Chapter 1
The Global Burden of Infectious Diseases

Paulo Pinheiro, Colin D. Mathers, and Alexander Krämer

1.1 Introduction

Over the last century, infectious diseases have lost a lot of their threat to individuals' health as well as to the health of populations living in industrialized countries. The continuous reduction and effective control of both mortality and morbidity from infectious diseases marks an impressive story of success in the history of public health in the developed world and has been linked to a wide range of improvements that occurred alongside the socioeconomic modernization of these societies. Although many factors (e.g., improved sanitation, development of antibiotics and vaccines, improved living conditions and food quality/availability, and improved health care and surveillance systems) that contributed significantly to the success have been identified, there are, however, still uncertainties about the underlying mechanisms and interactions that led to the decline of infectious disease mortality (Sagan 1987). The sustainable control of infectious diseases was also accompanied by an impressive rise of life expectancies which, in turn, gave chronic (non-communicable) diseases the opportunity to increase in quantity and importance for public health. This so-called epidemiological transition (Omran 1971, Olshansky and Ault 1986) may have resulted in the fact that infectious diseases have become somewhat marginalized in the public perception of the developed world.

From a global perspective, however, infectious diseases still play, and will continue to play, a significant role in public health since most of the regions of the world have not reached a level of modernization that is comparable with the industrialized world. Especially developing countries and countries in transition still face an enormous burden posed by communicable diseases on their populations' health. Changes in environment and human behavior due to the globalization of the world and the evolutionary dynamics of microbial agents may, furthermore, produce new ecological niches that enable the emergence or re-emergence of infections, thus posing a persistent threat to the developed world too.

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A. Krämer et al. (eds.), *Modern Infectious Disease Epidemiology*,
Statistics for Biology and Health, DOI 10.1007/978-0-387-93835-6_1,

This chapter aims to give an overview of the global and regional distribution of infectious diseases and puts its emphasis on the impact of infectious diseases on the population's health. For this purpose, the findings presented here will mainly rely on results from the Global Burden of Disease Project (Lopez et al. 2006). Using this approach, one is able to not only make comprehensive estimates of the magnitude of the burden of infectious diseases, but also to make comparative assessments of the burden of disease posed by non-communicable diseases and injuries. This makes it possible to identify the importance of communicable diseases relatively to other diseases.

The first part of this chapter provides an introduction to the GBD study, i.e., its conceptual and methodological basis, and dwells on the GBD core measure, the Disability-Adjusted Life Year (DALY). In the second part, main empirical findings on the current and future burden of disease that can be related directly to infectious conditions will be presented. These findings include published data from the GBD study as well as own estimates that were generated on the basis of available GBD statistics.

1.2 The Burden of Disease Approach

1.2.1 Conceptual Framework

Undisputedly, population health statistics are an important source of information for decision-makers and researchers in public health. Although there has been an increase in volume and quality of health data in the past, statistics on the health status of populations still suffer from several limitations that reduce their value for policy making and research purposes. These limitations include difficulties in comparing health indicators over time, across population groups, before and after specific health interventions, or the making of comparisons related to different health states and disease events. Furthermore, health statistics are globally unevenly distributed with many countries still lacking basic information on mortality and morbidity data.

In order to approach these difficulties, the World Bank, in collaboration with the World Health Organization (WHO) and the Harvard School of Public Health, started the Global Burden of Disease Project in the late 1980s. The main objective of the study was to generate a comprehensive and internally consistent, thus comparable set of estimates of mortality and morbidity by age, sex, and regions of the world. First estimates were made for the year 1990 (Murray and Lopez 1996). Also, the 1990 GBD study provided the public health community with a new conceptual und methodological framework, which was developed for integrating, validating, analyzing, and disseminating partial and fragmented information on the health of populations. The characteristics of this framework included the development of methods to estimate missing data and to assess the quality of available data, the incorporation of data on non-fatal health outcomes into summary measures of population health, and the development of a new metric, the Disability-Adjusted Life

Year (DALY) , to summarize the disease burden (Murray and Lopez 1996, 1997a). Since the original 1990 GBD study, WHO has undertaken some major revisions of the methodology resulting in improved updates of the global burden of disease for the years 2000–2002 (e.g., World Health Organization 2002).

The 2001 GBD study, which is the central source of information for this chapter, has quantified the burden of premature mortality and disability by age, sex, and region for 136 causes. These 136 causes are closely related to the diagnostic categories of the International Classification of Diseases (ICD) and are classified using a tree structure with four levels of disaggregation. In the GBD classification system, the first level of disaggregation defines three broad cause groups: group I causes include communicable, maternal, perinatal, and nutritional conditions; group II and group III causes comprise non-communicable diseases and injuries, respectively (Mathers et al. 2006).

Regional assessments of the burden of disease have been presented on a country level or on either the WHO (World Health Organization 2002) or the World Bank (World Bank 2002) regional grouping level. In this chapter, the estimates are presented in terms of the income and regional groupings of countries as given by the World Bank. Based on the economic and social data compilation according to the World Development Report 2003 (World Bank 2002) countries are divided into seven groups: the high-income countries constitute one group and the low- and middle-income countries comprise another group that can further be subdivided into six geographical regions.

1.2.2 The Measurement Unit Disability-Adjusted Life Year (DALY)

The measurement unit Disability-Adjusted Life Year (DALY) is a core element of the GBD study since it was exclusively designed to meet the major objectives of this study, i.e., the inclusion of non-fatal health outcomes in debates on international health policy, the decoupling of epidemiological assessments from advocacy, and the quantification of the burden of disease with a measure that could further be used for cost-effectiveness analysis. The technical basis for the DALY calculation is characterized by a high degree of complexity since a number of different features had to be incorporated into the development of the DALY formula in order to fulfil the overall aims of the GBD study. Thus, an adequate interpretation of results that are generated with this measure requires some methodological knowledge.

The DALY is a composite measure that combines time lost due to premature mortality with time of healthy life lost due to living in health states worse than ideal health (see Fig. 1.1). Thus, the DALY measure is a health gap measure that quantifies the difference between the actual health of a population and some defined ideal or goal for population health. Just like DALYs, the quality adjusted life year (QALY) measure is a way of measuring disease burden, including both the quality and the quantity of life lived. Though having several similarities in methodology and semantics with DALYs, QALYs are frequently used to measure the number of

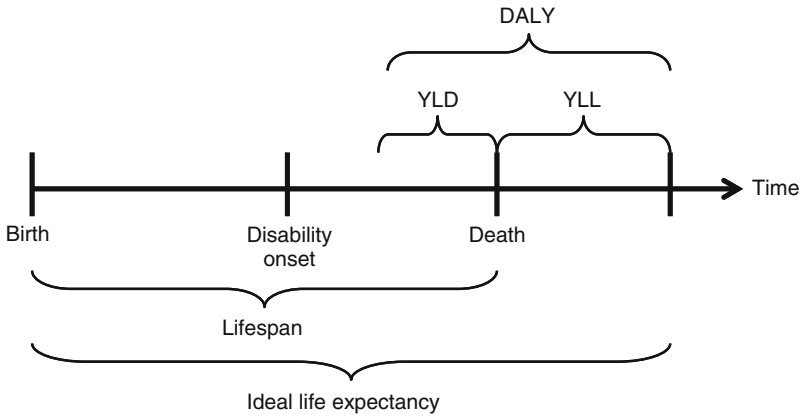

Fig. 1.1 The GBD measure Disability-Adjusted Life Year (DALY). It sums up years of life lost due to premature death (YLL) and healthy years of life lost due to disability (YLD). Premature death refers to some ideal goal of the life expectancy. YLD estimates use disability weights in order to determine the extent of health losses in lifetime. DALYs can be calculated for disease grouping like infectious diseases or cancers or injuries, and for single disease entities like, e.g., tuberculosis, thus making all kinds of comparisons possible

additional years of healthy life that would be added by a certain intervention, be it preventive or curative, population-based, or clinical.

For the DALY development some general assumptions were made in order to achieve the goals of the GBD study (Murray 1994, 1996). First, it was demanded that any health outcome that affects social welfare should in some way be reflected in the indicator of the burden of disease. Second, individual characteristics that should be considered in estimating the burden of disease should be restricted to age and sex since these variables are general to all communities and households. For the GBD purposes, socioeconomic variables were explicitly excluded from consideration reflecting the developers' notions of social justice. Third, like-health outcomes should be treated as like. The principle of treating like events equally was articulated in order to ensure comparability of the burden of disease across different communities or in the same community over a period of time, and implies that the health status of a person does not depend on his/her neighbor's health status. Fourthly, time was chosen to be the unit of measure for the burden of disease.

Estimates of the duration of time lost due to premature death are reflected in the DALY formula by the component Years of Life Lost (YLL). There are several options to estimate time lost due to mortality. For the calculation of DALYs, the use of the standard expected years of life lost method was chosen (Murray 1994, 1996). Basically, this method calculates the time of life lost due to premature death

with regard to a standard cohort life expectancy at each age. For the ideal standard, the expectations of life at each age are based on a model life table which has a life expectancy at birth for females of 82.5 years. This value was chosen since it was close to the highest national period life expectancy observed at that time. For males, a life expectancy at birth of 80 years was defined. This sex difference in life expectancies at birth of 2.5 years obviously does not reflect the average observed differences in populations which are significantly higher. It was chosen according to the developers' assumption about the biological differences in life expectancies when behavioral or contextual factors are equally distributed between the sexes.

Years of Life Lost due to Disability (YLD) are the morbidity component of the DALYs and are considered to be the most difficult estimate in a burden of disease study (Mathers et al. 2001). The assessment of the impact of non-fatal health outcomes on the burden of disease requires an in-depth understanding of the diseases specific epidemiology. Non-fatal health conditions are measured in the DALY formula in terms of disability, i.e., the functional loss of capacity. The data required to estimate the YLD component are the disability incidence and duration, the age of onset, and the distribution by severity classes, all of which must be disease specific and disaggregated by age and sex. To make the specified disabilities comparable, YLDs were combined with a disability weight ranging from 0 (full health equivalent) to 1 (health state equivalent to death). The bigger a disability weight, the more health losses are estimated. The disability weights again implied value choices since it was required to give preferences for health states in terms of a single number on an interval level scale. In the GBD framework, health state valuation was done by means of the person trade-off (PTO) technique (Murray 1996). The PTO method is a group exercise where specific descriptions of patients in different health states are presented to the participants. The participants are then asked to do an explicit trade-off between a collection of 1000 fictive, healthy people and each of the people in the presented health state, i.e., to indicate the number of disabled people equivalent to the 1000 healthy people. Disability weights are then calculated as the ratio of the number of the imaginary healthy people divided by the number of virtual people in the disabled health state. In the original 1990 GBD study, disability weights were derived for all conditions based on a set of 22 indicator conditions by expert panels from different regions of the world. Disability weights used for the updated GBD studies were based on the 1990 GBD disability weights.

Other key features of the DALY measure that affect the calculation of both YLL and YLD are social values with respect to age and time preferences (Murray 1994). An age weighting function was developed for the original GBD study based on findings indicating that there are social preferences to value years of life lived at young adult ages higher than years lived by young children or older ages. It was postulated that societies in general assign greater importance to preventing the deaths of young adults than of very young children or older adults because of different economic and social roles. Thus, according to the DALY developers, dependency of young children and elderly on young/middle-aged adults should be included in the DALY formulation. Technically, age weights are derived by the use of an exponential function. The proposal to incorporate age weights into the DALYs has led

to controversial discussions (e.g., Anand and Hanson 1997) and, as a consequence, resulted in updated GBD assessments that present estimates with, as well as without, age preferences.

Time preferences have been considered in the GBD study by means of a discounting rate that was applied to the DALY calculation (Murray 1994). Discounting of future benefits is a widely accepted economic concept that reflects the fact that most individuals prefer benefits now rather than in the future. It refers to the practice that things are valued in the future as less or more valuable than in the present. This concept was transferred to the GBD study in terms of valuing future health losses in comparison with the present ones. Similar to the age weights, a number of arguments have been presented for and against discounting future health. DALY incorporates an arbitrarily chosen 3% discount rate per year.

1.3 The global and Regional Burden of Infectious Diseases

1.3.1 Infectious Diseases and the Global and Regional Causes of Death

Worldwide, slightly more than 56.2 million people out of about 6.1 billion people living globally died in 2001. About 14.7 million, or 26%, of these deaths were from infectious diseases. Maternal and perinatal conditions and nutritional deficiencies (other group I conditions) accounted for 3.5 million deaths (6%), noncommunicable diseases (group II) for about 32.9 million deaths (59%), and injuries (group III) for about 5.2 million deaths (9%) (see Fig. 1.2).

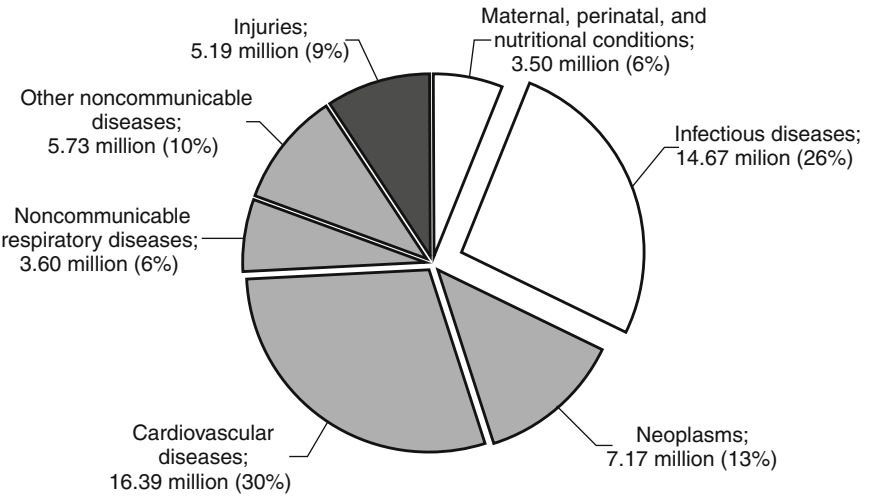

Fig. 1.2 Global causes of death, 2001 (GBD group I conditions: *white*; group II conditions: *gray*; group III conditions: *black*)

Among the infectious disease group, respiratory infectious diseases are the most common cause of death (3.8 million; 26.1% of all infectious causes of death), followed by HIV/AIDS (2.6 million; 17.5%), diarrheal diseases (1.8 million; 12.2%), tuberculosis (1.6 million; 10.9%), vaccine preventable childhood diseases (1.4 million; 9.3%), malaria (1.2 million; 8.2%), sexually transmitted diseases excluding HIV/AIDS (0.18 million; 1.2%), meningitis (0.17 million; 1.2%), hepatitis B and C (0.15 million; 1.0%), and tropical-cluster diseases (0.13 million; 0.8%). Other infectious diseases contributed to approx. 1.7 million deaths (11.4%) (see Fig. 1.3).

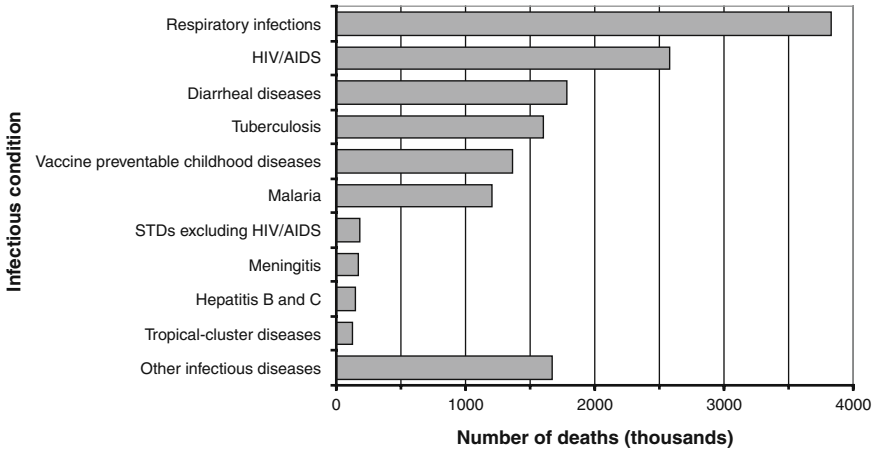

Fig. 1.3 Leading infectious causes of death worldwide, 2001

Table 1.1 shows the top 10 disease and injury causes of death in 2001 for low-and-middle-income countries and for high-income countries according to the World Bank's classification. Ischemic heart disease and cerebrovascular disease were the leading cause of death in both groups of countries, together responsible for more than one fifth of all deaths worldwide. Only 1.4 million of the total 7.1 deaths from ischemic heart disease, and 0.8 million of the total 5.4 million of deaths from cerebrovascular diseases lived in high-income countries reflecting the importance of cardio- and cerebrovascular diseases for health in low-and-middle-income countries. Lung cancer (0.5 million deaths) was the third leading cause of death in high-income countries, but was not among the ten leading causes of death in low- and middle-income countries. Here, five of the ten most common causes of death were infectious diseases, including lower respiratory infections, HIV/AIDS, diarrheal diseases, tuberculosis, and malaria. In contrast to these findings, only lower respiratory infections (0.34 million deaths) appear as an infectious condition in the top ten ranking of causes of death in high-income countries. According to the mortality data, high-income countries suffer not only a much lower burden than low-and middle-income countries but also a burden that is predominantly affected by non-communicable conditions.

When stratifying the mortality estimates by age groups, about 12.1 million deaths (21.5%) were attributable to children younger than 15 years of age in 2001. Nearly

Table 1.1 The ten leading causes of death, by broad income group, 2001

Low- and middle-income countries				High-income countries			
S.No.	Cause	Deaths (millions)	Percentage of total deaths	S.No.	Causes	Deaths (millions)	Percentage of total deaths
1	Ischemic heart disease	5.70	11.8	1	Ischemic heart disease	1.36	17.3
2	Cerebrovascular disease	4.61	9.5	2	Cerebrovascular disease	0.78	9.9
3	Lower respiratory infections	3.41	7.0	3	Trachea, bronchus, and lung cancers	0.46	5.8
4	HIV/AIDS	2.55	5.3	4	Lower respiratory infections	0.34	4.4
5	Perinatal conditions	2.49	5.1	5	Chronic obstructive pulmonary disease	0.30	3.8
6	Chronic obstructive pulmonary disease	2.38	4.9	6	Colon and rectal cancers	0.26	3.3
7	Diarrheal diseases	1.78	3.7	7	Alzheimer's and other dementias	0.21	2.6
8	Tuberculosis	1.59	3.3	8	Diabetes mellitus	0.20	2.6
9	Malaria	1.21	2.5	9	Breast cancer	0.16	2.0
10	Road traffic accidents	1.07	2.2	10	Stomach cancer	0.15	1.9

94% of these deaths occurred in low- and middle-income countries with seven of the top ten causes of death being infectious diseases and killing about 6.5 million children in 2001. Leading infectious diseases were lower respiratory infections, diarrheal diseases, and malaria.

The cause-of-death pattern distributed by age among people living in high-income countries is mainly characterized by the rise of non-communicable diseases in older age groups (see Fig. 1.4). Infectious diseases, as well as injuries play a negligible role here. Low- and middle-income countries show a different pattern when stratifying causes of death by age (see Fig. 1.4). Besides the increasing contribution of non-communicable diseases to the death numbers at higher ages that shows similarities with the pattern of high-income countries, there is also a crucial impact of infectious diseases on the mortality of the lower age groups, especially among children younger than age 5 in low- and middle-income countries. Furthermore, injuries

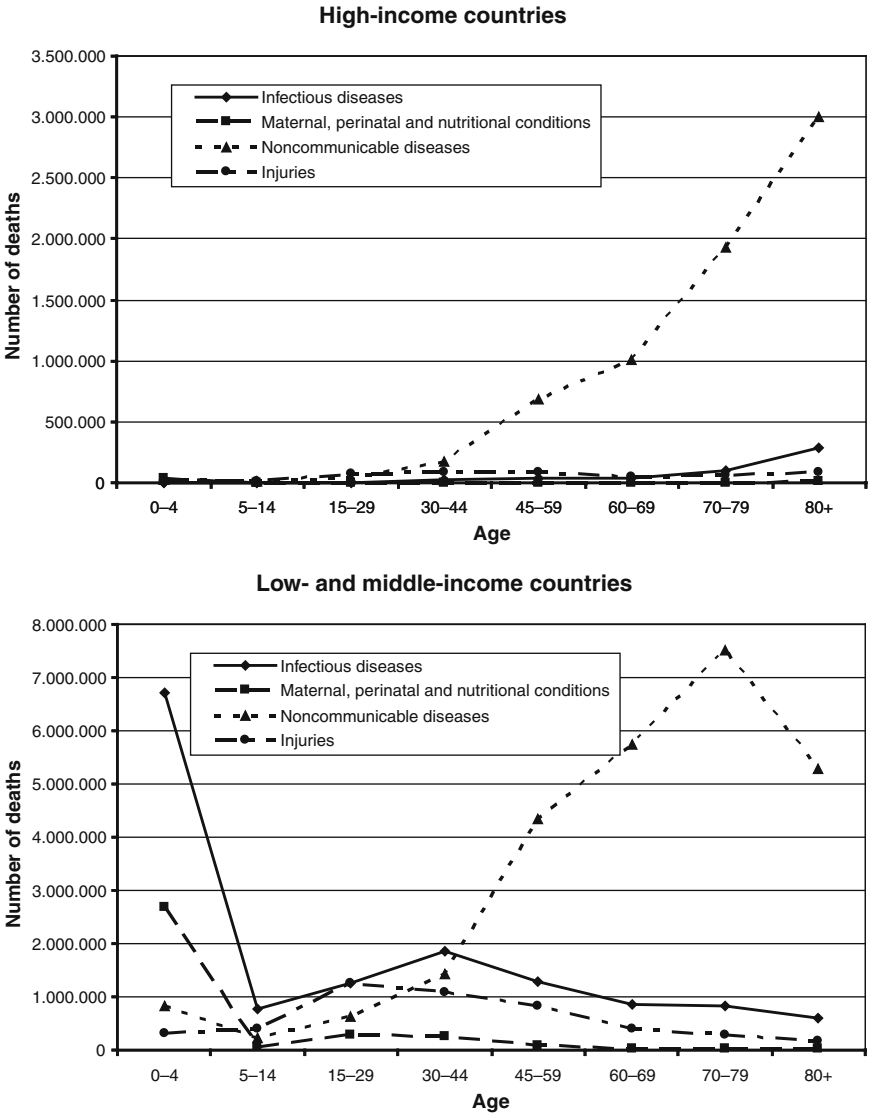

Fig. 1.4 Causes of death by age in high-income and low- and middle-income regions, 2001

can be identified in low- and middle-income countries as an important cause of death among young adults (peak values in age group 15–29 years).

According to the GBD estimates, child mortality (age 0–4 years) generally declined between 1990 and 2001 in all regions of the world mainly due to a substantial decrease of death rates from communicable diseases, especially for diarrheal and respiratory diseases. Mortality from diarrheal diseases fell from 2.4 million deaths in 1990 to about 1.6 million deaths in 2001 as a result of improvements in

diarrheal case management. Death rates from acute respiratory infections declined by more than 40% in all regions of the world except in South Asia (25%) and sub-Saharan Africa (15%). On the other hand, malaria and HIV/AIDS are the two diseases for which death rates have increased from 1990 to 2001 in children younger than 5 years, primarily in sub-Saharan Africa. Here, the proportion of deaths caused by malaria in children younger than 5 years increased from 15 to 22%.

Among adults aged 15–59 years, HIV/AIDS has become the leading cause of death worldwide in 2001 being responsible for 2.1 million adult deaths (14% of all deaths in adults). Deaths rates among adults aged 15–59 years have generally declined in all WHO regions of the world from 1990 to 2001 with two exceptions: Europe and Central Asia, and sub-Saharan Africa. Europe and Central Asia were the only regions where deaths rates from cardiovascular diseases and injuries have increased within this period. In sub-Saharan Africa, the rise of mortality among adults aged 15–59 years has been attributed to HIV/AIDS. In 2001, about 80% of the 2.1 million adult deaths from HIV/AIDS occurred in sub-Saharan Africa. Among all infectious diseases, HIV/AIDS has generally become the most important contributor to the global mortality. While HIV/AIDS accounted for 2% of all deaths in 1990, the proportion increased to 14% in 2001. Other deaths due to communicable diseases (including maternal, perinatal, and nutritional conditions) fell from one third of total deaths in 1990 to less than one fifth in 2001.

1.3.2 Infectious Diseases and the Global and Regional Burden of Disease

In addition to the mortality estimates presented in the section before and expressed in terms of death numbers, an assessment of the health burden caused by diseases and injuries as measured in DALYs offers several advantages: At first, the incorporation of non-fatal health outcomes into burden of disease calculations enables the assessment of the impact of chronic diseases, especially of those that are characterized by a low case-fatality, on a population's health. Then, the combination of non-fatal with fatal outcomes allows comparability between mortality with morbidity information. Finally, the presentation of results in terms of health losses gives an idea about a virtually existing preventive potential.

There have been several ways of how to report DALY estimates, depending on the fact whether or not non-uniform age weights and discount rates were applied to the DALY formula. Noteworthy is that these inconsistencies have resulted in limitations when comparing the presentations of GBD results by use of different publication sources. In the present section, DALYs will be used with uniform age weights and the standard GBD discount rate as presented by Lopez et al. (2006).

In 2001, the total global burden of disease was more than 1.536 million DALYs according to the GBD estimates. Across all regions of the world, the average burden of disease was 250 DALY per 1000 population, of which almost two thirds were due to years of life lost due to premature mortality and one third due to years of life lived with disability. The global burden of disease attributable to infectious diseases

accounted for slightly more than 400 million DALYs and thus for about 26% of the total burden of disease. Maternal and perinatal conditions and nutritional deficiencies (other group I conditions) accounted for about 148 million DALYs (10%), non-communicable diseases (group II) for about 808 million DALYs (53%), and injuries (group III) for about 167 million DALYs (11%) (see Fig. 1.5). In contrast to the cause-of-death analyses, DALY estimates capture the relevance of chronic conditions with low case-fatality such as neuropsychiatric disorders and sense organ disorders.

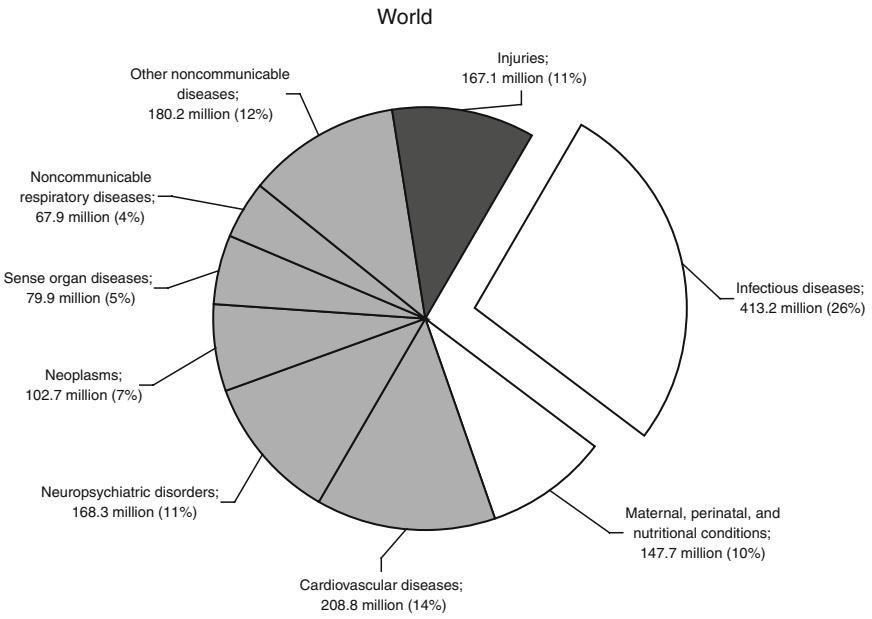

Fig. 1.5 Global burden of disease estimated by DALYs, 2001 (GBD group I conditions: *white*; group II conditions: *gray*; group III conditions: *black*)

Among all infectious diseases, respiratory infectious diseases were the most common cause of DALYs (89.2 million; 21.6% of all infectious disease DALYs), followed by HIV/AIDS (71.5 million; 17.3%), diarrheal diseases (59.1 million; 14.3%), vaccine preventable childhood diseases (43.3 million; 10.5%), malaria (40.0 million; 9.7%), tuberculosis (36.1 million; 8.7%), tropical-cluster diseases (10.3 million; 2.5%), sexually transmitted diseases excluding HIV/AIDS (9.5 million; 2.3%), meningitis (5.6 million; 1.4%), and hepatitis B and C (3.2 million; 0.8%). Other infectious diseases contributed to approx. 45.5 million DALYs (11.0%) (see Fig.1.6).

When comparing the DALY ranking with the death number ranking among the infectious condition group, respiratory infectious diseases, HIV/AIDS, and diarrheal diseases were the leading causes in both statistics. Using DALYs, a higher relevance to the burden can be attributed to vaccine preventable diseases, malaria, and tropical-cluster diseases, whereas, e.g., for tuberculosis less importance can be assigned. An

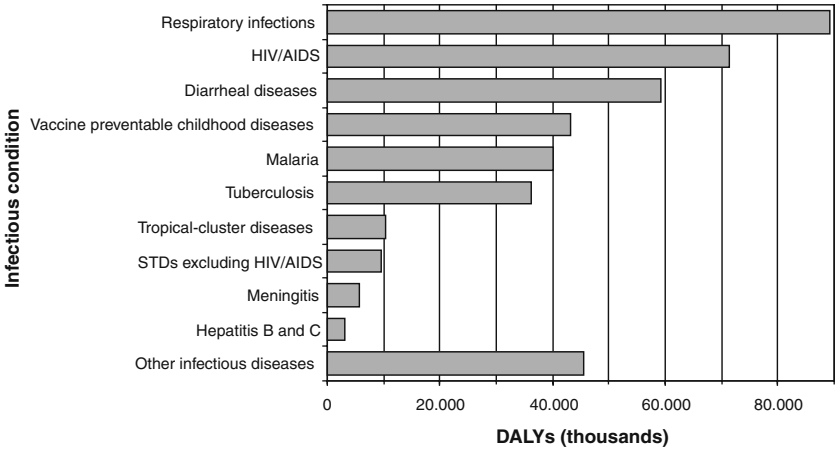

Fig. 1.6 Leading infectious conditions of the global burden of disease, 2001

important reason for the variability in the rankings is that DALYs incorporate the age at death into the calculation of years of life lost and thus assign a higher burden to diseases that cause premature death in early ages.

Table 1.2 shows the 20 leading causes of the global burden of disease. In contrast to the cause-of-death ranking, perinatal conditions and lower respiratory infectious

Table 1.2 The 20 leading causes of global burden of disease, 2001

S.No	Cause	DALYs (millions of years)	Percentage of total DALYs
1	Perinatal conditions	90.48	5.9
2	Lower respiratory infections	85.92	5.6
3	Ischemic heart disease	84.27	5.5
4	Cerebrovascular disease	72.02	4.7
5	HIV/AIDS	71.46	4.7
6	Diarrheal diseases	59.14	3.9
7	Unipolar depressive disorders	51.84	3.4
8	Malaria	39.97	2.6
9	Chronic obstructive pulmonary disease	38.74	2.5
10	Tuberculosis	36.09	2.3
11	Road traffic accidents	35.06	2.3
12	Hearing loss, adult onset	29.99	2.0
13	Cataracts	28.64	1.9
14	Congenital anomalies	24.95	1.6
15	Measles	23.11	1.5
16	Self-inflicted injuries	20.26	1.3
17	Diabetes mellitus	20.00	1.3
18	Violence	18.90	1.2
19	Osteoarthritis	17.45	1.1
20	Alzheimer's and other dementias	17.11	1.1

diseases are the two leading causes of burden followed by ischemic heart diseases and cerebrovascular diseases, these two conditions being the leading causes of death. Besides lower respiratory infections, 5 other infectious disease conditions are among the 20 leading causes of the global burden of disease: HIV/AIDS (5th rank), diarrheal diseases (6th), malaria (8th), tuberculosis (10th), and measles (15th).

Virtually, the entire global burden of disease (>98%) due to infectious diseases can be found in low- and middle-income countries. Here, infectious diseases account for 30% (407 million DALYs) of the total burden of disease. Maternal, perinatal, and nutritional conditions account for 10% (145 million DALYs), non-communicable diseases for 49% (678 million DALYs), and injuries for 11% (167 million DALYs). In high-income countries, the picture is completely different: Infectious diseases account for only 4% (5.8 million DALYs) of the total burden of disease, while other group I conditions contributed 2% (2.7 million DALYs), non-communicable diseases 86% (129 million DALYs), and injuries 8% (11.2 million DALYs) (see Fig. 1.7). The higher importance of infectious diseases for low- and middle-income countries can be confirmed by the fact that, in 2001, the leading causes of burden of disease included five communicable diseases (lower respiratory infections, HIV/AIDS, diarrheal diseases, malaria, and tuberculosis). The leading causes in high-income countries were all non-communicable conditions and included three conditions with few direct deaths but high disability (unipolar depressive disorders, adult-onset hearing loss, and alcohol use disorders).

HIV/AIDS was the fourth leading cause of burden of disease worldwide as well as in low- and middle-income countries in 2001. According to the GBD estimates it was the leading cause in the sub-Saharan Africa region, where it was followed by three other infectious diseases: malaria, lower respiratory infections, and diarrheal diseases. These four leading causes of burden of disease bore more than 42% of the total burden of disease in sub-Saharan Africa measured by DALYs.

The age-dependent distribution of the burden of disease in low- and middle-income and high-income countries shows patterns that are similar to those related to the mortality numbers with some slight modifications (see Fig. 1.8). In high-income countries, non-communicable diseases play an outstanding role in the burden of disease across all age groups. The use of DALYs not only depicts the importance of non-communicable conditions for higher age groups but also gives some hints to their relevance for younger age groups. Low- and middle-income countries face a double burden of disease: Children younger than 5 years of age are predominantly affected by infectious diseases. In addition, non-communicable conditions replace infectious diseases as the leading cause for the burden of disease in the subsequent age groups. When comparing the burden with the mortality pattern, the rise of the importance of non-communicable diseases becomes visible in earlier ages and thus enhances the relevance of non-communicable diseases for the younger age groups.

Between 1990 and 2001, there was a 20% decrease in the global per-head burden of disease due to the group I diseases (communicable, maternal, perinatal, and nutritional conditions). Without HIV/AIDS and the associated persistence of the burden attributable to tuberculosis, the reduction of group I conditions would have

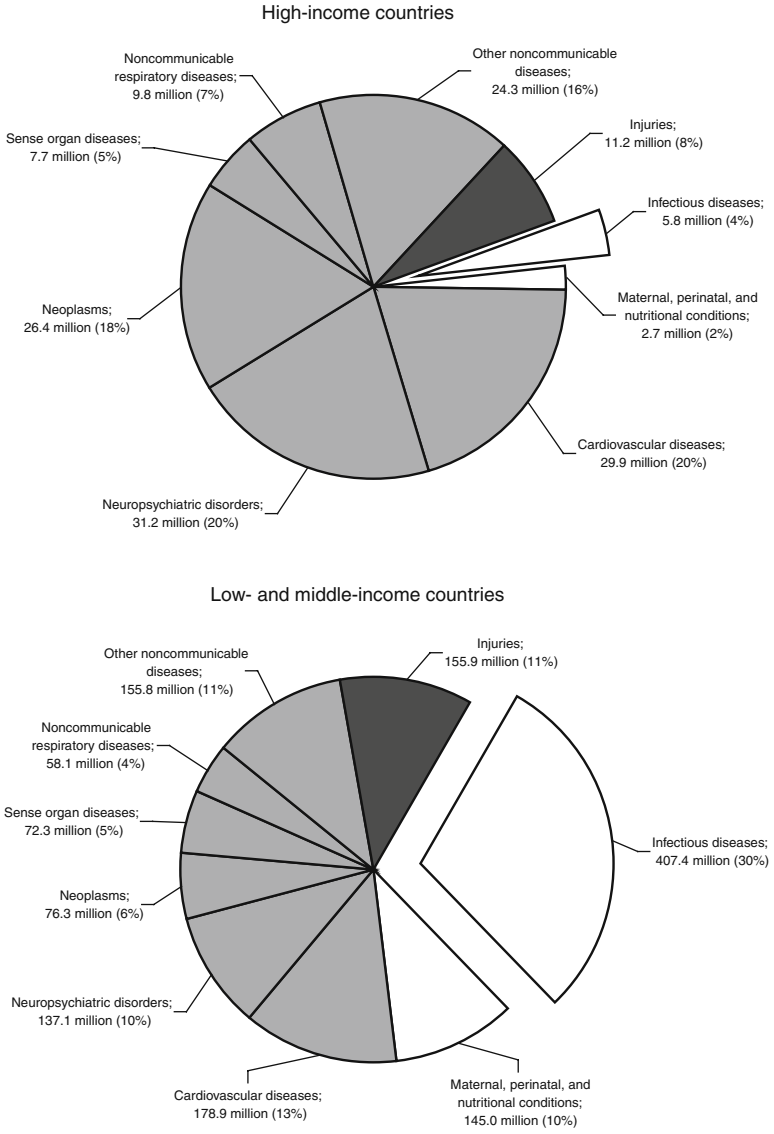

Fig. 1.7 Burden of disease in high-income and low- and middle-income countries estimated by DALYs, 2001 (GBD group I conditions: *white*; group II conditions: *gray*; group III conditions: *black*)

been almost 30% according to the GBD results. In line with the decrease of communicable diseases, the proportion of the burden of disease due to non-communicable diseases has shown a rise. In low- and middle-income countries almost half of the disease burden is from group II conditions, what marks an increase of 10% in its relative share since 1990.

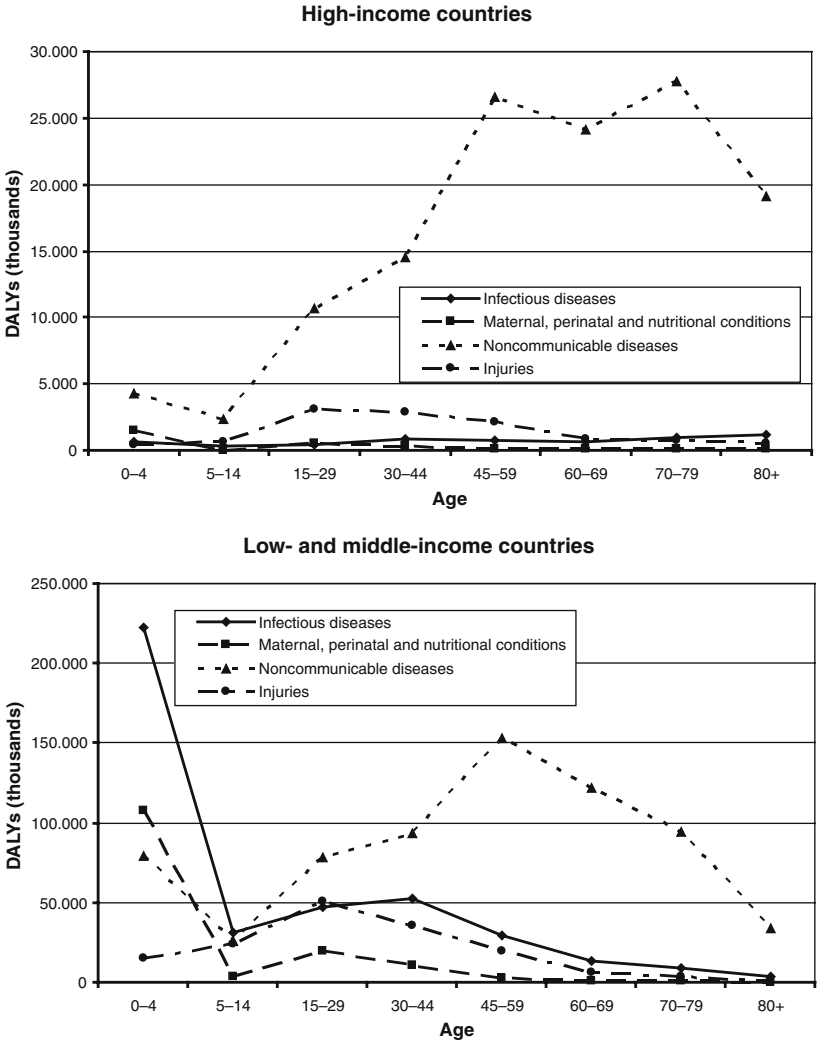

Fig. 1.8 The burden of disease by age in high-income and low- and middle-income regions, 2001

1.3.3 Projections of the Global Burden of Infectious Diseases from 2002 to 2030

The preparation of projections of mortality and burden of disease by cause represents another crucial part of the Global Burden of Disease project. On the basis of the initial estimates for 1990, first forecasts of global mortality and burden of disease trends by cause for 2000, 2010, and 2020 were presented under the assumption of three alternative scenarios (Murray and Lopez 1997b). However, it was shown that

the HIV/AIDS projections based on the GBD 1990 results substantially underestimated the spread of the HIV epidemic and the level of HIV/AIDS mortality around 2000; thus, the first projections are now considered to be outdated (Mathers and Loncar 2006). As a consequence, updated projections of mortality and burden of disease from 2002 to 2030 were prepared using new input information and methods similar to those of the original GBD study (Mathers and Loncar 2006). The main results of these projections with regard to infectious conditions are presented below.

Future health trends were projected under three scenarios – baseline, pessimistic, and optimistic – that were based on economic and social development. Age- and sex-specific deaths rates at country level were projected for ten major-cause clusters comprising infectious diseases within a cluster that summarizes group I conditions excluding HIV/AIDS. For forecasts of HIV/AIDS trends, separate projections were developed under several scenarios derived from existing UNAIDS (Joint United Nations Programme on HIV/AIDS) and WHO models.

Life expectancy at birth is projected to increase in all regions of the world in 2030, with the largest increases in the Africa and South Asia regions and the highest projected life expectancy for Japanese women at 88.5 years. Projected global deaths vary from 64.9 million (optimistic scenario) to 80.7 million (pessimistic scenario). Compared with death numbers in 2002 by age, a dramatic shift in the distribution of deaths from younger to older age is forecasted for 2030.

Large declines in mortality between 2002 and 2030 are projected for all of the major infectious disease conditions, with the exception of HIV/AIDS. The average annual rate of decline in age-standardized death rates is projected to vary between about 1.4% (malaria) and 5.3% (tuberculosis) and is greater for communicable causes than for non-communicable causes. In the opposite direction, HIV/AIDS projections show an average annual rate of increase of 3% for males and 2% for females.

Under the baseline scenario, HIV/AIDS deaths increase from 2.8 million in 2002 to 6.5 million in 2030. The total number of deaths caused by other communicable, maternal, perinatal, and nutritional conditions declines from 15.5 million in 2002 to 9.0 million in 2030. By contrast and as a result of the population aging and the increasing number of road traffic accidents, total deaths due to group II (non-communicable) and group III conditions (injuries) will significantly increase until 2030.

DALYs are projected to increase worldwide from 1.48 billion in 2002 to 1.54 billion in 2030. Although this means an increase of 3% of the total burden of disease, there is a decrease of the per-capita burden since the global population increase is projected to be 27%. Another factor that contributes to a decrease of DALY rates is the postponement of the age at death to older ages that is projected to occur from 2002 to 2030 and that results in a reduction of measured years of life lost. With regard to the three major GBD cause groups, the projections show significant changes in the proportional contribution to the burden of disease. Group I diseases are projected to contribute to 30% of the burden in 2030 as compared to more than 40% in 2002. In low-income countries the decline of the group I proportion is more pronounced, from 56% in 2002 to 41% in 2030. Group II conditions

are projected to increase to 57% in 2030; thus, non-communicable diseases will become the most important contributor to the global burden in 2030. According to the baseline scenario, there will be substantial changes in the global rank order of the leading causes of DALYs between 2002 and 2030. With the exception of HIV/AIDS, infectious diseases are projected to decline substantially in importance. Lower respiratory infections, tuberculosis, diarrheal diseases, and malaria are projected to move down up to 15 places in the global burden ranking. On the other hand, HIV/AIDS is projected to move up one place becoming the third most important contributor to DALYs in 2030. However, infectious diseases are projected to maintain an important role in low-income countries in 2030 where they account for four of the ten leading causes of burden of disease. These are HIV/AIDS (2nd rank), lower respiratory infections (5th), diarrheal diseases (8th), and malaria (10th).

1.4 Discussion

The estimates of the GBD study show that only a minor burden can be attributed to infectious diseases in high-income countries and, thus, this may suggest that the impact of communicable diseases on the population's health is of less importance compared with non-communicable diseases or injuries. However, in low- and middle-income countries the burden of infectious diseases will continue to remain high with implications for more efficient public health strategies. The planning of interventions should take into account the relative changes in incidence of different infectious disease entities.

According to the published projections of mortality and burden of disease, the impact of HIV/AIDS on population health is going to increase over the next decades. The estimates for HIV/AIDS, however, have recently been revised downward quite substantially. Due to better data from population-based surveys and due to new evidence on survival with HIV/AIDS, UNAIDS and WHO revised estimates for India (halving prevalence estimate from half a million to closer to quarter of a million) and for a number of African countries (UNAIDS 2007). The overall effect was a reduction of the death estimates from around 2.5 million to 2.1 million for 2007. For 2001, there would presumably be a similar, but smaller reduction in the total number of deaths and DALYs, respectively. Also, based on the new evidence, and on more optimistic assumptions that incidence will decline with increasing antiretroviral therapy (ART) coverage, the new projections of UNAIDS predict peak HIV/AIDS death numbers of around 2.3 million in 2012 and a decline to around 1.2 million by 2030. This is in strong contrast to the previous projections which predicted a continuing rise in HIV deaths to around 6 million in 2030. An update of GBD estimates which include the HIV/AIDS revisions is currently being completed, but has not yet been released.

When thinking about the relevance of infectious diseases for public health, there are other aspects specific to infectious diseases that have to be taken into account separately since they cannot be assessed with the burden of disease methodology, but add a potential and unpredictable burden to public health. They are not

only important for high-income countries with effective infectious disease control mechanisms but also affect low- and middle-income countries (see Chapter 3 for emerging infections).

Another important issue that has to be considered in the context of the burden of infectious diseases is the fact that microbial agents are increasingly being recognized as triggers and thus as causative factors for a number of chronic diseases (Carbone et al. 2005). Chronic diseases for which there is a strong evidence of infectious etiology are, e.g., allergic disorders (house dust mites, respiratory syncytial virus), peptic ulcer diseases and gastric lymphoma (*Helicobacter pylori*), cervical carcinoma (human papilloma virus), hepatocellular carcinoma (hepatitis B and C viruses), or post-streptococcal glomerulonephritis and rheumatic fever (group A streptococcus). Furthermore, there is a range of other chronic diseases for which there is suspicion of an infectious disease origin, e.g., multiple sclerosis (Epstein–Barr virus), Alzheimer's diseases (*Chlamydia pneumoniae*), and diabetes mellitus (enteroviruses) (Carbone et al. 2005). Even obesity, a risk factor for several chronic diseases, has recently been discussed to have an infectious etiology (Adenovirus 36) (Atkinson et al. 2005). Therefore, the assessment of the burden of infectious diseases by means of the GBD study might underestimate the real burden since the GBD approach links the burden estimates to primary causes. In conclusion, refined estimates to identify the proportion of the burden due to non-communicable diseases that can be attributed to an infectious etiology are helpful for a comprehensive assessment of the contribution of infectious diseases to the burden of disease.

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