Chapter 2
Global Challenges of Infectious Disease Epidemiology

Alexander Krämer and Md. Mobarak Hossain Khan

2.1 Introduction

As we have seen in the last chapter, infectious and parasitic diseases are major causes of morbidity and mortality worldwide, particularly in developing countries. Approximately 26% of global deaths and 26% of global burden of disease were attributed to infectious diseases in 2001 (Lopez et al. 2006; see Chapter 1). One in two deaths that are mostly preventable occurs in developing countries (Kim-Farley 2004; Folch et al. 2003). Looking to the remaining 21st century, we could imagine a decline in major infectious diseases like malaria and AIDS as a result of an adoption of effective prevention strategies and treatments or, like in the case of hepatitis B, as a consequence of worldwide vaccination programs in children. In addition, new vaccines, new treatment technologies, as well as an improvement in infrastructures can contribute to win the "battle against infectious diseases." However, for these prospects not to be doomed to fail, measures will have to be integrated much more than they are now into international health and public health policies, and there needs to be a multi- and interdisciplinary approach, a stronger facilitation of the participation of affected populations, and – above all – a committed and sustainable effort of all stakeholders. In this context, infectious disease public health plays the role of a moderator, and infectious disease epidemiology has the role of providing high-quality data and indicators for monitoring and surveillance as a basis for concerted and efficient public health actions.

2.2 Challenges

In an increasingly globalized world there are several structural aspects that determine and characterize the growing importance of infectious diseases in the modern world (Saker et al. 2004) (Table 2.1).

A. Krämer (✉)
Department of Public Health Medicine, School of Public Health, University of Bielefeld, Bielefeld, Germany
e-mail: alexander.kraemer@uni-bielefeld.de

A. Krämer et al. (eds.), *Modern Infectious Disease Epidemiology*,
Statistics for Biology and Health, DOI 10.1007/978-0-387-93835-6_2,

Table 2.1 Challenges of infectious diseases

Aspects	Components
Demographic and behavioral	Demographic transition Aging and immune dysfunction Changing behaviors Intravenous drug use
Mobility, migration, and globalization	High mobility and rural–urban migration Modern transportation systems International migration and migration of refugees International travel and tourism Travel medicine
Modern medical practices	Organ or tissue transplantation Chemotherapy Drugs causing immunosuppression Widespread use of antibiotics and antibiotic resistance Microbial adaptation and change Hospital infections Use of intensive care medicine
Modern food technology	Industrialized food production Food processing and food preservation technology Antibiotics and chemicals used in food production Global trade, commerce, and distribution of foods Changing demand, consumption, and behavioral pattern
Politics, ecology, and environment	War and civil conflict Political pressure (minorities) Social inequality (vulnerable groups) Global warming and climate change Environmental disasters (e.g., floods, hurricanes)
Urbanization and megacities	Accelerating urbanization and megacities Pollutions (e.g., water) Overcrowding, poverty, and lack of resources Inadequate infrastructure and governability Changing sexual behavior (e.g., prostitution) Ecological change due to urban extension (e.g., deforestation)
Emerging diseases	See Chapter 3

2.2.1 Demographic Transition and Aging

The shift from high to low mortality and fertility is known as the demographic transition. This shift occurred throughout Europe, North America, and a number of other areas in the 19th and early 20th centuries and started in many developing countries in the middle of the 20th century. The life expectancy has increased rapidly during the last century. For instance, in 1900, life expectancy at birth was 47 years in the United States, by 1950 it was 68 years, and it reached 77 years by 2000. Life expectancy rose even higher in Japan and many European countries, and it continues to increase. Many low-fertility countries have entered what some describe as a "second demographic transition" in which fertility falls below the replacement rate (Population Reference Bureau 2004). It is estimated that by 2025, 120 countries would have reached total fertility rates below replacement level (fertility rate of 2.1 children per woman), a substantial increase as compared to 1975, when only 22 countries had a total fertility rate below or equal to the replacement level (WHO 2002). This transition has been linked with greater educational and job opportunities for women, the availability of effective contraception, a shift away from formal marriage, the acceptance of child bearing outside marriage, and the rise of individualism and materialism (Population Reference Bureau 2004).

The global population aged 65 or older is projected to increase from 8% (almost 500 million) in 2006 to 13% (about 1 billion) in 2030 (National Institutes of Health 2007). Industrialized countries have the highest percentages of older people in the world today, although 60% of the world's older population now live in less developed countries and in 2030, this proportion is projected to increase to 71% (Kinsella and Phillips 2005).

Although advances in controlling infectious diseases have contributed a lot to increasing life expectancy (mainly by reducing child mortality) and resulted in a large population of elderly people, they are, ironically, the most vulnerable groups to serious infectious diseases clinically and are at greatest risk for death and complications from infections (Yoshikawa 2000). New emerging infectious disease variants can be especially risky for older people, who are more vulnerable than younger people to acute respiratory diseases. For example, the outbreak in 2003 of severe acute respiratory syndrome (SARS) affected older people disproportionately. In Hong Kong, people aged 65 and older accounted for about one-fifth of the reported SARS cases and two-thirds of the SARS deaths in 2003 (Kinsella and Phillips 2005), while the percentage of the older population (aged 65+ years) was about 12% in 2003 (HKSAR Government 2003).

Older persons have greater susceptibility to certain infections than do younger adults because aging is associated with immune dysfunction, especially in cell-mediated immunity. Elderly persons suffer from a variety of chronic disorders, some of which affect the integrity of host resistance to infections. Urinary tract infections, lower respiratory tract infections, skin and soft tissue infections, intra-abdominal infections (cholecystitis, diverticulitis, appendicitis, and abscesses), infective endocarditis, bacterial meningitis, tuberculosis, and herpes zoster appear to have a special predilection for elderly persons. The mortality rates of most of these infections are about three times higher among elderly patients than among younger adult patients with the same disease. In addition to the above-mentioned factors, perhaps several other factors such as delays in diagnosis and therapy, poor tolerance to invasive diagnostic and therapeutic procedures, delayed or poor response to antimicrobial therapy, and greater risk and incidence of nosocomial infections contribute to this higher morbidity and mortality (Yoshikawa 2000).

2.2.2 Mobility

Population mobility is not a new phenomenon. Since ancient times, there have been relentless movements of people in search of food, water, wealth, and security.

Nonetheless, despite this continual migration, large-scale movement of populations across continents is a relatively recent phenomenon. Advances in transportation technology, in particular the advent of fast trains, automobiles, and jet aircrafts, have played a crucial role in facilitating dramatic increases in population mobility during the last 50 years. Global travel has grown from 25 million trips in 1950 to 341 million in 1980 and 500 million in 1993 and is estimated to reach 1 billion by 2010 (Rodriguez-Garcia 2001).

Of all travel-related illnesses, infectious diseases pose perhaps the greatest threat to global health. Since most infectious diseases have an incubation period exceeding 36 h and any part of the world can now be reached within this time frame, the potential for rapid geographical spread is obvious (Saker et al. 2004). A recent example of the worldwide spread of an infectious agent through travel is the SARS epidemic. This epidemic started in Guangzhou, province of Guangdong, China, in late 2002 and then spread to Hong Kong, Taiwan, Singapore, Vietnam, Toronto (Canada), the United States, and Europe (e.g., Germany, France and Sweden). The cumulative total of probable SARS cases surpassed 5,000 on April 28, 6,000 on May 2, 7,000 on May 8, and 8,000 on May 22, 2003 (WHO 2003a). Results from mathematical modeling and computer simulations demonstrated that important air travel routes had played a crucial role in the worldwide SARS spread (Hufnagel et al. 2004).

Furthermore, medical advice to travelers is often poor. This points to the importance of services of travel medicine through experts who are well trained in the prevention of infections caused by travel. Such advice applies not only to the consultation of clients before they start their journey but also to persons who come home from foreign countries. It is often the case that imported infections such as diarrheal diseases, hepatitis, malaria, and many others are not diagnosed at all or not diagnosed in due time and may thus cause avoidable morbidity and mortality.

Another structural element for the growing importance of infectious diseases in this context of population mobility is mass migration. According to the estimate of the United Nations, in 2005 about 191 million people – 3% of the world's population – were international migrants. Between 1995 and 2000, around 2.6 million migrants per year moved from less developed to more developed regions and mostly settled in the United States and Canada (Population Reference Bureau 2007). Various kinds of migrations can be distinguished such as labor migration and migration due to education. Another important group of migrants are refugees (rose from 8.7 million to 9.9 million globally during 2006) (Population Reference Bureau 2007), which have increased rapidly during the last 50 years due to interstate war, internal conflicts, political and economic instability, natural disasters (e.g., droughts), cultural and religious reasons (Saker et al. 2004). Such a huge migration exposes people to high health hazards including the potential acquisition of infections (vulnerable populations). An example is the high prevalence of infectious diseases such as cholera and dysentery among inhabitants in a refugee camp of Zaire who had moved there from Rwanda in 1994. Normally the refugee camps or temporary shelters in low-income countries are overcrowded, and the provision of sanitation, clean water, food, and health care is inadequate. Moreover, barriers to vectors and animals carrying infectious diseases are insufficient, and person-to-person contact is amplified (Saker et al. 2004).

2.2.3 Modern Medical Practices

One of the causes of an increasing importance of infectious diseases is unwanted effects of modern medical practices. During the 1960s and 1970s, there was a great deal of hope that humankind had tackled some of the worst infectious diseases through medical advances in antibiotics, vaccines, and other treatments (Brower and Chalk 2003). Without doubt, emergency and intensive care medicines provide life-saving services, but high-tech medicines may also cause threats to patients. Increasingly aggressive medical and therapeutic interventions, including implanted foreign bodies, organ transplantations, and xenotransplantations, have created a cohort of particularly vulnerable persons and increased the risk of infections. According to the report of Weinstein (1998), nosocomial infection rates in adults and pediatric intensive care units (ICUs) are approximately three times higher than elsewhere in hospitals. Artificial ventilation can lead to pneumonias and arterial and venous catheters can cause local or generalized infections due to insufficient hygiene. When a catheter is inserted through the patient's skin into a blood vessel, this can provide a route for bacteria living on the patient's skin to reach the patient's bloodstream and cause potentially lethal infection (Farr 2002). Patients with vascular catheters and monitoring devices have more bloodstream infections due to coagulase-negative staphylococci. Fungal urinary tract infections have also increased in ICU patients, presumably because of extensive exposure to broad-spectrum antibiotics (Weinstein 1998). In order to prevent the rejection of organ transplants in transplantation surgery, immunosuppressive therapy that may facilitate generalized infections in immunosuppressed transplant patients is required. In patients in oncology wards with tumors, chemotherapy is beneficial for the suppression of tumor growth but may facilitate the invasion of various infectious agents – potentially leading to life-threatening generalized infections. Therefore, the mortality of tumor patients is also determined by potential side effects of medical tumor therapy. Examples are generalized infections in immunosuppressed patients due to cytomegalovirus, aspergillosis, cryptococcosis, and many other agents.

Antibiotic resistance is a serious and growing public health threat in all nations around the globe. The past few decades have seen an alarming increase in the prevalence of resistant microbial pathogens in serious infections (Masterton 2005). An obvious example is penicillin. In 1942, the first US patient with streptococcal infection was miraculously cured with a small dose of penicillin. Nowadays penicillin-resistant streptococcus is widespread. Increasing travel and migration probably contributes to the growth of resistance problems (Zhang et al. 2006). Antibiotic-resistant infections are important because they result in more prolonged illness, longer hospitalization, greater risk of death, and higher costs for the healthcare system than do infections with antibiotic-sensitive strains of the same species. The two most important causes of patients receiving antibiotic-resistant pathogens in hospitals have been the volume of antibiotic use and patient-to-patient transmission (Farr 2002). Resistant strains are found in various types of infectious agents, such as parasites (e.g., malaria), viruses (e.g., HIV, hepatitis B), and bacteria (e.g., methicillin-resistant *Staphylococcus aureus*, MRSA). Interestingly, the prevalence of MRSA varies greatly between different developed countries (high prevalence in the United States and low prevalence in The Netherlands), thus pointing to the challenge of reducing the burden through controlled use of antibiotics and efficient hygienic measures. Recently, multi-drug-resistant (MDR) tuberculosis is a growing problem – particularly in Russia, the Newly Independent States, and countries in Eastern Europe – that will require increasing public health intervention efforts in the future. While the WHO strategy of directly observed treatment (DOTS) proves successful in settings and regions where it is applied, at the same time the emergence of extremely multi-drug-resistant tuberculosis (XMDR), in which all known antibiotics against tuberculosis fail, poses enormous challenges for public health and necessitates the development of new anti-tuberculosis drugs (see Chapter 16).

Antibiotic resistance also contributes to the growing disease burden due to nosocomial infections. Nosocomial infections are usually linked to sophisticated medical technology and the use of invasive devices (Allegranzi and Pittet 2007). These infections make up a substantial proportion of the infectious disease burden in both developed and developing countries. For instance, at any time, over 1.4 million people worldwide suffer from infectious complications associated with health care (WHO 2005b). In developed countries, between 5 and 10% of patients acquire one or more nosocomial infections and approximately 15–40% of those admitted to intensive care are thought to be affected. Every year approximately 3 million people in the European Union contract a nosocomial infection, of which 50,000 die (ECDC 2007). In 2002, the estimated number of nosocomial infections in the United States was approximately 1.7 million and the estimated deaths associated with these infections were 98,987; of these, 35,967 were for pneumonia, 30,665 for bloodstream infections, 13,088 for urinary tract infections, 8,205 for surgical site infections, and 11,062 for infections of other sites (Klevens et al. 2007). The risk of nosocomial infection for patients is 2–20 times higher in developing countries than in industrialized countries (Allegranzi and Pittet 2007; Lazzari et al. 2004). An estimated 40% or more patients could suffer from health care-associated infections which are preventable and every day 4,384 children die due to such infections in developing countries (WHO 2005a).

A complex array of factors that promote nosocomial infections include preexisting diseases and decreased patient immunity, invasive diagnostic and therapeutic techniques, the widespread antimicrobial resistance, lack of infection control measures and environmental hygiene, lack of resources, inappropriate use of antibiotics, use of counterfeit drugs, understaffing and lack of training of health-care professionals, and governments that are overwhelmed with larger health issues and cannot commit to infection control procedures and standards (Allegranzi and Pittet 2007; WHO 2005a; Lazzari et al. 2004). At least 50% of all medical equipments in most developing countries are unusable, or only partly usable, at any given time. Approximately 77% of all reported cases of substandard and counterfeit drugs occur in developing countries. About 4.2 billion injections are administered each year in India and two out of three injections given are unsafe, posing serious health hazards to recipients, health workers, and the community. In Brazil and Indonesia, more than half of newborn babies admitted to neonatal units acquire a nosocomial infection, and 12–52% of them die (WHO 2005a).

2.2.4 Modern Food Technology

The globalization of food increases the likelihood of pandemics of foodborne diseases. These diseases are a considerable burden for both developing and developed countries, and hence they are a growing public health concern (Elmi 2004). For instance, each year, foodborne diseases cause approximately 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths in the United States (Mead et al. 1999), 5.4 million cases in Australia (OzFoodNet 2006), and 1.7 million cases, 21,997 hospitalizations, and 687 deaths in the United Kingdom (Adak et al. 2005). The causes of foodborne diseases include viruses, bacteria, parasites, toxins, metals, and prions and the symptoms of foodborne diseases range from mild gastroenteritis to life-threatening neurologic, hepatic, and renal syndromes. Foodborne disease outbreaks are now more far-reaching due to modern mass food production and widespread food distribution (Hall et al. 2002).

A number of factors such as increasing travel, international food supply and trade, changes in animal husbandry and agronomic processes, changes in food technology, production, processing, and distribution, changes in lifestyle (e.g., introduction of uncooked items into our diets) and consumer demands, and increasingly susceptible populations (e.g., growing number of elderly) can facilitate foodborne infections all over the world (Elmi 2004; Blaser 1996). Due to modern transportation systems, food grown in one country can now be transported and consumed all across the world. A person can be exposed to a foodborne illness in one country and expose others to the infection in a location thousands of kilometers from the original source of infection (ECDC 2007; Elmi 2004). Food can be contaminated in one country and cause outbreaks of foodborne diseases in another one due to globalization of food trade (Sanders 1999). International trade has three main consequences: (i) the rapid transfer of microorganisms from one country to another; (ii) the time between processing and consumption of food is increasing, leading to increased opportunity for contamination and time/temperature exposure of the products and hence the risk of foodborne illness; and (iii) people are more likely to be exposed to a higher number of different strains/types of foodborne pathogens (Elmi 2004).

Currently, prevailing food insecurity and food crisis including rising food prices may pose enormous challenges particularly in developing countries. There are over 800 million undernourished people in the world and this number could increase sharply as a result of the current food crisis. Extrapolation suggested that globally up to 105 million people could become poor due to rising food prices between 2005 and 2007 (World Bank 2008). Food insecurity and food crisis may influence the risk of acquiring infectious diseases as well as the number of deaths through poverty and malnutrition. Only in Ethiopia, about 12 million children under the age of 5 years are at risk for severe malnutrition as a result of the current food crisis

(USAID 2008). Malnutrition causes severe deficiencies – calories, zinc, and vitamin A – that facilitate infectious diseases in these populations. People weakened by diarrhea, pneumonia, malaria, and measles are becoming sicker or die if they cannot get adequate food. Globally, malnutrition is responsible for 3.5–5.5 million child deaths every year (USAID 2008).

The extensive use of chemical fertilizers and pesticides, in addition to damaging the environment, introduces toxic residues into the food chain and consequently into our bodies. The use of untreated sewage for irrigation and increased use of manure rather than chemical fertilizers contribute to an increased risk of infections through the consumption of fresh fruits and vegetables. People demand a wider variety of food than in the past and nowadays almost every type of fruit is available on the international food markets the entire year round regardless of seasonal changes in growth. Long storage of food and the increased use of refrigeration to prolong the shelf-life of food may lead to its deterioration – including the development of infectious agents. Changing lifestyles such as going to restaurants frequently, eating foreign cuisine, and consuming fresh fruits and vegetables also increase the risk of foodborne diseases (Elmi 2004). Consumption patterns may enhance unhealthy food production and distribution because the consumer desires ubiquitous availability of all foods at low prices. Additionally, hygienic measures in the processes of food production and consumption may be insufficient and thus facilitate the spread of infections.

2.2.5 Politics and Environment

Ecological factors and political and socioeconomic conditions also influence the spread of infectious diseases. As we have already seen, political pressure may result in migration movements of populations. Low socioeconomic status is often associated with a higher burden of infectious diseases (see Chapter 6). For migrants, the access to health-care services may be reduced due to cultural or language barriers. Also for poorer native inhabitants of a country, the utilization of health-care services is less efficient compared to representatives of the high socioeconomic class. Due to recently growing levels of social inequality, not only in developing countries but also in developed ones, these problems are currently increasing and will probably continue to increase in the future. Therefore, health security particularly for vulnerable groups remains an important tool of national and international politics. This also holds for the growing worldwide fear of international terrorism including the use of biological agents such as the smallpox virus, *Bacillus anthracis*, and others.

Increasingly, there is scientific evidence that most of the recent global climate changes are man-made (anthropogenic) and mainly are due to increased CO_2 levels in the atmosphere resulting from industrialization and traffic. During the 20th century, world average surface temperature increased by approximately 0.6°C and approximately two-thirds of that warming occurred since 1975. Climatologists forecast further warming along with changes in precipitation and climate variability during the coming century and beyond. Climate change influences the functioning of many ecosystems and is a major threat to human health in lower income countries, predominantly within tropical and subtropical countries (WHO 2003b). This is of major importance for the prevalence and spread of infectious diseases because the breeding sites of vector-borne diseases such as malaria, dengue, yellow fever, and many others are extended. Generally, warmer temperatures enhance vector breeding and reduce the pathogen's maturation period within the vector organism. It is estimated that if the global temperature increased by 2–3°C, the number of people who are at risk of malaria would increase by around 3–5%, i.e., several hundred million. In 2030, the estimated risk of diarrhea will be up to 10% higher in some regions than it would have been without climate change (WHO 2003b). In existing endemic areas the spread of vector-borne infections is facilitated and the endemic regions themselves may grow, with a consequence that, in the future, parasitic diseases will occur in areas not yet or not anymore endemic for these infections (see Chapter 3).

In addition, there are further manifestations of global climate changes associated with infectious diseases. Climate changes will cause greater frequency of infectious disease epidemics following floods and storms. It will also cause substantial health effects following population displacement from the sea level rise and increased storm activity (Intergovernmental Panel on Climate Change 2007; WHO 2003b). Flooding has always occurred due to seasonal variations and special weather conditions such as monsoon rains and others. What is alarming, however, is the amount of rainfall and the frequency with which it occurs not only in flooding endemic regions like India and Bangladesh but also in areas that until recently have only rarely or never been affected by heavy rains. It is obvious that waterborne infectious agents can multiply at much higher rates under such conditions. Rainfall can also influence the transportation and dissemination of infectious agents, while temperature affects their growth and survival (WHO 2003b). Environmental catastrophes and disasters such as earth quakes including massive tsunamis on December 26, 2004, in south and southeast Asia mainly in Indonesia, Sri Lanka, and India (USAID 2005), Hurricane Katrina in Louisiana on August 29, 2005 (US Department of Commerce 2006), and Cyclone Sidr in Bangladesh on November 15, 2007 (United Nations 2007), led to the spread of infections in the affected regions. Briefly, climate changes cause population displacement, crowding, inadequate shelter, poor access to safe water, inadequate hygiene and sanitation, unsafe food preparation and handling practices, malnutrition, poor access to health services along with huge logged water as a result of severe flooding/cyclones/tsunamis, all of which increase the risk of waterborne, foodborne (cholera, typhoid, *Shigella dysenteriae*), and vector-borne diseases (malaria, typhoid, dengue) among the affected people (WHO 2007; Khasnis and Nettleman 2005; Wilder-Smith 2005).

2.2.6 Urbanization and Megacities

Urbanization processes represent one of the most important dimensions that determine present and future public health needs. For 200 years, the proportion of the population living in cities has constantly been rising: from approximately 3% in the year 1800 to approximately 13% in 1900, 29% in 1950, 38% in 1975, 47% in 2000, and 49% in 2005 (United Nations 2006; Moore et al. 2003; Dadao and Hui 2006). While the whole world has been predominantly rural until 2005, now the world is on the verge of becoming more urban than rural for the first time. In 2008, more than half of the world population lived in urban areas (Population Reference Bureau 2007). By 2030, urban dwellers will make up roughly 60% of the world's population. Cities offer the lure of better employment, education, health care, and culture; and they contribute disproportionately to national economies (Moore et al. 2003). Whereas until World War II urbanization had primarily been a major feature of developed countries, after World War II, urbanization processes were increasingly observed in the developing world also due to intensified industrialization and migration processes.

Recently the term "megacities" was created to characterize very big cities (Hinrichsen et al. 2002; United Nations 2006). However, there is no adequate definition, as the benchmark of the population concentration that differentiates megacities from other urban areas varies. Planetearth (2005) and the German National Committee on Global Change Research (NKGCF 2005) defined megacities as the metropolitan areas with more than 5 million inhabitants. The United Nations (UN) coined the term megacities to describe cities with 8 million or more inhabitants but its present threshold for a megacity is 10 million (Hinrichsen et al. 2002; United Nations 2006). Hence we distinguish three different categories: megacities from 5 to <8 million inhabitants, megacities from 8 to <10 million inhabitants, and those with a population above 10 million citizens. The future growth is predominantly expected in developing countries, particularly in south Asia, southeast Asia and China. The overall growth of the urban population from 1970 to 2025 is expected to be much higher in developing countries than in developed countries. It is estimated that by the year 2030 approximately 4.9 billion people will live in urban areas (United Nations 2006).

According to Kraas (2003), megacities share some common characteristics such as the fact that they represent nodal points of globalization processes, in which a concentration of national, regional, and global economic activities can be observed with particularly high concentrations of industrial production. Besides their high population densities, megacities are often characterized by uncontrolled spatial expansion, increasing traffic volumes, and severe infrastructural deficits that may represent manifestations of a loss of governability. The latter can lead to unregulated and disparate land and property markets, resulting in an insufficient housing provision. In these megacities a trained and highly specialized workforce can be distinguished from a cheap labor market, and accordingly a formal economic sector can be distinguished from an informal economic sector.

Worldwide, approximately 1 billion people are estimated to live in shanty towns, favelas, or so-called marginal settlements (Riley et al. 2007). Megacities are endangered by both environmental and man-made hazards (Kraas 2007). High burdens of health risks originate from these hazards and threaten megacity populations. Higher air and surface temperatures in combination with other environmental conditions, especially in big cities, make them "urban heat islands." Higher temperature in these cities is caused by daytime heat retained by the fabric of multi-storied buildings and by a reduction in cooling vegetation (Grimm et al. 2008; Kovats and Akhtar 2008). However, low temperature levels, frost, and avalanches can also harm megacity populations. Man-made hazards, which can be distinguished from environmental hazards, may lead to pollutions of air, water, and soil, to accidents with a much higher burden in developing countries (e.g., car crashes), to large-scale fires, and to industrial explosions and releases of toxic gas (see Kraas 2003 for details and examples).

Briefly, increased health problems in megacities are associated with many dimensions such as loss of governability, lack of infrastructure, poverty, diversity of culture and ethnicity, migration, pollution, lack of health knowledge, and insufficient health-care systems. Here we want to highlight some factors that influence the occurrence of infectious diseases in megacity populations (Fig. 2.1). With respect to the climate, it is noteworthy to mention that most megacities are located in tropical and subtropical areas predisposing their inhabitants to tropical diseases. Housing conditions can be characterized by poor sanitation and sewage disposal, overcrowding, and a high prevalence of vermin, which may transmit infections. A poor infrastructure may lead to a high contact rate in, e.g., buses and trains (due to overcrowding) and to a lack of adequate water supply and health-care services (e.g., vaccinations) and therefore facilitates the occurrence of outbreaks and epidemics. The clean water supply may be insufficient, particularly in marginal settlements or slums, and available water can be heavily contaminated by infectious agents due to discharge of untreated industrial wastes, leaching from waste dumps into surface and water, inadequate treatment of sewage, and poor solid waste management. Sanitation may be poor, rivers may be contaminated, and sewage and garbage disposal may be missing. Prostitution enhances the spread of sexually transmitted infections (e.g., HIV) and immigration can lead to the import of infections. Educational deficits particularly in women and mothers facilitate unsafe practices and deficient services for their children (e.g., in the case of diarrheal diseases). Knowledge deficits also arise when important information on outbreaks or epidemics is only insufficiently distributed to the general public. Moreover, health-care system services may be characterized by scarce or lacking equipment (posing

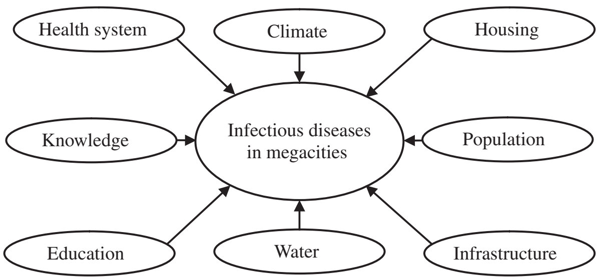

Fig. 2.1 Factors related to infectious diseases in megacities

problems with sterility), poor overall hygienic standards, the overuse and misuse of antibiotics, and low vaccination rates.

2.3 Solution Strategies to Meet These Challenges

2.3.1 Functions of Infectious Disease Epidemiology

Preventing and reducing the spread of infectious disease among humans is an essential function of public health. Epidemiology is often called the core science of public health, which studies the distribution and determinants of disease risk in human populations. Starting in the middle of the 19th century, infectious disease epidemiology applies the fundamentals of epidemiology to study infectious diseases and deals with questions about conditions for disease emergence, spread, and persistence. It describes the prevalence and incidence of infectious diseases through which the epidemiological trends can be characterized for different world regions (see Chapters 5 and 11).

A further task is to assess the expansion and transmission routes of the infectious pathogens in human population groups and, where appropriate, to investigate the nature of transmission, the infection probability per contact between the infected and the susceptible persons, the frequency and intensity of this contact and to determine the risk and protective factors of infectious and associated diseases. In collaboration with microbiologists, infectious disease epidemiology characterizes the features of the pathogen as well as its virulence, its pathogenicity, and, where appropriate, its resistance. It also specifies different molecular subtypes and strains of the pathogens (see also Chapter 7). Another vital task of infectious disease epidemiology is to investigate outbreaks. This investigation includes verifying, confirming the diagnosis, developing a case definition and case finding, describing the data in terms of time, place, and person, identifying risks, formulating and testing of a hypothesis, planning for further studies, establishing control measures, and communicating the findings to prevent larger epidemics (see Chapter 9).

Infectious disease epidemiology also identifies population groups vulnerable to specific infections for targeted prevention and intervention measures. Furthermore, it includes investigation of the immune status of the populations among others to evaluate the effectiveness and coverage of vaccination programs, thereby contributing to public health surveillance. Mathematical models help to better understand the transmission dynamics and spread of infections, to identify the factors governing the transmission process in order to develop effective control strategies, and to evaluate the effectiveness of surveillance strategies and intervention measures. Mathematical modeling in combination with health economic analyses supports public health experts and policy makers in designing effective public health policy to best protect populations from detrimental effects of infectious diseases. Model calculations also provide information about where the existing infectious disease surveillance must be replaced by new and more effective surveillance methods (for advanced reading, see Chapters 8 and 12).

2.3.2 Interdisciplinary Approaches

Infectious diseases are a leading cause of death worldwide and hence a great challenge for every nation. The present chapter shows that many structural aspects are associated with the increasing burden of both re-emerging and new infectious diseases. Taken together, these structural aspects of infectious diseases are highly interrelated and therefore the study of infectious disease clearly requires expertise from numerous fields such as public health, epidemiology, demography, social science, sociology, anthropology, economics, food science, medicine, hospital management, clinical studies, environmental science, climatology, ecology, agriculture, microbiology, geography, geomatics, urban and regional planning, meteorology, statistics, and mathematics. Coordinated collaborations among various disciplines will promote our understanding of the many possible perspectives on infectious disease problems.

As an example, the role of climate in the emergence of human infectious diseases requires interdisciplinary cooperation among physicians, climatologists, biologists, and social scientists (Patz et al. 1996). Combating emerging infectious diseases will succeed only when various disciplines work together, such as animal studies, epidemiology, immunology, ecology, environmental studies, microbiology, pharmacology, public health, medicine, nursing, cultural, political, and social studies (Lashley 2004). To control and eradicate malaria, proper physical and social planning, understanding the geography, entomology, epidemiology, behavior, and lifecycle of malarial parasites, cooperation between the policy makers, malaria specialists, neighboring countries, and international communities are important (Woube 1997). Increasing population mobility and large-scale migrations within and between countries in association with rapid urbanization have particularly profound implications for the ecology of infectious diseases, interacting in complex ways with other biological and social factors and opening multiple pathways for the emergence of new infections and the resurgence of existing ones. Therefore, collaboration between ecologists, urban planners, and epidemiologists is extremely important (Eisenberg et al. 2007). Quantifying the contributions of various factors to emergence and spread of infections requires expertise from statistics and mathematics. Dedicated efforts from many other partners such as local and state health departments, agencies, professional societies, universities, research institutes, health-care providers and organizations, domestic and international organizations are also needed to effectively organize infectious disease control and prevention.

The public health community, in particular, must take the leading responsibility to work more actively with other sectors that have important roles and interests in reducing infectious diseases. Even greater efforts will be necessary to deal with poverty, a particularly recalcitrant contributor to, and consequence of, some infectious diseases (Binder et al. 1999). At the national level, coordination among public health authorities at all levels of government needs to be substantially enhanced and developed in conjunction with mechanisms that allow for greater interaction across state borders and local boundaries. Greater involvements with private sectors are also important in relation to the research, development, and manufacture of vaccines and antibiotics and the development of microbial surveillance technology. Increased state investment is critical to develop a functional and coherent national policy for combating infectious disease. In conclusion, through the reinforced interdisciplinary collaboration in scientific research and increased knowledge transfer, we hope to be able to ultimately control infectious diseases, to reduce the burden of morbidity and mortality they cause, and to improve the quality of life of populations.

References

Adak GK, Meakins SM, Yip H, Lopman BA, O'Brien SJ (2005) Disease risks from foods, England and Wales, 1996–2000. Emerg Infect Dis 11: 365–372

Allegranzi B, Pittet D (2007) Healthcare-associated infection in developing countries: simple solutions to meet complex challenges. Infect Control Hosp Epidemiol 28: 1323–1327

Binder S, Levitt AM, Sacks JJ, Hughes JM (1999) Emerging infectious diseases: public health issues for the 21st century. Science 284: 1311–1313

Blaser MJ (1996) How safe is our food? Lessons from an outbreak of salmonellosis. N Engl J Med 334:1324–1325

Brower J, Chalk P (2003) Factors associated with the increased incidence and spread of infectious diseases. In: The global threat of new and reemerging infectious diseases: Reconciling U. S. National Security and Public Health Policy. Rand Science and Technology, McLean, VA, pp. 13–30

Dadao L, Hui L (2006) Urbanization and environmental issues in China. In: Wuyi W, Krafft T, Kraas F (eds) Global change, urbanization and health. China Meteorological Press, China, pp. 3–10

ECDC (2007) The first European communicable disease epidemiological report. European Centre for Disease Prevention and Control, Stockholm

Eisenberg JNS, Desai MA, Levy K, Bates SJ, Liang S, Naumoff K, Scott JC (2007) Environmental determinants of infectious disease: a framework for tracking causal links and guiding public health research. Environ Health Res 115: 1216–1223

Elmi M (2004) Food safety: current situation, unaddressed issues and the emerging priorities. Eastern Mediterranean Health J 10: 794–800

Farr BM (2002) Prevention and control of nosocomial infections. Business Briefing: Global Healthcare 3: 37–41

Folch E, Hernandez I, Barragan M, Franco-Paredes C (2003) Infectious diseases, non-zero-sum thinking, and the developing world. Am J Med Sci 326: 66–72

German National Committee on Global Change Research (NKGCF) (2005) Global change research in Germany. Department of Earth and Environmental Sciences, München

Grimm NB, Faeth SH, Golubiewski NE, Redman CL, Wu J, Bai X, Briggs JM (2008) Global change and the ecology of cities. Science 139:756–760

Hall GV, D'Souza RM, Kirk MD (2002) Foodborne disease in the new millennium: out of the frying pan and into the fire? Med J Australia 177: 614–618

Hinrichsen D, Salem R, Blackburn R (2002) Meeting the urban challenge. Population Reports, Series M, No. 16. The John Hopkins Bloomberg School of Public Health, Baltimore

The Hong Kong Special Administrative Region (HKSAR) Government (2003) Hong Kong: The Facts. Hong Kong 2003

Hufnagel L, Brockmann D, Geisel T (2004) Forecast and control of epidemics in a globalized world. PNAS 101: 15124–15129

Intergovernmental Panel on Climate Change (2007) Climate change 2007: Synthesis report. World Meteorological Organization, UNEP, Geneva

Khasnis AA, Nettleman MD (2005) Global warming and infectious disease. Arch Med Res 36: 689–696

Kim-Farley RJ (2004) Global strategies for control of communicable diseases. In: Detels R, McEwen J, Beaglehole R, Tanaka H (eds) Oxford textbook of public health. Oxford University Press, Oxford, pp. 1839–1859

Kinsella K, Phillips DR (2005) Global aging: The challenge of success. Population Bulletin 60, No. 1. Population Reference Bureau, Washington DC

Klevens RM, Edwards JR, Richards Jr. CL, Horan TC, Gaynes RP, Pollock DA, Cardo DM (2007) Estimating health care-associated infections and deaths in U.S. hospitals, 2002. Public Health Reports 122: 160–166

Kovats S, Akhtar R (2008) Climate, climate change and human health in Asian cities. Environ Urban 20:165–175

Kraas F (2003) Megacities as global risk areas. Petermanns Geographische Mitteilungen 147: 6–15

Kraas F (2007) Megacities and global change in East, Southeast and South Asia. Asien 103: s9–s22

Lashley FR (2004) Emerging infectious diseases: vulnerabilities, contributing factors and approaches. Expert Rev Anti Infect Ther 2: 299–316

Lazzari S, Allegranzi B, Concia E (2004) Making hospitals safer: the need for a global strategy for infection control in health care settings. World Hosp Health Serv 40: 32, 34, 36–42

Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJL (eds) (2006) Global burden of disease and risk factors. Oxford University Press, New York

Masterton RG (2005) A new understanding of antibiotic resistance in nosocomial infections. Br J Intensive Care Spring: 20–26

Mead PS, Slutsker L, Dietz V, McCaig LF, Bresee JS, Shapiro C, Griffin PM, Tauxe RV (1999) Food-related illness and death in the United States. Emerg Infect Dis 5: 607–625

Moore M, Gould P, Keary BS (2003) Global urbanization and impact on health. Int J Hyg Environ Health 206: 269–278

National Institutes of Health (2007) Why population aging matters: A global perspective. National Institute on Aging (Publication No. 07–6134) Washington, DC

OzFoodNet (2006) Burden and causes of foodborne disease in Australia: annual report of the OzFoodNet network, 2005. Commun Dis Intell 30: 278–300

Patz JA, Epstein PR, Burke TA, Balbus JM (1996) Global climate change and emerging infectious diseases. JAMA 275: 217–223

Planetearth (2005) Megacities-our global urban future. Earth Sciences for Society Foundation, Leiden

Population Reference Bureau (2004) Transitions in world population. Population Bulletin 59, No. 1. Population Reference Bureau, Washington DC

Population Reference Bureau (2007) World population highlights. Population Bulletin 62, No. 3. Population Reference Bureau, Washington DC

Riley LW, Ko AI, Unger A, Reis MG (2007) Slum health: diseases of neglected populations. BMC Int Health Human Rights 7: 2 (doi:10.1186/1472–698X-7-2)

Rodriguez-Garcia R (2001) The health-development link: travel as a public health issue. J Commu Health 26: 93–112

Saker L, Lee K, Cannito B, Gilmore A, Campbell-Lendrum D (2004) Globalization and infectious diseases: a review of the linkages. WHO, Geneva

Sanders TAB (1999) Food production and food safety. BMJ 318: 1689–1693

United Nations (2006) World urbanizations prospects: the 2005 revision. United Nations, New York

United Nations (2007) SIDR cyclone Bangladesh 2007. Office of the UN Resident Coordinator, Dhaka

USAID (2008) Global food insecurity and price increase update # 3. May 30, USAID

USAID (2005) Indian Ocean-Earthquake and Tsunamis. Office of US Foreign Disaster Assistance (OFDA), USAID

US Department of Commerce (2006) Hurricane Katrina August 13–31, 2005. National Oceanic and Atmospheric Administration (NOAA), Silver Spring

Weinstein RA (1998) Nosocomial infection update. Emerg Infect Dis 4: 416–420

WHO (2002) Active ageing: a policy framework. Second United Nations World Assembly on Ageing, Madrid

WHO (2003a) Update 62 – More than 8000 cases reported globally, situation in Taiwan, data on in-flight transmission, report on Henan Province, China. WHO, Geneva. Available at: http://www.who.int/csr/don/2003_05_22/en/

WHO (2003b) Climate change and human health-risks and responses: summary. WHO, Geneva

WHO (2005a) Preventable hospital infections are a major cause of death and disability for patients (SEA/PR/1407). WHO: Regional Office for South-East Asia, New Delhi

WHO (2005b) Global patient safety challenge 2005–2006: clean care is safer care. World Alliance for Patient Safety, Geneva

WHO (2007) Communicable disease risk assessment and interventions: Cyclone Sidr disaster-Bangladesh. WHO, Geneva

Wilder-Smith A (2005) Tsunami in South Asia: what is the risk of post-disaster infectious disease outbreaks? Ann Acad Med Singapore 34: 625–631

World Bank (2008) Addressing the food crisis: the need for rapid and coordinated action. A document prepared for G8 Finance Ministers Summit, June 13–14, Osaka.

Woube M (1997) Geographical distribution and dramatic increases in incidences of malaria: consequences of the resettlement scheme in Gambela, SW Ethiopia. Indian J Malariol 34: 140–163

Yoshikawa TT (2000) Epidemiology and unique aspects of aging and infectious diseases. Clin Infect Dis 30: 931–933

Zhang R, Eggleston K, Rotimi V, Zeckhauser R (2006) Antibiotic resistance as a global threat: evidence from China, Kuwait and the United States. Globalization Health 2: 6 (doi: 10.1186/1744-8603-2-6)

Springer
http://www.springer.com/978-0-387-93834-9

Modern Infectious Disease Epidemiology
Concepts, Methods, Mathematical Models, and Public Health
Krämer, A.; Kretzschmar, M.; Krickeberg, K. (Eds.)
2010, XVI, 443 p., Hardcover
ISBN: 978-0-387-93834-9