# Aging and Infectious Diseases in the Developing World

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**Although demographic aging does not remain restricted to industrialized countries, the medical challenge arising from the aging population will be distinct in the developing world. This is particularly true with respect to infectious diseases, which have a distinct spectrum in the elderly population, as well as a greater overall relevance in the developing world. Tropical diseases have a specific presentation and epidemiology in elderly patients. Infectious diseases with a worldwide distribution impact elderly patients in the developing world in a specific manner, which is most obvious with respect to human immunodeficiency virus and tuberculosis but is also true with respect to "trivial" manifestations of infection, such as diarrhea and pneumonia. Malnutrition contributes in a major way to the immunodeficiency of elderly patients in the developing world. Poorly controlled use of antimicrobial drugs leads to multidrug-resistant microorganisms, which, together with the limited resources available for drug treatment, makes appropriate treatment of infections in elderly patients in developing countries very difficult. Infections in elderly patients will have an increasing impact on the public health and economy of developing countries.**

Infections in elderly patients are a major medical problem. After a period of neglect, this problem is now receiving the deserved attention of the medical community [1–3]. Specific manifestations of infectious diseases in the elderly population are addressed by several reports in the "Aging and Infectious Diseases" section of *Clinical Infectious Diseases*. However, these reports have almost exclusively focused on the situation in industrialized countries, which differs substantially from that in developing countries. In developing countries, different types of pathogens are encountered, poverty and malnutrition lead to amplified severity of commonly encountered infections, transmission of pathogens is increased as a results of deficient infrastructure (e.g., water supply, sewage system, and hospital hygiene), and there is a lack of resources to treat the specific medical needs of elderly patients. Thus, the problems associated with infections in elderly patients and their impact on the medical and socioeconomic systems in developing countries need a specific assessment.

In this review, we address the following questions: demographic aging is now well established in industrialized countries [4], but to what extent will it occur in the developing world? Are there specific manifestations of tropical infectious diseases (such as malaria or leishmaniasis) in elderly patients? What is the impact of ubiquitous infectious diseases such as tuberculosis, AIDS, and pneumonia on the elderly population? What is the impact of malnutrition and dietary changes? And lastly, what is the impact of these elements on society in developing countries?

The information in this review has been gathered from Medline database searches and from data services provided by the World Health Organization (WHO) and the United Nations. In addition, data have been kindly provided by colleagues who performed studies in developing countries.

## AGING OF THE POPULATION IN DEVELOPING COUNTRIES

***Change in the demographic structure.*** Demographic aging is now well established, and the elderly population (age, >65 years) will exceed 1 billion persons in 2030 [4]. To date, the projection of population aging predicts that the proportion of elderly individuals will be as great as 19.6% and 23.0% of the population in North America and Europe, respectively, compared with 4.6% in Africa and 11.5% in both Asia and Latin America. However, these proportions are changing [5, 6], and in 2030, more than three-quarters of the elderly population are predicted to live in developing countries. This fast-changing

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pace in the demographic structure results from a phenomenon called the "demographic transition," in which the successive or concomitant reduction in death and birth rates [5] results in the former boosting population size and the latter increasing the proportion of elderly individuals. At present, the increase in the elderly population of developing countries is dramatically faster than the increase observed in industrialized countries (i.e., those in Europe, North America, Australia/New Zealand, and Japan) [4], which has taken place over more than a century [7]. Because aging is associated with a higher prevalence of chronic and debilitating diseases leading to disability, health care needs will increase among the aging population and will place more pressure on the already constrained health care resources of developing countries [8, 9].

***Infectious diseases of major relevance.*** The demographic transition is associated with an epidemiological transition in the causes and age of death. A predominant feature of this transition is a decrease in the number of deadly infections occurring during childhood [10]. On the contrary, it is projected that, in 2020, three-quarters of all deaths in developing countries could be due to age-associated diseases. These are predominantly noncommunicable diseases, such ascardiovascular disease, cancer, and diabetes. What is the role of infection in the death of elderly individuals? Statistics from the WHO [11] suggest that, in Europe and the United States, ~5% of the population >60 years old will die as a consequence of infection, compared with ~20% in Africa. However, although this relative difference in the importance of infection as a cause of death in industrialized countries versus developing countries is certainly relevant, the absolute numbers should be regarded with caution. Indeed, although studies using death certificates to identify causes of death usually find a relatively low importance of infection in industrialized countries, autopsy studies suggest a much higher contribution of infections to the overall causes of death (20%–30%) [12]. In the developing world, the leading infectious causes of death are respiratory tract infections, diarrheal diseases, tuberculosis, malaria, and AIDS, which together represent >90% of deaths [11]. The remaining 10% are due to tropical diseases and various other infections [11]. In industrialized countries, respiratory tract infections, bloodstream infections, urinary tract infections, and infections of the digestive system represent 90% of infection-related deaths; other diseases such as tuberculosis, hepatitis B and C, diarrheal diseases, and AIDS represent nearly all of the remaining 10% [11]. As already stated by Kalache in 1996, many infectious diseases "no longer kill but neither do they die" [7, pp. 22–31]. This aphorism is also a reminder that the impact of infectious diseases should not only be measured by mortality rate, but also by morbidity and quality of life, particularly in the aging population. These parameters are much more difficult to assess objectively, but understanding them will be increasingly important in the future.

## TROPICAL INFECTIONS IN OLDER ADULTS

Little is known about the presentation of tropical disease in elderly patients. Because many of these illnesses have been reemerging during the last decade, an understanding of their specific manifestations in elderly patients is very important.

***Malaria.*** Malaria is a major cause of morbidity and mortality in developing countries [11]. Higher parasite loads [13] and a higher proportion of severe forms (e.g., cerebral complications, more-frequent fatal outcome) have been reported to be associated with malaria among elderly individuals without immunity, as compared with the younger adult population [14–16]. The situation in areas of endemicity is more complex. Because of the development of immunity, the incidence of fatal disease decreases with age [17–19]; it occurs most commonly in children <5 years old, is less frequent among adolescent individuals, and is relatively rare among adults. However, epidemiological reports now suggest an increase in fatal disease in elderly individuals [11, 20]. From an immunological point of view, this makes sense, because immune protection from severe malaria needs continuous reactivation [17–19], suggesting that it might not withstand age-associated loss of immune function; moreover, a heightened Th1 response is thought to be protective against malaria [19], and immunosenescence is characterized by a shift from a Th1 response to a predominantly Th2 response [2, 21].

We are aware of only a single study [20] that addresses symptoms of malaria in elderly individuals with immunity. This study analyzed elderly patients who were hospitalized for malaria in the infectious diseases department of the Dakar University hospitals in Senegal. All cases were due to *Plasmodium falciparum* infection. In these patients, asthenia, myalgia, and coma were the 3 most common symptoms, found in 95%, 95%, and 75% of the cases, respectively [20]. Note that fever was observed in only 58% of the elderly patients. This contrasts with results typically found in middle aged patients, among whom the most commonly observed symptoms are fever (80%–95%), asthenia (20%–30%), and myalgia (20%) [22, 23]. Coinfection (e.g., urinary tract infection and pneumonia) is common in elderly patients and was observed in 40% [20], compared with 20%–30% of middle-aged patients [22]. Overall mortality in these elderly patients from Dakar was 32% [20], which is higher than the mortality rate associated with severe malaria in the middle-aged patient population (10%–25%) [22, 23]. Of interest, elderly patients who did not fulfill established criteria of malaria severity [23] also had a very high mortality rate [20].

Taken together, these data show that *P. falciparum* infection

is very severe in elderly patients with immunity. The reasons for this are certainly complex and need further studies.

***Leishmaniasis.*** Similar to other parasitic infections, visceral leishmaniasis (also known as kala-azar) is a re-emerging disease [24]. The annual estimates for the worldwide incidence and prevalence of this disease are 0.5 million and 2.5 million, respectively [11]. Kala-azar is clustered in eastern Africa, northeastern India, and South America [24], where it accounts for ~1 of every 1000 deaths due to infectious disease [11]. These relative numbers are the same for both young and old adults [11]. Thus, at present, kala-azar is not a problem that is particularly prevalent in the elderly population. However, this situation might change. Indeed, it is now clearly established that latent infection with *Leishmania* exists, as illustrated by the reactivation of *Leishmania* in patients with HIV infection [25, 26] and transplant recipients [27]. In a manner similar to that of latent *Mycobacterium tuberculosis* infection, survival of *Leishmania* amastigotes occurs within macrophages [12]. The rate of positive *Leishmania* skin test results among the elderly population in affected countries is high: 30%, 60%, and 70% in India, Brazil, and The Sudan, respectively [24, 28, 29]. Thus, even if only 1% of elderly individuals eventually experience a reactivation of leishmaniasis, this infection might become a relevant geriatric problem in affected countries.

***Helminthiasis.*** In recent years, numerous re-emerging helminth zoonoses have been described [30], but, thus far, few of them have been associated with the aging population. One example that has been associated with this population is chronic infection with the hookworm *Necator americanus* in China. Symptoms of chronic disease depend on the worm burden and have been described as anemia and hypoproteinemia [31]. The prevalence of infection increases with age: from ~20% in adolescent individuals, to ~50% in middle aged individuals, and to >80% in very old individuals (age, >80 years) [32]. In addition, the egg count in the stool of infected persons increases with age and is >100-fold higher in very old individuals than in adolescents [32]. Given the correlation between egg count and chronic symptoms, it is likely that the high parasite density observed in elderly individuals aggravates typical age-associated problems such as anemia and hypoproteinemia [32].

## SPECIFIC ASPECTS OF UBIQUITOUS INFECTIONS

***AIDS.*** The number of elderly patients with HIV infection is increasing throughout the world [33–35]. In industrialized countries, HIV-infected individuals aged ⩾50 years account for 10%–15% of HIV-infected individuals [33, 34], but seroprevalence in this age group remains relatively low (~0.1%; M. Gebhard [Federal Public Health Office, Bern, Switzerland] and M. Rickenbach [University Hospital, Lausanne, Switzerland], personal communication). In developing countries, elderly individuals represent a smaller fraction of HIV-infected individuals (4.5%, 5.6%, and 7.6% in Asia, Africa, and Latin America, respectively) [35–37], but HIV type 1 seroprevalence is often much higher: for example, 2.5% of the elderly population in rural villages of Cameroon [38] and 15% of the elderly population in Dar es Salaam (the capital of Tanzania) [39] have been reported to be HIV positive. In some developing countries, HIV infection is now one of the main causes of hospitalization for people >55 years of age [36]. The main route of HIV infection in the elderly population is heterosexual transmission; transmission by men who have sex with men and injection drug users plays only a minor role [36, 39, 40]. Nosocomial HIV transmission also plays a role in developing countries [41] but, to the best of our knowledge, no data are available for the elderly population.

The main presenting features of HIV infection in elderly Africans at hospitalization are wasting (40%–50%), fever (39%–89%), weight loss (40%–100%), and diarrhea (30%–60%) [36, 38, 39]. One study reported a 10.5-month delay between the onset of symptoms and hospital admission [36]. HIV-positive elderly individuals in developing countries have a shorter survival than does the younger population [36, 37, 39]. Data from Malawi, however, suggest that this increased mortality is, at least in part, attributable to the age-related increase in overall mortality (figure 1) [42]. Coinfections (including tuberculosis, malaria, leishmaniasis, pneumonia, and diarrheal syndrome) [43–45] might have an important impact on mortality in elderly patients, but no data concerning this question are available.

The HIV pandemic not only affects the elderly population through direct infection with the virus, but it also has a major indirect impact. HIV increases the spread of pathogens in community and hospital settings. Given their decreased host defense, elderly individuals are likely to be plagued by this sec-

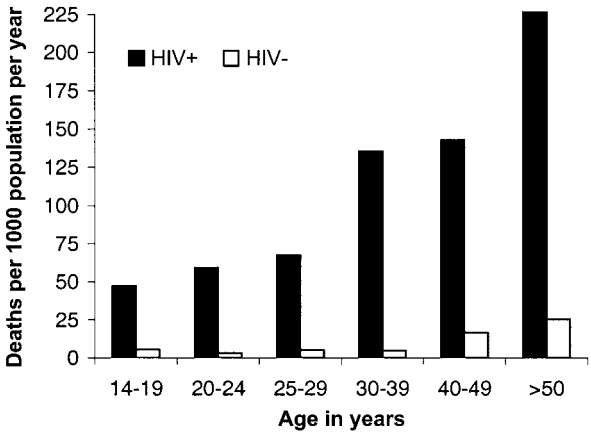


**Figure 1.** Deaths per 1000 population per year, by age group, within a 10-year period (1991–2001) in Malawi [42]. Note the dramatic impact of HIV infection on all age groups and particularly on the population >50 years of age. HIV+, HIV-positive patients; HIV−, HIV-negative patients.

ondary wave of infections. Such an HIV-induced increase in pathogen transmission has been documented for tuberculosis [45] but may also apply to malaria, pneumonia, and other infections [44–47].

Of the various consequences of the HIV pandemic, it is illness and death among the younger generation as a result of HIV infection that has possibly the most dramatic impact on the elderly population in the developing world [35, 48, 49]. This impact is on the level of emotional, economic, physical, and social well-being [48–51]. The elderly population has to function as caregivers for their HIV-infected adult children and guarantee the upbringing and education of their orphaned grandchildren [35, 49]. To make things worse, as the burden of HIV infection overwhelms the health care systems in the developing world, health care provided to elderly patients decreases [48–50]. Thus, the HIV epidemic transforms the elderly population into major care-providers and—at the same time—deprives them of medical care. A recent study by the WHO [49] concludes that, in HIV-plagued developing countries, health care for the elderly population should be a priority, because it is of primary importance for the sustainability of the care that the elderly population provides.

***Tuberculosis.*** In developing countries (in particular, those located in sub-Saharan Africa and Asia), tuberculosis is much more common than in industrialized countries. Although, in industrialized countries, annual incidence rates of tuberculosis show a slight decrease both in younger adults (age, 25–64 years) and in elderly individuals (age, >65 years) [52], in developing countries, the incidence of tuberculosis is still increasing [52, 53], and—at least in some countries—this increase affects the elderly population preferentially (increases are 30%–300% greater than in the younger population) [52].

As in industrialized countries [54, 55], the presentation of tuberculosis in the elderly population of developing countries is atypical, with more disseminated disease and more-frequent lower lobe involvement in the case of pulmonary tuberculosis [56, 57]. The time periods from the onset of symptoms to the establishment of diagnosis are longer and outcomes are worse than they are in the younger population [57–60].

In general, antituberculous treatment in elderly populations is efficient and safe, but drug-induced hepatitis and interactions with other drugs may be relevant problems [54]. In most developing countries, antituberculous drugs, which are relatively cheap, can be obtained. Instrumental to the distribution of drugs (but also instrumental to increasing compliance and avoiding resistance) is Directly Observed Therapy Strategy (commonly known as DOTS) [53]. However, the difficulties faced by the elderly population in obtaining access to health care (e.g., limited financial sources, functional disabilities, and remote living areas) may lead to an exclusion from treatment, a situation that has already been documented in India [57]. In Taiwan, rates of drug resistances have been found in the elderly population that are higher than those in the general population [59].

***Diarrhea.*** Infectious diarrhea is one of the main causes of morbidity and mortality in developing countries [11]. Causative microorganisms are numerous and include bacteria (e.g., *Vibrio cholerae* and *Shigella, Salmonella,* and *Campylobacter* species), viruses (e.g., Noroviruses and Rotavirus) and protozoa (e.g., *Giarda* and *Cryptosporidium* species) [61]. The varying levels of prevalence reflect the level of hygiene and sanitation in the respective areas [11, 62–64], and an increasing number of studies [62, 65, 66] report diarrhea as a health problem in the elderly population in developing countries. The World Health Report 2002 [11] cites diarrhea as the second or third most important cause of death due to infection among individuals >60 years of age in developing countries. Thus, although often considered to be trivial, infectious diarrhea in elderly patients is a very important health problem in the developing world.

***Influenza.*** Because of the lack of efficient surveillance programs in developing countries, it is difficult to assess the real impact of influenza in elderly patients. However, studies of several outbreaks in Taiwan and South Africa show that influenza is associated with greater morbidity and mortality in elderly patients than in the general population [67–69], and studies from Argentina, Brazil, and China demonstrate the efficacy of vaccination in the elderly population with respect to the prevention of both influenza-like illness and pneumonia [70–72].

***Common infections in the elderly population.*** In industrialized countries, pneumonia, urinary tract infections, and skin and soft-tissue infections are the most relevant infections in elderly patients [2, 73, 74]. In developing countries, the incidence of these infections is comparably high. Thus, tropical infections do not replace common infections in the developing world but are superimposed on the infectious problems that are seen in elderly individuals in the industrialized world. In developing countries, pneumonia is one of the leading causes of death in elderly patients (those >60 years of age) [11]. In South Africa, invasive pneumococcal disease is 3-fold higher in the elderly population than in the younger population [43], and the mortality rate is higher, as well [75–78] (OR, 1.5 per decade [77]). The prevalence of meningitis is high among elderly Senegalese, compared with the general adult population of Senegal [66, 79]. Meningitis is the fourth-most common infectious pathology requiring hospitalization [66] and is also associated with poor outcome [66, 79]. Studies from South America, India, and Africa investigating the global impact of infections in elderly patients conclude that, compared with the younger population, elderly patients with an infectious disease are hospitalized more often and have a higher mortality rate,

a longer duration of hospital stay, and a higher risk of secondary disability [74–80].

The limited data available on nosocomial infections in developing countries suggest that, as in industrialized countries [81, 82], elderly patients in developing countries are more likely to acquire infections during hospitalization [83, 84]. The deficiency of hospital infection-control practices enhances the magnitude of the problem in the developing world [84–86].

***Emerging infectious diseases.*** Emerging infectious diseases are mostly thought of in the context of the younger population. However, this picture is incomplete, and numerous emerging infections may be associated with a higher prevalence and a distinct clinical presentation in the elderly population. For example, during an outbreak of West Nile virus infection in New York City, 73% of individuals with clinically apparent disease were >60 years of age, and the relative risk for individuals >80 years of age to acquire the disease was 50 times greater than that for young adults [87, 88]. During a West Nile virus infection outbreak in Israel, 64% of hospitalized patients were >64 years old, and all patients with fatal cases were >77 years old [87, 88]. A study of Dengue fever in Puerto Rico [89] showed that infected individuals >64 years old had a greater risk for hospitalization and death but—of interest—a decreased risk for hemorrhage.

## NUTRITION AND INFECTION IN OLDER ADULTS

The immunodeficiency of elderly individuals is often attributed to immunosenescence and is thus considered irreversible. However, malnutrition (energy, protein, and micronutrient deficiency), which is found in 5%–10% of community-dwelling elderly individuals but is also found in 30%–60% of hospitalized elderly patients in industrialized countries, is probably at least as important a factor as is the aging of the immune system [90, 91]. In developing countries, malnutrition in elderly individuals is even more common; for example, in Africa, where >50% of elderly households are in food poverty [92], 9.5%–46.8% of the community-dwelling elderly population (age, ⩾60 years) have a body mass index of <18.5 kg/m$^2$. For comparison, only 6.1% of the community-dwelling elderly population (⩾60 years of age) in Switzerland have a body mass index of <20 kg/m$^2$ [92–95].

Paradoxically, malnutrition increasingly coexists with obesity in the developing world. Economic development and urbanization have led to a rapid change in dietary customs, with an increased intake of fats, animal products, and refined foods and a decreased intake of fresh vegetables and fibers [95]. This phenomenon, called the "nutrition transition," leads to higher rates of obesity and chronic disease [95]. This, in turn, will increase the risk of infection in elderly individuals, because obesity leads to chronic diseases such as diabetes mellitus and diverticulosis, which bring an increased risk of infection, and because qualitative malnutrition enhances the immunodeficiency of elderly individuals [95].

## ANTIMICROBIAL DRUGS AND MICROBIAL RESISTANCE

Numerous studies from developing countries show increasing rates of bacterial resistance [86, 96]. Resistant microorganisms relevant for community- and hospital-acquired infections include *Neisseria meningitidis, Salmonella* species, *Streptococcus pneumoniae, M. tuberculosis,* methicillin-resistant *Staphylococcus aureus, Escherichia coli,* and *P. falciparum* [64, 86, 96, 97]. The impact of this resistance development on the elderly population is now increasingly studied [83–86]. As an example, C. Bantar (Committee for Prevention and Control of Nosocomial Infections, Hospital San Martín, Paraná, Entre Ríos, Argentina) provided us with some unpublished data on Argentinean outpatients presenting with urinary tract infection. This data shows higher rates of ciprofloxacin resistance for *E. coli, Proteus mirabilis,* and *Klebsiella pneumoniae* in patients ⩾65 years of age, compared with younger patients (table 1). Reasons for the increased development of antibiotic resistance in the elderly population of developing countries are numerous [2, 86, 96].

## PUBLIC HEALTH AND SOCIOECONOMIC IMPACT

Clearly, the aging of the population in developing countries will increase the number of infectious episodes simply because of the increased susceptibility of elderly individuals to infectious agents. Will these elderly patients with infections also represent a reservoir that, in turn, leads to increased transmission to the younger population? At first consideration, this appears rather unlikely, because the elderly population has a lower mobility and a decreased risk of sexual transmission. However, the possibility has to be considered seriously. Taking the example of methicillin-resistant *S. aureus,* nursing homes and long-term care institutions are major reservoirs for the efficient propa-

**Table 1. Ciprofloxacin resistance in urinary tract infection of Argentinian outpatients, 2000–2003.**

| | Ciprofloxacin-resistant isolates, by patient age in years | |
|---|---|---|
| Bacterium | <65 | >65 |
| *Escherichia coli* | 461 (7.3) | 325 (21.3) |
| *Proteus mirabilis* | 45 (4.5) | 32 (25.0) |
| *Klebsiella pneumoniae* | 31 (6.6) | 31 (19.3) |

**NOTE.** Data are no. of ciprofloxin-resistant isolates (% of isolates). Data were provided by C. Bantar (Hospital San Martín, Paraná, Entre Ríos, Argentina).

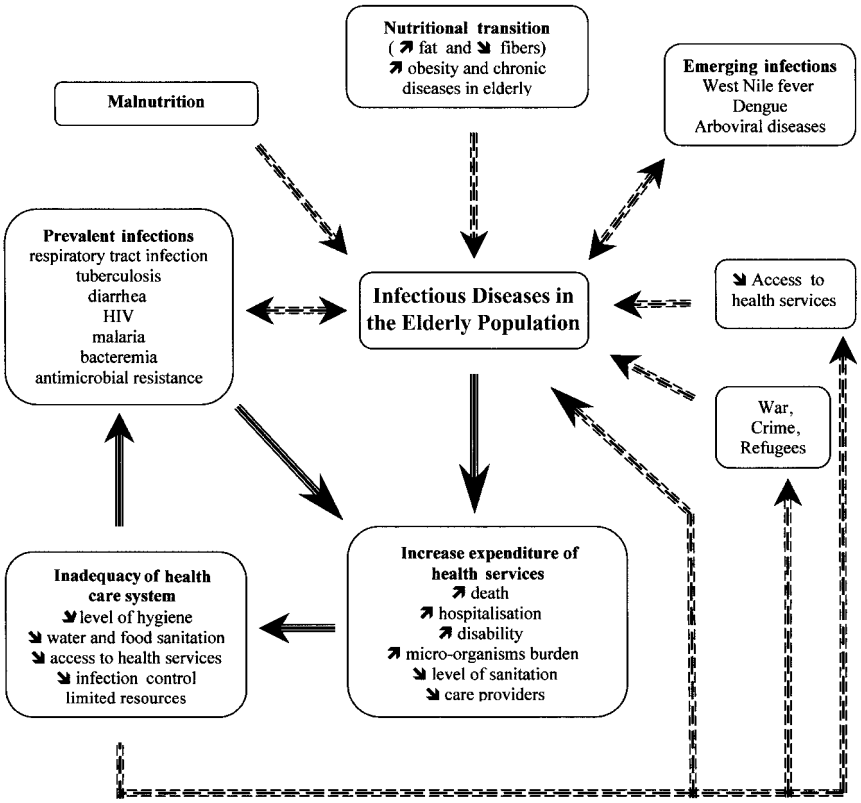


**Figure 2.** Impact of infectious disease in the elderly population on health care services *(solid arrows)* and factors contributing to an increase in the burden of infectious disease in elderly individuals *(patterned arrows)*. These circumstances create a vicious circle, limiting resources.

gation of this multidrug-resistant organism [83–85, 98]. Changes in the socioeconomic environment are likely to lead to increased rates of institutionalization of elderly individuals in developing countries [99]. Such an institutionalization of elderly individuals will not only lead to major costs for society but will create a major platform for nosocomial transmission. In the developing world, this might even be relevant with respect to nosocomial transmission of certain emerging infections. However, community-dwelling elderly individuals with infections might also contribute to increased transmission of pathogens. Diarrheal diseases are frequent in elderly individuals in developing countries and can be readily transmitted [62, 65, 66]. A decrease in the success rate of antituberculosis treatment in the elderly population might lead to an increased rate of tuberculosis transmission, possibly even involving drug-resistant mycobacteria [57].

From what we have described thus far, it is clear that infections in elderly individuals will substantially increase the societal costs in developing countries during the next decades. Sociocultural factors, such as urban migration and the rupture of both traditional family bonds and common cultural beliefs, are also involved in increasing both the burden of infection [86, 100] and the social isolation of elderly individuals [86]. Only a few developing countries apply social security schemes, forcing elderly individuals to rely on family care [6, 99], which is eroding because of poverty, continuing urbanization, and the growing participation of women in the workforce [6, 99]. Thus, costs for medical care and for nursing homes will increase. As the financial resources required for proper health care of elderly individuals are often not available, infections may go untreated, which will enhance the magnitude of the problem through reverse transmission from the infected elderly population to the uninfected younger population and through the decreased capacity of elderly individuals to function as socially relevant caretakers. A vicious cycle is established: the increased medical needs of the elderly population cannot be met because of limited and misused resources, and insufficient health care for elderly individuals will lead to a further increase in health care costs for the general population (figure 2).

There is no simple solution for the problems related to infectious disease in the aging population of developing countries [86, 101, 102]. Infection-control programs have been implemented with some degree of success [103], but they usually do not consider specifics with respect to the elderly population, and they invariably lack long-term impact if they are not accompanied by broader socioeconomic measures [49, 86]. Targets for such broader measures include hygiene, water and food sanitation [86, 96, 104], veterinary surveillance, control of drug

sales (i.e., the number of prescriptions and the quality of the drugs), and many other factors.

## PERSPECTIVE

In developing countries, the aging of the population structure will be faster than that which occurred during the previous century in industrialized countries. Such a rapidly aging population in countries with limited financial resources will raise a multitude of problems. Health problems—and in particular those associated with infectious disease—are only one element in this complex situation. But, as was sadly demonstrated by the AIDS epidemic, medical problems can overwhelm and destroy all other aspects of society.

We would, however, like to emphasize that the aging of the population in developing countries should not be viewed as a problem per se. On the contrary, the increasing population of elderly individuals represents a formidable chance for the preservation and transmission of knowledge and competence to younger generations. In 1962, the Malian writer Amadou Hampate Bâ said a sentence that has become a famous quote: "When an old man dies, a library burns down" [105]. Today, elderly individuals are probably saving the society in AIDS-ridden sub-Saharan Africa. Thus, taking care of the needs of elderly individuals in developing countries is not simply a gesture of charity but is, rather, an imperative for survival and development.


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### References


1. Yoshikawa TT. Perspective: aging and infectious diseases: past, present, and future. J Infect Dis **1997**; 176:1053–7.
2. Gavazzi G, Krause KH. Ageing and infection. Lancet Infect Dis **2002**;2: 659–66.
3. High KP. Infection in an ageing world. Lancet Infect Dis **2002**; 2:655.
4. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat. World population prospects: the 2002 revision and world urbanization prospects. New York: United Nations, **2002**.
5. Kinsella K. Demographic aspects. In: Ebrahim S, Kalache A, eds. Epidemiology in old age. Vol. 1. London: BMJ Publishing Group, **1996**:32–40.
6. Lloyd-Sherlock P. Population ageing in developed and developing regions: implications for health policy. Soc Sci Med **2000**; 51:887–95.
7. Kalache A. Ageing worldwide. In: Ebrahim S, Kalache A, eds. Epidemiology in old age. Vol. 1. London: BMJ Publishing Group, **1996**: 22–31.
8. Jamison DT, Mosley WH. Disease control priorities in developing countries: health policy responses to epidemiological change. Am J Public Health **1991**; 81:15–22.
9. Peters DH, Rao KS, Fryatt R. Lumping and splitting: the health policy agenda in India. Health Policy Plan **2003**; 18:249–60.
10. Omran AR. Epidemiologic transition in the United States: the health factor in population change. Popul Bull **1977**; 32:1–42.
11. World Health Organization. The world health report 2002. Geneva: World Health Organization, **2002**
12. Janssens JP, Herrmann F, MacGee W, Michel JP. Cause of death in older patients with anatomo-pathological evidence of chronic bronchitis or emphysema: a case-control study based on autopsy findings. J Am Geriatr Soc **2001**; 49:571–6.
13. Gjorup IE, Ronn A. Malaria in elderly nonimmune travelers. J Travel Med **2002**; 9:91–3.
14. Muhlberger N, Jelinek T, Behrens RH, et al. Age as a risk factor for severe manifestations and fatal outcome of falciparum malaria in European patients: observations from TropNetEurop and SIMPID Surveillance Data. Clin Infect Dis **2003**; 36:990–5.
15. Baird JK, Masbar S, Basri H, Tirtokusumo S, Subianto B, Hoffman SL. Age-dependent susceptibility to severe disease with primary exposure to *Plasmodium falciparum*. J Infect Dis **1998**; 178:592–5.
16. Schwartz E, Sadetzki S, Murad H, Raveh D. Age as a risk factor for severe *Plasmodium falciparum* malaria in nonimmune patients. Clin Infect Dis **2001**; 33:1774–7.
17. Soe S, Druilhe P. The implications of naturally acquired immunity to malaria in Southeast Asia. Trends Parasitol **2002**; 18:8–10.
18. Kleinschmidt I, Sharp B. Patterns in age-specific malaria incidence in a population exposed to low levels of malaria transmission intensity. Trop Med Int Health **2001**; 6:986–91.
19. Baird JK. Age-dependent characteristics of protection v. susceptibility to *Plasmodium falciparum*. Ann Trop Med Parasitol **1998**; 92:367–90.
20. N'Diaye CL. Paludisme: aspects épidémiologiques, cliniques et évolutifs chez la personne âgée à Dakar. Infectious Disease Departement. Dakar: Cheikh Anta Diop University, **2003**:96.
21. Castle SC. Clinical relevance of age-related immune dysfunction. Clin Infect Dis **2000**; 31:578–85.
22. Tran TH, Day NP, Nguyen HP, et al. A controlled trial of artemether or quinine in Vietnamese adults with severe falciparum malaria. N Engl J Med **1996**; 335:76–83.
23. World Health Organization. Severe falciparum malaria. World Health Organization, Communicable Diseases Cluster. Trans R Soc Trop Med Hyg **2000**; 94(Suppl 1):S1–90.
24. Ashford RW. The leishmaniases as emerging and reemerging zoonoses. Int J Parasitol **2000**; 30:1269–81.
25. Kubar J, Marty P, Lelievre A, et al. Visceral leishmaniosis in HIV-positive patients: primary infection, reactivation and latent infection. Impact of the CD4+ T-lymphocyte counts. AIDS **1998**; 12:2147–53.
26. Morales MA, Cruz I, Rubio JM, et al. Relapses versus reinfections in patients coinfected with *Leishmania infantum* and human immunodeficiency virus type 1. J Infect Dis **2002**; 185:1533–7.
27. Hernandez-Perez J, Yebra-Bango M, Jimenez-Martinez E, et al. Visceral leishmaniasis (kala-azar) in solid organ transplantation: report of five cases and review. Clin Infect Dis **1999**; 29:918–21.
28. EL-Safi SH, Bucheton B, Kheir MM, et al. Epidemiology of visceral leishmaniasis in Atbara River area, eastern Sudan: the outbreak of Barbar El Fugara village (1996–1997). Microbes Infect **2002**; 4: 1439–47.
29. Werneck GL, Rodrigues L, Santos MV, et al. The burden of *Leishmania chagasi* infection during an urban outbreak of visceral leishmaniasis in Brazil. Acta Trop **2002**; 83:13–8.
30. McCarthy J, Moore TA. Emerging helminth zoonoses. Int J Parasitol **2000**; 30:1351–60.
31. Liu LX, Weller PF. Strongyloidiasis and other intestinal nematode infections. Infect Dis Clin North Am **1993**; 7:655–82.

32. Bethony J, Chen J, Lin S, et al. Emerging patterns of hookworm infection: influence of aging on the intensity of Necator infection in Hainan Province, People's Republic of China. Clin Infect Dis **2002**; 35:1336–44.
33. Chiao EY, Ries KM, Sande MA. AIDS and the elderly. Clin Infect Dis **1999**; 28:740–5.
34. Shah SS, McGowan JP, Smith C, Blum S, Klein RS. Comorbid conditions, treatment, and health maintenance in older persons with human immunodeficiency virus infection in New York City. Clin Infect Dis **2002**; 35:1238–43.
35. Knodel J, Watkins S, VanLandingham M. AIDS and older persons: an international perspective. J Acquir Immune Defic Syndr **2003**; 33: S153–S165.
36. Ibara JR, Itoua C, Gathse A, et al. Acquired immunodeficiency syndrome in elderly persons in a tropical zone: apropos of 175 cases in the Congo [in French]. Bull Soc Pathol Exot **2002**; 95:100–2.
37. Kumarasamy N, Solomon S, Flanigan TP, Hemalatha R, Thyagarajan SP, Mayer KH. Natural history of human immunodeficiency virus disease in southern India. Clin Infect Dis **2003**; 36:79–85.
38. Nyambi P, Zekeng L, Kenfack H, et al. HIV infection in rural villages of Cameroon. J Acquir Immune Defic Syndr **2002**; 31:506–13.
39. Mtei LN, Pallangyo KP. HIV infection in elderly medical patients. East Afr Med J **2001**; 78:144–7.
40. Holmgren B, da Silva Z, Larsen O, Vastrup P, Andersson S, Aaby P. Dual infections with HIV-1, HIV-2 and HTLV-I are more common in older women than in men in Guinea-Bissau. AIDS **2003**; 17:241–53.
41. Yerly S, Quadri R, Negro F, et al. Nosocomial outbreak of multiple bloodborne viral infections. J Infect Dis **2001**; 184:369–72.
42. Crampin AC, Floyd S, Glynn JR, et al. Long-term follow-up of HIV-positive and HIV-negative individuals in rural Malawi. AIDS **2002**; 16:1545–50.
43. Jones N, Huebner R, Khoosal M, Crewe-Brown H, Klugman K. The impact of HIV on *Streptococcus pneumoniae* bacteraemia in a South African population. AIDS **1998**; 12:2177–84.
44. French N, Nakiyingi J, Lugada E, Watera C, Whitworth JA, Gilks CF. Increasing rates of malarial fever with deteriorating immune status in HIV-1–infected Ugandan adults. AIDS **2001**; 15:899–906.
45. Corbett EL, Steketee RW, ter Kuile FO, Latif AS, Kamali A, Hayes RJ. HIV-1/AIDS and the control of other infectious diseases in Africa. Lancet **2002**; 359:2177–87.
46. McDonald LC, Archibald LK, Rheanpumikankit S, et al. Unrecognised *Mycobacterium tuberculosis* bacteraemia among hospital inpatients in less developed countries. Lancet **1999**; 354:1159–63.
47. Pintado V, Lopez-Velez R. HIV-associated visceral leishmaniasis. Clin Microbiol Infect **2001**; 7:291–300.
48. Knodel J, VanLandingham M. The impact of the AIDS epidemic on older persons. AIDS **2002**; 16(Suppl 4):S77–83.
49. World Health Organization. Impact of AIDS on older people in Africa: Zimbabwe case study. Geneva: World Health Organization, **2002**.
50. Wilson AO, Adamchak DJ. The grandmothers' disease--the impact of AIDS on Africa's older women. Age Ageing **2001**; 30:8–10.
51. Knodel J, VanLandingham M, Saengtienchai C, Im-em W. Older people and AIDS: quantitative evidence of the impact in Thailand. Soc Sci Med **2001**; 52:1313–27.
52. World Health Organization. World Health Organization Report 2003: global tuberculosis control surveillance. WHO/CDS/TB/2003.316. Geneva: World Health Organization, **2003**.
53. Raviglione MC. The TB epidemic from 1992 to 2002 [review]. Tuberculosis (Edinb) **2003**; 83:4–14.
54. Janssens JP, Zellweger JP. Clinical epidemiology and treatment of tuberculosis in elderly patients [in German]. Schweiz Med Wochenschr **1999**; 129:80–9.
55. Rajagopalan S. Tuberculosis and aging: a global health problem. Clin Infect Dis **2001**; 33:1034–9.
56. Rizvi N, Shah RH, Inayat N, Hussain N. Differences in clinical presentation of pulmonary tuberculosis in association with age. J Pak Med Assoc **2003**; 53:321–4.
57. Arora VK, Singla N, Sarin R. Profile of geriatric patients under DOTS in Revised National Tuberculosis Control Programme. Indian J Chest Dis Allied Sci **2003**; 45:231–5.
58. Carvalho AC, Nunes ZB, Martins M, et al. Clinical presentation and survival of smear-positive pulmonary tuberculosis patients of a university general hospital in a developing country. Mem Inst Oswaldo Cruz **2002**; 97:1225–30.
59. Liaw YS, Yang PC, Yu CJ, et al. Clinical spectrum of tuberculosis in older patients. J Am Geriatr Soc **1995**; 43:256–60.
60. Harries AD, Hargreaves NJ, Gausi F, Kwanjana JH, Salaniponi FM. High early death rate in tuberculosis patients in Malawi. Int J Tuberc Lung Dis **2001**; 5:1000–5.
61. Farthing MJ. Diarrhoea: a significant worldwide problem. Int J Antimicrob Agents **2000**; 14:65–9.
62. Chai JY, Kim NY, Guk SM, et al. High prevalence and seasonality of cryptosporidiosis in a small rural village occupied predominantly by aged people in the Republic of Korea. Am J Trop Med Hyg **2001**; 65: 518–22.
63. Coker AO, Isokpehi RD, Thomas BN, Amisu KO, Obi CL. Human campylobacteriosis in developing countries. Emerg Infect Dis **2002**; 8:237–44.
64. Isenbarger DW, Hoge CW, Srijan A, et al. Comparative antibiotic resistance of diarrheal pathogens from Vietnam and Thailand, 1996–1999. Emerg Infect Dis **2002**; 8:175–80.
65. Gambhir IS, Jaiswal JP, Nath G. Significance of *Cryptosporidium* as an aetiology of acute infectious diarrhoea in elderly Indians. Trop Med Int Health **2003**; 8:415–9.
66. Ba AB. Pathologie infectieuse du sujet àgé: à propos de 773 cas dans le CHU de Dakar de 1979 à1988. Infectious disease departement. Dakar: Cheikh Anta Diop University, **1989**:76.
67. Besselaar TG, Schoub BD, Blackburn NK. Impact of the introduction of A/Sydney/5/97 H3N2 influenza virus into South Africa. J Med Virol **1999**; 59:561–8.
68. Simonsen L. The global impact of influenza on morbidity and mortality. Vaccine **1999**; 17:S3–10.
69. Retailliau HF, Gale JL, Beasley RP, Hattwick MA. Excess mortality and influenza surveillance in Taiwan. Int J Epidemiol **1978**; 7:223–9.
70. Stamboulian D, Bonvehi PE, Nacinovich FM, Ruttimann RW. Immunization against influenza in the elderly: the Argentinian experience, 1993–1997. Vaccine **1999**; 17(Suppl 1):S53–6.
71. Gutierrez EB, Li HY, Santos AC, Lopes MH. Effectiveness of influenza vaccination in elderly outpatients in Sao Paulo city, Brazil. Rev Inst Med Trop Sao Paulo **2001**; 43:317–20.
72. Jianping H, Xin F, Changshun L, et al. Assessment of effectiveness of Vaxigrip. Vaccine **1999**; 17(Suppl 1):S57–8.
73. Yoshikawa TT. Epidemiology and unique aspects of aging and infectious diseases. Clin Infect Dis **2000**; 30:931–3.
74. Karstaedt AS, Khoosal M, Crewe-Brown HH. Pneumococcal bacteremia in adults in Soweto, South Africa, during the course of a decade. Clin Infect Dis **2001**; 33:610–4.
75. Fedson DS, Scott JA, Scott G. The burden of pneumococcal disease among adults in developed and developing countries: what is and is not known. Vaccine **1999**; 17(Suppl 1):S11–8.
76. Saldias F, Mardonez JM, Marchesse M, Viviani P, Farias G, Diaz A. Community-acquired pneumonia in hospitalized adult patients: clinical presentation and prognostic factors [in Spanish]. Rev Med Chil **2002**; 130:1373–82.
77. Scott JA, Hall AJ, Muyodi C, et al. Aetiology, outcome, and risk factors for mortality among adults with acute pneumonia in Kenya. Lancet **2000**; 355:1225–30.
78. Dey AB, Nagarkar KM, Kumar V. Clinical presentation and predictors of outcome in adult patients with community-acquired pneumonia. Natl Med J India **1997**; 10:169–72.
79. Dioum M. Méningites purulentes du sujet àgé: à propos de 63 cas hospitalisé au CHU de Dakar de 1980 à 1989. Infectious diseases departement. Dakar: Cheikh Anta Diop University, **1990**:81.
80. Ba AB. Pathologie infectieuse du sujet àgé: à propos de 773 cas dans

le CU de Dakar de 1979 à1988. Infectious disease departement. Dakar: Cheikh Anta Diop University, **1989**:76.
81. Emori TG, Banerjee SN, Culver DH, et al. Nosocomial infections in elderly patients in the United States, 1986–1990. National Nosocomial Infections Surveillance System. Am J Med **1991**; 91:289S–93S.
82. Strausbaugh LJ. Emerging health care-associated infections in the geriatric population. Emerg Infect Dis **2001**; 7:268–71.
83. Sadoyama G, Gontijo Filho PP. Risk factors for methicillin resistant and sensitive *Staphylococcus aureus* infection in a Brazilian university hospital. Braz J Infect Dis **2000**; 4:135–43.
84. Wang X, Zhou H, Wang X, et al. A study on nosocomial infection among inpatients in Beijing Hospital for elderly [in Chinese]. Zhonghua Liu Xing Bing Xue Za Zhi **2001**; 22:212–4.
85. Kesah C, Ben Redjeb S, Odugbemi TO, et al. Prevalence of methicillin-resistant *Staphylococcus aureus* in eight African hospitals and Malta. Clin Microbiol Infect **2003**; 9:153–6.
86. Okeke IN, Lamikanra A, Edelman R. Socioeconomic and behavioral factors leading to acquired bacterial resistance to antibiotics in developing countries. Emerg Infect Dis **1999**; 5:18–27.
87. Berner YN, Lang R, Chowers MY. Outcome of West Nile fever in older adults. J Am Geriatr Soc **2002**; 50:1844–6.
88. Nash D, Mostashari F, Fine A, et al. The outbreak of West Nile virus infection in the New York City area in 1999. N Engl J Med **2001**; 344:1807–14.
89. Garcia-Rivera EJ, Rigau-Perez JG. Dengue severity in the elderly in Puerto Rico. Rev Panam Salud Publica **2003**; 13:362–8.
90. High KP. Nutritional strategies to boost immunity and prevent infection in elderly individuals. Clin Infect Dis **2001**; 33:1892–900.
91. Vellas B, Lauque S, Andrieu S, et al. Nutrition assessment in the elderly. Curr Opin Clin Nutr Metab Care **2001**; 4:5–8.
92. Charlton KE, Rose D. Nutrition among older adults in Africa: the situation at the beginning of the millenium. J Nutr **2001**; 131: 2424S–8S.
93. Kyle UG, Unger P, Mensi N, Genton L, Pichard C. Nutrition status in patients younger and older than 60 y at hospital admission: a controlled population study in 995 subjects. Nutrition **2002**; 18:463–9.
94. Jones G, Steketee RW, Black RE, Bhutta ZA, Morris SS. How many child deaths can we prevent this year? Lancet **2003**; 362:65–71.
95. Tucker KL, Buranapin S. Nutrition and aging in developing countries. J Nutr **2001**; 131:2417S–23S.
96. Hart CA, Kariuki S. Antimicrobial resistance in developing countries. BMJ **1998**; 317:647–50.
97. Dosso M, Bissagnene E, Coulibaly M, et al. Acquired resistance and prescription of antibiotics in Africa: a critical assessment. Med Mal Infect **2000**; 30(Suppl 3):197–204.
98. Yoshikawa TT. Antimicrobial resistance and aging: beginning of the end of the antibiotic era? J Am Geriatr Soc **2002**; 50:S226–9.
99. Brodsky J, Habib J, Hirschfeld M, Siegel B. Care of the frail elderly in developed and developing countries: the experience and the challenges. Aging Clin Exp Res **2002**; 14:279–86.
100. Kunin CM, Lipton HL, Tupasi T, et al. Social, behavioral, and practical factors affecting antibiotic use worldwide: report of Task Force 4 [review]. Rev Infect Dis **1987**; 9(Suppl 3):S270–85.
101. Starling C. Infection control in developing countries. Curr Opin Infect Dis **2001**; 14:461–6.
102. Archibald LK, Reller LB. Clinical microbiology in developing countries. Emerg Infect Dis **2001**; 7:302–5.
103. Bantar C, Sartori B, Vesco E, et al. A hospitalwide intervention program to optimize the quality of antibiotic use: impact on prescribing practice, antibiotic consumption, cost savings, and bacterial resistance. Clin Infect Dis **2003**; 37:180–6.
104. Quick RE, Kimura A, Thevos A, et al. Diarrhea prevention through household-level water disinfection and safe storage in Zambia. Am J Trop Med Hyg **2002**; 66:584–9.
105. Bâ AH. In: Program and abstracts of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) Conference, Geneva, 1962. Geneva: UNESCO, **1962**.