Chapter 2
The Burden of Disease Approach for Measuring Population Health

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2.1 Introduction

Quantitative assessments of the health status of a population are undisputedly an important source of information to support decision-making and priority-setting processes in the field of Public Health. A common practice to (a) indicate the average level and the distribution of health in a population and (b) identify the impact of diseases on population health has been the use of findings on the epidemiology of diseases and injuries, their causes and risk factors. One major part of such efforts has targeted the determination of mortality patterns based on death and causes of death statistics. In addition, findings on mortality and its derivative life expectancy have widely been used as surrogates to inform about the overall health status as well as to identify the most important health problems in a population.

The remarkable changes in demographic and epidemiological factors and risk patterns in virtually all populations across the world over the last decades (Rowland 2003; Omran 1971; Smith 1988) have a significant impact on the health status of a population. Scientific as well as public discussions about the health effects associated with the transition models are also ongoing. The observation of decreasing death and birth rates, increasing life expectancies at birth and disease patterns shifting from infectious towards chronic conditions in nearly all populations over the world has e.g. raised the issue whether increases in the quantity of life have been accompanied by benefits in the quality of life. Several hypotheses on health in ageing populations have since then been postulated and scenarios ranging from a compression to an expansion of the lifetime burden due to morbidity have been presented (for more details see Nusselder 2003). Also, because of growing importance of non-communicable diseases and their often non-fatal impact on health, it has been concluded that death and causes of death statistics have increasingly

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A. Krämer et al. (eds.), *Health in Megacities and Urban Areas*, Contributions to Statistics, DOI 10.1007/978-3-7908-2733-0_2,

become inaccurate measures when exclusively used as surrogates to describe the overall health status of a population (for an updated discussion on health statistics see e.g. Murray 2007). Assessing the impact of non-fatal health outcomes on health has thus become an issue of major concern. One approach to meet the need for new methods when assessing population health has been the use of burden of disease studies and development of measures that combine information on mortality and non-fatal health outcomes to a single number (Field and Gold 1998). Such measures are usually referred to as Summary Measures of Population Health (SMPH) and have become key measures in many of the current burden of disease (BoD) assessments.

This chapter aims at providing basic information on the BoD approach and health measures from the SMPH group. A focus will be set on the measure Disability Adjusted Life Year (DALY) to exemplify the level of complexity inherent in a SMPH. To outline the informative value of DALY estimates, a selection of findings from the Global Burden of Disease (GBD) study will then be presented. Finally, potentials and limitations of the burden of disease approach will be discussed and conclusions about the value of BoD data that require linking health with spatial information will be drawn.

2.2 The BoD: A Definitional Approach

Obviously, there is no unambiguous understanding of the burden of disease idea in the literature. In a broader sense, BoD or sometimes burden of ill-health (e.g. Smith et al. 1999; Allender and Rayner 2007; Balakrishnan et al. 2009), is frequently used to include a wide range of different approaches that aim at assessing the impact of disease events on various dimensions of human life including health. Among the large number of attempts to define BoD, a definition given by the Connecticut Department of Public Health in 1999 appears to be useful to determine some key characteristics of a BoD approach. They defined BoD as

> a general term used in public health and epidemiological literature to identify the cumulative effect of a broad range of harmful disease consequences on a community, including the health, social, and economic costs to the individual and to society (Connecticut Department of Public Health 1999).

This definition plausibly illustrates that, in general, a BoD framework (a) targets the identification of consequences resulting from disease events, (b) might not be restricted to the impact on health but also relates to effects on social and economic realities, and (c) is related to communities, or populations rather than to individuals. This rather unspecific understanding of burden of disease allows for assessing the impact of diseases on a population with a wide range of outcomes from virtually all areas of life and enables many different disciplines such as epidemiology, social sciences, or economic sciences to develop their particular burden of disease approach by use of their routine methodologies and indicators.

The understanding of BoD has in the recent past increasingly been associated with a particular approach jointly developed by the World Bank, the World Health Organization (WHO) and the Harvard School of Public Health in the late 1980s: The Global Burden of Disease (GBD) Project. A main objective of this ground-breaking project was to generate a comprehensive and internally consistent comparable set of estimates of mortality and morbidity by age, sex, and regions of the world (Murray and Lopez 1996). First estimates were made for the year 1990. Also, the GBD Project provided the public health community with a new conceptual und methodological framework that was developed for integrating, validating, analyzing, and disseminating partial and fragmented information on the health of populations (e.g. Murray 1994). As a result of the fast dissemination and general acceptance of this particular burden of disease technique, though its results and its relevance for public health have critically been discussed (e.g. Arnesen and Nord 1999; Anand and Hanson 1997), the BoD understanding has since then become narrowed and is now predominantly associated with the WHO GBD approach. According to Colin Mathers

> BoD analysis provides a standardized framework for integrating all available information on mortality, causes of death, individual health status, and condition-specific epidemiology to provide an overview of the levels of population health and the causes of loss of health (Mathers 2006).

Using this definition, BoD can be considered as a conceptual and methodological approach that aims at (a) a consistent and comprehensive assessment of disease and injury consequences, (b) an assessment of population health in terms of health losses by using common metric for mortality and morbidity outcomes. To meet these objectives, the WHO GBD framework included the development of methods to assess the quality of available data and to estimate non-available data, the integration of information on non-fatal health outcomes with information on premature death into SMPH, and the development of a new metric, the DALY, to summarize the BoD (Murray and Lopez 1996, 1997). The GBD Project is an ongoing effort and since the original 1990 GBD Study there have been some major revisions of the methodology resulting in improved updates of the global BoD (e.g. Mathers et al. 2003; Lopez et al. 2006a; WHO 2008).

BoD estimates have in recent time increasingly been accepted and used in public health as an additional source to inform about the level of health in a given population. The number of publications that include "burden of disease" in the title or abstract and are listed in PubMed (the most popular database for accessing articles on life sciences and biomedical topics) has continuously increased over the last years starting from the time when the results from the first GBD were initially published in 1996 (Murray and Lopez 1996) (see Fig. 2.1). A major part of the studies were based on the WHO GBD approach that mainly made use of DALYs as BoD indicator. Such estimates have been presented for many populations and with different spatial resolutions, from local (e.g. Andra Pradesh) (Mahapatra 2001), over national (e.g. US, the Netherlands, South Africa) (Michaud et al. 2006; Melse et al. 2000; Bradshaw et al. 2003), to international levels (e.g. WHO 2002).

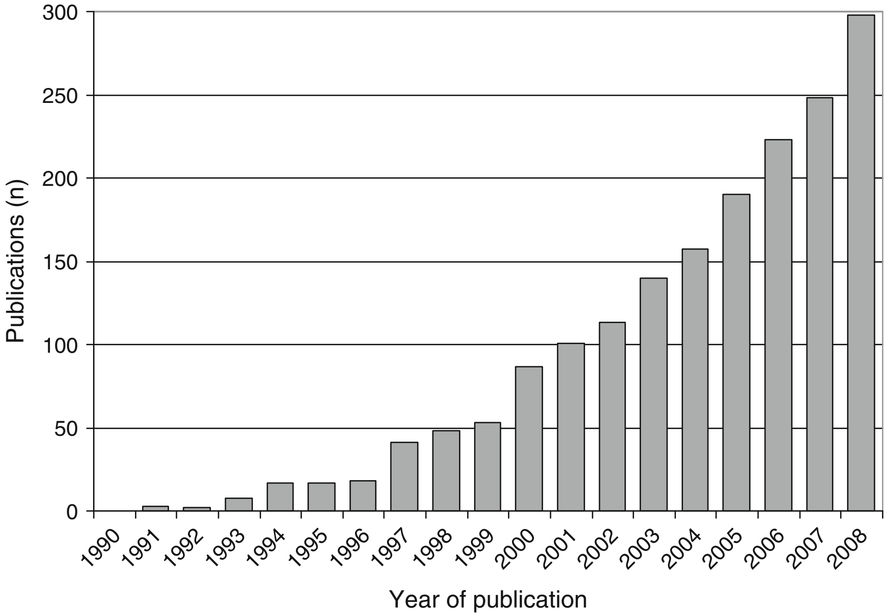


Fig. 2.1 Number of PubMed listed publications with "burden of disease" in title or abstract (date of query: 29.12.2009)

Additionally, estimates are available for some selected diseases and risk factors (chikungunya, dengue, food borne pathogens) (Krishnamoorthy et al. 2009; Luz et al. 2009; van Lier and Havelaar 2007).

2.3 The GBD Project

The first GBD study was designed to meet various objectives. A major objective was the quantification of health losses caused by diseases and injuries in a comprehensive and comparable way. Comprehensiveness and comparability referred to the inclusion of the whole spectrum of diseases and injuries as well as to the inclusion of populations up to a global level. Also, the study aimed at assessing the impact of non-fatal health outcomes on population health, thus, adding the morbidity to the mortality perspective. Further, it was demanded to develop and use a metric that together allowed for the assessment of the disease burden and for an economic appraisal of intervention options. The implementation of the GBD study can roughly be characterised by a four step procedure. The initial step focuses on the assessment of the current BoD using a SMPH. For the GBD study, the DALY was developed to assess estimates of disease burdens. SMPH and the DALY measure will be described in detail at a later stage of this chapter. In a second step, it is intended to attribute the identified amount of burden to various known risk factors by applying the Comparative Risk Assessment (CRA) methodology. Having current and past burden of disease estimates available, it is then intended to make projections of the future BoD in a further step. Here, it is also aimed to identify BoD trends when the current exposures to a risk factor are changed to a specified counterfactual exposure in order to assess the amount of burden that is potentially avoidable. In a last step, burden of disease estimates are linked to cost-effectiveness analyses to allow for an economic appraisal of the impact of different intervention options on the burden reduction (Shih et al. 2009). The GBD study has quantified the burden of premature mortality and disability by age, sex, and region for more than 100 disease and injury causes. The disease and injury 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). For more detailed information about the GBD concept see (Murray and Lopez 1996).

The GBD study is an ongoing effort and various milestones have been reached after the presentation of the first estimates for the year 1990 (Murray and Lopez 1996). Since then, annual assessments were published in the World Health reports between 1999 and 2004 (e.g. WHO 2000, 2002). Findings from the comparative risk assessment were presented for 26 global risk factors (WHO report 2002; Ezzati et al. 2004). A comprehensive overview and discussion of the measures from the SMPH group was edited in 2002 (Murray et al. 2002). Country tools for national as well as environmental BoD assessment were developed and made freely available for the Public Health community (see www.who.org). Also, first projections of the future BoD and injuries from 2002 to 2030 were published (Mathers and Loncar 2006). Currently, the efforts are focused on the new GBD 2010 Study, which commenced in Spring 2007, to produce estimates of the BoD, injuries and risk factors for two time periods, 1990 and 2005. The study is expected to produce a first set of estimates by November 2010 (Global Burden of Disease Study 2010).

2.4 The SMPH Measures

These are

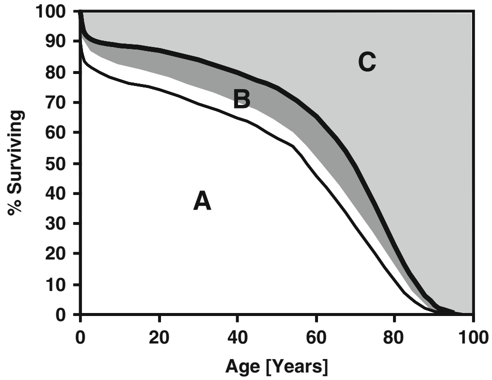
> measures that combine information on mortality and non-fatal health outcomes to represent the health of a particular population as a single numerical index (Field and Gold 1998).

According to this definition, the SMPH assess the health status of a population by integrating information on mortality and morbidity into a single number and thus are qualified to meet the demands of many BoD assessments on a health measure. Also, SMPH are considered to be a health indicator of use as they include non-fatal health outcomes in their estimates and thus reasonably extend the traditionally available set of population health indicators. Since the idea of a population health indicator that brings together data on mortality and morbidity was first presented in the mid 1960s (Sanders 1964), much efforts have been put in the conceptualisation and implementation of composite health measures (Robine et al. 2003; Murray et al. 2002) resulting in a marked increase of the availability of SMPH.

The SMPH family can broadly be divided into two groups: health expectancy (HE) and health gap (HG). Summary measures from the HE group basically aim at estimating years of life that can be expected to live in full health (Mathers 2002). The HE concept can be considered as an extended notion of the life expectancy concept that adds some information on the health status of a population (e.g. prevalence of disability) to information on the mortality. Widely accepted HE measures in use are e.g. the Healthy Life Years (HLY), the Disability Free Life Expectancy (DFLE) or the Disability Adjusted Life Expectancy (DALE). A core methodology for HE estimates is the so-called Sullivan-Method. In brief, this method requires to build up a period life table based on age- and sex-specific death numbers in a population and to include information on the age- and sex-specific prevalence of people living in a state less than full health such as disability (Sullivan 1966). The HLY indicator is currently in use as part of the European Union's structural core indicators to represent the health of the European population (Jagger et al. 2008). The DFLE and DALE measures differ in the way that the DALE measure includes a graduated valuation of the severity of disability, e.g. indicated by disability weights, while the DFLE uses a dichotomous graduation of disability versus non-disability. DALEs were presented as a part of the findings from the GBD study to represent the life expectancy of a population taking current prevalence rates of disability into account (Murray and Lopez 1997; Mathers et al. 2001).

The HG measures on the other hand provide information on years of healthy life lost and thus, focus on the quantification of health losses in a population. The most common member from the HG family is the DALY measure. The DALY indicator was developed to meet the objectives of the first GBD study in 1990 and has since then largely diffused into the field of Public Health and been used for many global, national, regional and local burden of disease assessments (Michaud et al. 2006; Melse et al. 2000; Bradshaw et al. 2003; Chapman 2006; Kominski et al. 2002; Dodhia and Philips 2008; Mahapatra 2001).

The HG measures are normative measures because the calculation of health losses calls for the definition of a health goal in order to allow for estimates of losses of health. Figure 2.2 illustrates the basic idea behind the HG approach and shows the survivorship curve of a hypothetical initial birth cohort with the x-axis showing the age in years and y-axis the percentage of survivors over a lifespan of 100 years. The upper curve in the figure indicates for each age along the x-axis the proportion of the hypothetical cohort that will remain alive at that age and includes people living in an ideal health state as well as people living in a state worse than perfect health. To distinguish people living in ideal health from people living in a health state worse than perfect, a second curve (in this example indicated by the lower curve) needs to be identified in order to allow for estimates of the burden due to non-fatal health outcomes. While areas A and B under the survivorship curve can be



The philosophy of a health gap measure is illustrated on the basis of a survivorship curve for a hypothetical cohort. Upper horizontal line: health goal; upper curve: survivorship curve; lower curve: proportion of people living in ideal health; area A: years of life lived in ideal health; Area B: years of life lived in a health state worse than ideal, including a proportion shaded in gray indicating years of life lost due to living in a health state worse than ideal; area C: years of life lost due to premature death.

Fig. 2.2 The basic idea behind the concept of a health gap measure

used to represent life expectancy at birth, health expectancies can be derived from these areas by taking into account some lower weights for area B, i.e. the years lived in health states worse than perfect. For HG estimates, additional information on the health goal is needed in order to assess the difference between the current health of the population and the goal for population health. In Fig. 2.2, the health goal is indicated by the upper horizontal line enclosing area C and assuming that everyone in the hypothetic cohort lives in ideal health until the maximum age indicated. Only the definition of a health goal enables to assess the life lost due to premature mortality and to identify the mortality gap in a population. In the example of Fig. 2.2, the mortality gap is represented as the area C. To finalize the HG assessment, there is the need to additionally account for the health losses due to living in health states worse than perfect and to add losses identified in area B to the losses in area C due premature mortality. Health losses due to living in health states worse than perfect can be assessed by weighting health states less than ideal health and using a scale between 0 and 1 where a weight of one implies that the time lived in a particular health state is equivalent to the time lost due to premature mortality.

2.5 The DALY Measure

Among the composite HG measures, the DALY is undisputedly the one that has attracted most attention over the last years. Though, the DALY seems readily understandable at a first glance, its construction is characterised by a high degree of complexity. The following section will therefore provide the basic information on the DALY concept in order to contribute to a comprehensive understanding of the DALY measure that allows for an adequate interpretation of findings and enables to outline the potential as well as limitations when using the DALY.

The conceptual framework of the DALY measure was developed to explicitly meet the objectives of the GBD study. As the DALY was claimed to comprehensively quantify health losses, a concept was required to incorporate both mortality and non-fatal health outcomes into a single measurement unit (Murray and Lopez 1996). Another main target defined for the DALY was to assess burden of disease amounts and patterns up to a global level. Meeting this objective, a basic assumption was made to treat like events equally to ensure comparability between different populations. So e.g. a loss of a finger in Zimbabwe should contribute to the same burden as a loss of a finger in Turkey (Murray 1994). Further, DALY uses time as unit of measure to represent the disease burden in a given population. Chosen time as the unit of measure, the DALYs can then be based on both, incidence or prevalence data. In the past, there has been much debate about the choice of the adequate epidemiologic input measure for the DALY. For fatal health outcomes, it is obvious that there is no other way than using the incidence approach for calculating the burden due to premature death. For non-fatal health outcomes, the use of an incidence as well as a prevalence perspective is basically feasible (Murray 1994). It was argued that estimates of the non-fatal health outcomes can lead to different amounts of DALYs when the structure and dynamics of a population or a disease are not constant over time. For this reason, it was decided for the GBD study to calculate DALYs based on an incidence perspective in order to achieve a higher sensitivity towards burden of disease trends (Murray 1994). More technically, the DALY is calculated as the sum of the Years of Life Lost (YLL) representing mortality as years of healthy life lost due to premature death and the Years of Life Lost due to Disability (YLD) representing years of healthy life lost due to non-fatal health outcomes. Thus, YLLs represent the impact of fatal outcomes on population health whereas YLDs account for the impact of non-fatal health outcomes based on the concept of disability. YLLs and YLDs as calculated for the first GBD study are then based on further specifications. YLLs are estimated as standard expected years of life lost reflecting the reference that is used as the ideal population health goal. Technically, the calculation of years of healthy life lost due to premature death refers to a standard life table for a hypothetical cohort with a life expectancy at birth of 82.5 years for women and 80 years for men. These values were chosen based on the observation that approx 82.5 years were the highest observed life expectancy at birth at that time (Japanese women) and based on the assumption that the sex-specific gap of about 2.5 years explains the differences attributable to the human biology when leaving out gender-specific causes due the different social roles of men and women. Thus e.g. a death of a woman at age 40 would contribute to 42.5 healthy years of life lost. The idea of using a hypothetical cohort with standard life expectancies is basically similar to the technique of standardised mortality rates. Using an ideal standard also allows for treating events equally even if they occur in different social and physical environments all over the world and thus enables to draw cross-national comparisons of the BoD and injuries which is a major objective of the GBD study.

To comprehensively assess the disease burden in a population, DALYs include the YLDs to estimate the years of healthy life lost due to non-fatal health outcomes. An essential demand for the YLD implementation decision is the clarification of how non-fatal health outcomes are understood. For the YLDs in the GBD study, the concept of disability according to the International Classification of Impairments, Disabilities and Handicaps (ICIDH) of the WHO was chosen because it was regarded to be most suitable for the objectives of the project. Besides, the reason of data availability, using disability as definition of non-fatal health outcomes also allows for cross-national comparisons, leaving out the social and environmental background. Beyond the conceptualisation of non-fatal health outcomes, the quantification and comparability of disease and injury specific severity of a disability is a further issue of relevance. Here, a common approach is to define disability weights for the different diseases and injuries. There are many approaches to derive disability weights (e.g. visual analogue scale, standard gambling method, person trade off, time trade off) (for an overview see Gold et al. 2002; Murray and Lopez 1996; Torrance 1976, 1986) in the first GBD study the Person Trade-Off (PTO) method was used to derive disability weights for the different disease and injury events from the GBD classification system (Murray and Lopez 1996). In the PTO exercises, a group of health professionals were asked to trade off the life extension of people living in different health stages. These exercises resulted in disease and injury specific disability weights ranging from 0 reflecting a health state equivalent to perfect health and 1 reflecting a health state equivalent to death. A complete list of disability weights for all diseases included in the GBD classification system was provided by Lopez and colleagues (Lopez et al. 2006b). To finalize the calculations of the YLD component, information on disease and injury specific incidence and duration is needed.

To complete the outline of the DALY framework, other specifications that apply to YLL as well as YLD have to be considered. The first GBD study incorporated two social value choices into the DALY measure, namely time discounting and age weighting (Murray and Lopez 1996). Time discounting describes preferences of time as they are commonly used in the field of economics. These preferences are based on observations that people prefer benefits today rather than in the future and, thus, discount future benefits. The existence of time preferences was also assumed in the context of health and for the assessment of the burden on health. People prefer to have a healthier life now rather than in the future. Time preferences were integrated into the DALY framework and implemented with an annual 3% time discounting for future health losses. Additionally, the initial GBD study also included an age-weighting function in the DALY measure. This concept is based on the theory of human capital (Drummond 1997). According to this rationale, people give higher weights to an individual in productive age, and lower weights to very young and older people. This refers to the understanding, that younger and older people are often dependent on the social and financial support of people in productive age. Thus, for the first GBD study, higher weights for people in

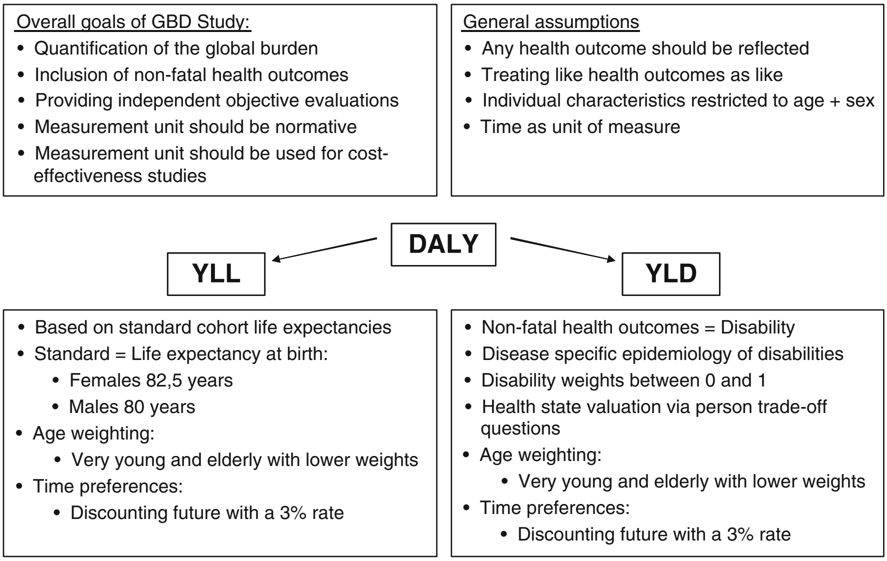


Fig. 2.3 The DALY (Disability Adjusted Life Year) concept

productive age were used. Figure 2.3 gives a comprehensive summary and overview of the DALY concept.

Although the original GBD DALY measure, its components and methodology have been debated in the literature and various international forums since its first publication in 1996 (Arnesen and Kapiriri 2004; Anand and Hanson 1997, 1998), the DALY measure has increasingly been used in various national and sub-national burden of disease studies (e.g. national studies: USA, the Netherlands, South Africa, Zimbabwe; e.g. regional studies Los Angeles, London, Andra Pradesh) (Michaud et al. 2006; Melse et al. 2000; Bradshaw et al. 2003; Chapman 2006; Kominski et al. 2002; Dodhia and Philips 2008; Mahapatra 2001).

2.6 Core Findings from the GBD Study

The GBD study has provided the public health community with numerous findings over the last decades (see Murray et al. 1994; Lopez et al. 2006a; WHO 2008). The GBD project is an ongoing effort resulting in refined concepts, methods and updated results. Regional findings are usually presented in low-, middle- and high-income categories as defined by the World Bank. Here, countries are not only grouped geographically but also based on their gross national income. This section provides a selection of some main global and regional findings on the BoD as measured in DALYs.

In 2001 the global average BoD across all regions of the world was 250 DALYs per 1,000 population, of which about two-thirds were due to premature death. YLL

Table 2.1 The 20 leading causes of global burden of disease, 2001

	Cause	DALYs (million of years)	% 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

Source: Lopez et al. (2006b)

varied substantially across regions, with e.g. YLL rates nearly five times higher in Sub-Saharan Africa than in high-income countries. YLD rates varied less, with Sub-Saharan Africa having again higher rates than high-income countries.

The 20 leading causes of global BoD in 2001 are shown in Table 2.1. There are four usually non-fatal conditions among the top 20 causes of burden of which unipolar depressive disorders are identified to be the most relevant non-fatal contributor to the global burden. This finding illustrates not only the relevance of non-fatal conditions for population health but also the importance to include non-fatal health outcomes into burden assessments.

In low- and middle-income countries, the leading causes of the BoD included five communicable and four non-communicable causes among the top ten, whereas the top ten causes in high-income countries exclusively consisted of non-communicable conditions. The burden of non-communicable diseases is becoming increasingly important, not only because of a global increase of absolute DALY levels but also because of an increase in the proportion of the non-communicable burden on the total burden in low- and middle-income countries. While the proportion of the burden from non-communicable disease in high-income countries has remained fairly stable over the last decades, the proportion in low- and middle-income countries has increased with now almost 50% of the adult disease burden being attributable to non-communicable conditions with the conclusion that the populations living in many developing countries are suffering from a double BoD (Fig. 2.4 and Table 2.2).

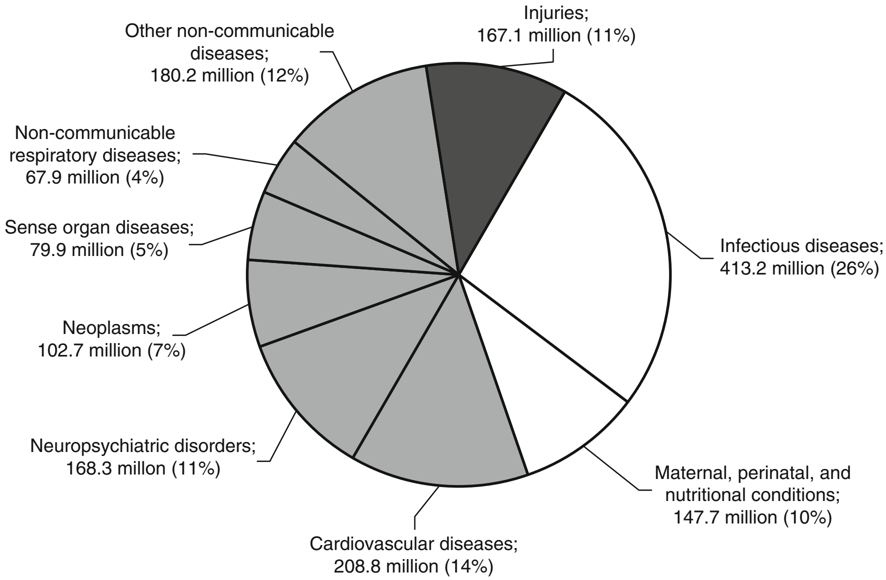


Fig. 2.4 The global burden of disease estimated by DALYs, 2001 (GBD group I conditions: *white*; group II conditions: *gray*; group III conditions: *black*) (*Source*: Lopez et al. 2006b)

Table 2.2 The ten leading causes of global burden of disease, by broad income group, 2001

Low- and middle-income countries				High-income countries			
	Cause	DALYs (millions of years)	% of total DALYs		Cause	DALYs (millions of years)	% of total DALYs
1	Perinatal conditions	89.07	6.4	1	Ischemic heart disease	12.39	8.3
2	Lower respiratory infections	83.61	6.0	2	Cerebrovascular disease	9.35	6.3
3	Ischemic heart disease	71.88	5.2	3	Unipolar depressive disorders	8.41	5.6
4	HIV/AIDS	70.80	5.1	4	Alzheimer's and other dementias	7.47	5.0
5	Cerebrovascular disease	62.67	4.5	5	Trachea, bronchus, and lung cancers	5.40	3.6
6	Diarrheal diseases	58.70	4.2	6	Hearing loss, adult onset	5.39	3.6
7	Unipolar depressive disorders	43.43	3.1	7	Chronic obstructive pulmonary disease	5.28	3.5
8	Malaria	39.96	2.9	8	Diabetes mellitus	4.19	2.8
9	Tuberculosis	35.87	2.6	9	Alcohol use disorders	4.17	2.8
10	Chronic obstructive pulmonary disease	33.45	2.4	10	Osteoarthritis	3.79	2.5

Source: Lopez et al. (2006b)

Injuries, both unintentional and intentional, accounted for about 11% of the global BoD and have been identified as the "hidden" epidemic (see Fig. 2.3). A proportion of the burden due to injuries on the total burden of even up to 30% has been reported for male adults aged 15–44 years in various parts of the world (e.g. Europe and Central Asia, Latin America and the Caribbean). In this age group, road traffic accidents, violence, and self-inflicted injuries were usually among the top ten leading causes of the BoD. Furthermore, the burden of road traffic accidents is increasing and especially affects the health of the young male population in developing countries of Sub-Saharan Africa and South and Southeast Asia.

The GBD study provides information not only on the burden at a global or regional but also at a national level. Country-specific data on the burden are readily accessible (see http://www.who.int/healthinfo/global_burden_disease/estimates_country/en/index.html) and represent the highest spatial resolution that is available from the global BoD assessments. An example that illustrates the opportunity for cross-country comparisons is given for Bangladesh, China and Germany. Table 2.3 shows the age-adjusted DALY rates per 100,000 population in 2002 for these countries. DALY rates are presented for the total burden as well as for the burden due to group I, II, and III conditions. Figure 2.5 additionally informs about the proportion of

Table 2.3 Age-standardized DALY rates per 100,000 population in Bangladesh, China, and Germany, 2002 (group I: communicable, maternal, perinatal, and nutritional conditions; group II: non-communicable conditions; group III: injuries)

	DALYs per 100,000 population			
Country	All causes	Group I	Group II	Group III
Bangladesh	25,292	9,877	12,455	2,960
China	15,149	3,162	9,710	2,276
Germany	10,114	581	8,671	862

Source: http://www.who.int/entity/healthinfo/statistics/bodgbddeathdalyestimates.xls (date of query: 29.08.2009)

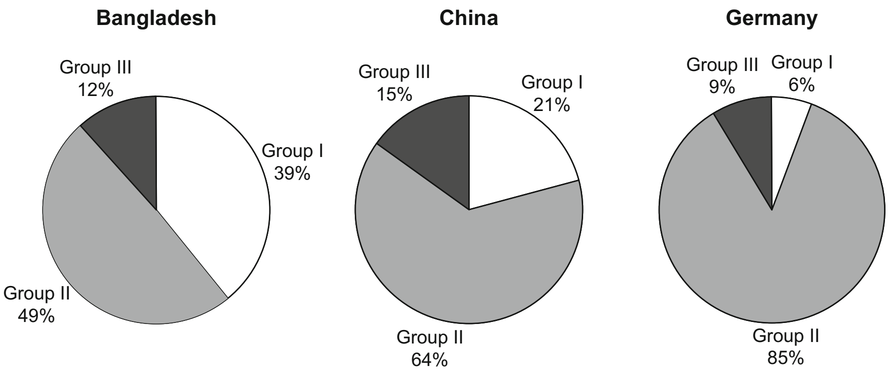


Fig. 2.5 The burden of disease in Bangladesh, China, and Germany estimated by DALYs, 2002 (group I: communicable, maternal, perinatal, and nutritional conditions, group II: non-communicable conditions; group III: injuries)

the group I, II, and III conditions on the total BoD and injuries. In brief, the Bangladesh population suffers not only the highest overall burden but also the highest burden when stratified by each of the three groups. This finding confirms that non-communicable diseases affect not only high-income countries such as Germany but also low- and middle income countries such as Bangladesh or China. Also, Fig. 2.5 points out that Bangladesh – alike many other developing countries – suffers a double BoD by communicable and non-communicable diseases.

2.7 Linking Health with Spatial Information: Potentials and Limitations of the BoD Approach

There is increasing demand for coherent and comprehensive information on the vulnerability and adaptation of populations to changes in the natural and physical environment because issues such as climate change and urbanisation or mega-polisation have become top of the agenda of many policy-making and research institutions. The creation of a harmonised data set that allows for e.g. conclusions on the impact of climate change or urbanisation on the overall health of populations requires the combination of data sets from different disciplines such as geography, climatology, public health, or epidemiology. Using population health as outcome of interest and as a proxy for a population's vulnerability to environmental changes is undisputedly of high value but is also limited due to several characteristics in the collection and processing of health data. Although the quantity and quality of health data have markedly increased in the past, there are still many difficulties in the handling of these quantitative datasets, especially when policy-maker and researcher in public health aim at comprehensive assessments of the overall health of populations. One frequent limitation of health information is the comparability of data, e.g. with regard to different health status, diseases, health determinants, or populations. Also, the global coverage of health data is still unequally distributed especially in low-income countries which still lack information on mortality and on a wide range of important diseases (Boerma and Stansfield 2007). Health data that are routinely collected within surveillance systems usually show a level of spatial and temporal resolution that is of limited use. The spatial resolution if available usually covers administrative boundaries often at a coarse level and is not consistent with the spatial domains preferred by others like climatologists who use climatic zones or modellers who use grids.

The concept of the GBD study as outlined above offers several potentials to overcome some basic problems when merging health data with data from other sources. With the objectives to assess overall levels of population health and to produce comprehensive and comparable estimates, the GBD study basically complies with some requirements on the structure of health information to allow for a spatial arrangement of findings other than administrative boundaries. Also, focusing the measurements on health losses rather than health expectancies and selecting an approach stratified by sex, ages, diseases, injuries and risk factors facilitate the assessment of the impact of various environmental determinants on population health. The disease-specific approach and the attribution of the prevalent burden to known risk factors can further be considered useful because of greater availability of and access to health data. Moreover, the GBD concept offers solutions for the handling of missing data and low data quality to ensure the comprehensiveness of the burden findings. Another non-negligible aspect of the GBD approach is the fact that it is an ongoing effort with updated results that has obtained increasing acceptance in Public Health over the last years.

However, the GBD estimates as currently presented have their limitations when used for the purpose of spatial analyses. A major limitation is the fact that a stratification of results is restricted to age and sex. Other important determinants of health such as socioeconomic status, or living and occupational conditions are not assessed by the GBD study. Further, the spatial resolution of the findings from the GBD project is fairly coarse and limited to national levels representing the highest level of resolution available. Thus, when looking at an urban level, data on burden of disease as presented by the GBD is not available. Identifying the burden of disease patterns in urban areas poses in turn the need for gathering data. Using GBD methods, data on both mortality and morbidity as described in the previous sections is needed and requires the collection of various epidemiologic variables. Traditional surveillance methods (e.g. death registries) as implemented in developed societies are of limited use in highly informal settlements such as urban slums. High informal movement from rural areas to urban settlements hamper tracking both acute and chronic disease events. Since many studies aim at gathering data about the epidemiology of different diseases in urban areas, the combination of data from different studies and possible modelling and validation of data with methods provided by the WHO (e.g. DisMod Software) may help to shed more light on disease burden patterns and to approach a comprehensive view of population health in megacities. Combining burden of disease with spatial information could then also help to investigate hot spots of disease burden in areas prone to different risk factors.

Also, there are in general difficulties in the understanding of the DALY measure and in the interpretation of DALY estimates, especially when contrasting the DALY with other health proxies such as death rates or life expectancies. Finally, focussing on a disease-specific approach might be considered a limitation because it does not allow for investigating health domains other than the absence of disease.

In conclusion, the BoD approach offers several potentials when health information are sought to be included in spatial analyses. A major advantage of the WHO GBD approach over other approaches used in public health is the possibility to generate comprehensive and comparable estimates of a population's health status and thus to represent overall health in spatial arrangements. The use of currently available BoD assessments is however limited by the level of stratification and resolution of the available data. This in turn implies that the arrangement and harmonisation of BoD data with spatial data from other disciplines needs to be clarified in advance when considering the WHO BoD approach for small scale analyses.

References

Allender S, Rayner M (2007) The burden of overweight and obesity-related ill health in the UK. Obesity Reviews. Vol. 8, pp 467 – 473

Anand S, Hanson K (1997) Disability-adjusted life years: a critical review. Journal of Health Economics; Vol. 16; pp 685–702

Anand S, Hanson K (1998) DALYs: efficiency versus equity. World Development Report 26:307–310

Arnesen T, Kapiriri L (2004). Can the value choices in DALYs influence global priority-setting? Health policy Amsterdam, Netherlands 70:137–149

Arnesen T, Nord E (1999) The value of DALY life: problems with ethics and validity of disability adjusted life years. British Medical Journal 319:1423–1425

Balakrishnan R, Allender S, Scarborough P, Webster P, Rayner M (2009) The burden of alcohol-related ill health in the United Kingdom. Oxford Journal of Public Health Vol. 31, pp 366–73

Boerma JT, Stansfield SK (2007). Health statistics now: are we making the right investments? The Lancet Vol. 369, pp 779–786

Bradshaw D, Groenewald P, Laubscher R, Nannan N, Nojilana B, Norman R, Pieterse D, Schneider M, Bourne DE, Timaeus IM, Dorrington R, Johnson L (2003) Initial burden of disease estimates for South Africa, 2000. South African Medical Journal. Vol. 93; pp 682–688

Chapman G (2006) The burden of disease in Zimbabwe in 1997 as measured by disability-adjusted life years lost. Tropical Medicine and International Health. vol. 11, pp 660–671

Connecticut Department of Public Health (1999) Looking Toward 2000 – An Assessment of Health Status and Health Services; Hartford, Connecticut, page 368

Dodhia H, Philips K (2008) Measuring burden of disease in two inner London boroughs using Disability Adjusted Life Years. Journal of Public Health. pp 1–9

Drummond MF (1997) Methods for the Economic Evaluation of Health Care Programmes. Oxford: Oxford University Press

Ezzati M, Lopez AD, Rodgers AA, Murray CJL (2004). Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors. Geneva, World Health Organization

Field MJ, Gold MR (1998) Summarizing Population Health – Directions for the Development and Application of Population Metrics. Washington DC; National Academy Press

Global Burden of Disease Study (2010) www.globalburden.org [last visit 14.07.2010]

Gold MR, Stevenson D, Fryback DG (2002). HALYS AND QALYS AND DALYS, OH MY: Similarities and Differences in Summary Measures of Population Health. Annual Review of Public Health 23:pp 115–134

Jagger C, Gillies C, Moscone F, Cambois E, Van Oyen H, Nusselder W, Robine JM; EHLEIS team (2008) Inequalities in healthy life years in the 25 countries of the European Union in 2005: a cross-national meta-regression analysis. Lancet 372:2124–2131

Kominski GF, Simon PA, Ho A, Luck J, Lim YW, Fielding JE (2002) Assessing the burden of disease and injury in Los Angeles County using disability-adjusted life years. Public Health Report 117: pp 185–191

Krishnamoorthy K, Harichandrakumar KT, Krishna KA, Das LK (2009) Burden of chikungunya in India: estimates of disability adjusted life years (DALY) lost in 2006 epidemic. Indian Journal of Vector Bourne Diseases 46:pp 26–35

Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJL (2006a) Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. The Lancet 367: pp 1747–1757

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

Luz PM, Grinsztejn B, Galvani AP (2009) Disability adjusted life years lost to dengue in Brazil. Journal of Tropical Medicine and International Health 14: pp 237–246

Mahapatra P (2001) Estimating national burden of disease: sensitivity to local data; the burden of disease in Andhra Pradesh, 1999. Institute of Health Systems. Hyderabad, India

Mathers C (2006) Introduction to Burden of Disease. BoD Workshop Bielefeld, January 2006

Mathers CD (2002) Health expectancies: an overview and critical appraisal. In: Murray CJL, Salomon JA, Mathers CD, Lopez AD (2002) Summary Measures of Population Health; pp 177–204

Mathers CD, Bernard C, Moesgaard Iburg K, Inoue M, Ma Fat D, Shibuya K, Stein C, Tomijima N, Xu H (2003) Global Burden of Disease in 2002: data sources, methods and results. World Health Organisation, Geneva

Mathers CD, Loncar D (2006). Projections of Global Mortality and Burden of Disease from 2002 to 2030. PLoS Medicine 3:pp e442

Mathers CD, Lopez AD, Murray CJL (2006) The burden of disease and mortality by condition: data, methods and results for 2001. In: Lopez AD, Mathers CD, Ezzati M, Murray CJL, Jamison DT, eds. Global burden of disease and risk factors. New York, Oxford University Press: pp 45–240

Mathers CD, Sadana R, Salomon JA, Murray CJL, Lopez AD (2001) Healthy life expectancy in 191 countries, 1999.The Lancet 357:1685–1691

Melse JM, Essink-Bot ML, Kramers PG, Hoeymans NA (2000) National burden of disease calculation: Dutch disability-adjusted life-years. Dutch Burden of Disease Group; American Journal of Public Health. Vol. 90; pp 1241–1247

Michaud C, McKenna M, Begg S, Tomijima N, Majmudar M, Bulzacchelli M, Ebrahim S, Ezzati M, Salomon J, Gaber Kreiser J, Hogan M, Murray CJL (2006): The burden of disease and injury in the United States 1996; Population Health Metrics, Vol. 4:11

Murray CJL & Lopez AD (1996) The Global Burden of Disease. Cambridge; Harvard School of Public Health

Murray CJL (1994) Quantifying the burden of disease: the technical basis for disability- adjusted life years. Bulletin of the World Health Organization 72: pp 429–445

Murray CJL (2007) Towards good practice for health statistics: lessons from the Millennium Development Goal health indicators. Lancet 2007 369; pp 862–73

Murray CJL, Lopez AD (1997) Regional patterns of disability-free life expectancy and disability-adjusted life expectancy: Global Burden of Disease Study. The Lancet 349; pp 1347–1352

Murray CJL, Lopez AD, Jamison DT (1994). The global burden of disease in 1990 : summary results, sensitivity analysis and future directions. Bulletin of the World Health Organisation, 1994 72; pp 495–509

Murray, CJL, Salomon JA, Mathers CD, Lopez AD (2002). Summary measures of population health: concepts, ethics, measurement and applications. Geneva, World Health Organization

Nusselder WJ (2003) Compression of Morbidity. In: Robine JM, Jagger C, Mathers CD, Crimmins EM, Suzman RM (2003) Determining Health Expectancies. John Wiley and Sons Ltd. The Atrium, Southern Gate, Chichester, West Sussex, England: pp 35–58

Omran AR (1971) The Epidemiologic Transition: A Theory of the Epidemiology of Population Change. The Milbank Memorial Fund Quarterly 49; pp 509–538

Robine JM, Jagger C, Mathers CD, Crimmins EM, Suzman RM, (2003) Determining Health Expectancies Chichester UK: John Wiley

Rowland DT. The demographic transition. In: Demographic Concepts and Methods. 2003

Sanders, B. S. (1964). "Measuring community health levels." American Journal of Public Health 54; pp 1063–1070

Shih STF, Cater R, Sinclair C. Mihalopoulos C, Vos T (2009) Economic evaluation of skin cancer prevention in Australia; Journal of Preventive Medicine 49; pp 449–453

Smith KR (1988) The Risk Transition. East-West Center

Smith KR, Corvalán CF, Kjellström T (1999) How Much Global Ill Health Is Attributable to Environmental Factors? Epidemiology. Vol. 10; pp 573–584

Sullivan DF (1966) Conceptual problems in developing an index of health. Vital and Health Statistics. vol. 2:1–18

Torrance GW (1976) Social preferences for health states: an empirical evaluation of three measurement techniques. Socio-Economic Planning and Science 10: pp 129–136

Torrance GW (1986) Measurement of health state utilities for economic appraisal; Journal of Health Economics. Vol. 5; pp 1–30

van Lier EA, Havelaar, AH (2007) Disease burden of infectious disease in Europe: a pilot study

WHO (2008) The global burden of disease: 2004 update. World Health Organisation, Geneva

World Health Organisation (2000) The World Health Report 2000. Health Systems: Improving Performance. Geneva, World Health Organisation

World Health Organisation (2002) The World Health Report 2002. Reducing Risk, Promoting Healthy Life. Geneva, World Health Organisation

http://www.springer.com/978-3-7908-2732-3

Health in Megacities and Urban Areas
Krämer, A.; Khan, M.H.; Kraas, F. (Eds.)
2011, XIV, 319 p., Hardcover
ISBN: 978-3-7908-2732-3
A product of Physica-Verlag Heidelberg