

GLOBAL BURDEN OF DISEASE AND INJURY SERIES

VOLUME IV



# THE GLOBAL EPIDEMIOLOGY OF INFECTIOUS DISEASES

EDITED BY:  
CHRISTOPHER J. L. MURRAY  
ALAN D. LOPEZ  
COLIN D. MATHERS



WORLD HEALTH ORGANIZATION  
GENEVA

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FOREWORD TO  
THE *GLOBAL BURDEN OF  
DISEASE AND INJURY SERIES*

RALPH H. HENDERSON

The collection and use of timely and reliable health information in support of health policies and programmes have been actively promoted by the World Health Organization since its foundation. Valid health statistics are required at all levels of the health system, ranging from data for health services support at the local community level, through to national statistics and information used to monitor the effectiveness of national health strategies. Equally, regional and global data are required to monitor global epidemics and to continuously assess the effectiveness of global public health approaches to disease and injury prevention and control, as coordinated by WHO technical programmes. Despite the clear need for epidemiological data, reliable and comprehensive health statistics are not available in many Member states of WHO, and, indeed, in many countries the ascertainment of disease levels, patterns and trends is still very uncertain.

In recent years, monitoring systems, community-level research and disease registers have improved in both scope and coverage. Simultaneously, research on the epidemiological transition has increased our understanding of how the cause structure of mortality changes as overall mortality rates decline. As a consequence, estimates and projections of various epidemiological parameters, such as incidence, prevalence and mortality, can now be made at the global and regional level for many diseases and injuries. The Global Burden of Disease Study has now provided the public health community with a set of consistent estimates of disease and injury rates in 1990. The Study has also attempted to provide a comparative index of the burden of each disease or injury, namely the number of Disability-Adjusted Life Years (DALYs) lost as a result of either premature death or years lived with disability.

The findings published in the Global Burden of Disease and Injury Series provide a unique and comprehensive assessment of the health of populations as the world enters the third millennium. We also expect that the methods described in the various volumes in the series will stimulate

Member States to improve the functioning and usefulness of their own health information systems. Nonetheless, it must be borne in mind that the results from an undertaking as ambitious as the Global Burden of Disease Study can only be approximate. The reliability of the data for certain diseases, and for some regions, is extremely poor, with only scattered information available in some cases. To extrapolate from these sources to global estimates is clearly very hazardous, and could well result in errors of estimation. The methods that were used for some diseases (e.g. cancer) are not necessarily those applied by other scientists or institutions (e.g. the International Agency for Research on Cancer) and hence the results obtained may differ, sometimes considerably, from theirs. Moreover, the concept of the DALY as used in this Study is still under development, and further work is needed to assess the relevance of the social values that have been incorporated in the calculation of DALYs, as well as their applicability in different socio-cultural settings. In this regard, WHO and its various partners are continuing their efforts to investigate burden-of-disease measurements and their use in health policy decision-making.

Dr Ralph H. Henderson is former Assistant Director-General of the World Health Organization.

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FOREWORD TO  
THE *GLOBAL BURDEN OF  
DISEASE AND INJURY SERIES*

DEAN T. JAMISON

Rational evaluation of policies for health improvement requires four basic types of information: a detailed, reliable assessment of epidemiological conditions and the burden of disease; an inventory of the availability and disposition of resources for health (i.e. a system of what has become known as national health accounts); an assessment of the institutional and policy environment; and information on the cost-effectiveness of available technologies and strategies for health improvement. The *Global Burden of Disease and Injury Series* provides, on a global and regional level, a detailed and internally consistent approach to meeting the first of these information needs, that concerning epidemiological conditions and disease burden. It fully utilizes what information exists while, at the same time, pointing to great variation—across conditions and across countries—in data quality. In the *Global Burden of Disease and Injury Series*, Christopher Murray, Alan Lopez and literally scores of their collaborators from around the world present us with a tour de force: its volumes summarize epidemiological knowledge about all major conditions and most risk factors; they generate assessments of numbers of deaths by cause that are consistent with the total numbers of deaths by age, sex and region provided by demographers; they provide methodologies for and assessments of aggregate disease burden that combine—into the Disability-Adjusted Life Year or DALY measure—burden from premature mortality with that from living with disability; and they use historical trends in main determinants to project mortality and disease burden forward to 2020. Publication of the *Global Burden of Disease and Injury Series* marks the transition to a new era of health outcome accounting—an era for which these volumes establish vastly higher standards for rigour, comprehensiveness and internal consistency. I firmly predict that the official reporting of health outcomes in many countries and globally will increasingly embody the approach and standards described in this series.

*The Global Burden of Disease and Injury Series* culminates an evolutionary process that began in the late 1980s. Close and effective collaboration

between the World Bank and the World Health Organization initiated, supported and contributed substantively to that process.

## BACKGROUND

Work heading to the *Global Burden of Disease and Injury Series* proceeded in three distinct phases beginning in 1988. Intellectual antecedents go back much further (see Murray 1996, or Morrow and Bryant 1995); perhaps the most relevant are Ghana's systematic assessment of national health problems (Ghana Health Assessment Project Team 1981) and the introduction of the QALY (quality-adjusted life year)—see, for example Zeckhauser and Shepard (1976). My comments here focus on the three phases leading directly to the *Global Burden of Disease and Injury Series*.

Phase 1 constituted an input to a four-year long "Health Sector Priorities Review" initiated in 1988 by the World Bank; its purpose was to assess "...the significance to public health of individual diseases for related clusters of diseases...and what is now known about the cost and effectiveness of relevant interventions for their control" (Jamison et al. 1993, p. 3; that volume provides the results of the review). Dr Christopher Murray of Harvard University introduced the DALY as a common measure of effectiveness for the review to use across interventions dealing with diverse diseases, and Dr Alan Lopez of the World Health Organization prepared estimates of child deaths by cause that were consistent with death totals provided by demographers at the World Bank (Lopez 1993). At the same time, and in close coordination, a World Bank effort was preparing consistent estimates for adult (15-59) mortality by cause for much of the developing world (Feachem et al. 1992). Ensuring this consistency was a major advance and is a precondition for systematic attempts to measure disease burden. (Estimates of numbers of deaths by cause that are not constrained to sum to a demographically-derived total seem inevitably to result in substantial overestimates of deaths due to each cause.) Phase 1 of this effort, then, introduced the DALY and established important consistency standards to guide estimation of numbers of deaths by cause.

Phase 2 constituted the first attempt to provide a comprehensive set of estimates not only of numbers of deaths by cause but also of total disease burden including burden from disability. This effort was commissioned as background for the World Bank's *World Development Report 1993: Investing in Health*; it was co-sponsored by the World Bank and the World Health Organization; and it was undertaken under the general guidance of a committee chaired by Dr JP Jardel (then Assistant Director-General of WHO). The actual work was conceptualised, managed and integrated by Drs Murray and Lopez and involved extensive efforts by a large number of individuals, most of whom were on the WHO staff. First publication of the estimates of 1990 disease burden appeared in Appendix B of *Investing in Health* (World Bank 1993) and, more extensively, in Murray, Lopez and Jamison (1994). The World Health Organization subsequently published

a volume containing a full account of the methods used and a somewhat revised and far more extensive presentation of the results (Murray and Lopez 1994).

Preparation and publication of the *Global Burden of Disease and Injury Series* constitutes Phase 3 of this sequence of efforts. As in the earlier phases, the *Global Burden of Disease and Injury Series* was undertaken to inform a policy analysis—in this case an assessment of priorities for health research and development in developing countries being guided by WHO's Ad Hoc Committee on Health Research Relating to Future Intervention Options. The Committee sought updated estimates of disease burden for 1990, projections to 2020 and an extension of the methods to allow assessment of burden attributable to selected risk factors. The committee's report (Ad Hoc Committee 1996) and the *Global Burden of Disease and Injury Series* appear as companion documents.

Chapters summarizing results from the *Global Burden of Disease and Injury Series* appear in volume I, *The Global Burden of Disease*; underlying epidemiological statistics for over 200 conditions appear in volume II, *Global Health Statistics*. The next two volumes of the Series provide, for the first time, chapters detailing the data on each condition or cluster of conditions in the areas of reproductive health and infectious diseases.

Will there be a fourth phase? I am sure there will. Reporting of the disease-specific and risk factor analysis in the *Global Burden of Disease and Injury Series* will provoke constructive and perhaps substantial criticism and improvements; country-specific assessments will multiply (over 20 are now under way) and they, too, will modify and enrich current estimates, see for example, Lozano et al. 1994. Estimates of *trends* in deaths by cause have recently been initiated, which will serve as the precursor for estimates of trends in disease burden. Methodologies will be criticized and, I would predict, constructively revised. Unfinished elements of the agenda discussed in the next section will be completed. Phase 4, centred on the estimation of global and regional disease burden for 2000 and including a look at the past, will take us well beyond where we now are.

## THE AGENDA

Disease burden (or numbers of deaths by cause) were initially partitioned in three separate ways for different age, sex and regional groupings (Murray et al. 1994). One partition is by *risk factor*—genetic, behavioural, environmental and physiological. The second is by disease. The third is by consequence—*premature mortality* at different ages and different *types of disability* (e.g. sensory, cognitive functioning, pain, affective state, etc.). A fourth partition, by reason for remaining burden, was later introduced (Ad Hoc Committee, 1996).

Disaggregation by risk factor helps guide policy concerning primary and secondary prevention, including development of new preventive measures. Disaggregation by disease helps guide policy concerning cure, secondary

prevention and palliation; and disaggregation by consequence helps guide policies for rehabilitation.

Work on the disease burden assessment agenda began with assessments of mortality and burden by disease; the *Global Burden of Disease and Injury Series* advances the agenda in that domain by revising and adding great detail on disease burden estimates. More recently, the World Health Report for 2002 (World Health Organization, 2002) provides an extensive assessment of the burden from a range of important risk factors; this extends usefulness of the work to the domain of prevention policy.

There remains, however, an important unfinished agenda. The disease burden associated with different types of disability remains to be assessed; perhaps part of the reason for neglect of rehabilitation in most discussion of health policy is the lack of even approximate information on burden due to disability or on the DALY gains per unit cost of rehabilitative intervention.

A related agenda item—relevant to planning for curative and, particularly, rehabilitative intervention—is to present disease burden estimates from a current prevalence perspective. The dominant perspective of work so far undertaken, including in the *Global Burden of Disease and Injury Series*, is that of adding up over time the burden that will result from all conditions incident in a given year (here 1990); this well serves the development of primary prevention policy and of treatment policy for diseases of short duration. The prevalence perspective complements the incidence one by assessing how much burden is being experienced during a particular year by chronic conditions or by disabilities; those conditions or disabilities will often have been generated sometime in the past. From an incidence perspective, disability in this year from, say, an injury occurring a decade ago would generate DALY loss in the year of incidence; but to guide investment in rehabilitation we need to know how much disability exists today, i.e., we need a prevalence perspective. Murray and Lopez in *The Global Burden of Disease* and in *Global Health Statistics* provide the basic estimates of prevalence of different disabilities and first glimpses of the prevalence perspective.

A final major agenda item is to establish for each condition and in the aggregate how much of the potential current burden is in fact being averted by existing interventions and how much of the remaining burden persists because of lack of any intervention, lack of cost-effective interventions, or because of inefficiency of the system.

## USES OF DALY AND DISEASE BURDEN MEASUREMENT

DALYs have six major uses to underpin health policy. Five of these relate to measurement of the burden of disease; the final one concerns judging the relative priority of interventions in terms of cost-effectiveness.

*Assessing performance.* A country-specific (or regional) assessment of the

burden of disease provides a performance indicator that can be used over time to judge progress or across countries or regions to judge relative performance. These comparisons can be either quite aggregated (in terms of DALYs lost per thousand population) or finely disaggregated to allow focused assessment of where relative performance is good and where it is not. The *Global Burden of Disease and Injury Series* with its burden assessments for eight regions in 1990—and with the increasing number of country-specific assessments that it will report—will provide, I predict, the benchmark for all subsequent work. The most natural comparison is to the development of National Income and Product Accounts (NIPAs) by Simon Kuznets and others in the 1930s, which culminated in 1939 with a complete NIPA for the United Kingdom prepared by James Meade and Richard Stone at the request of the UK Treasury. NIPAs have, in the subsequent decades, transformed the empirical underpinnings of economic policy analysis. One of the leading proponents of major changes in NIPAs has put in this way:

The national income and product accounts for the United States (NIPAs), and kindred accounts in other nations, have been among the major contributions to economic knowledge over the past half century...Several generations of economists and practitioners have now been able to tie theoretical constructs of income output, investment, consumption, and savings to the actual numbers of these remarkable accounts with all their fine detail and soundly meshed interrelations. (Eisner 1989).

My own expectation is that this series will, over a decade or two, initiate a transformation of health policy analysis analogous to that initiated for economic policy by the introduction of NIPAs in the late 1930s. Today most health policy work concerns only cost, finance, process and access; burden of disease (and risk factor) assessments should soon allow full incorporation of performance measures in policy analysis.

*Generating a forum for informed debate of values and priorities.* The assessment of disease burden in a country-specific context in practice involves participation of a broad range of national disease specialists, epidemiologists and, often, policy makers. Debating the appropriate values for, say, disability weights or for years of life lost at different ages helps clarify values and objectives for national health policy. Discussing the inter-relations among diseases and their risk factors in the light of local conditions sharpens consideration of priorities. And the entire process brings technically informed participants to the table where policy is discussed. The preparation of a well-defined product generates a process with much value of its own.

*Identifying national control priorities.* Many countries now identify a relatively short list of interventions, the full implementation of which

becomes an explicit priority for national political and administrative attention. Examples include interventions to control tuberculosis, poliomyelitis, HIV infection, smoking and specific micronutrient deficiencies. Because political attention and administrative capacity are in relatively fixed and short supply, the benefits from using those resources will be maximized if they are directed to interventions that are both cost-effective and aimed at problems associated with a high burden. Thus, national assessments of disease burden are instrumental for establishing this short list of control priorities.

*Allocating training time for clinical and public health practitioners.* Medical schools offer a fixed number of instructional hours; training programmes for other levels and types of practitioners are likewise limited. A major instrument for implementing policy priorities is to allocate this fixed time resource well—again that means allocation of time to training in interventions where disease burden is high and cost-effective interventions exist.

*Allocating research and development resources.* Whenever a fixed effort will have a benefit proportional not to the size of the effort but rather to the size of the problem being addressed, estimates of disease burden become essential for formulation of policy. This is the case with political attention and with time in the medical school curriculum; and it is likewise true for the allocation of research and development resources. Developing a vaccine for a broad range of viral pneumonias, for example, would have perhaps hundreds of times the impact of a vaccine against disease from Hanta virus infection. Thus information on disease or risk factor burden is one (of several) vital inputs to inform research and development resource allocation. Indeed, as previously noted, this series—with its disease burden assessments for 1990, its projections to 2020 and its initial assessment of burden due to risk factors—was commissioned to inform a WHO Committee charged with assessing health research and development priorities for developing countries (Ad Hoc Committee 1996).

The Committee sought not only to know the burden by condition, but also to partition the burden remaining for each condition into several distinct parts reflecting the importance of the reasons for the remaining disease burden. This division into four parts was undertaken for several conditions; a major agenda item for future analysis is to undertake such a partitioning systematically for all conditions so that there could be reasonably approximate answers to such questions as “How much of the remaining disease burden cannot be addressed without major biomedical advances?” Or, “How much of the remaining disease burden could be averted by utilizing existing interventions more efficiently?” Arguably most of the spectacular gains in human health of the past century have resulted from advances in knowledge (although improvements in income and education have also played a role). If so, improving research and development policy in health may be more important than improving

policy in health systems or finance; improved assessments and projections of disease burden will be critical to that undertaking.

*Allocating resources across health interventions.* Here disease burden assessment often plays a minor role; the task is to shift resources to interventions which, at the margin, will generate the greatest reduction in DALY loss. When there are major fixed costs in mounting an intervention—as is the case with political and managerial attention for national control priorities—burden estimates are indeed required to optimize resources allocation. But, typically, much progress can be made with only an understanding of how the DALYs gained from an intervention vary with the level of expenditure on it; such assessments are the stuff of cost-effectiveness analysis. The DALY as a common measure of effectiveness allows comparison of cost-effectiveness across intervention addressing all conditions; such an initial effort was undertaken for the World Bank's "Health Sector Priorities Review" (Jamison et al. 1993) in the late 1980s using a forerunner to the DALY utilized in this series.

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The *Global Burden of disease and Injury Series* contains the only available internally consistent, comprehensive and comparable assessments of causes of death, incidence and prevalence of disease and injury, measures and projections of disease burden, and measures of risk factor burden. In that sense the authors' contributions represent a landmark achievement and provide an invaluable resource for policy analyst and scholars. This effort dramatically raises the standard by which future reporting of health conditions will be judged. Yet, the very need for the ad hoc assessments that the volumes in this series report, points to important gaps in the international system for gathering, analysing and distributing policy-relevant data on the health of populations. Without information on how levels and trends in key indicators in their own countries compare with other countries, national decision-makers will lack benchmarks for judging performance. Likewise students of health systems will lack the empirical basis for forming outcome-based judgements on which policies work—and which do not. I hope, then, that one follow-on to the *Global Burden of Disease and Injury Series* will be the institutionalization of continued efforts to generate and analyse internationally comparable data on health outcomes.

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## PREFACE

This fourth volume of the *Global Burden of Disease and Injuries Series* provides the reader with information on the epidemiology and burden of major infectious and parasitic diseases. As with previous volumes of the Global Burden of Disease study, the chapters in this book detail the situation as experienced in the year 1990. Since then the epidemiology of some of the conditions described has changed, and where this is the case the authors have added a brief paragraph acknowledging this. The chapters therefore do not provide a detailed update on the *current* burden of disease, which is accommodated in the documentation of the Global Burden of Disease 2000 and published elsewhere.

In Chapter 1 Bern focuses on diarrhoeal diseases which were a major contributor to the global burden of infectious disease in the year 1990 and still account for high numbers of infections in childhood. This is followed by five detailed and focussed chapters on the burden of vaccine-preventable diseases. In Chapters 2 and 3 Robertson and Galazka describe the epidemiology and burden of pertussis and diphtheria, respectively. In Chapter 4 Clemens and colleagues concentrate on the global epidemiology of measles which has undergone significant change in recent years. While approximately 4 million children died of measles in 1990, it is estimated that this number has fallen well below 1 million in 2000. In Chapter 5 Shibuya and Murray summarise the global burden of poliomyelitis, which has similarly been transformed by recent efforts in poliomyelitis eradication. Birmingham and Galazka give a detailed account of the epidemiology of tetanus in Chapter 6.

In Chapter 7 Daumerie informs the reader about the global situation of leprosy, followed by Chapter 8 in which LeDuc describes the epidemiology of dengue. Chapter 9 by Bundy and colleagues provides an overview of intestinal nematode infestations, which give rise to considerable disease burden world-wide. In Chapter 10 Thylefors and colleagues focus on the global burden of trachoma whose epidemiology has undergone some change in the recent past. Moncayo gives a detailed account of the burden

of Chagas' Disease in the Americas in Chapter 11 and provides a pertinent update on recent efforts to eliminate the disease. The volume concludes with Chapter 12 by the late Mott and finalised by Mathers who describe the epidemiology of schistosomiasis.

This volume summarises the burden of twelve major infectious and parasitic diseases. Volume 3 also contained chapters detailing the global epidemiology of HIV/AIDS and of other sexually transmitted diseases in 1990. These chapters provide information on the data sources and methodological approaches to measuring infectious disease burden that are still relevant today for analysis of current burden, as well as for interpreting time trends between 1990 and 2000 estimates of infectious disease burden. It is our hope that these chapters will also stimulate further debate about the availability and validity of the data, methods and assumptions used to arrive at disease estimates and spur efforts to improve the availability and quality of epidemiological data on these diseases.

This will be the final volume of the original *Global Burden of Disease and Injuries Series*. The Global Burden of Disease study has stimulated further constructive debate, methodological developments and new analyses in summary measures of population health (Murray et al. 2002), in comparative risk assessment (Ezzati et al. 2004) and in the assessment of priorities for interventions (Tan Torres Edejer et al. 2003). Methods and data sources for the assessment of the burden of nutritional deficiencies, non-communicable diseases and injuries have also evolved and are being progressively documented as part of the Global Burden of Disease 2000 project (draft documentation is available at [www.who.int/evidence/bod](http://www.who.int/evidence/bod)). Substantial documentation of the Global Burden of Disease 2000 study has also been published in peer reviewed journals and books, and we anticipate that there will be further publications containing revised and more extensive presentation of the methods and results.

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This volume has been in preparation for some time, and where authors were unable to finalise their chapters others have completed the task, where possible. Former authors who were unable to conclude their work are acknowledged as co-authors in this volume. We are particularly grateful for the pioneering manuscripts of those who sadly passed away while preparing this publication: A Galazka and K Mott. To acknowledge their invaluable contribution to this volume and burden of disease epidemiology at large, Maureen Birmingham and Susan Robertson have kindly taken on the task to complete the chapters by A Galazka, and the editors that of K Mott.

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