in human medicine through (1) expanded outreach and better education of health care providers, drug dispensers, and the general public on the inherent dangers associated with the inappropriate use of antimicrobials; and (2) the increased use of diagnostic tests, as well as the development and use of rapid diagnostic tests, to determine the etiology of infection and thereby ensure the more appropriate use of antimicrobials.

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Another important pair of recommendations reflect the present realities that “the reporting of infectious diseases by health care providers and laboratories remains inadequate” and that open lines of communication are essential to robust systems of surveillance, investigation, and response:

The agency should develop innovative strategies to improve communication between health care providers and public health authorities...

CDC should take the necessary actions to enhance infectious disease reporting by medical health care and veterinary health care providers. The agency should develop innovative strategies to improve communication between health care providers and public health authorities, and it should do so by working with other public health agencies federal, state, and local; health sciences educators; and professional medical organizations. *(The committee specifically identifies what it believes are some of the obligatory actors in these categories.)*

CDC should expeditiously implement automated electronic laboratory reporting of notifiable infectious diseases from all relevant major clinical laboratories (e.g., microbiology, pathology) to their respective state health departments as part of a national electronic infectious disease reporting system. This set of actions would not only improve surveillance but assist in the control of antimicrobial resistance.

Other recommendations in the report involve the development and use of diagnostics, the education and training of the microbial threat workforce, the need for new antimicrobial drugs, vector-borne and zoonotic (animal to human) disease control, a comprehensive infectious disease research agenda for the United States, and the establishment of interdisciplinary infectious disease centers.

TRUMPETING THE MESSAGE

No responsible assessment of microbial threats to health in the 21st century can end without a call to action on what the committee has called a potentially “catastrophic storm of microbial threats.”

Dramatic advances in science, technology, and medicine have enabled us to make great strides forward in our struggle to prevent and control infectious diseases, yet we cannot fall prey to an illusory complacency. We must understand that pathogens—old and new—are endlessly resourceful in adapting to and breaching our defenses. We must also understand that factors relating to society, the environment, and our increasing global interconnectedness actually enhance the likelihood of disease emergence and spread. Moreover, it is a sad reality that today we must also grapple with the intentional use of biological agents to do harm, human against human.

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Thus the prevention and control of infectious diseases are fundamental to individual, national, and global security. Failure to recognize—and act on—this essential truth will surely lead to disaster. We must therefore continue to trumpet a message of urgency and concern.

That message is basically this: the magnitude of the problem requires renewed commitment. Despite our past achievements, we have still not done enough in our defense, or in the defense of others. But as we look at our prospects, it is clear that the best defense against any disease outbreak will be a robust public health system, both in its science and practice, and that sustained attention, dedication, and support will be essential.

Only in this way will we be able to ensure the health and safety of our nation—and the world. We certainly know that in our complex global village, numerous forces converge to make us more vulnerable; but we also know that a great many opportunities stand before us to make a real and enduring difference.

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For More Information...

Copies of *Microbial Threats To Health: Emergence, Detection, and Response* are available for sale from the National Academies Press; call (800) 624-6242 or (202) 334-3313 (in the Washington metropolitan area), or visit the NAP home page at www.nap.edu. The full text of this report is available at <http://www.nap.edu>

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