



National
Intelligence
Estimate

**The Global Infectious Disease
Threat and Its Implications
for the United States**



*NIE 99-17D
January 2000*

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Key Judgments

The Global Infectious Disease Threat and Its Implications for the United States

New and reemerging infectious diseases will pose a rising global health threat and will complicate US and global security over the next 20 years. These diseases will endanger US citizens at home and abroad, threaten US armed forces deployed overseas, and exacerbate social and political instability in key countries and regions in which the United States has significant interests.

Infectious diseases are a leading cause of death, accounting for a quarter to a third of the estimated 54 million deaths worldwide in 1998. The spread of infectious diseases results as much from changes in human behavior—including lifestyles and land use patterns, increased trade and travel, and inappropriate use of antibiotic drugs—as from mutations in pathogens.

- Twenty well-known diseases—including tuberculosis (TB), malaria, and cholera—have reemerged or spread geographically since 1973, often in more virulent and drug-resistant forms.
- At least 30 previously unknown disease agents have been identified since 1973, including HIV, Ebola, hepatitis C, and Nipah virus, for which no cures are available.
- Of the seven biggest killers worldwide, TB, malaria, hepatitis, and, in particular, HIV/AIDS continue to surge, with HIV/AIDS and TB likely to account for the overwhelming majority of deaths from infectious diseases in developing countries by 2020. Acute lower respiratory infections—including pneumonia and influenza—as well as diarrheal diseases and measles, appear to have peaked at high incidence levels.

Impact Within the United States

Although the infectious disease threat in the United States remains relatively modest as compared to that of noninfectious diseases, the trend is up. Annual infectious disease-related death rates in the United States have nearly doubled to some 170,000 annually after reaching an historic low in

1980. Many infectious diseases—most recently, the West Nile virus—originate outside US borders and are introduced by international travelers, immigrants, returning US military personnel, or imported animals and foodstuffs. In the opinion of the US Institute of Medicine, the next major infectious disease threat to the United States may be, like HIV, a previously unrecognized pathogen. Barring that, the most dangerous known infectious diseases likely to threaten the United States over the next two decades will be HIV/AIDS, hepatitis C, TB, and new, more lethal variants of influenza. Hospital-acquired infections and foodborne illnesses also will pose a threat.

- Although multidrug therapies have cut *HIV/AIDS* deaths by two-thirds to 17,000 annually since 1995, emerging microbial resistance to such drugs and continued new infections will sustain the threat.
- Some 4 million Americans are chronic carriers of the *hepatitis C* virus, a significant cause of liver cancer and cirrhosis. The US death toll from the virus may surpass that of HIV/AIDS in the next five years.
- *TB*, exacerbated by multidrug resistant strains and HIV/AIDS co-infection, has made a comeback. Although a massive and costly control effort is achieving considerable success, the threat will be sustained by the spread of HIV and the growing number of new, particularly illegal, immigrants infected with TB.
- *Influenza* now kills some 30,000 Americans annually, and epidemiologists generally agree that it is not a question of whether, but when, the next killer pandemic will occur.
- Highly virulent and increasingly *antimicrobial resistant pathogens*, such as *Staphylococcus aureus*, are major sources of hospital-acquired infections that kill some 14,000 patients annually.
- The doubling of US food imports over the last five years is one of the factors contributing to tens of millions of *foodborne illnesses* and 9,000 deaths that occur annually, and the trend is up.

Regional Trends

Developing and former communist countries will continue to experience the greatest impact from infectious diseases—because of malnutrition,

poor sanitation, poor water quality, and inadequate health care—but developed countries also will be affected:

- **Sub-Saharan Africa**—accounting for nearly half of infectious disease deaths globally—will remain the most vulnerable region. The death rates for many diseases, including HIV/AIDS and malaria, exceed those in all other regions. Sub-Saharan Africa’s health care capacity—the poorest in the world—will continue to lag.
- **Asia and the Pacific**, where multidrug resistant TB, malaria, and cholera are rampant, is likely to witness a dramatic increase in infectious disease deaths, largely driven by the spread of HIV/AIDS in South and Southeast Asia and its likely spread to East Asia. By 2010, the region could surpass Africa in the number of HIV infections.
- The **former Soviet Union (FSU)** and, to a lesser extent, Eastern Europe also are likely to see a substantial increase in infectious disease incidence and deaths. In the FSU especially, the steep deterioration in health care and other services owing to economic decline has led to a sharp rise in diphtheria, dysentery, cholera, and hepatitis B and C. TB has reached epidemic proportions throughout the FSU, while the HIV-infected population in Russia alone could exceed 1 million by the end of 2000 and double yet again by 2002.
- **Latin American** countries generally are making progress in infectious disease control, including the eradication of polio, but uneven economic development has contributed to widespread resurgence of cholera, malaria, TB, and dengue. These diseases will continue to take a heavy toll in tropical and poorer countries.
- **The Middle East and North Africa** region has substantial TB and hepatitis B and C prevalence, but conservative social mores, climatic factors, and the high level of health spending in the oil-producing states tend to limit some globally prevalent diseases, such as HIV/AIDS and malaria. The region has the lowest HIV infection rate among all regions, although this is probably due in part to above-average underreporting because of the stigma associated with the disease in Muslim societies.
- **Western Europe** faces threats from several infectious diseases, such as HIV/AIDS, TB, and hepatitis B and C, as well as from several economically costly zoonotic diseases (that is, those transmitted from animals to humans). The region’s large volume of travel, trade, and immigration increases the risks of importing diseases from other regions, but its highly developed health care system will limit their impact.

Response Capacity

Development of an effective global surveillance and response system probably is at least a decade or more away, owing to inadequate coordination and funding at the international level and lack of capacity, funds, and commitment in many developing and former communist states. Although overall global health care capacity has improved substantially in recent decades, the gap between rich and poorer countries in the availability and quality of health care, as illustrated by a typology developed by the Defense Intelligence Agency's Armed Forces Medical Intelligence Center (AFMIC), is widening.

Alternative Scenarios

We have examined three plausible scenarios for the course of the infectious disease threat over the next 20 years:

Steady Progress

The least likely scenario projects steady progress whereby the aging of global populations and declining fertility rates, socioeconomic advances, and improvements in health care and medical breakthroughs hasten movement toward a "health transition" in which such noninfectious diseases as heart disease and cancer would replace infectious diseases as the overarching global health challenge. We believe this scenario is unlikely primarily because it gives inadequate emphasis to persistent demographic and socioeconomic challenges in the developing countries, to increasing microbial resistance to existing antibiotics, and because related models have already underestimated the force of major killers such as HIV/AIDS, TB, and malaria.

Progress Stymied

A more pessimistic—and more plausible—scenario projects little or no progress in countering infectious diseases over the duration of this Estimate. Under this scenario, HIV/AIDS reaches catastrophic proportions as the virus spreads throughout the vast populations of India, China, the former Soviet Union, and Latin America, while multidrug treatments encounter microbial resistance and remain prohibitively expensive for developing countries. Multidrug resistant strains of TB, malaria, and other infectious diseases appear at a faster pace than new drugs and vaccines, wreaking havoc on world health. Although more likely than the "steady progress" scenario, we judge that this scenario also is unlikely to prevail because it underestimates the prospects for socioeconomic development, international collaboration, and medical and health care advances to constrain the spread of at least some widespread infectious diseases.

Deterioration, Then Limited Improvement

The most likely scenario, in our view, is one in which the infectious disease threat—particularly from HIV/AIDS—worsens during the first half of our time frame, but decreases fitfully after that, owing to better prevention and control efforts, new drugs and vaccines, and socioeconomic improvements. In the next decade, under this scenario, negative demographic and social conditions in developing countries, such as continued urbanization and poor health care capacity, remain conducive to the spread of infectious diseases; persistent poverty sustains the least developed countries as reservoirs of infection; and microbial resistance continues to increase faster than the pace of new drug and vaccine development. During the subsequent decade, more positive demographic changes such as reduced fertility and aging populations; gradual socioeconomic improvement in most countries; medical advances against childhood and vaccine-preventable killers such as diarrheal diseases, neonatal tetanus, and measles; expanded international surveillance and response systems; and improvements in national health care capacities take hold in all but the least developed countries. Barring the appearance of a deadly and highly infectious new disease, a catastrophic upward lurch by HIV/AIDS, or the release of a highly contagious biological agent capable of rapid and widescale secondary spread, these developments produce at least limited gains against the overall infectious disease threat. However, the remaining group of virulent diseases, led by HIV/AIDS and TB, continue to take a significant toll.

Economic, Social, and Political Impact

The persistent infectious disease burden is likely to aggravate and, in some cases, may even provoke economic decay, social fragmentation, and political destabilization in the hardest hit countries in the developing and former communist worlds, especially in the worst case scenario outlined above:

- The economic costs of infectious diseases—especially HIV/AIDS and malaria—are already significant, and their increasingly heavy toll on productivity, profitability, and foreign investment will be reflected in growing GDP losses, as well, that could reduce GDP by as much as 20 percent or more by 2010 in some Sub-Saharan African countries, according to recent studies.
- Some of the hardest hit countries in Sub-Saharan Africa—and possibly later in South and Southeast Asia—will face a demographic upheaval as HIV/AIDS and associated diseases reduce human life expectancy by as

much as 30 years and kill as many as a quarter of their populations over a decade or less, producing a huge orphan cohort. Nearly 42 million children in 27 countries will lose one or both parents to AIDS by 2010; 19 of the hardest hit countries will be in Sub-Saharan Africa.

The relationship between disease and political instability is indirect but real. A wide-ranging study on the causes of state instability suggests that infant mortality—a good indicator of the overall quality of life—correlates strongly with political instability, particularly in countries that already have achieved a measure of democracy. The severe social and economic impact of infectious diseases is likely to intensify the struggle for political power to control scarce state resources.

Implications for US National Security

As a major hub of global travel, immigration, and commerce with wide-ranging interests and a large civilian and military presence overseas, the United States and its equities abroad will remain at risk from infectious diseases.

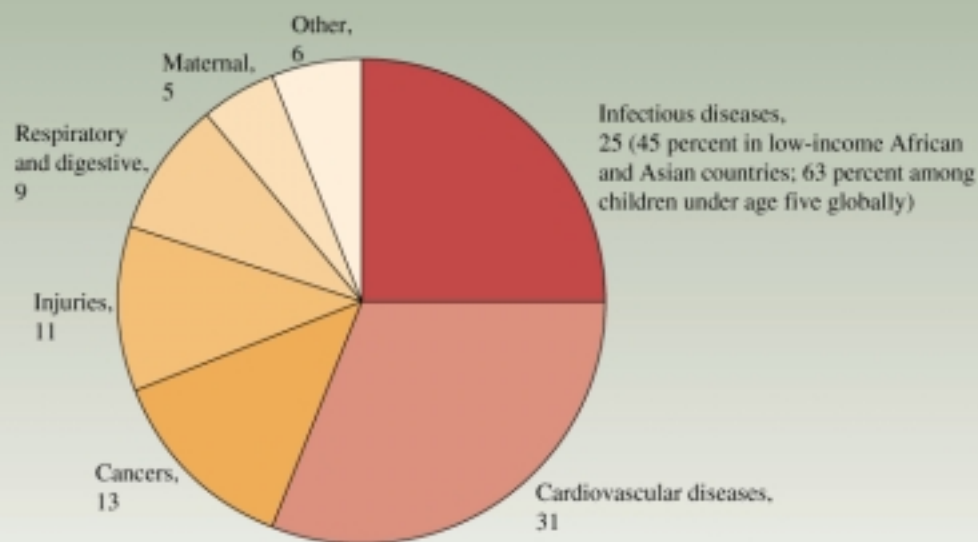
- Emerging and reemerging infectious diseases, many of which are likely to continue to originate overseas, will continue to kill at least 170,000 Americans annually. Many more could perish in an epidemic of influenza or yet-unknown disease or if there is a substantial decline in the effectiveness of available HIV/AIDS drugs.
- Infectious diseases are likely to continue to account for more military hospital admissions than battlefield injuries. US military personnel deployed at NATO and US bases overseas, will be at low-to-moderate risk. At highest risk will be US military forces deployed in support of humanitarian and peacekeeping operations in developing countries.
- The infectious disease burden will weaken the military capabilities of some countries—as well as international peacekeeping efforts—as their armies and recruitment pools experience HIV infection rates ranging from 10 to 60 percent. The cost will be highest among officers and the more modernized militaries in Sub-Saharan Africa and increasingly among FSU states and possibly some rogue states.

- Infectious diseases are likely to slow socioeconomic development in the hardest-hit developing and former communist countries and regions. This will challenge democratic development and transitions and possibly contribute to humanitarian emergencies and civil conflicts.
- Infectious disease-related embargoes and restrictions on travel and immigration will cause frictions among and between developed and developing countries.
- The probability of a bioterrorist attack against US civilian and military personnel overseas or in the United States also is likely to grow as more states and groups develop a biological warfare capability. Although there is no evidence that the recent West Nile virus outbreak in New York City was caused by foreign state or nonstate actors, the scare and several earlier instances of suspected bioterrorism showed the confusion and fear they can sow regardless of whether or not they are validated.

Figure 1
Leading Causes of Death, 1998

53.9 million from all causes, worldwide.

Percent



Note: Cancers, cardiovascular, and respiratory/digestive deaths can also be caused by infections and raise the percentage of deaths due to infectious diseases even more.

Source: WHO, 1999.

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Scope Note

The Global Infectious Disease Threat and Its Implications for the United States

Senior policymakers in recent years have expressed concern about the implications of the growing global infectious disease threat for the United States. A 1996 Presidential Decision Directive (NST-7) called for a more focused US policy on infectious diseases, including establishment of a worldwide surveillance and response system in cooperation with other countries and international institutions such as the World Health Organization. More recently, the 1997 US Strategic Plan for International Affairs listed protecting human health and reducing the spread of infectious diseases as US strategic goals. In response to these concerns, this National Intelligence Estimate (NIE) assesses the infectious disease threat from international sources to the United States; to US military personnel overseas; and to regions and countries in which the United States has or may have significant equities. It also examines the capacity of the international community to develop a comprehensive surveillance and response system at the national and international levels. It does not focus on the biological warfare threat to the United States.¹ (U)

The Estimate builds on a conference on infectious diseases held jointly with the State Department's Bureau of Intelligence and Research. The NIE has been reviewed by Dr. Joshua Lederberg, President Emeritus of Rockefeller University; Dr. Stephen M. Ostroff, Associate Director for Epidemiologic Science, National Center for Infectious Diseases; and Mr. Richard J. Smith, Former Principal Deputy Assistant Secretary of State for Oceans and Environmental Scientific Affairs. (U)

¹ For a comprehensive discussion of this topic, see NIE 99-05CX/D (Secret NF), August 1999, *Worldwide BW Programs: Trends and Prospects*. (C NF)

Discussion

The Global Infectious Disease Threat and Its Implications for the United States

Patterns of Infectious Diseases

Broad advances in controlling or eradicating a growing number of infectious diseases—such as tuberculosis (TB), malaria, and smallpox—in the decades after the Second World War fueled hopes that the global infectious disease threat would be increasingly manageable. Optimism regarding the battle against infectious diseases peaked in 1978 when the United Nations (UN) member states signed the “Health for All 2000” accord, which predicted that even the poorest nations would undergo a health transition before the millennium, whereby infectious diseases no longer would pose a major danger to human health. As recently as 1996, a World Bank/World Health Organization (WHO)–sponsored study by Christopher J.L. Murray and Alan D. Lopez projected a dramatic reduction in the infectious disease threat. This optimism, however, led to complacency and overlooked the role of such factors as expanded trade and travel and growing microbial resistance to existing antibiotics in the spread of infectious diseases. Today:

- Infectious diseases remain a leading cause of death (see figure 1). Of the estimated 54 million deaths worldwide in 1998, about one-fourth to one-third were due to infectious diseases, most of them in developing countries and among children globally.
- Infectious diseases accounted for 41 percent of the global disease burden measured in terms of Disability-Adjusted Life Years (DALYS) that gauge the impact of both deaths and disabilities, as compared to 43 percent for noninfectious diseases and 16 percent for injuries.
- Although there has been continuing progress in controlling some vaccine-preventable childhood diseases such as polio, neonatal tetanus, and measles, a White House–appointed interagency working group identified at least 29 previously unknown diseases that have appeared globally since 1973, many of them incurable, including HIV/AIDS, Ebola hemorrhagic fever, and hepatitis C. Most recently, Nipah encephalitis was identified. Twenty well-known diseases such as malaria, TB, cholera, and dengue have rebounded after a period of decline or spread to new regions, often in deadlier forms (see table 1).
- These trends are reflected in the United States as well, where annual infectious disease deaths have nearly doubled to some 170,000 since 1980 after reaching historic lows that year, while new and existing pathogens, such as HIV and West Nile virus, respectively, continue to enter US borders.

Table 1
Examples of Pathogenic Microbes and the Diseases
They Cause, Identified Since 1973

Year	Microbe	Type	Disease
1973	Rotavirus	Virus	Infantile diarrhea
1977	Ebola virus	Virus	Acute hemorrhagic fever
1977	<i>Legionella pneumophila</i>	Bacterium	Legionnaires' disease
1980	Human T-lymphotrophic virus I (HTLV 1)	Virus	T-cell lymphoma/leukemia
1981	Toxin-producing <i>Staphylococcus aureus</i>	Bacterium	Toxic shock syndrome
1982	<i>Escherichia coli O157:H7</i>	Bacterium	Hemorrhagic colitis; hemolytic uremic syndrome
1982	<i>Borrelia burgdorferi</i>	Bacterium	Lyme disease
1983	Human Immunodeficiency Virus (HIV)	Virus	Acquired Immuno-Deficiency Syndrome (AIDS)
1983	<i>Helicobacter pylori</i>	Bacterium	Peptic ulcer disease
1989	Hepatitis C	Virus	Parentally transmitted non-A, non-B liver infection
1992	<i>Vibrio cholerae O139</i>	Bacterium	New strain associated with epidemic cholera
1993	Hantavirus	Virus	Adult respiratory distress syndrome
1994	Cryptosporidium	Protozoa	Enteric disease
1995	Ehrlichiosis	Bacterium	Severe arthritis?
1996	nvCJD	Prion	New variant Creutzfeldt-Jakob disease
1997	HVN1	Virus	Influenza
1999	Nipah	Virus	Severe encephalitis

Source: US Institute of Medicine, 1997; WHO, 1999.

The Deadly Seven

The seven infectious diseases that caused the highest number of deaths in 1998, according to WHO and DIA's Armed Forces Medical Intelligence Center (AFMIC), will remain threats well into the next century. HIV/AIDS, TB, malaria, and hepatitis B and C—are either spreading or becoming more drug-resistant, while lower respiratory infections, diarrheal diseases, and measles, appear to have at least temporarily peaked (see figure 2).

HIV/AIDS. Following its identification in 1983, the spread of HIV intensified quickly. Despite progress in some regions, HIV/AIDS shows no signs of abating globally (see figure 3). Approximately 2.3 million people died from AIDS worldwide in 1998, up dramatically from 0.7 million in 1993, and there were 5.8 million new infections. According to WHO, some 33.4 million people were living with HIV by 1998, up from 10 million in 1990, and the number could approach 40 million by the end of 2000.

A Word About Data

All data concerning global disease incidence, including WHO data, should be treated as broadly indicative of trends rather than accurate measures of disease prevalence. Much disease incidence in developing countries, in particular, is either unreported or under-reported due to a lack of adequate medical and administrative personnel, the stigma associated with many diseases, or the reluctance of countries to incur the trade, tourism, and other losses that such revelations might produce. Since much morbidity and mortality are multicausal, moreover, diagnosis and reporting of diseases can vary

and further distort comparisons. WHO and other international entities are dependent on such data despite its weaknesses and are often forced to extrapolate or build models based on relatively small samples, as in the case of HIV/AIDS. Changes in methodologies, moreover, can produce differing results. The ranking of AIDS mortality ahead of TB mortality in figure 2, for example, partly owes to the fact that HIV-positive individuals dying of TB were included in the AIDS mortality category in the most recent WHO survey.

Although infection and death rates have slowed considerably in developed countries owing to the growing use of preventive measures and costly new multidrug treatment therapies, the pandemic continues to spread in much of the developing world, where 95 percent of global infections and deaths have occurred. Sub-Saharan Africa currently has the biggest regional burden, but the disease is spreading quickly in India, Russia, China, and much of the rest of Asia. HIV/AIDS probably will cause more deaths than any other single infectious disease worldwide by 2020 and may account for up to one-half or more of infectious disease deaths in the developing world alone.

TB. WHO declared TB a global emergency in 1993 and the threat continues to grow, especially from multidrug resistant TB (see figure 4). The disease is especially prevalent in Russia, India, Southeast Asia, Sub-Saharan Africa, and parts of Latin America. More than 1.5 million people died of TB in 1998, excluding those

infected with HIV/AIDS, and there were up to 7.4 million new cases. Although the vast majority of TB infections and deaths occur in developing regions, the disease also is encroaching into developed regions due to increased immigration and travel and less emphasis on prevention. Drug resistance is a growing problem; the WHO has reported that up to 50 percent of people with multidrug resistant TB may die of their infection despite treatment, which can be 10 to 50 times more expensive than that used for drug-sensitive TB. HIV/AIDS also has contributed to the resurgence of TB. One-quarter of the increase in TB incidence involves co-infection with HIV. TB probably will rank second only to HIV/AIDS as a cause of infectious disease deaths by 2020.

Glossary

Infectious Disease

An illness due to a specific infectious agent that is spread from an infected person, animal, or inanimate reservoir to a susceptible host, either directly or indirectly, through an intermediate plant or animal host, vector, or the inanimate environment.

Endemic

The constant presence of a disease or infectious agent within a given geographic area.

Epidemic

The occurrence in an area of a disease or illness in excess of what may be expected on the basis of past experience for a given population (in the case of a new disease, such as AIDS, any occurrence may be considered “epidemic”).

Pandemic

A worldwide epidemic affecting an exceptionally high proportion of the global population.

Prevalence

The number of existing cases of a disease among a total or specified population in a given period of time; usually expressed as a percent or as the number of cases per thousand, 10,000, and so forth.

Malaria, a mainly tropical disease that seemed to be coming under control in the 1960s and 1970s, is making a deadly comeback—especially in Sub-Saharan Africa where infection rates increased by 40 percent from 1970 to

1997 (see figure 5). Drug resistance, historically a problem only with the most severe form of the disease, is now increasingly reported in the milder variety, while the prospects for an effective vaccine are poor. In 1998, an estimated 300 million people were infected with malaria, and more than 1.1 million died from the disease that year. Most of the deaths occurred in Sub-Saharan Africa. According to the US Agency for International Development (USAID), Sub-Saharan Africa alone is likely to experience a 7- to 20-percent annual increase in malaria-related deaths and severe illnesses over the next several years.

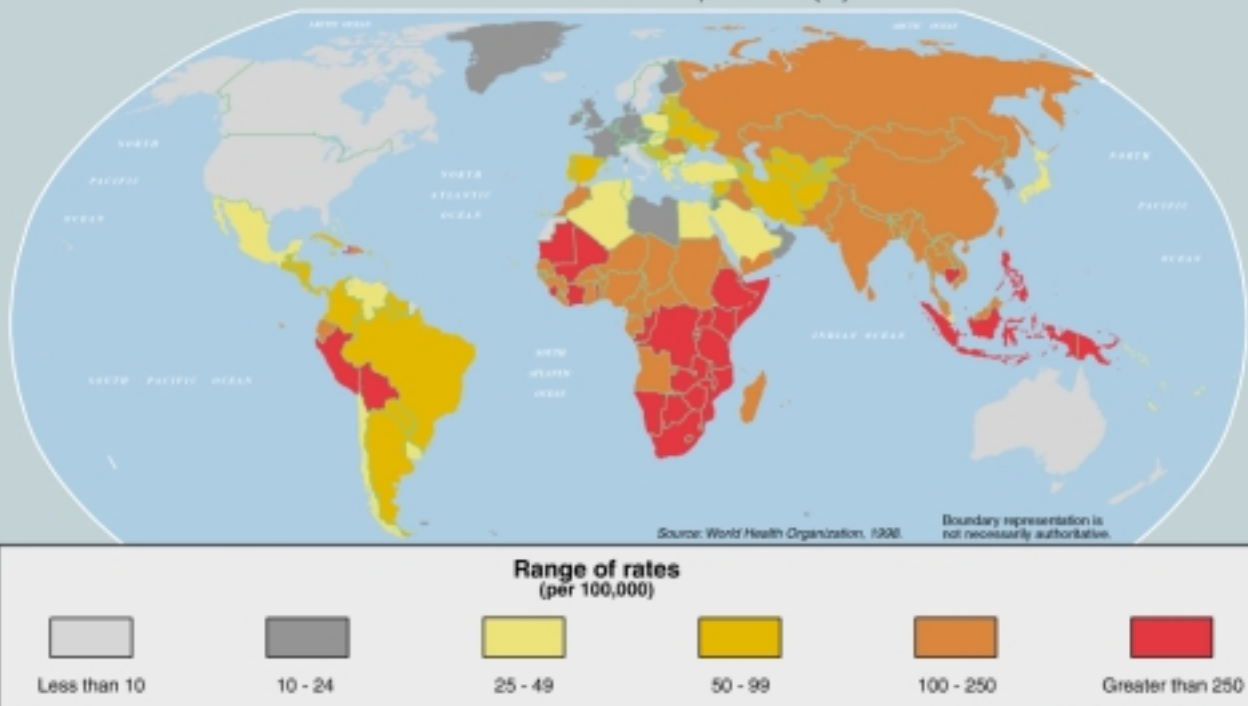
Hepatitis B and C. Hepatitis B, which caused at least 0.6 million deaths in 1997, is highly endemic in the developing world, and some 350 million people worldwide are chronic carriers (see figure 6). The less prevalent but far more lethal hepatitis C identified in 1989 has grown dramatically and is a significant contributor to cirrhosis and liver cancer. WHO estimated that 3 percent of the global population was infected with the hepatitis C virus by 1997 (see figure 7), which means that more than 170 million people were at risk of developing the diseases associated with this virus. Various studies project that up to 25 percent of people with chronic hepatitis B and C will die of cirrhosis of the liver and liver cancer over the next 20 to 30 years.

Lower respiratory infections, especially influenza and pneumonia, killed 3.5 million people in 1998, most of them children in developing countries, down from 4.1 million in 1993. Owing to immunosuppression from malnutrition and growing microbial resistance to commonly used drugs such as penicillin, these

Figure 3
Global HIV/AIDS Prevalence, 1998 (U)



Figure 4
Estimated TB Incidence, 1997 (U)



these regions in the absence of improvements in water quality and sanitation.

Measles. Despite substantial progress against measles in recent years, the disease still infects some 42 million children annually and killed about 0.9 million in 1998, down from 1.2 million in 1993. It is a leading cause of death among refugees and internally displaced persons during complex humanitarian emergencies. Measles will continue to pose a major threat in developing countries (see figure 8), particularly Sub-Saharan Africa, until the still relatively low vaccination rates are substantially increased. It also will continue to cause periodic epidemics in areas such as South America with higher, but still inadequate, vaccination rates.

Factors Affecting Growth and Spread

With few exceptions, the resurgence of the infectious disease threat is due as much to dramatic changes in human behavior and broader social, economic, and technological developments as to mutations in pathogens (see table 2). Changes in human behavior include population dislocations, living styles, and sexual practices; technology-driven medical procedures entailing some risks of infection; and land use patterns. They also include rising international travel and commerce that hasten the spread of infectious diseases; inappropriate use of antibiotics that leads to the development of microbial resistance; and the breakdown of public health systems in some countries owing to war or economic decline. In addition, climate changes enable diseases and vectors to expand their range. Several of these factors interact, exacerbating the spread of infectious diseases.

Table 2
Factors Contributing to Infectious Disease Reemergence and Associated Diseases

Contributing Factor(s)	Associated Infectious Diseases
Human demographics and behavior	Dengue/dengue hemorrhagic fever, sexually transmitted diseases, giardiasis
Technology and industry	Toxic shock syndrome, nosocomial (hospital-acquired) infections, hemorrhagic colitis/hemolytic uremic syndrome
Economic development and land use	Lyme disease, malaria, plague, rabies, yellow fever, Rift Valley fever, schistosomiasis
International travel and commerce	Malaria, cholera, pneumococcal pneumonia
Microbial adaptation and change	Influenza, HIV/AIDS, malaria, <i>Staphylococcus aureus</i> infections
Breakdown of public health measures	Rabies, tuberculosis, trench fever, diphtheria, whooping cough (pertussis), cholera
Climate change	Malaria, dengue, cholera, yellow fever

Source: Adapted from US Institute of Medicine, 1997.

Human Demographics and Behavior

Population growth and urbanization, particularly in the developing world, will continue to facilitate the transfer of pathogens among people and regions. Frequent and often sudden population movements within and across borders caused by ethnic conflict, civil war, and famine will continue to spread diseases rapidly in affected areas, particularly among refugees. As of 1999, there were some 24 major humanitarian emergencies worldwide involving at least 35 million refugees and internally displaced people. Refugee camps, found

mainly in Sub-Saharan Africa and the Middle East, facilitate the spread of TB, HIV, cholera, dysentery, and malaria. Well over 120 million people lived outside the country of their birth in 1998, and millions more will emigrate annually, increasing the spread of diseases globally. Behavioral patterns, such as unprotected sex with multiple partners and intravenous drug use, will remain key factors in the spread of HIV/AIDS.

Technology, Medicine, and Industry

Although technological breakthroughs will greatly facilitate the detection, diagnosis, and control of certain infectious and noninfectious illnesses, they also will introduce new dangers, especially in the developed world where they are used extensively. Invasive medical procedures will result in a variety of hospital-acquired infections, such as *Staphylococcus aureus*. The globalization of the food supply means that nonhygienic food production, preparation, and handling practices in originating countries can introduce pathogens endangering foreign as well as local populations. Disease outbreaks due to *Cyclospora spp*, *Escherichia coli*, and *Salmonella spp*. in several countries, along with the emergence, primarily in Britain, of Bovine Spongiform Encephalopathy, or “mad cow” disease, and the related new variant Creutzfeldt-Jakob disease (nvCJD) affecting humans, result from such food practices.

Economic Development and Land Use

Changes in land and water use patterns will remain major factors in the spread of infectious diseases. The emergence of Lyme disease in the United States and Europe has been linked to reforestation and increases in the deer tick population, which acts as a vector, while conversion of grasslands to farming in Asia

encourages the growth of rodent populations carrying hemorrhagic fever and other viral diseases. Human encroachment on tropical forests will bring populations into closer proximity with insects and animals carrying diseases such as leishmaniasis, malaria, and yellow fever, as well as heretofore unknown and potentially dangerous diseases, as was the case with HIV/AIDS. Close contact between humans and animals in the context of farming will increase the incidence of zoonotic diseases—those transmitted from animals to humans. Water management efforts, such as dambuilding, will encourage the spread of water-breeding vectors such as mosquitoes and snails that have contributed to outbreaks of Rift Valley fever and schistosomiasis in Africa.

International Travel and Commerce

The increase in international air travel, trade, and tourism will dramatically increase the prospects that infectious disease pathogens such as influenza—and vectors such as mosquitoes and rodents—will spread quickly around the globe, often in less time than the incubation period of most diseases. Earlier in the decade, for example, a multidrug resistant strain of *Streptococcus pneumoniae* originating in Spain spread throughout the world in a matter of weeks, according to the director of WHO’s infectious disease division. The cross-border movement of some 2 million people each day, including 1 million between developed and developing countries each week, and surging global trade ensure that travel and commerce will remain key factors in the spread of infectious diseases.

Table 3
Examples of Drug-Resistant Infectious Agents and
Percentage of Infections That Are Drug Resistant,
by Country or Region

Pathogen	Drug	Country/Region	Percentage of Drug-Resistant Infections
<i>Streptococcus pneumoniae</i>	Penicillin	United States	10 to 35
		Asia, Chile, Spain, Hungary	20 58
<i>Staphylococcus aureus</i>	Methicillin	United States	32
	Multidrug	Japan	60
<i>Mycobacterium tuberculosis</i>	Any drug	United States	13
	Any drug	New York City	16
	Multidrug	Eastern Europe	20
<i>Plasmodium falciparum</i> malaria	Chloroquine	Kenya	65
		Ghana	45
		Zimbabwe	59
		Burkina Faso	17
	Mephloquine	Thailand	45
<i>Shigella dysenteriae</i>	Multidrug	Burundi, Rwanda	100

Note: Antimicrobial resistance occurs when a disease-carrying microbe (bacteria, virus, parasite, or fungus) is no longer affected by a drug that previously was able to kill the microbe or prevent it from growing. Even among populations of microorganisms that are susceptible to a particular antimicrobial agent, at least a small percentage of those organisms are naturally resistant, and their proportion will grow as the others succumb to the antimicrobial agent. Eventually this process renders the agent ineffective against the microorganism.

Source: US Institute of Medicine, 1997; WHO, 1999.

Microbial Adaptation and Resistance

Infectious disease microbes are constantly evolving, oftentimes into new strains that are increasingly resistant to available antibiotics. As a result, an expanding number of strains of diseases—such as TB, malaria, and pneumonia—will remain difficult or virtually impossible to treat. At the same time, large-scale use of antibiotics in both humans and livestock will continue to encourage development of microbial resistance. The firstline drug treatment for malaria is no longer effective in over 80 of the 92 countries where the disease is a major health problem. Penicillin has substantially lost its effectiveness against several diseases, such as pneumonia, meningitis, and gonorrhea, in

many countries. Eighty percent of *Staphylococcus aureus* isolates in the United States, for example, are penicillin-resistant and 32 percent are methicillin-resistant. A US Centers for Disease Control and Prevention (USCDC) study found a 60-fold increase in high-level resistance to penicillin among one group of *Streptococcus pneumoniae* cases in the United States and significant resistance to multidrug therapy as well. Influenza viruses, in particular, are particularly efficient in their ability to survive and genetically change, sometimes into deadly strains. HIV also displays a high rate of genetic mutation that will present significant problems in the development of an effective vaccine or new, affordable therapies.

Breakdown in Public Health Care

Alone or in combination, war and natural disasters, economic collapse, and human complacency are causing a breakdown in health care delivery and facilitating the emergence or reemergence of infectious diseases. While Sub-Saharan Africa is the area currently most affected by these factors, economic problems in Russia and other former communist states are creating the context for a large increase in infectious diseases. The deterioration of basic health care services largely accounts for the reemergence of diphtheria and other vaccine-preventable diseases, as well as TB, as funds for vaccination, sanitation, and water purification have dried up. In developed countries, past inroads against infectious diseases led to a relaxation of preventive measures such as surveillance and vaccination. Inadequate infection control practices in hospitals will remain a major source of disease transmission in developing and developed countries alike.

Climate Change

Climatic shifts are likely to enable some diseases and associated vectors—particularly mosquito-borne diseases such as malaria, yellow fever, and dengue—to spread to new areas. Warmer temperatures and increased rainfall already have expanded the geographic range of malaria to some highland areas in Sub-Saharan Africa and Latin America and could add several million more cases in developing country regions over the next two decades. The occurrence of waterborne diseases associated with temperature-sensitive environments, such as cholera, also is likely to increase.

Regional Trends and Response Capacity

The overall level of global health care capacity has improved substantially in recent decades, but in most poorer countries the availability of

various types of health care—ranging from basic pharmaceuticals and postnatal care to costly multidrug therapies—remains very limited. Almost all research and development funds allocated by developed country governments and pharmaceutical companies, moreover, are focused on advancing therapies and drugs relevant to developed country maladies, and those that are relevant to developing country needs usually are beyond their financial reach. This is generating a growing controversy between rich and poorer nations over such issues as intellectual property rights, as some developing countries seek to meet their pharmaceutical needs with locally produced generic products. Malnutrition, poor sanitation, and poor water quality in developing countries also will continue to add to the disease burden that is overwhelming health care infrastructures in many countries. So too, will political instability and conflict and the reluctance of many governments to confront issues such as the spread of HIV/AIDS. A global composite measure of health care infrastructure devised by DIA's Armed Forces Medical Intelligence Center (AFMIC) assesses factors such as the priority attributed to health care, health expenditures, the quality of health care delivery and access to drugs, and the extent of surveillance and response systems. The AFMIC typology highlights the disparities in health care capacity (see figure 9), as do various WHO, UNAIDS, and World Bank studies.

Sub-Saharan Africa

Sub-Saharan Africa will remain the region most affected by the global infectious disease phenomenon—accounting for nearly half of infectious disease-caused deaths worldwide. Deaths from HIV/AIDS, malaria, cholera, and several lesser known diseases exceed those in

FIGURE 9
Foldout
#752049

all other regions. Sixty-five percent of all deaths in Sub-Saharan Africa are caused by infectious diseases. Rudimentary health care delivery and response systems, the unavailability or misuse of drugs, the lack of funds, and the multiplicity of conflicts are exacerbating the crisis. According to the AFMIC typology, with the exception of southern Africa, most of Sub-Saharan Africa falls in the lowest category. Investment in health care in the region is minimal, less than 40 percent of the people in countries such as Nigeria and the Democratic Republic of the Congo (DROC) have access to basic medical care, and even in relatively well off South Africa, only 50 to 70 percent have such access, with black populations at the low end of the spectrum.

Four-fifths of all HIV-related deaths and 70 percent of new infections worldwide in 1998 occurred in the region, totaling 1.8-2 million and 4 million, respectively. Although only a tenth of the world's population lives in the region, 11.5 million of 13.9 million cumulative AIDS deaths have occurred there. Eastern and southern African countries, including South Africa, are the worst affected, with 10 to 26 percent of adults infected with the disease. Sub-Saharan Africa has high TB prevalence, as well as the highest HIV/TB co-infection rate, with TB deaths totaling 0.55 million in 1998. The hardest hit countries are in equatorial and especially southern Africa. South Africa, in particular, is facing the biggest increase in the region.

Sub-Saharan Africa accounts for an estimated 90 percent of the global malaria burden (see figure 10). Ten percent of the regional disease burden is attributed to malaria, with roughly 1 million deaths in 1998. Cholera, dysentery, and other diarrheal diseases also are major killers in the region, particularly among children, refugees, and internally displaced populations.

Forty percent of all childhood deaths from diarrheal diseases occur in Sub-Saharan Africa. The region also has a high rate of hepatitis B and C infections and is the only region with a perennial meningococcal meningitis problem in a "meningitis belt" stretching from west to east. Sub-Saharan Africa also suffers from yellow fever, while trypanosomiasis or "sleeping sickness" is making a comeback in the DROC and Sudan, and the Marburg virus also appeared in DROC for the first time in 1998. Ebola hemorrhagic fever strikes sporadically in countries such as the DROC, Gabon, Cote d'Ivoire, and Sudan (see figure 11).

Asia and the Pacific

Although the more developed countries of Asia and the Pacific, such as Japan, South Korea, Australia, and New Zealand, have strong records in combating infectious diseases, infectious disease prevalence in South and Southeast Asia is almost as high as in Sub-Saharan Africa. The health care delivery system of the Asia and Pacific region—the majority of which is privately financed—is particularly vulnerable to economic downturns even though this is offset to some degree by much of the region's reliance on traditional medicine from local practitioners. According to the AFMIC typology, 90 to 100 percent of the populations in the most developed countries, such as Japan and Australia, have access to high-quality health care. Forty to 50 percent have such access among the large populations of China and South Asia, while southeast Asian health care is more varied, with less than 40 percent enjoying such access in Burma and Cambodia, and 50 to 70 percent in Thailand, Malaysia, and the Philippines. In South and Southeast Asia, reemergent diseases such as TB, malaria, cholera, and dengue fever are rampant, while HIV/AIDS, after a late start, is growing faster than in any other region.

populations having access to basic health care in Chile, Costa Rica, and Cuba on the upper end of the scale. Less than 50 percent have such access in Haiti, most of Central America, and the Amazon basin countries, including the rural populations in Brazil.

Cholera reemerged with a vengeance in the region in 1991 for the first time in a century with 400,000 new cases, and while dropping to 100,000 cases in 1997, it still comprises two-thirds of the global cholera burden. TB is a growing problem regionwide, especially in Brazil, Peru, Argentina, and the Dominican Republic where drug-resistant cases also are on the rise. Haiti does not provide data but probably also has a high infection rate. HIV/AIDS also is spreading rapidly, placing Latin America third behind Sub-Saharan Africa and Asia in HIV prevalence. Prevalence is high in Brazil and especially in the Caribbean countries (except Cuba), where 2 percent of the population is infected. Malaria is prevalent in the Amazon basin. Dengue reemerged in the region in 1976, and outbreaks have taken place in the last few years in most Caribbean countries and parts of South America. Hepatitis B and C prevalence is greatest in the Amazon basin, Bolivia, and Central America, while dengue hemorrhagic fever is particularly prevalent in Brazil, Colombia, and Venezuela. Yellow fever has made a comeback over the last decade throughout the Amazon basin, and there have been several recent outbreaks of gastrointestinal disease attributed to E. coli infection in Chile and Argentina. Hemorrhagic fevers are present in almost all South American countries, and most hantavirus pulmonary syndrome occurs in the southern cone.

Middle East and North Africa

The region's conservative social mores, climatic factors, and high levels of health spending in oil-producing states tend to limit some

globally prevalent diseases, such as HIV/AIDS and malaria, but others, such as TB and hepatitis B and C, are more prevalent. The region's advantages are partially offset by the impact of war-related uprooting of populations, overcrowded cities with poor refrigeration and sanitation systems, and a dearth of water, especially clean drinking water. Health care capacity varies considerably within the region, according to the AFMIC typology. Israel and the Arabian Peninsula states minus Yemen are in far better shape than Iraq, Iran, Syria, and most of North Africa. Ninety to 100 percent of the Israeli population and 70 to 90 percent of the Saudi population have good access to health care. Elsewhere, access ranges from less than 40 percent in Yemen to 50 to 70 percent in the smaller Gulf states, Jordan and Tunisia, while most North African states fall into the 40- to 50-percent category.

The HIV/AIDS impact is far lower than in other regions, with 210,000 cases, or 0.13 percent of the population, including 19,000 new cases, in 1998. This owes in part to above-average underreporting because of the stigma associated with the disease in Muslim societies and the authoritarian nature of most governments in the region. TB, including multidrug resistant varieties, is more problematic, especially in Iran, Iraq, Yemen, Libya, and Morocco, with an estimated 140,000 deaths in 1998. Malaria is significant only in Iran, Iraq, and Yemen, but diarrheal and childhood diseases caused 0.3 million deaths each in 1998. Other prominent or reemerging diseases in the region include all types of hepatitis, with Egypt reporting the highest prevalence worldwide of the C variety. Brucellosis now infects some 90,000 people; leishmaniasis and sandfly fever also are endemic in the region; and various hemorrhagic fevers occur, as well.

The Former Soviet Union and Eastern Europe

The sharp decline in health care infrastructure in Russia and elsewhere in the former Soviet Union (FSU) and, to a lesser extent, in Eastern Europe—owing to economic difficulties—are causing a dramatic rise in infectious disease incidence. Death rates attributed to infectious diseases in the FSU increased 50 percent from 1990 to 1996, with TB accounting for a substantial number of such deaths. According to the AFMIC typology, access to health care ranges from 50 to 70 percent in most European FSU states, including Russia and Ukraine, and from 40 to 50 percent in FSU states located in Central Asia. This is generally supported by WHO estimates indicating that only 50 to 80 percent of FSU citizens had regular access to essential drugs in 1997, as compared to more than 95 percent a decade earlier as health care budgets and government-provided health services were slashed. Access to health care is generally better in Eastern Europe, particularly in more developed states such as Poland, the Czech Republic, and Hungary, where it ranges from 70 to 90 percent, while only 50 to 70 percent have access in countries such as Bulgaria and Romania. More than 95 percent of the population throughout the East European region had such access in 1987, according to WHO.

Crowded living conditions are among the causes fueling a TB epidemic in the FSU, especially among prison populations—while surging intravenous drug use and rampant prostitution are substantially responsible for a marked increase in HIV/AIDS incidence. There were 111,000 new TB infections in Russia alone in 1996, a growing number of them multidrug resistant, and nearly 25,000 deaths due to TB—numbers that could increase significantly following periodic releases of prisoners to relieve overcrowding. The number of new infections for the entire FSU in 1996 was

188,000, while East European cases totaled 54,000. More recent data indicate that the TB infection rate in Russia more than tripled from 1990 to 1998, with 122,000 new cases reported in 1998 and the total number of cases expected to reach 1 million by 2002. After a slow and late start, HIV/AIDS is spreading rapidly throughout the European part of the FSU beyond the original cohort of intravenous drug users, though it is not yet reflected in official government reporting. An estimated 270,000 people were HIV-positive in 1998, up more than five-fold from 1997. Although Ukraine has been hardest hit, Russia, Belarus, and Moldova have registered major increases. Various senior Russian Health Ministry officials predict that the HIV-positive population in Russia alone could reach 1 million by the end of 2000 and could reach 2 million by 2002. East European countries will fare better as renewed economic growth facilitates recovery of their health care systems and better enables them to expand preventive and treatment programs.

Diphtheria reached epidemic proportions in the FSU in the first half of the decade, owing to lapses in vaccination. Reported annual case totals grew from 600 cases in 1989 to more than 40,000 in 1994 in Russia, with another 50,000 to 60,000 in the rest of the FSU. Cholera and dysentery outbreaks are occurring with increasing frequency in Russian cities, such as St. Petersburg and Moscow, and elsewhere in the FSU, such as in T'bilisi, owing to deteriorating water treatment and sewerage systems. Hepatitis B and C, spread primarily by intravenous drug use and blood transfusions, are on the rise, especially in the non-European part of the FSU. Polio also has reappeared owing to interruptions in vaccination, with 140 new cases in Russia in 1995.

Western Europe

Western Europe faces threats from a number of emerging and reemerging infectious diseases such as HIV/AIDS, TB, and hepatitis B and C, as well as several zoonotic diseases. Its status as a hub of international travel, commerce, and immigration, moreover, dramatically increases the risks of importing new diseases from other regions. Tens of millions of West Europeans travel to developing countries annually, increasing the prospects for the importation of dangerous diseases, as demonstrated by the importation of typhoid in 1999. Some 88 percent of regional population growth in the first half of the decade was due to immigration; legal immigrants now comprise about 6 percent of the population, and illegal newcomers number an estimated 6 million. Nonetheless, the region's highly developed health care infrastructure and delivery system tend to limit the incidence and especially the death rates of most infectious diseases, though not the economic costs. Access to high-quality care is available throughout most of the region, although governments are beginning to limit some heretofore generous health benefits, and a growing antivaccination movement in parts of Western Europe, such as Germany, is causing a rise in measles and other vaccine-preventable diseases. The AFMIC typology gives somewhat higher marks to northern over some southern European countries, but the region as a whole is ranked in the highest category, along with North America.

After increasing sharply for most of the 1980s and 1990s, HIV infections, and particularly HIV/AIDS deaths, have slowed considerably owing to behavioral changes among high-risk populations and the availability and funding for multidrug treatment. Some 0.5 million people were living with HIV/AIDS in 1998, down

slightly from 510,000 the preceding year, and there were 30,000 new cases and 12,000 deaths, with prevalence somewhat higher in much of southern Europe than in the north. TB, especially its multidrug resistant strains, is on the upswing, as is co-infection with HIV, particularly in the larger countries, with some 50,000 TB cases reported in 1996. Hepatitis C prevalence is growing, especially in southern Europe. Western Europe also continues to suffer from several zoonotic diseases, among which is the deadly new variant Creutzfeldt-Jakob disease (nvCJD), linked to the bovine spongiform encephalopathy or "mad cow disease" outbreak in the United Kingdom in 1995 that has since ebbed following implementation of strict control measures. Other recent disease concerns include meningococcal meningitis outbreaks in the Benelux countries and leishmaniasis-HIV co-infection, especially in southern Europe.

International Response Capacity

International organizations such as WHO and the World Bank, institutions in several developed countries such as the US CDC, and Non-governmental Organizations (NGOs) will continue to play an important role in strengthening both international and national surveillance and response systems for infectious diseases. Nonetheless, progress is likely to be slow, and development of an integrated global surveillance and response system probably is at least a decade or more away. This owes to the magnitude of the challenge; inadequate coordination at the international level; and lack of funds, capacity, and, in some cases, cooperation and commitment at the national level.

Some countries hide or understate their infectious disease problems for reasons of international prestige and fear of economic losses. Total international health-related aid to low- and middle-income countries—some \$2-3 billion annually—remains a fraction of the \$250 billion health bill of these countries.

WHO

WHO has the broadest health mandate under the UN system, including establishing health priorities, coordinating global health surveillance, and emergency assistance in the event of disease outbreaks. Health experts give WHO credit for major successes, such as the eradication of smallpox, near eradication of polio, and substantial progress in controlling childhood diseases, and in facilitating the expansion of primary health care in developing countries. It also has come under criticism for becoming top heavy, unfocused in its mission, and overly optimistic in its health projections. WHO defenders blame continued member state parsimony that has kept WHO's regular biennial budget to roughly \$850 million for several years and forced it to rely more on voluntary contributions that often come with strings attached as the cause of its shortcomings.

The election last year of Gro Harlem Brundtland as Secretary General, along with a series of reforms, including expansion of the Emerging and other Communicable Diseases Surveillance and Control (EMC) Division, has placed WHO in a better position to revitalize itself. Internal oversight and transparency have been expanded, programs and budgets are undergoing closer scrutiny, and management accountability is looming larger. Brundtland has moved quickly to streamline upper-level management and has installed new top managers, mostly

Other UN Agencies Involved in Health Care

WHO competes for resources with the many other UN agencies that are increasingly involved in health care. The United Nations Children's Fund (UNICEF) focuses on children's health. The United Nations AIDS Program (UNAIDS) focuses on improving the response capacity toward HIV/AIDS at the country, regional, and global levels in cooperation with WHO and other UN agencies. Other UN agencies involved in health care issues include the UN Development Program (UNDP); the UN Family Planning Agency (UNFPA); the UN High Commissioner for Refugees (UNHCR); the UN Educational, Scientific and Cultural Organization (UNESCO); the International Labor Organization (ILO); the Food and Agricultural Organization (FAO); and the World Food Program (WFP).

from outside the organization, including from the private sector. She also is working to strengthen country offices and to make the regional offices more responsive to central direction. WHO is increasing its focus on the fight against resurgent malaria, while a better-funded EMC is expanding efforts to establish a global surveillance and response system in cooperation with UNAIDS, UNICEF, and national entities such as the US CDC, the US DoD, and France's Pasteur Institute.

The World Bank

The growing sense that health is linked inexorably to socioeconomic development, has prompted the World Bank to expand its health activities. According to a 1997 study by the US Institute of Medicine, the most significant change in the global health arena over the past decade has been the growth in both financial and intellectual influence of the World Bank, whose health loans have grown to \$2.5 billion annually, including \$800 million for infectious diseases. Health experts generally welcome the Bank's greater involvement in the health sector, viewing it as efficient and responsive in areas such as health sector financial reform. Some remain concerned that the Bank's emphasis on fiscal balance can sometimes have a negative health and social impact in developing countries. Some developing countries resent what they perceive as the domination of Bank decisionmaking and priority setting by the richer countries.

Nongovernmental Organizations

Another major change in the global health arena over the last decade is the increasingly important role of NGOs, which provide direct assistance, including emergency shelter and aid, as well as long-term domestic health care delivery. NGOs also build community awareness and support for WHO and other international and bilateral surveillance and response efforts. At the same time, health experts note that NGOs, like their governmental counterparts, are driven in part by their own self interests, which sometimes conflict with those of host and donor governments.

Bilateral Assistance

The United States, through USAID, the CDC, the National Institutes for Health (NIH), and the

Defense Department's overseas laboratories, is a major contributor to international efforts to combat infectious diseases. It is joined increasingly by other developed nations and regional groupings, such as the European Union (EU), that provide assistance bilaterally, as well as through international organizations and NGOs. The Field Epidemiology Training Programs—run jointly by the CDC and WHO—as well as the EU-US Task Force on Emerging Diseases and the US-Japan Common Scientific Agenda, are key examples of developed-country programs focusing on infectious diseases.

National Limitations

A major obstacle to effective global surveillance and control of infectious diseases will continue to be poor or inaccurate national health statistical reporting by many developing countries and lack of both capacity and will to properly direct aid (see figure 12) and to follow WHO and other recommended health care practices. Those areas of the world most susceptible to infectious disease problems are least able to develop and maintain the sophisticated and costly communications equipment needed for effective disease surveillance and reporting. In addition to the barriers dictated by low levels of development, revealing an outbreak of a dreaded disease may harm national prestige, commerce, and tourism. For example, nearly every country initially denied or minimized the extent of the HIV/AIDS virus within its borders, and even today, some countries known to have significant rates of HIV infection refuse to cooperate with WHO, which can only publish the information submitted by surveying nations. Only a few, such as Uganda, Senegal, and Thailand, have launched major preventative efforts, while many WHO members do not

Alternative Scenarios and Outlook for Infectious Diseases

The impact of infectious diseases over the next 20 years will be heavily influenced by three sets of variables. The first is the relationship between increasing microbial resistance and scientific efforts to develop new antibiotics and vaccines. The second is the trajectory of developing and transitional economies, especially concerning the basic quality of life of the poorest groups in these countries. The third is the degree of success of global and national efforts to create effective systems of surveillance and response. The interplay of these drivers will determine the overall outlook.

On the positive side, reduced fertility and the aging of the population, continued economic development, and improved health care capacity in many countries, especially the more developed, will increase the progress toward a *health transition* by 2020 whereby the impact of infectious diseases ebbs, as compared to noninfectious diseases. On the negative side, continued rapid population growth, urbanization, and persistent poverty in much of the developing world, and the paradox in which some aspects of socioeconomic development—such as increased trade and travel—actually foster the spread of infectious diseases, could slow or derail that transition. So, too, will growing microbial resistance among resurgent diseases, such as malaria and TB, and the proliferation or intensification of new ones, such as HIV/AIDS.

Two scenarios—one optimistic and one pessimistic—reflect differences in the international health community concerning the global

outlook for infectious diseases. We present and critically assess these scenarios, elaborate on the pessimistic scenario, and develop a third, combining some elements of each, that we judge as more likely to prevail over the period of this Estimate.

The Optimistic Scenario: Steady Progress

According to a key 1996 World Bank/WHO study cited earlier that articulated the optimistic scenario, a *health transition*—resulting from key drivers, such as aging populations, socioeconomic development, and medical advances—already is under way in developed countries and also in much of Asia and Latin America that is likely to produce a dramatic reduction in the infectious disease threat. The study projects that deaths caused primarily by infectious diseases will fall steadily from 34 percent of the total disease burden in 1990 to 15 percent in 2020. Those from noninfectious diseases are likely to climb from 55 percent of the total disease burden to 73 percent, with the remainder of deaths due to accidents and other types of injuries. According to the study's ranking of major disease threats over this 30-year time frame, noninfectious diseases generally will rise in importance, led by heart disease and mental illness, as will accidental injuries. TB will remain in 7th place in 2020, and HIV/AIDS will move from 28th place to 10th, with the two combined accounting for more than 90 percent of infectious disease-caused deaths among adults, almost all of them in developing countries. Lower respiratory infections will fall from the top spot to sixth place, however, while

Toward a Global Surveillance and Response System

Although a formal, fully integrated surveillance and response system does not yet exist at the global level, the WHO's Emerging and other Communicable Diseases Surveillance and Control (EMC) Division, working with UNAIDS and more than 200 collaborating centers and laboratories, is making some progress.

- Independent networks of laboratories monitoring specific diseases and the microbial resistance phenomenon are being expanded or established, while networks for reporting and exchanging information about infectious disease outbreaks are being enhanced. These networks include one on influenza encompassing more than 100 worldwide laboratories; a network for HIV/AIDS and other sexually transmitted diseases; several new or smaller networks focusing on hepatitis C and yellow fever; and one on microbial resistance in general. The EMC has taken the lead in revising*

international health reporting requirements to encompass a broader array of diseases.

- Member states' capacities to monitor infectious diseases are being enhanced by increasing the number of developing country health professionals capable of monitoring and responding to disease outbreaks.*
- Global infectious disease control efforts are being improved by better assisting countries to deal with disease outbreaks, such as ensuring that trained experts, vaccines, and therapeutics are available to deal with such outbreaks.*
- The global exchange of information among and within surveillance networks is being improved by expanding the availability of equipment for electronic communication through the Internet and World Wide Web sites, such as PROMED.*

measles and malaria will drop precipitously from 8th and 11th place to 24th and 25th, respectively (see figures 13 and 14).

Ageing Populations. Demographic changes are one key to this scenario, which projects that declining fertility and infant mortality, along with increased life expectancy, will result in an aging global population more apt to be felled by noninfectious diseases and by accidental

injury than by infectious diseases, which tend to occur among the very young. While these trends are generally evident on a global scale, there is considerable variance by region and level of development. Fertility has been cut by a half over the last 50 years in most regions of the world, infant mortality worldwide dropped from 129 to 60 per 1,000 live births from 1960 to 1996, and life expectancy worldwide increased from 50 to 64 years, according to the

1998 UN Human Development Report. The overall population growth rate, meanwhile, will slow to 1.2 percent annually by 2015, as compared to 1.7 percent between 1970 and 1995.

Socioeconomic Progress. Under this scenario, continued improved access to safe food and water in developing countries, better nutrition, and improved literacy will sharply reduce infant and adult mortality, already cut by more than half in developing countries since 1965. The number of people with an average per capita caloric intake of 2,700 per day is projected to increase from 1.8 billion in 1990-92 to 2.7 billion by 2010—or roughly 50 percent—and adult literacy in the least developed countries is expected to grow from 49 percent in 1995 to 61 percent in 2010. All of these factors would thus produce better health and health practices for young and old alike.

Economic Gains. The optimistic scenario assumes that worldwide economic growth and rising incomes will further reduce poverty and provide funding for improvements in health care infrastructure, though it will be uneven in scope and by region. Real per capita income levels from 1970 to 1995, for example, increased by 200 percent in east Asia, 60 percent in south Asia, and 25 to 50 percent in Latin America.

Improved Health Care Capacity. Improvements in health care delivery in accordance with WHO’s “health for all” goal are projected to continue in such areas as prenatal care for women, contraception, childhood and adult immunization, and availability of essential drugs. Already more than 90 percent of women in developed and transitional countries and 50 percent in the least developed countries receive some prenatal care. The number of women in developing countries using contraceptives

Table 4
Projected Change in the Rank Order of Global Disease Burden for Leading Causes, Worldwide 1990-2020, According to the Optimistic Scenario^a

1990 Rank Order	Disease or Injury	2020 Rank Order
1	Lower respiratory infections	6
2	Diarrheal diseases	9
3	Conditions arising during perinatal period	11
4	Unipolar major depression	2
5	Ischemic heart disease	1
6	Cerebrovascular disease	4
7	Tuberculosis	7
8	Measles	25
9	Road traffic deaths	3
10	Congenital abnormalities	13
11	Malaria	24
12	Chronic obstructive pulmonary disease	5
13	Falls	19
14	Iron-deficiency anemia	39
15	Protein-energy malnutrition	37
16	War	8
17	Self-inflicted injuries	14
19	Violence	12
28	HIV	10
33	Trachea, bronchus, and lung cancers	15

^aOf the six infectious diseases ranked in 1990, only lower respiratory infections, diarrheal diseases, and measles are trending downward as projected, while malaria is increasing and tuberculosis and HIV are growing far faster than projected. Nonetheless, more pessimistic experts have not developed an alternative model and generally adopt the projections of the Murray and Lopez model.

Source: Adapted from World Bank, WHO, 1996, edited by Christopher J. L. Murray and Alan D. Lopez.

increased from 9 percent in 1965 to 60 percent in 1998. Immunization rates against six common vaccine-preventable diseases have increased from 5 percent to 80 percent of the relevant population over the last two decades.

And access to drugs continues to expand, except in the former communist states in Eastern Europe and in the former Soviet Union. All of these factors will combine to reduce childhood diseases and mortality.

Medical Advances. The optimistic scenario also notes that several diseases are on the verge of elimination or close to it, such as polio, neonatal tetanus, and leprosy, while measles incidence also will be reduced dramatically as vaccination rates increase in the least developed countries. Research efforts are projected to result in the development of more effective, safer, and in some cases, less expensive vaccines. Disease agents against which vaccines have been developed recently include Lyme disease, while several others—such as for malaria, dengue fever, and Ebola—are in various stages of development. As the human genetic code is deciphered, additional genes that influence infectious disease risk are likely to be discovered.

Scenario Assessment. Our overall judgment is that the “steady progress” scenario is very unlikely to transpire over the time period of this Estimate. Although the scenario captures some real trends, it overstates the progress achievable, while underestimating the risks.

- The global life expectancy increases projected by the optimists are likely to be substantially offset by HIV/AIDS and related diseases, such as TB, which are already causing a major reduction in life expectancy in the most heavily affected Sub-Saharan African countries and will be spreading extensively throughout heavily populated Asia during the time period of the Estimate. Optimists acknowledge that HIV/AIDS and TB will be

the overarching infectious disease threats by 2020, but they understate the magnitude of that threat, while their projections of a steep decline in malaria deaths is belied by the disease’s resurgence and growing death toll.

- The picture of steady socioeconomic progress is not consistent with the most recent surveys of conditions in developing countries undertaken by the United Nations, the World Bank, and other international agencies. These studies point to a slowing of progress in basic social indicators in much of the developing world, even before the recent global financial crisis.
- Although we judge that economic growth is likely to continue, we are less confident that the dramatic reductions in poverty achieved in many countries in the last generation will be sustained. Growth is likely to be halting in many countries, owing to structural economic problems and the impact of recurring developing world economic crises.
- The rapidly expanding costs of many drugs, especially those that attack critical infectious diseases, such as HIV/AIDS and multidrug resistant TB and malaria, threaten to limit the sustainability of improved health care. Furthermore, despite economic growth, pressures on government budgets, especially from rising pension and other costs, may limit the prospects for increased health financing.
- The optimists may place too much emphasis on the steady progress of science, which is inconsistent with the demonstrated difficulty of developing new drugs and vaccines for complex pathogens such as HIV and malaria.

The Pessimistic Scenario: Progress Stymied

Surprisingly, even the most pessimistic epidemiologists have done little to project the long-term implications of their analysis and simply adopt the longer term projections of the World Bank/WHO model in the absence of a worst case model. We have developed a worst case scenario culled from a variety of epidemiological and broader health studies. This scenario highlights the dangers posed by microbial resistance among reemerging diseases such as TB and malaria. It takes a more concerned view of new diseases and of the HIV/AIDS pandemic, in particular, and is skeptical about the adequacy of world health care capacity to confront these challenges. It emphasizes continuing and difficult-to-address poverty challenges in developing countries and projects an *incomplete health transition* that prolongs the heavy infectious disease burden in the least developed countries and sustains their role as reservoirs of infection for the rest of the world.

A Not-So-Benign Demographic Picture.

Although the global population growth rate is slowing, world population still will expand by 80 million annually through 2015, mostly in developing countries, where especially the youngest population cohorts will remain highly susceptible to infectious diseases. Infant mortality in the least developed countries is running at nearly double the global average and is eight times that of developed countries, while life expectancy is 23 years below that of developed countries and 13 years below the global average. These trends will be especially evident in urban areas where poverty, overcrowding, poor sanitation, and polluted drinking water create conditions in which infectious diseases and relevant vectors, such as mosquitoes and rodents, thrive. The problem will only worsen when the number of people living in cities

exceeding 10 million more than doubles to 450 million by 2015, with almost all of the increase occurring in developing world cities.

Disparate Socioeconomic Development.

Although the broad long-term trend in global economic growth is likely to be upward, this scenario posits a growing prosperity gap between the developed and developing countries and within developing countries, particularly the poorest cohort. Despite the near doubling of real per capita income from 1970 to 1995 globally, for example, it declined in Sub-Saharan Africa, and income gaps within these countries are widening substantially, as well. One-fifth of developing country populations remain malnourished—the biggest risk factor for infectious diseases—3 billion lack adequate sanitation, and 1 billion still have no access to safe drinking water. Recurring economic crises in developing countries, moreover, are likely to have a negative impact on foreign and domestic investor willingness to invest in them, slowing their economic growth rates further and widening the gap with developed countries.

Inadequate Health Care Delivery and Disease

Surveillance. Tightening of health care eligibility requirements, privatization, and the growing costs of health care, particularly for HIV/AIDS patients, are likely to continue to squeeze health care delivery worldwide, but the impact will be greatest in Sub-Saharan Africa as well as in China—where 80 percent of the rural population no longer has subsidized health care—and in the former communist states. Under this scenario access to essential drugs and basic medical care in these regions will remain poor or deteriorate, and many Sub-Saharan African countries, in particular, will continue to rely on international and NGO assistance for a

modicum of health care and surveillance capability. Although current global surveillance and response capabilities are likely to improve, the emergence of an integrated global network is at least a decade or more away, owing to inadequate capacity and cooperation and resource constraints.

Toward a Postantibiotic Era? The growth and intensity of antimicrobial resistance among infectious pathogens increases, due both to pathogen mutation and to inappropriate and indiscriminate use of therapeutic drugs in both developed and developing countries. Two-thirds of all oral antibiotics worldwide are obtained without a prescription and are inappropriately used against diseases such as TB, malaria, pneumonia, and more routine childhood infections. These practices contribute to antimicrobial resistance and the severe, nearly impossible to treat hospital-acquired infections. Even vancomycin, the last defense against a number of such infections, is losing effectiveness. According to WHO, “In the struggle for supremacy, the microbes are sprinting ahead and the gap between their ability to mutate into resistant strains and man’s ability to counter them is widening fast.” Some epidemiologists and health experts have even suggested that we may be entering a postantibiotic era in which existing antimicrobials, in general, will lose their effectiveness against the most common infectious diseases.

Inadequate Drug and Vaccine Development. The development of new antimicrobial drugs and vaccines does not keep pace with new and resistant pathogens owing to the complexity of pathogens such as HIV and malaria, the slow pace of new antimicrobial development and approval, and in many cases a lack of commercial incentives for drug companies to develop new antibiotics for diseases prevalent in developing countries. Most recent efforts to develop

new or more effective drugs and vaccines against dengue, malaria, *E. coli*, TB, and several other infectious diseases are likely to be prolonged. WHO estimates that development of an effective vaccine against malaria, for example, is at least seven to 15 years away, while a cure for HIV/AIDS is likely to be even more distant. The majority of new drugs and vaccines, moreover, are likely to be beyond the reach of most developing country populations because of their cost.

Continued Threat From HIV/AIDS. The threat from HIV/AIDS and related diseases over the next two decades continues to surge. Although behavioral changes and multidrug treatments will slow infection and death rates in developed countries, these advances are likely to be more than offset by the rapid spread of the disease among the vast populations of India, Russia, China, and Latin America. HIV/AIDS burden projections since the start of the pandemic have consistently been surpassed, while the slow pace of behavioral changes in the developing world, high costs of available treatment, and the obstacles to developing a cure portend more increases in the future. The 1996 joint World Bank/WHO model’s projections that HIV/AIDS deaths would peak in 2006 with 1.7 million deaths, for example, were already exceeded by the 2.3 million deaths in 1998. Two other models likewise have underestimated the HIV/AIDS threat, albeit less so. Similarly, the World Bank/WHO model’s baseline projection of roughly 2.2 million TB deaths in 2020 is likely to be exceeded in the next decade, as may its worst case scenario of 3.2 million deaths if HIV co-infection surges. According to UNAIDS epidemiologists, Asia alone is likely to outstrip Sub-Saharan Africa in the absolute number of HIV carriers by 2010. When coupled with the poor prospects for developing a cure and likely growing resistance to the

multidrug therapies now in use, the HIV/AIDS burden could reach catastrophic proportions over the next 20 years (see figure 14).

The “Infectiousness” of Noninfectious Diseases. Prospects that the infectious disease threat may not diminish, as compared to non-communicable diseases, are further buttressed by the growing body of evidence that infectious pathogens cause or contribute to many diseases—such as diabetes, cancer, heart disease, and ulcers—previously thought to be caused by environmental or lifestyle factors. WHO and other institutions estimate that up to 15 percent of cancers, for example, could be avoided by preventing the infectious diseases associated with them, including more than 50 percent of stomach and cervical cancers and 80 percent of liver cancers.

Scenario Assessment. Our overall judgment is that the “progress stymied” scenario, while more plausible than the optimistic scenario, is also unlikely to develop over the period of this Estimate. Although the pessimistic scenario provides an important counterpoint to the assumptions in the “steady progress” scenario, it understates the likely longer term impact of economic development, scientific progress, and political pressures in responding to the infectious disease threat.

- The demographic projections understate the likely impact of continued progress in reducing infant mortality.
- Improvements in the economic conditions of poor countries and the poorest within countries are probably more important for the infectious disease outlook than the widening “prosperity gap” both between countries and within countries. Although the outlook for Sub-Saharan Africa remains bleak, for the rest of the world progress against infectious

diseases would stall only under the most dire global economic scenario.

- The negative impact on health care delivery of privatization and the transitions in former communist states is likely to be most heavily felt in the immediate future. Free market reforms eventually will improve health care delivery.
- The current success of the “mutating microbes” in the race against scientific innovation will, in and of itself, call forth a greater research effort that will, over time, increase the likelihood of a reversal of this trend.
- The rapid spread of HIV/AIDS in developing and former communist countries is likely to reinvigorate international efforts to address the virus through both medical and behavioral approaches. It will especially give impetus to the search for a more cost-effective approach than at present.
- While growth in surveillance and response capabilities are slow, they are real and are unlikely to be reversed.

The Most Likely Scenario: Deterioration, Then Limited Improvement

According to this scenario, continued deterioration during the first half of our time frame—led by hard core killers such as HIV/AIDS, TB, and malaria—is followed by limited improvement in the second half, owing primarily to gains against childhood and vaccine-preventable diseases such as diarrheal diseases, neonatal tetanus, and measles. The scale and scope of the overall infectious disease threat diminishes, but the remaining threat consists of especially deadly or incurable diseases such as HIV/AIDS, TB, hepatitis C and possibly, heretofore, unknown diseases, with HIV/AIDS and TB

likely comprising the overwhelming majority of infectious disease deaths in developing countries alone by 2020.

Scenario Assessment

Because some elements of both the optimistic and pessimistic scenarios cited above are likely to appear during the 20-year time frame of this Estimate, we are likely to witness neither steady progress against the infectious disease threat nor its unabated intensification. Instead, progress is likely to be slow and uneven, with advances, such as the recent development of a new type of antibiotic drug against certain hospital-acquired infections, frequently offset by renewed setbacks, such as new signs of growing microbial resistance among available HIV/AIDS drugs and withdrawal of a promising new vaccine against rotavirus because of adverse side effects. On balance, negative drivers, such as microbial resistance, are likely to prevail over the next decade, but given time, positive ones, such as gradual socioeconomic development and improved health care capacity, will likely come to the fore in the second decade.

- The negative trends cited in the pessimistic scenario above, such as persistent poverty in much of the developing world, growing microbial resistance and a dearth of new replacement drugs, inadequate disease surveillance and control capacity, and the high prevalence and continued spread of major killers such as HIV/AIDS, TB, and malaria, are likely to remain ascendant and worsen the overall problem during the first half of our time frame.
- Sub-Saharan Africa, India, and Southeast Asia will remain the hardest hit by these diseases. The European FSU states and China are likely to experience a surge in HIV/AIDS and related diseases such as TB. The developed countries will be threatened principally

by the real possibility of a resurgence of the HIV/AIDS threat owing to growing microbial resistance to the current spectrum of multi-drug therapies and to a wide array of other drugs used to combat infectious diseases.

The broadly positive trends cited in the more optimistic scenario, such as aging populations, global socioeconomic development, improved health care capacity, and medical advances, are likely to come to the fore during the second half of our time frame in all but the least developed countries, and even the least developed will experience a measure of improvement.

- Aging populations and expected continued declines in fertility throughout Asia, Latin America, the former FSU states, and Sub-Saharan Africa will sharply reduce the size of age cohorts that are particularly susceptible to infectious diseases owing to environmental or behavioral factors.
- Socioeconomic development, however fitful, and resulting improvements in water quality, sanitation, nutrition, and education in most developing countries will enable the most susceptible population cohorts to better withstand infectious diseases both physically and behaviorally.
- The worsening infectious disease threat we posit for the first decade of our time frame is likely to further energize the international community and most countries to devote more attention and resources to improved infectious disease surveillance, response, and control capacity. The WHO's new campaign against malaria, recent developed country consideration of tying debt forgiveness for the poorest countries in part to their undertaking stronger commitments to combat disease, self-initiated efforts by Sub-Saharan African governments to confront HIV/AIDS, and

greater pharmaceutical industry willingness to provide more drugs to poor countries at affordable prices are likely to be harbingers of more such efforts as the infectious disease threat becomes more acute.

- The likely eventual approval of new drugs and vaccines—now in the developmental stage—for major killers such as dengue, diarrheal diseases, and possibly even malaria will further ease the infectious disease burden and help counter the microbial resistance phenomenon.

Together, these developments are likely to set the stage for at least a limited improvement in infectious disease control, particularly against childhood and vaccine-preventable diseases, such as respiratory infections, diarrheal diseases, neonatal tetanus, and measles in most developing and former communist countries. Given time—and barring the appearance of a deadly and highly infectious new disease, a catastrophic expansion of the HIV/AIDS pandemic, or the release of a highly contagious biological agent capable of rapid and widescale secondary spread—such medical advances, behavioral changes, and improving national and international surveillance and response capacities will eventually produce substantial gains against the overall infectious disease threat. In the event that HIV/AIDS takes a catastrophic turn for the worse in both developed and developing countries, even the authors of the optimistic World Bank/WHO model concur that all bets are off.

Economic, Social, and Political Impacts

The persistent infectious disease burden is likely to aggravate and, in extreme cases, may even provoke social fragmentation, economic

decay, and political polarization in the hardest hit countries in the developing and former communist worlds in particular, especially in the worst case scenario outlined above. This, in turn, will hamper progress against infectious diseases. Even under the most likely scenario that posits some attenuation of the infectious disease threat in the second half of our time frame, new and reemergent infectious diseases are likely to have a disruptive impact on global economic, social, and political dynamics.

Economic Impact Likely To Grow Macroeconomic Impact

The macroeconomic costs of the infectious disease burden are increasingly significant for the most seriously affected countries despite the partially offsetting impact of declines in population growth, and they will take an even greater toll on productivity, profitability, and foreign investment in the future. A senior World Bank official considers AIDS to be the single biggest threat to economic development in Sub-Saharan Africa. A growing number of studies suggest that AIDS and malaria alone will reduce GDP in several Sub-Saharan African countries by 20 percent or more by 2010.

- The impact of infectious diseases on annual GDP growth in heavily affected countries already amounts to as much as a 1-percentage point reduction in the case of HIV/AIDS on average and 1 to 2 percentage points for malaria, according to World Bank studies. A recent Namibian study concluded that AIDS cost the country nearly 8 percent of GDP in 1996, while a study of Kenya projected that GDP will be 14.5 percent smaller in 2005 than it otherwise would have been without the cumulative impact of AIDS. The annual cost of malaria to Kenya's GDP was estimated at 2 to 6 percent and at 1 to 5 percent for Nigeria.

Infectious Disease-Related Trade Disruptions

Infectious diseases will continue to cause costly periodic disruptions in trade and commerce in every region of the world.

- ***Avian flu in Hong Kong.*** *The avian influenza outbreak in 1997 cost the former colony hundreds of millions of dollars in lost poultry production, commerce, and tourism, with airport arrivals in November of that year alone down by 22 percent from the preceding year.*
- ***BSE and nvCJD in Britain.*** *The outbreak of BSE and new variant Creutzfeldt-Jakob disease in the United Kingdom in 1995 prompted a mass slaughter of cattle, drastically cut beef consumption, and led to the imposition of a three-year EU embargo against British beef. The losses to the British economy were estimated by the WHO at \$5.75 billion, including \$2 billion in lost beef exports.*
- ***Cyclospora in Guatemalan raspberries.*** *The outbreak of cyclospora-related illness in the United States and Canada associated with raspberries from Guatemala led to curbs in imports that cost Guatemala several million dollars in lost revenue.*
- ***Cholera in Peru.*** *The outbreak of cholera in 1991 cost the Peruvian fishing industry an estimated \$775 million in lost tourism and trade because of a temporary ban on seafood exports.*
- ***Foot and mouth disease in Taiwan.*** *In 1997 an outbreak of foot and mouth disease (FMD) devastated Taiwan's pork industry—one of the largest in the world—shutting down exports for a full year.*
- ***Nipah in Malaysia.*** *In 1999, the Nipah virus caused the shutdown of over half of the country's pig farms and an embargo against pork exports.*
- ***Plague in India.*** *The plague outbreak in Surat, India, in 1994 and ensuing panic sparked a sudden exodus of 0.5 million people from the region and led to abrupt shutdowns of entire industries, including aviation, and tourism, as several countries froze trade, banned travel from India, and sent some Indian migrants home. The WHO estimated the outbreak cost India some \$2 billion.*

\$500 billion, according to estimates by the Global AIDS Policy Coalition at Harvard University. In Latin America, the Pan-American Health Organization in 1994 estimated it would take a decade and \$200 billion to bring the cholera pandemic in the region under control through a massive water cleanup effort, or nearly 80 percent of total developing

country health spending for that year. The direct costs of fighting malaria in Sub-Saharan Africa increased from \$800 million in 1989 to \$2.2 billion in 1997, largely owing to the far higher cost of treating the growing number of drug-resistant cases, and the trend toward higher costs is likely to continue.

surging HIV/AIDS case load—which is unlikely given its fiscal difficulties. In addition to the cost of the drugs, few countries can afford to build and maintain the health care infrastructure that makes effective treatment possible.

Disruptive Social Impact

At least some of the hardest-hit countries, initially in Sub-Saharan Africa and later in other regions, will face a demographic catastrophe as HIV/AIDS and associated diseases reduce human life expectancy dramatically and kill up to a quarter of their populations over the period of this Estimate (see table 5). This will further impoverish the poor and often the middle class and produce a huge and impoverished orphan cohort unable to cope and vulnerable to exploitation and radicalization.

Life Expectancy and Population Growth.

Until the early 1990s, economic development and improved health care had raised the life expectancy in developing countries to 64 years, with prospects that it would go higher still. The growing number of deaths from new and reemergent diseases such as AIDS, however, will slow or reverse this trend toward longer life spans in heavily affected countries by as much as 30 years or more by 2010, according to the US Census Bureau. For example, life expectancy will be reduced by 30 years in Botswana and Zimbabwe, by 20 years in Nigeria and South Africa, by 13 years in Honduras, by eight years in Brazil, by four years in Haiti, and by three years in Thailand.

Family Structure. The degradation of nuclear and extended families across all classes will produce severe social and economic dislocations with political consequences, as well. Nearly 35 million children in 27 countries will have lost one or both parents to AIDS by 2000;

by 2010, this number will increase to 41.6 million. Nineteen of the hardest hit countries are in Sub-Saharan Africa, where HIV/AIDS has been prevalent across all social sectors. Children are increasingly acquiring HIV from their mothers during pregnancy or through breastfeeding, ensuring prolongation and intensification of the epidemic and its economic reverberations. With as much as a third of the children under 15 in hardest-hit countries expected to comprise a “lost orphaned generation” by 2010 with little hope of educational or employment opportunities, these countries will be at risk of further economic decay, increased crime, and political instability as such young people become radicalized or are exploited by various political groups for their own ends; the pervasive child soldier phenomenon may be one example.

Destabilizing Political and Security Impact

In our view, the infectious disease burden will add to political instability and slow democratic development in Sub-Saharan Africa, parts of Asia, and the former Soviet Union, while also increasing political tensions in and among some developed countries.

- The severe social and economic impact of infectious diseases, particularly HIV/AIDS, and the infiltration of these diseases into the ruling political and military elites and middle classes of developing countries are likely to intensify the struggle for political power to control scarce state resources. This will hamper the development of a civil society and other underpinnings of democracy and will increase pressure on democratic transitions in regions such as the FSU and Sub-Saharan Africa where the infectious disease burden will add to economic misery and political polarization.

Table 5
Projected Demographic Indicators for 2010 in Selected Countries
With and Without AIDS

Country	Projected Child Mortality ^a Per 1,000 Live Births, 2010		Projected Life Expectancy, 2010	
	With AIDS	Without	With AIDS	Without
Sub-Saharan Africa				
Botswana	120	38	38	66
Burkina Faso	145	109	46	61
Burundi	129	91	45	61
Cameroon	108	78	50	63
Cote d'Ivoire	121	84	47	62
Dem. Rep. of Congo	116	97	52	60
Ethiopia	183	137	39	55
Kenya	105	45	44	69
Lesotho	122	71	45	66
Malawi	203	136	35	57
Namibia	119	38	39	70
Nigeria	113	68	46	65
Rwanda	166	106	38	59
South Africa	100	49	48	68
Swaziland	152	78	37	63
Tanzania	131	96	46	61
Uganda	121	92	48	60
Zambia	161	97	38	60
Zimbabwe	116	32	39	70
Latin America				
Brazil	31	21	68	76
Haiti	129	119	54	59
Honduras	55	29	60	73
Southeast Asia				
Burma	80	70	59	63
Cambodia	134	124	53	57
Thailand	25	21	73	75

^a Probable deaths before age 5.

Source: Adapted from United States Bureau of the Census, 1998.

- A study by Ted Robert Gurr, et al., on the causes of state instability in 127 cases over a 40-year period ending in 1996 suggests that infant mortality is a good indicator of the overall quality of life, which correlates

strongly with political instability. According to the research, three variables out of 75—high infant mortality—which in developing countries owes substantially to infectious diseases; low openness to trade; and incomplete

democratization accounted for two-thirds of demonstrated instability. The study defined “instability” as revolutionary wars, ethnic wars, genocides, and disruptive regime transitions. High infant mortality has a particularly strong correlation with the likelihood of state failure in partial democracies.

Infectious diseases also will affect national security and international peacekeeping efforts as militaries and military recruitment pools experience increased deaths and disabilities from infectious diseases. The greatest impact will be among hard-to-replace officers, non-commissioned officers, and enlisted soldiers with specialized skills and among militaries with advanced weapons and weapons platforms of all kinds.

- HIV/AIDS prevalence in selected militaries, mostly in Sub-Saharan Africa, generally ranges from 10 to 60 percent (see table 6). This is considerably higher than their civilian populations and owes to risky lifestyles and deployment away from home. Commencement of testing and exclusion of HIV-positive recruits in the militaries of a few countries, is reducing HIV prevalence but it continues to grow in most militaries.
- Militaries in key FSU states are increasingly experiencing the impact of negative health developments within their countries, such as deteriorating health infrastructure and reduced funding. One in three Russian draftees currently is rejected for various health reasons, as compared to one in 20 in 1985, according to one Russian newspaper report.
- Mounting infectious disease-caused deaths among the military officer corps in military-dominated and democratizing polities also

may contribute to the deprivation, insecurity, and political machinations that incline some to launch coups and counter-coups aimed, more often than not, at plundering state coffers.

It is difficult to make a direct connection between high HIV/AIDS and other infectious disease prevalence in military forces and performance in battle. But, given that a large number of officers and other key personnel are dying or becoming disabled, combat readiness and capability of such military forces is bound to deteriorate.

- Infectious disease-related deaths and disabilities are likely to have the greatest impact on the capabilities of Sub-Saharan militaries, particularly those that have achieved at least a modest level of modernization in weapons systems and platforms. Over the longer term, the consequences of the continuing spread of deadly diseases such as HIV/AIDS on the capabilities of the more modernized militaries in FSU states and possibly China and certain rogue states with large armies and modern weapons arsenals may be severe as well.

The negative impact of high infectious disease prevalence on national militaries also is likely to be felt in international and regional peacekeeping operations, limiting their effectiveness and also making them vectors for the further spread of diseases among coalition peacekeepers and local populations.

- Although the United Nations officially requires that prospective peacekeeping troops be “disease free,” it is difficult to enforce this

Table 6
HIV Prevalence in Selected Militaries in
Sub-Saharan Africa

Country	Estimated HIV Prevalence (percent)
Angola	40 to 60
Congo (Brazzaville)	10 to 25
Cote d'Ivoire	10 to 20
Democratic Republic of the Congo	40 to 60
Eritrea	10
Nigeria	10 to 20
Tanzania	15 to 30

Source: DIA/AFMIC, 1999.

rule with such methods as HIV testing, given the paucity of available troops and the potential noncompliance of many contributing states.

- Healthy peacekeeping forces will remain at risk of being infected by disease-carrying forces and local populations, as well as by high-risk behavior and inadequate medical care.

In developed countries, the political debate over AIDS and other infectious diseases is likely to focus on budgetary issues and negligence in the handling of blood and food-stuffs, as well as on treatment of infectious diseases.

- HIV blood and other controversies in several European countries have sparked political uproars and led to the dismissal or prosecution of government officials, and have even contributed to the fall of some governments.

Infectious diseases also will loom larger in global interstate relations as related embargoes and boycotts to prevent their spread create trade frictions and controversy over culpability, such as in the recently ended three-year EU embargo of British beef, which was imposed to stop the spread of mad cow disease. Developed countries, moreover, will come under pressure from international and nongovernmental organizations, as well as from developing countries, to deal with infectious disease-related instability and economic and medical needs in the hardest-hit countries. A growing controversy, in this regard, will be over drug-related intellectual property rights, in which developing countries will press for more and cheaper drugs from developed country pharmaceutical firms and resort to producing their own generic brands if they are rebuffed. States will remain concerned, as well, about the growing biological warfare threat from rogue states and terrorist groups.

Infectious Diseases and US National Security

As a major hub of global travel, immigration, and commerce, along with having a large civilian and military presence and wide-ranging interests overseas, the United States will remain at risk from global infectious disease outbreaks, or even a bioterrorist incident using infectious disease microbes. Infectious diseases will continue to kill nearly 170,000 Americans annually and many more in the event of an epidemic of influenza or yet-unknown disease or a

steep decline in the effectiveness of available HIV/AIDS drugs. Although several emerging infectious diseases, such as HIV/AIDS, were first identified in the United States, most, including HIV/AIDS, originate outside US borders, with the entry of the West Nile virus in 1999 a case in point (see inset).

Threats to the US Civilian Population

The US civilian population will remain directly vulnerable to a wide variety of infectious diseases, from resurgent ones such as multidrug resistant TB to deadly newer ones such as HIV/AIDS and hepatitis C. Infectious disease-related deaths in the United States have increased by about 4.8 percent per year since 1980 to 59 deaths per 100,000 people by 1996, or roughly 170,000 deaths annually, as compared to an annual decrease of 2.3 percent in the preceding 15 years and an alltime low of 36 deaths per 100,000 in 1980 (see figure 17). The USCDC estimates that the total direct and indirect medical costs from infectious diseases comprise some 15 percent of all US health care expenditures or \$120 billion in 1995 dollars.

In the opinion of the US Institute of Medicine, the next major infectious disease threat to the United States may be, like HIV, a previously unrecognized pathogen. Barring that, the most likely known infectious diseases to directly and significantly impact the United States over the next decade will be HIV/AIDS, hepatitis C, and multidrug resistant TB, or a new, more lethal variant of influenza. Foodborne illnesses and hospital-acquired infections also pose a threat:

- **HIV/AIDS** was first identified in the United States in 1983 but originated in Sub-Saharan Africa. In the United States, HIV/AIDS deaths surged from 7,000 in 1985 to 50,000 in 1995 before dropping dramatically to 17,000 in 1997 as a result of behavioral and

therapeutic changes among the most at risk populations. The total number of those infected reached 890,000 for all of North America in 1998, including 44,000 new infections, most of them in the United States. Although HIV/AIDS-related death rates have declined sharply, the poor prospects that a vaccine will be available over the next decade or more, along with the likelihood that the virus will develop growing resistance to the protease-inhibitor drugs now in use, portend a continued rise in the infection rate and a renewed rise in the death rate.

- **Hepatitis C.** Some 4 million Americans are chronic carriers of hepatitis C, which was first identified in the United States in 1989. The hepatitis C burden will continue to grow for at least another decade due to the disease's long incubation period, with the number of deaths possibly surpassing HIV/AIDS deaths by 2005 even though the rate of new infections is dropping, owing to improved blood supply testing. About 15 percent of those infected will develop life-threatening cirrhosis of the liver, and many more will experience a more slowly developing chronic liver disease, including cancer. The disease also will remain the leading cause of liver transplantation.
- **Foodborne illnesses.** According to the USCDC, tens of millions of foodborne illness cases, including 9,000 deaths, occur each year in the United States. The threat from foodborne illnesses will persist given changing consumption patterns and further globalization of the food supply.

- The threat from highly virulent, *antimicrobial-resistant pathogens* such as *Staphylococcus aureus*, *Streptococcus pneumoniae*, and enterococci—which kill some 14,000 hospital patients annually—is likely to grow, particularly if the remaining small arsenal of effective drugs, such as vancomycin, becomes ineffective.
- **TB.** After declining dramatically for several decades, TB in the first half of the 1990s made a comeback in urban areas and in some 13 states with large refugee and immigrant populations, where some 23,000 to 27,000 cases were reported annually, up from a low of 22,000 in 1984. More alarming was the rise of multidrug resistant TB from 10 percent of total cases before 1984 to 52 percent of cases resistant to at least one drug and 32 percent resistant to two or more of the five frontline anti-TB drugs a decade later. Some high-risk populations in prisons and those with HIV/AIDS have experienced death rates from TB as high as 70 to 90 percent. Although a massive and costly intervention by state and local authorities reversed the overall infection rate to 18,000 by 1998, the multidrug resistant TB threat persists, and TB incidence continues to grow among immigrant populations. About 40 percent of all active TB cases in the United States—up from 16 percent in 1982—currently occur among immigrants, particularly illegal ones from countries where TB is highly endemic.
- **Influenza.** Although the deadly 1918 influenza pandemic that caused more than 0.5 million US deaths appears to have started in the United States, almost all others have originated in China and Southeast Asia. Epidemiologists generally agree that the threat of another “killer” influenza pandemic is high and that it is not a question of whether, but when, it will occur. Even in the absence of a widespread “killer” pandemic, influenza has

caused 30,000 US deaths annually in recent years—nearly double the annual average in the 1972-84 period, owing in part to the high vulnerability to the disease of the growing cohort of older Americans and HIV-infected persons. Influenza will remain essentially an uncontrolled disease because the viruses are highly efficient in their ability to survive and change into more virulent strains. USCDC researchers predict that, in an influenza epidemic infecting 15 percent of the US population, the mean number of expected deaths would be approximately 97,000 in one year, regardless of immunization status. The number of hospitalizations would total 314,000, and the number of outpatient cases would reach 18 million. If the attack rate were 35 percent, the number of expected deaths would be 227,000 in one year and all other illness rates would be correspondingly higher.

Other Infectious Disease Threats

Other diseases that are periodically imported and are more likely to be costly in economic terms rather than in lives lost include malaria, cholera, and various animal diseases:

- **Malaria.** Malaria was domestically eliminated in the 1960s but has reemerged over the last two decades due to the increase in immigration and international travel. Currently, some 1,200 cases of malaria are reported to the USCDC annually, with about half occurring among US travelers to highly endemic countries in the tropics and the other half among foreign nationals entering the United States, primarily agricultural workers and illegal migrants. Although malaria outbreaks have been relatively isolated and have been brought under control quickly, the disease has the potential to become reestablished in the United States because of the abundance of mosquito vectors, especially in southern states.

Mechanisms of Disease Entry Into the United States

The following are a few prominent methods of pathogen entry into the United States:

- ***International travel.*** More than 57 million Americans traveled outside the United States for recreational and business purposes in 1998—often to high risk countries—more than double the number just a decade before. In addition, tens of millions of foreign-born travelers enter the United States every year. Travelers on commercial flights can reach most US cities from any part of the world within 36 hours—which is shorter than the incubation periods of many infectious diseases.
- ***Immigration.*** Approximately 1 million immigrants and refugees enter the United States legally each year, often from countries with high infectious disease prevalence, while several hundred thousand enter illegally. The USCDC has the authority to detain, isolate, or provisionally release persons at US ports of entry showing symptoms of any one of seven diseases (yellow fever, cholera, diphtheria, infectious TB, plague, suspected smallpox, and viral hemorrhagic fevers). Although each individual must undergo a medical examination before entering the country, potentially excludable conditions may be in the incubating and therefore less detectable stages.
- ***Moreover, US law prohibits the Immigration and Naturalization Service from returning refugees who have credible reasons to fear political persecution, including those refugees afflicted with infectious diseases.***
- ***Returning US military forces.*** Although US military populations are immunized against many infectious diseases and are especially sensitized to detecting any symptoms before or after their return to the United States, not all cases are likely to be detected, especially among National Guardsmen and Reservists, who are far more likely to enter the civilian health care system and may not associate a later-developing illness with their overseas travel.
- ***The globalization of food supplies.*** Foodborne illnesses have become more common as the number of food imports has doubled over the past five years, owing to changing consumer preferences and increased trade. At certain times of the year, more than 75 percent of the fruits and vegetables available in grocery stores and restaurants are imported and, therefore, potentially more likely to be infected with pathogenic microorganisms, according to a foodborne disease expert.

- Fears that *cholera*, which has become endemic in Latin America over the past decade, would find its way into the United States have not been realized, but isolated cases have been occurring at a more frequent rate than at any time since 1962 when cholera surveillance commenced. Thus, the disease looms as a potential threat.
- *Dengue*. Dengue, along with the far more serious dengue hemorrhagic fever and dengue shock syndrome, was reintroduced into the United States in the mid-1980s by foreign travelers; the mosquito vector is now widespread throughout the southeast. There were 90 cases in 1998, all of which were acquired overseas.
- *Foreign animal diseases*. In addition to the more obvious human impacts, imported animal diseases present considerable potential risks to the domestic economy, trade, and commerce. Those potentially capable of significantly harming US agriculture include **foot and mouth disease (FMD)**, **avian influenza**, **bovine spongiform encephalopathy**, and **African swine fever**. An outbreak of foot and mouth disease in the US livestock industry could cost as much as \$20 billion over 15 years in increased consumer costs, reduced livestock productivity, and restricted trade, according to USDA estimates. Another USDA study revealed that, if African swine fever were to become reestablished in the US swine population, the cost over a 10-year period would be \$5.4 billion.

Threats to Deployed Military Forces

Deployed US military forces have historically experienced higher rates of hospital admission from infectious diseases than from battlefield combat and noncombat injuries (see figure 18

and table 7). In addition to disease transmission between deployed troops and indigenous populations, warfare-related social disruption often creates refugees and internally displaced persons that can pass infections along to US military forces. Allied coalition forces may themselves bring infectious diseases into an area for the first time and transmit them to US forces and the indigenous population.

Threats to deployed US forces will vary by country, region, and the nature of the deployment and its mission:

- Least threatened will be US forces deployed in longstanding US, NATO, and other allied bases in Europe, especially northern Europe, and in Japan, where base medical facilities, food sources and handling, as well as local health care infrastructures are on a par with US standards.
- At highest risk will be those forces deployed to less developed regions for contingency operations such as humanitarian, peacekeeping, and peace enforcement missions. Local medical care in such regions often is poor, and infectious disease prevalence is high, both among the local population and sometimes among coalition peacekeeping forces.
- Specific examples of diseases that have and may continue to appear in association with military and peacekeeping operations include respiratory diseases such as TB and influenza, diarrheal diseases, malaria, hepatitis A and E, sexually transmitted diseases, dengue and dengue hemorrhagic fever, and leishmaniasis.

Table 7
Disease Threats to US Forces in the Gulf

Disease Category	Examples	Endemic Levels ^a
Diarrheal	Bacterial, protozoal, viral	Moderately-to-highly endemic
Other foodborne or waterborne	Hepatitis A and E, typhoid/paratyphoid fevers	Moderately-to-highly endemic
Vectorborne	Malaria	Focally endemic in Oman, Saudi Arabia, UAE
	Sandfly fever, Leishmaniasis, other arboviral (including dengue, West Nile, Sindbis, Crimean-Congo hemorrhagic fevers)	Endemic
Person-to-person/close contact	Tuberculosis, meningococcal meningitis	Low-to-moderately endemic
Sexually transmitted and/or bloodborne contact	Hepatitis B/D and C, Gonorrhea	Moderately-to-highly endemic
Other endemic	Brucellosis, Q fever, leptospirosis, trachoma, intestinal parasites, anthrax	Endemic, especially in lower socio-economic groups

^a Usual level of disease occurrence in an area.

Source: DIA/AFMIC, 1997.

United States has already been demonstrated and could recur. The West Nile virus scare, and several earlier instances of suspected bioterrorism, showed, as well, the confusion and fear they can sow regardless of whether or not they are validated.

- The threat to US forces and interests overseas also will continue to increase as more nations develop a capability to field at least limited numbers of biological weapons, and nihilistic and religiously motivated groups contemplate opting for them to cause maximum casualties.