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DISEASE, BURDEN OF

Statistics on the health status of populations have been collected for centuries but typically have been collected for specific purposes. Vital registration systems have been in existence since the seventeenth century in some European countries and provide valuable information on numbers of dead by age and sex, and, in combination with census counts, on the overall level of mortality and its changes. Where all or most deaths are certified as to the underlying cause by a qualified medical practitioner—a much later development, even in Europe—these systems are a useful source of data on leading health problems. In countries where vital registration is still deficient, estimates of death rates by cause of death for the population classified by age and sex can be built up from data on mortality collected in surveys or through demographic surveillance systems, supplemented by a "verbal autopsy" (questioning relatives of the deceased) to arrive at the cause of death based on reported symptoms at or around the time of death.

Data on the incidence or prevalence of specific diseases and injuries have been collected in many countries for decades to serve as the basis for determining epidemiological priorities and for the evaluation of specific disease control programs. However, these data are often fragmentary or limited to a specific sub-population and are of limited value for assessing overall population health levels.

To give guidance in setting global priorities for the health sector, the causes and extent of ill-health and premature mortality in populations around the world need to be assessed. To be truly useful, such assessments must take into account not only the conditions leading to premature death, defined with reference to some standard survival curve, but also the prevalence, severity, and duration of the non-fatal consequences, or sequelae, of diseases and injuries. The Global Burden of Disease Study was initiated in the early 1990s to assess the contribution of over 100 diseases and injuries to premature death and ill-health in 1990, using a single metric. The study was subsequently expanded to include the estimated impact of ten major risk factors on disease and injury burden worldwide, also as of 1990. A revision of the study, under preparation, provides similar information for the year 2000.

Measuring the Disease Burden

The concept of capturing both the fatal and non-fatal effects of a specific disease or injury in a single metric is attractive for policy formulation since it permits a more complete assessment of the benefits of specific interventions. Clearly, an event-count framework, such as the number of deaths and the number of incident cases, is inappropriate as a guide for health policy since that framework does not take into account the public health implications of preventing deaths at younger versus older ages, nor does it capture variations in the duration and severity of non-fatal incident cases. In order to overcome these limitations, a time-based metric was constructed to gauge the total loss from disability and premature death—namely, Disability-Adjusted Life Years (DALYs). DALYs combine the number of years of life lost (YLLs) due to death prior to the normal life span and the number of years lived with a disability, weighted by the severity of the disability (YLDs). Hence for any disease, DALYs = YLLs + YLDs.

To estimate YLLs, a standard life expectancy of 82.5 years for females and 80.0 years for males was used to yield age-specific life expectancy targets or *norms* for the assessment of years of life lost at each age. For the calculation, the world was divided into eight regions and the same life expectancy target was assumed to apply to each region. To calculate YLDs, all major sequelae were identified for each disease or injury (e.g., measles, ischaemic heart disease, or motor vehicle accidents). A total of 107 diseases and injuries were considered, yielding a set of 483 disabling sequelae. For each of these sequelae and for each age and sex group, the incidence and average

duration of the disability were estimated, and the resulting estimate of total person-years of disabled life were weighted by an assessment of the severity of the disability (see below). The results for each disability were applied to the total of incident cases in 1990 to calculate YLDs for the cause.

The disability weights were arrived at in the following manner. A representative sample of 22 *indicator conditions* was taken from the full set of 483 sequelae, spanning the range of severity from very mild (e.g., vitiglio on the face) to very severe (e.g., quadriplegia). Based on the opinions of public health experts familiar with the characteristics of each condition, the person trade-off technique and other health-state valuation methods were used to assign each indicator condition a disability weight in the range from 0 (perfect health) to 1 (death). The resulting weights were then grouped into seven broad severity classes and each class given the average weight of the conditions in it. All remaining 461 conditions were then assigned to one of the seven classes based on their characteristics.

Finally, an age-weighting function was introduced to assign greater weight to years lived (or lost) at younger ages, its shape reflecting empirical evidence about societal values. Thus, for example, several studies have shown that individuals prefer to save the lives of young adults over young children, if forced to choose. A 3 percent discount rate was also applied to both YLLs and YLDs to bring future years back to present-value terms. Thus, for example, a year of life lived at age 40 sometime in the future has a different, less certain value for society than a year of life lived by a 40 year old today.

Data Sources

Vital registration data on causes of death were used, with adjustments for miscoding and underreporting, for about 80 countries. For India and China, sample registration systems and disease surveillance points yielded reliable data on mortality conditions for representative samples of the population. Other available sources such as demographic and epidemiological surveillance sites and community-based research studies were used to estimate disease patterns in some regions, particularly in sub-Saharan Africa and parts of Asia. For each disease, experts provided estimates of incidence, duration, and case-fatality rates, by age, sex, and region, which were modeled via the disease modeling software DISMOD to ensure internal consistency of all epidemiological parameters. Projections to 2020 were also made on the basis of a broad deterministic model relating levels of income, education, and smoking to observed mortality rates over the period from 1950 to 1990.

Findings

Each disease or injury was classified into one of three broad groups:

- Group I, communicable, maternal, perinatal, and nutritional conditions;
- Group II, non-communicable diseases;
- Group III, injuries.

Worldwide, one death in every three is from a Group I cause. Virtually all of these deaths are in developing regions. One death in ten is from Group III causes (injuries), and just over half of all deaths worldwide in 1990 were from Group II causes (non-communicable diseases). In most developing regions, Group II causes of death already exceeded Group I causes in 1990, indicating that the epidemiological transition was well advanced. In these regions, the ratio of Group II to Group I deaths in 1990 was 4.5 in China and 2 in Latin America. The transition was less advanced in India, where the ratio was 0.8, and least advanced in sub-Saharan Africa, with a ratio of 0.4.

Just over 50 million people died worldwide in 1990, the leading causes of death being ischaemic heart disease (6.3 million deaths); stroke (4.4 million); lower respiratory diseases (primarily pneumonia, 4.3 million; diarrheal diseases (2.9 million); perinatal conditions, (2.4 million); and chronic obstructive pulmonary disease (primarily chronic bronchitis and emphysema, 2.2 million). Looking at years of life lost, however, yields a different ranking because the various causes of death have different average age patterns. The leading causes of YLLs were lower respiratory infections (11.7% of global YLLs for 1990), diarrheal diseases (10.2%), and perinatal conditions (8.9%)—followed at some distance by ischaemic heart disease (4.5%), measles (3.9%), and tuberculosis and stroke (3.5%). Arguably, this ranking is much more relevant for prioritization of programs to prevent premature mortality than the ranking by numbers of deaths.

When disease burden is assessed on the basis of DALYs, rather than deaths, conditions that are not leading causes of death but are nonetheless prevalent

TABLE 1

Leading Causes of Loss of Disability-Adjusted Life Years (DALYs), 1990

	World	DALYs (million)	% total	Developed Regions	DALYs (million)	% total	Developing Regions	DALYs (million)	% total
1.	Lower respiratory infections	112.9	8.2	Ischaemic heart disease	16.0	9.9	Lower respiratory infections	110.5	9.1
2.	Diarrheal diseases	99.6	7.2	Unipolar major depression	9.8	6.1	Diarrheal diseases	99.2	8.1
3.	Perinatal conditions	92.3	6.7	Cerebrovascular disease	9.4	5.9	Perinatal conditions	89.2	7.3
4.	Unipolar major depression	50.8	3.7	Road traffic accidents	7.1	4.4	Unipolar major depression	41.0	3.4
5.	Ischaemic heart disease	46.7	3.4	Alcohol use	6.4	4.0	Tuberculosis	37.9	3.1
6.	Cerebrovascular disease	38.5	2.8	Osteoarthritis	4.7	2.9	Measles	36.5	3.0
7.	Tuberculosis	38.4	2.8	Trachea/Bronchus/Lung cancers	4.6	2.8	Malaria	31.7	2.6
8.	Measles	36.5	2.6	Dementias	3.8	2.4	Ischaemic heart disease	30.7	2.5
9.	Road traffic accidents	34.3	2.5	Self-inflicted injuries	3.8	2.3	Congenital abnormalities	29.4	2.4
10.	Congenital abnormalities	32.9	2.4	Congenital abnormalities	3.5	2.2	Cerebrovascular disease	29.1	2.4
Top 10 causes		583.1	42.3	Top 10 causes	69.0	42.9	Top 10 causes	535.3	43.9

SOURCE: World Health Organization (Murray and Lopez, 1996a, Table 5.2).

and disabling are given increased prominence. Worldwide, about 1.38 billion DALYs were lost as a result of premature deaths and new incident cases of disease and injury in 1990. The leading causes of DALYs in developed and developing regions are shown in Table 1. The global pattern more or less mirrors that suggested by YLLs, with the notable exception of depression, which ranks as the fourth leading cause of DALYs lost worldwide and the second leading cause in developed countries. As might be expected, more than half of the top ten leading causes of DALYs lost in developing regions are Group I causes, reinforcing the need for strengthened disease control measures for communicable diseases in poorer populations. Preliminary results for 2000 suggest a similar pattern, with the exception of HIV/AIDS, which was estimated to have caused 6.1 percent of the global DALYs lost in 2000, making it the third leading cause of DALYs lost in that year.

In terms of underlying causes of the burden of disease and injury, by far the most significant of those quantified was protein-energy malnutrition, which alone was estimated to have caused 16 percent of DALYs lost in 1990, followed by unsafe water and sanitation (6.8%). Unsafe sex, tobacco, alcohol, and occupational risks each causes about 2.5 percent to 3.5 percent of the disease and injury burden, about the same as measles and malaria. Quantifying disease burden both in terms of disease outcomes (e.g., lung cancer, ischaemic heart disease) and underlying attributable causes (e.g., tobacco, high blood pressure) provides critical input for allocative decisions in health sector programs.

Conclusion

The burden of disease approach has stimulated wide interest and debate about the construction of summary measures of population health, such as DALYs, and on the applicability of these methods in various countries. The data requirements for estimating mortality, incidence, prevalence, and duration of disease and injury in an internally consistent fashion has stimulated a reevaluation of the utility of traditional data collection in the health sector and has identified key gaps in knowledge about the causes and levels of major health problems. In developed countries, this has led to greater efforts to improve the cross-population comparability of survey data on the prevalence of disabling conditions; in developing countries, it has demonstrated the urgency of improving knowledge about the levels, patterns, and causes of adult mortality. As more children survive to adulthood, reliable data on their survival and trends in leading causes of death and disability will become increasingly important.

See also: *Disability, Demography of; Epidemiological Transition; Health Transition; Mortality Decline.*

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ALAN D. LOPEZ

DISEASE, CONCEPTS AND CLASSIFICATION OF

The classification of diseases is the subject of the branch of medicine called nosology. Contemporary classification efforts range from those primarily intended to clarify and standardize the nomenclature of diseases, such as the College of American Pathologists' Systematized Nomenclature of Medicine (SNOWMED) and the National Institute of Health's Unified Medical Language System (UMLS), to taxonomies focused on diagnostic terminology that emphasize an ordered hierarchical system reflecting natural relationships between diseases, such as the World Health Organization's International Statistical Classification of Diseases and Related Health Problems (ICD).

The Early History of Disease Classification

The classificatory approach to disease is ancient, but the classification of diseases in a modern sense dates roughly from the fifteenth and sixteenth centuries. The concept that diseases are directly identifiable through their symptomatology is most evident in the revolutionary work of Paracelsus (born Theophrastus von Hohenheim, 1493–1541). Paracelsus's suggestion that natural symptoms may provide direct evidence leading to a probable diagnosis or classification of a disease despite a potentially unobservable cause of the illness was evident in practice by the seventeenth century, when nosology took form.

Throughout the eighteenth century the pathological view was guided by the concept that a specific cause could be identified for all episodes of ill health, and physicians concentrated on the observation of symptoms and the categorization of disease. Even the inevitability of death from natural causes and the presumption of a biologically acceptable risk of infant death gave way to perceptions that a cause for all illnesses could be diagnosed and that these causes of disease constituted social problems that could be resolved.

Swedish naturalist Carolus Linnaeus (1707–1778), best known for his botanical classifications, attempted to provide a systematic classification of diseases during that period. His classification is notable for including a broad range of morbidity conditions, including functional health limitations (loss of movement, impeded motion, etc.) and mental health conditions as they were understood at the time (delirium, melancholia, bulimia, etc.). In a fashion similar to his botanical classification, Linnaeus designated genera, species, and subspecies of disease. Not surprisingly, his classification is not predicated on a single classificatory principle. Linnaeus did emphasize symptomatology. However, his classification reflects elements of alchemy, astrology, and the prevailing miasmatic environmental view of disease. Other, similar classification attempts by individual physicians of that time (e.g., Francois Bossier de Lacroix's *Nosologia Methodica* and William Cullen's *Classification*) were not theoretically grounded and did not embody a clear notion of symptoms derived from causal agents. Arguably, the effect was to produce complex nosologies, competing classifications, and confusion.

The Nineteenth Century and the Advent of Germ Theory

Competing conceptions of disease were and still are also rooted in strongly held social hypotheses and are debated in the context of political, economic, and religious interests. The establishment over the course of the early nineteenth century of various "centres of calculation" in England, including the General Register Office (GRO), the Alkali Inspectorate, and the inspectors of the Passenger Acts and Factory Acts, provided a governmental context for often lively debates about the development of mor-