Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010

Christopher J L Murray†‡, Theo Vos, Rafael Lozano, Mohsen Naghavi, Abraham D Flaxman, Catherine Michaud, Majid Ezzati, Kenji Shibuya, Joshua A Salomon, Safa Abdalla*, Victor Aboyans*, Jerry Abraham*, Ilana Ackerman*, Rakesh Aggarwal*, Stephanie Y Ahn*, Mohammed K Ali*, Mohammad A AlMazroa*, Miriam Alvarado*, H Ross Anderson*, Laurie M Anderson*, Kathryn G Andrews*, Charles Atkinson*, Larry M Baddour*, Adil N Bahalim*, Suzanne Barker-Collo*, Lope H Barrero*, David H Bartels*, Maria-Gloria Basáñez*, Amanda Baxter*, Michelle L Bell*, Emelia J Benjamin*, Derrick Bennett*, Eduardo Bernabé*, Kavi Bhalla*, Bishal Bhandari*, Boris Bikbov*, Aref Bin Abdulhak*, Gretchen Birbeck*, James A Black*, Hannah Blencowe*, Jed D Blore*, Fiona Blyth*, Ian Bolliger*, Audrey Bonaventure*, Soufiane Boufous*, Rupert Bourne*, Michel Boussinesq*, Tasanee Braithwaite*, Carol Brayne*, Lisa Bridgett*, Simon Brooker*, Peter Brooks*, Traolach S Brugha*, Claire Bryan-Hancock*, Chiara Bucello*, Rachelle Buchbinder*, Geoffrey Buckle*, Christine M Budke*, Michael Burch*, Peter Burney*, Roy Burstein*, Bianca Calabria*, Benjamin Campbell*, Charles E Canter*, Hélène Carabin*, Jonathan Carapetis*, Loreto Carmona*, Claudia Cella*, Fiona Charlson*, Honglei Chen*, Andrew Tai-Ann Cheng*, David Chou*, Sumeet S Chugh*, Luc E Coffeng*, Steven D Colan*, Samantha Colquhoun*, K Ellicott Colson*, John Condon*, Myles D Connor*, Leslie T Cooper*, Matthew Corriere*, Monica Cortinovis*, Karen Courville de Vaccaro*, William Couser*, Benjamin C Cowie*, Michael H Criqui*, Marita Cross*, Kaustubh C Dabhadkar*, Manu Dahiya*, Nabila Dahodwala*, James Damsere-Derry*, Goodarz Danaei*, Adrian Davis*, Diego De Leo*, Louisa Degenhardt*, Robert Dellavalle*, Allyne Delossantos*, Julie Denenberg*, Sarah Derrett*, Don C Des Jarlais*, Samath D Dharmaratne*, Mukesh Dherani*, Cesar Diaz-Torne*, Helen Dolk*, E Ray Dorsey*, Tim Driscoll*, Herbert Duber*, Beth Ebel*, Karen Edmond*, Alexis Elbaz*, Suad Eltahir Ali*, Holly Erskine*, Patricia J Erwin*, Patricia Espindola*, Stalin E Ewoigbokhan*, Farshad Farzadfar*, Valery Feigin*, David T Felson*, Alize Ferrari*, Cleusa P Ferri*, Eric M Fèvre*, Mariel M Finucane*, Seth Flaxman*, Louise Flood*, Kyle Foreman*, Mohammad H Forouzanfar*, Francis Gerry R Fowkes*, Marlene Fransen*, Michael K Freeman*, Belinda J Gabbe*, Sherine E Gabriel*, Emmanuela Gakidou*, Hammad A Ganatra*, Bianca Garcia*, Flavio Gaspari*, Richard F Gillum*, Gerhard Gmel*, Diego Gonzalez-Medina*, Richard Gosselin*, Rebecca Grainger*, Bridget Grant*, Justina Groeger*, Francis Guillemin*, David Gunnell*, Ramyani Gupta*, Juanita Haagsma*, Holly Hagan*, Yara A Halasa*, Wayne Hall*, Diana Haring*, Josep Maria Haro*, James E Harrison*, Rasmus Havmoeller*, Roderick J Hay*, Hideki Higashi*, Catherine Hill*, Bruno Hoen*, Howard Hoffman*, Peter J Hotez*, Damian Hoy*, John J Huang*, Sydney E Ibeanusi*, Kathryn H Jacobsen*, Spencer L James*, Deborah Jarvis*, Rashmi Jasrasaria*, Sudha Jayaraman*, Nicole Johns*, Jost B Jonas*, Ganesan Karthikeyan*, Nicholas Kassebaum*, Norito Kawakami*, Andre Keren*, Jon-Paul Khoo*, Charles H King*, Lisa Marie Knowlton*, Olive Kobusingye*, Adofo Koranteng*, Rita Krishnamurthi*, Francine Laden*, Ratilal Lalloo*, Laura L Laslett*, Tim Lathlean*, Janet L Leasher*, Yong Yi Lee*, James Leigh*, Daphna Levinson*, Stephen S Lim*, Elizabeth Limb*, John Kent Lin*, Michael Lipnick*, Steven E Lipshultz*, Wei Liu*, Maria Loane*, Summer Lockett Ohno*, Ronan Lyons*, Jacqueline Mabweijano*, Michael F MacIntyre*, Reza Malekzadeh*, Leslie Mallinger*, Sivabalan Manivannan*, Wagner Marcenes*, Lyn March*, David J Margolis*, Guy B Marks*, Robin Marks*, Akira Matsumori*, Richard Matzopoulos*, Bongani M Mayosi*, John H McAnulty*, Mary M McDermott*, Neil McGill*, John McGrath*, Maria Elena Medina-Mora*, Michele Meltzer*, Ziad A Memish*, George A Mensah*, Tony R Merriman*, Ana-Claire Meyer*, Valeria Miglioli*, Matthew Miller*, Ted R Miller*, Philip B Mitchell*, Charles Mock*, Ana Olga Mocumbi*, Terrie E Moffitt*, Ali A Mokdad*, Lorenzo Monasta*, Marcella Montico*, Maziar Moradi-Lakeh*, Andrew Moran*, Lidia Morawska*, Rintaro Mori*, Michele E Murdoch*, Michael K Mwaniki*, Kovin Naidoo*, M Nathan Nair*, Luigi Naldi*, K M Venkat Narayan*, Paul K Nelson*, Robert G Nelson*, Michael C Nevitt*, Charles R Newton*, Sandra Nolte*, Paul Norman*, Rosana Norman*, Martin O'Donnell*, Simon O'Hanlon*, Casey Olives*, Saad B Omer*, Katrina Ortblad*, Richard Osborne*, Doruk Ozgediz*, Andrew Page*, Bishnu Pahari*, Jeyaraj Durai Pandian*, Andrea Panozo Rivero*, Scott B Patten*, Neil Pearce*, Rogelio Perez Padilla*, Fernando Perez-Ruiz*, Norberto Perico*, Konrad Pesudovs*, David Phillips*, Michael R Phillips*, Kelsey Pierce*, Sébastien Pion*, Guilherme V Polanczyk*, Suzanne Polinder*, C Arden Pope III*, Svetlana Popova*, Esteban Porrini*, Farshad Pourmalek*, Martin Prince*, Rachel L Pullan*, Kapa D Ramaiah*, Dharani Ranganathan*, Homie Razavi*, Mathilda Regan*, Jürgen T Rehm*, David B Rein*, Guiseppe Remuzzi*, Kathryn Richardson*, Frederick P Rivara*, Thomas Roberts*, Carolyn Robinson*, Felipe Rodriguez De Leòn*, Luca Ronfani*, Robin Room*, Lisa C Rosenfeld*, Lesley Rushton*, Ralph L Sacco*, Sukanta Saha*, Uchechukwu Sampson*, Lidia Sanchez-Riera*, Ella Sanman*, David C Schwebel*, James Graham Scott*, Maria Segui-Gomez*, Saeid Shahraz*, Donald S Shepard*, Hwashin Shin*, Rupak Shivakoti*, David Singh*, Gitanjali M Singh*, Jasvinder A Singh*, Jessica Singleton*, David A Sleet*, Karen Sliwa*, Emma Smith*, Jennifer L Smith*, Nicolas J C Stapelberg*, Andrew Steer*, Timothy Steiner*, Wilma A Stolk*, Lars Jacob Stovner*, Christopher Sudfeld*, Sana Syed*, Giorgio Tamburlini*, Mohammad Tavakkoli*, Hugh R Taylor*, Jennifer A Taylor*, William J Taylor*, Bernadette Thomas*, W Murray Thomson*, George D Thurston*, Imad M Tleyjeh*, Marcello Tonelli*, Jeffrey A Towbin*, Thomas Truelsen*, Miltiadis K Tsilimbaris*, Clotilde Ubeda*, Eduardo A Undurraga*, Marieke J van der Werf*, Jim van Os*, Monica S Vavilala*, N Venketasubramanian*, Mengru Wang*, Wenzhi Wang*, Kerrianne Watt*, David J Weatherall*, Martin A Weinstock*, Robert Weintraub*, Marc G Weisskopf*, Myrna M Weissman*, Richard A White*, Harvey Whiteford*, Natasha Wiebe*, Steven T Wiersma*, James D Wilkinson*, Hywel C Williams*, Sean R M Williams*, Emma Witt*, Frederick Wolfe*, Anthony D Woolf*, Sarah Wulf*, Pon-Hsiu Yeh*, Anita K M Zaidi*, Zhi-Jie Zheng*, David Zonies*, Alan D Lopez†

Summary

Background Measuring disease and injury burden in populations requires a composite metric that captures both premature mortality and the prevalence and severity of ill-health. The 1990 Global Burden of Disease study proposed disability-adjusted life years (DALYs) to measure disease burden. No comprehensive update of disease burden worldwide incorporating a systematic reassessment of disease and injury-specific epidemiology has been done since the 1990 study. We aimed to calculate disease burden worldwide and for 21 regions for 1990, 2005, and 2010 with methods to enable meaningful comparisons over time.

Methods We calculated DALYs as the sum of years of life lost (YLLs) and years lived with disability (YLDs). DALYs were calculated for 291 causes, 20 age groups, both sexes, and for 187 countries, and aggregated to regional and global estimates of disease burden for three points in time with strictly comparable definitions and methods. YLLs were calculated from age-sex-country-time-specific estimates of mortality by cause, with death by standardised lost

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*Authors listed alphabetically

life expectancy at each age. YLDs were calculated as prevalence of 1160 disabling sequelae, by age, sex, and cause, and weighted by new disability weights for each health state. Neither YLLs nor YLDs were age-weighted or discounted. Uncertainty around cause-specific DALYs was calculated incorporating uncertainty in levels of all-cause mortality, cause-specific mortality, prevalence, and disability weights.

Findings Global DALYs remained stable from 1990 (2·503 billion) to 2010 (2·490 billion). Crude DALYs per 1000 decreased by 23% (472 per 1000 to 361 per 1000). An important shift has occurred in DALY composition with the contribution of deaths and disability among children (younger than 5 years of age) declining from 41% of global DALYs in 1990 to 25% in 2010. YLLs typically account for about half of disease burden in more developed regions (high-income Asia Pacific, western Europe, high-income North America, and Australasia), rising to over 80% of DALYs in sub-Saharan Africa. In 1990, 47% of DALYs worldwide were from communicable, maternal, neonatal, and nutritional disorders, 43% from non-communicable diseases, and 10% from injuries. By 2010, this had shifted to 35%, 54%, and 11%, respectively. Ischaemic heart disease was the leading cause of DALYs worldwide in 2010 (up from fourth rank in 1990, increasing by 29%), followed by lower respiratory infections (top rank in 1990; 44% decline in DALYs), stroke (fifth in 1990; 19% increase), diarrhoeal diseases (second in 1990; 51% decrease), and HIV/AIDS (33rd in 1990; 351% increase). Major depressive disorder increased from 15th to 11th rank (37% increase) and road injury from 12th to 10th rank (34% increase). Substantial heterogeneity exists in rankings of leading causes of disease burden among regions.

Interpretation Global disease burden has continued to shift away from communicable to non-communicable diseases and from premature death to years lived with disability. In sub-Saharan Africa, however, many communicable, maternal, neonatal, and nutritional disorders remain the dominant causes of disease burden. The rising burden from mental and behavioural disorders, musculoskeletal disorders, and diabetes will impose new challenges on health systems. Regional heterogeneity highlights the importance of understanding local burden of disease and setting goals and targets for the post-2015 agenda taking such patterns into account. Because of improved definitions, methods, and data, these results for 1990 and 2010 supersede all previously published Global Burden of Disease results.

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†Joint senior authors
‡Corresponding author
See Online for appendix
For **interactive versions of figures 2, 3, 5, 7, and 10** see http://healthmetricsandevaluation.org/gbd/visualizations/regional
Queensland Centre for Mental Health Research (A Baxter MPH, H Erskine BPsySc, A Ferrari BPsySc, J-P Khoo MBBS, S Saha PhD, Prof H Whiteford MBBS), **School of Population Health** (Prof T Vos PhD, J D Blore PhD, F Charlson MPH, H Higashi PhD, Y Y Lee MHEcon, R Norman PhD, A Page PhD, Prof A D Lopez PhD), **Centre for Clinical Research** (J G Scott PhD), **Queensland Brain Institute** (Prof J McGrath MD), **University of Queensland, Brisbane, QLD, Australia** (B Garcia MPH, Prof W Hall PhD); **Institute for Health Metrics and Evaluation** (A D Flaxman PhD, M Naghavi PhD, Prof R Lozano MD, S Y Ahn MPH, M Alvarado BA, K G Andrews MPH, C Atkinson BS, I Bolliger AB, R Burstein BA, B Campbell BA, D Chou BA, K E Colson BA, Prof S D Dharmaratne MBBS, A Delossantos BS, M H Forouzanfar MD, M K Freeman BA, E Gakidou PhD, D Gonzalez-Medina BA, D Haring BS, S L James MPH, R Jasrasaria BA, N Johns BA, S S Lim PhD, S Lockett Ohno BA, M F MacIntyre EdM, L Mallinger MPH, A A Mokdad MD, M N Nair MD, K Ortblad BA, D Phillips BS, K Pierce BA, D Ranganathan BS, T Roberts BA, L C Rosenfeld MPH, E Sanman BS, M Wang MPH, S Wulf MPH, Prof C J L Murray MD), **Department of Epidemiology, School of Public Health** (L M Anderson PhD), **Department of Anesthesiology and Pain Medicine** (N Kassebaum MD), **University of Washington, Seattle, WA, USA** (Prof W Couser MD, H Duber MD, B Ebel MD, Prof C Mock MD, C Olives PhD, Prof F P Rivara MD, B Thomas MD, Prof M S Vavilala MD); **China Medical Board, Boston, MA, USA** (C Michaud MD); **MRC-HPA Centre for Environment and Health, Department of Epidemiology and Biostatistics, School of Public Health** (Prof M Ezzati PhD), **Imperial College London, London,**

Introduction

Summary measures of population health combine information on mortality and non-fatal health outcomes to provide unique perspectives on levels of health and key contributing causes to loss of health.[1] There are three related but distinct uses of summary measures of population health at the global, regional, national, or subnational levels. Summary measures can be used, first, to compare overall population health across communities and over time; for example, national estimates of healthy life expectancy (HALE) have been published for 191 countries.[2] The second and more common use of summary measures is to provide a coherent overall picture as to which diseases, injuries, and risk factors contribute the most to health loss in a given population. The comparative view provided by summary measures helps decision-makers, researchers, and citizens understand what the most important problems are and whether they are getting better or worse. This information, along with information on the costs, intervention effectiveness, and equity implications of health interventions and policy options, lays the foundation for a debate on priorities for health policy action and research that is clearly informed by the best available evidence. Third, summary measures can help guide an assessment of where health information systems are strong or weak by identifying which data sources required for their calculation are missing, of low quality, or highly uncertain. Different users in different contexts will make use of summary measures for any of the three purposes.

The only comprehensive effort to date to estimate summary measures of population health for the world, by cause, is the ongoing Global Burden of Diseases, Injuries, and Risk Factors (GBD) enterprise. For a summary measure of population health, the GBD study uses disability-adjusted life years (DALYs), which are the sum of years of life lost due to premature mortality (YLL) and years lived with disability (YLD). While the term disability has taken on many different meanings in different settings,[3–7] in the GBD lexicon it refers to any short-term or long-term health loss, other than death. The construct of health in the GBD study is defined in terms of functioning, which encompasses multiple domains of health such as mobility, pain, affect, and cognition.[8] Final GBD results for 1990 were published in 1996 and 1997.[9–14] GBD estimates were produced for 1999, 2000, 2001, 2002, and 2004 by WHO.[15–19] Although GBD results have been estimated by WHO for 1999–2004, and incorporated new approaches to mortality measurement,[20] these updates undertook systematic analysis of the epidemiological data for only a subset of disease sequelae.[21] DALY results have been referenced extensively in global health debates and decision-making. The first results from the GBD study for 1990 were published in the *World Development Report 1993: Investing in Health*.[22] The study has led to many national burden of disease studies in developed and developing countries using similar methods.[23–75] Subnational studies

have also been done in many countries.[76–81] Quantifying health loss in terms of DALYs has led to increased attention to mental health problems[82] and injuries,[83] non-fatal health effects of neglected tropical diseases,[84] and more generally non-communicable diseases (NCDs).[85]

The Global Burden of Diseases, Injuries, and Risk Factors Study 2010 (GBD 2010)[86] has been implemented as a collaboration of seven institutions: the Institute for Health Metrics and Evaluation (IHME) as the coordinating centre providing academic leadership; the University of Queensland School of Population Health; WHO; the Johns Hopkins Bloomberg School of Public Health; the Harvard School of Public Health; Imperial College London; and the University of Tokyo. The GBD 2010 has been undertaken to apply comparable, systematic, and rigorous epidemiological assessment of all diseases and injuries. The number of disease and injury sequelae has expanded from 483 to 1160. The study also uses a much more detailed set of age groups, 20 instead of eight; and 21 regions instead of the 14 used in the GBD 2000 study.[86]

In the GBD 1990 study, results were computed with several variants of DALYs reflecting different social-value choices for discounting and age-weighting. The base case reported for DALYs used a 3% discount rate and age weights that placed the greatest emphasis on health outcomes in young adults. WHO has continued in its updates for 1999, 2000, 2001, 2002, and 2004 to use this base case set of social-value choices although other variants have been calculated. One publication for 2001 reported discounted DALYs without age-weighting.[87] On the basis of broad consultation,[86] the base case for DALYs in GBD 2010 has been simplified to omit both discounting and age-weighting. YLLs are calculated with reference to a new reference-standard life expectancy at each age; for example, a death at age 5 years counts as 81·4 YLLs and a death at age 60 counts as 27·8 YLLs.[86] The reference standard has been computed on the basis of the lowest age-specific death rates recorded across countries in 2010. YLDs are based on the product of the prevalence of a sequela and its associated disability weight. Of note, the empirical basis for disability weights in the GBD 2010 derives from judgments of the general public about health severity, by contrast with the GBD 1990 study that relied on judgments of health-care professionals.[3] A key tenet of the GBD analytical philosophy is not to allow advocates for the importance of specific diseases to choose the disability weights associated with specific disorders (panel).

The goal of the GBD 2010 has been to synthesise available data on the epidemiology of all major diseases and injuries to provide a comprehensive and comparable assessment of the magnitude of 291 diseases and injuries and their associated sequelae in 1990, 2005, and 2010. In this Article, we summarise the results of a large and complex study involving hundreds of researchers. The findings draw on millions of observations of epidemiological parameters over the past three decades. By

Panel: Disability-adjusted life years and Global Burden of Disease definitions

1. Disability-adjusted life years (DALYs) are a summary metric of population health. DALYs represent a health gap; they measure the state of a population's health compared to a normative goal. The goal is for individuals to live the standard life expectancy in full health.
2. DALYs are the sum of two components: years of life lost due to premature mortality (YLLs) and years lived with disability (YLDs).
3. YLLs are computed by multiplying the number of deaths at each age x by a standard life expectancy at age x. The standard selected represents the normative goal for survival and has been computed based on the lowest recorded death rates across countries in 2010.
4. YLDs are computed as the prevalence of different disease-sequelae and injury-sequelae multiplied by the disability weight for that sequela. Disability weights are selected on the basis of surveys of the general population about the loss of health associated with the health state related to the disease sequela.
5. DALYs are an absolute measure of health loss; they count how many years of healthy life are lost due to death and non-fatal illness or impairment. They reflect the number of individuals who are ill or die in each age-sex group and location. Population size and composition influences the number of DALYs in a population.
6. The GBD 2010 disease-and-injury-cause list is a hierarchical list of 291 diseases and injuries. At the first level of disaggregation causes are divided into three broad groups: communicable, maternal, neonatal, and nutritional disorders; non-communicable diseases; and injuries. At each level in the hierarchy, the cause list provides a set of mutually exclusive and collectively exhaustive categories.
7. Sequelae—in total, we have identified 1160 sequelae of the 291 diseases and injuries. For example, diabetic neuropathy is a sequela of diabetes mellitus. To avoid double counting, a sequela can only appear in the cause-sequela list once even if the same outcome might be claimed by more than one disease.
8. Health states—across the 1160 sequelae, 220 unique health states were identified. For example, both malaria and hookworm have mild anaemia as a sequela. Mild anaemia is a unique health state. The list of unique health states serves two purposes: (a) to allow assessment of the total burden of some health states such as anaemia across various causes; and (b) to simplify the task of measuring disability weights for sequelae.
9. DALYs presented in this study are not age-weighted and are not discounted for time preference. Base case tabulations for the GBD 1990 and GBD 2000 studies used age-weighting and a 3% discount rate.
10. Because of improved data and methods, comparisons between 1990 and 2010 should be based exclusively on the results of this study.

UK (Prof M-G Basáñez PhD, Prof P Burney MD, K Foreman MPH, D Jarvis FFPH, S O'Hanlon MSc, L Rushton PhD); **Department of Global Health Policy** (Prof K Shibuya MD), **University of Tokyo, Tokyo, Japan** (Prof N Kawakami MD); **Department of Biostatistics** (M M Finucane PhD), **School of Public Health** (Prof J A Salomon PhD, G Danaei MD, F Laden ScD, J K Lin AB, M Miller MD, G M Singh PhD, C Sudfeld ScM, M Tavakkoli MD, M G Weisskopf PhD, R A White MA), **Department of Epidemiology** (W Liu MD), **Harvard Humanitarian Initiative** (L M Knowlton MD), **Boston Children's Hospital** (Prof S D Colan MD), **Brigham and Women's Hospital** (S Jayaraman MD), **Harvard Medical School, Harvard University, Boston, MA, USA** (D H Bartels BA, K Bhalla PhD); **Sudanese Public Health Consultancy Group, Sudan** (S Abdalla MBBS); **Department of Cardiology, Dupuytren University Hospital, Limoges, France** (Prof V Aboyans MD); **University of Texas, San Antonio, TX, USA** (J Abraham MPH); **Centre for International Child Health** (A Steer MBBS), **Department of Pediatrics** (R Weintraub MBBS), **Centre for Health Policy, Programs and Economics** (Prof L Degenhardt PhD), **School of Population Health** (Prof R Room PhD), **University of Melbourne, Melbourne, VIC, Australia** (I Ackerman PhD, Prof P Brooks MD, Prof R Marks MBBS, Prof H R Taylor MD); **Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, India** (Prof R Aggarwal MD); **Schools of Public Health and Medicine** (S B Omer MBBS), **Emory University, Atlanta, GA, USA** (M K Ali MBChB, K C Dabhadkar MBBS, K M V Narayan MD, H A Ganatra MBBS); **Ministry of Health, Riyadh, Saudi Arabia** (M A AlMazroa MD, Prof Z A Memish MD); **St George's University of London, London, UK** (Prof H R Anderson MD, R Gupta MSc, E Limb MSc); **Mayo Clinic, Rochester, MN, USA** (Prof L M Baddour MD, P J Erwin MLS, Prof S E Gabriel MD); **Independent Consultant,**

Geneva, Switzerland (A N Bahalim MEng); University of Auckland, Auckland, New Zealand (S Barker-Collo PhD); Department of Industrial Engineering, School of Engineering, Pontificia Universidad Javeriana, Bogota, Colombia (L H Barrero ScD); Global Partners in Anesthesia and Surgery (D Ozgediz MD), Yale University, New Haven, CT, USA (Prof M L Bell PhD, J J Huang MD); School of Medicine (Prof D T Felson MD), Boston University, Boston, MA, USA (Prof E J Benjamin MD); Clinical Trial Service Unit and Epidemiological Studies Unit (D Bennett PhD), University of Oxford, Oxford, UK (Prof C R Newton MD, D J Weatherall MD); Dental Institute (E Bernabé PhD), Hospital NHS Trust (Prof R J Hay DM), Institute of Psychiatry, King's College London, London, UK (Prof M Prince MD); Institute of Dentistry (M Dahiya BDS), Queen Mary University of London, London, UK (B Bhandari MSc, Prof W Marcenes PhD); Moscow State University of Medicine and Dentistry, Research Institute of Transplantology and Artificial Organs, Moscow, Russia (B Bikbov MD); King Fahad Medical City, Riyadh, Saudi Arabia (A Bin Abdulhak MD, I M Tleyjeh MD); Michigan State University, East Lansing, MI, USA (Prof G Birbeck MD); MRC Epidemiology Unit, Cambridge, UK (J A Black MPhil); London School of Hygiene and Tropical Medicine, London, UK (Prof S Brooker DPhil, H Blencowe MBChB, K Edmond PhD, Prof N Pearce PhD, R L Pullan PhD, J L Smith MSc); Department of Rheumatololgy, Northern Clinical School (E Smith PhD), Faculty of Health Sciences (M Fransen PhD), Institute of Bone and Joint Research (Prof L March MD, L Sanchez-Riera MD), Sydney School of Public Health (T Driscoll PhD, J Leigh MBBS), University of Sydney, Sydney, NSW, Australia (F Blyth PhD, L Bridgett PhD, M Cross PhD, Prof G B Marks PhD, N McGill FRACP); Inserm, Paris, France (A Bonaventure MD, A Elbaz MD); Transport and Road Safety Research (S Boufous PhD), National

the synthetic nature of the work, we provide a high-level overview of key findings. Because this study uses consistent definitions and improved methods to assess the GBD over two decades, the findings supersede all previously published GBD results.

Methods

Study design

The division of countries into 21 epidemiological regions, the choice of 20 age groups, and the primary methods for each of the 18 components of the study are described by Murray and colleagues.[86] We provide only a brief description here. The GBD cause list has 291 diseases and injuries, which are organised in a hierarchy with up to four levels of disaggregation. For each cause, there are from one to 24 sequelae. In total, the study includes 1160 sequelae. The expansion of the cause list and the criteria used to add causes and sequelae across various revisions of the GBD study is described elsewhere.[86]

Causes of death

YLLs have been computed on the basis of cause-of-death estimates for 235 of 291 causes of death for 20 age groups, both sexes, and 187 countries. Two disorders, sudden infant death syndrome (SIDS) and aortic aneurysm, cause only YLLs. Cause of death estimates have been developed with a comprehensive database of vital registration, verbal autopsy, surveillance, and other sources covering 187 countries from 1980 to 2010. Quality of each observation has been assessed, and various revisions of the International Classification of Diseases and Injuries (ICD) have been mapped. Deaths assigned to causes that are not likely to underlie causes of death have been reassigned with standardised algorithms.[88,89] All observations were converted to the 20 standard GBD age groups. For 133 causes, including all major causes of death excluding HIV/AIDS, we used the Cause of Death Ensemble model (CODEm) strategy to develop ensembles of the best performing models that meet two plausibility criteria. The first criterion is that the direction of the regression coefficient for a covariate is in the expected direction, and the second is that the coefficient has a p value less than 0·05. Performance is assessed in terms of rigorous out-of-sample predictive validity testing based on the root-mean-squared error of the log of the age-specific death rates, the percentage of time that trend is accurately predicted, and the coverage of the uncertainty intervals (UIs). For HIV/AIDS, we have used CODEm for countries with high-quality vital registration systems and the UNAIDS 2012 revision estimates by age and sex for the remaining countries. Natural history models have been used for African trypanosomiasis, measles, whooping cough, hepatitis E, typhoid and paratyphoid fevers, leishmaniasis, HIV/AIDS, and congenital syphilis. Aetiologies or subcauses for diarrhoea, lower respiratory infections, meningitis, chronic kidney diseases, maternal disorders, cirrhosis, and liver cancer have been based on meta-regression of published studies on aetiology, disease registry data, and, where appropriate, vital registration data. For some rarer causes such as diphtheria or varicella, negative binomial regression has been used; for a few causes that rarely account for mortality, fixed proportions of the parent cause in the hierarchy have been used by age, sex, and region. A key aspect of the GBD method is to enforce consistency between the sum of cause-specific mortality and independently assessed levels of all-cause mortality derived from demographic sources (see Wang and colleagues[90] for details on the all-cause-mortality analysis). Uncertainty in cause-of-death model predictions has been captured with standard simulation methods by taking 1000 draws[91] for each age, sex, country, year, and cause (see Lozano and colleagues[92] for more details on causes-of-death methods). Consistency with all-cause mortality is enforced at the draw level. Final uncertainty for YLLs reflects uncertainty in the levels of all-cause mortality in each age-sex-country-year as well as uncertainty in the estimation of each cause of death for that age-sex-country-year.

Years lived with disability

The second component of DALYs is YLDs. YLDs have been estimated for 1160 sequelae of the diseases and injuries in the hierarchical cause list. YLDs are the product of prevalence times the disability weight for a sequela. Prevalence estimation for each sequela begins with a systematic analysis of published and available unpublished data sources for prevalence, incidence, remission, and excess mortality. For most sequelae, estimates have been made based on the database for all age-sex-country-year groups, with a Bayesian meta-regression method developed for the GBD 2010 (DisMod-MR). The meta-regression can handle data reported for any age interval and can use two types of covariates: those that explain true variation in prevalence; and those that explain variation across studies due to study design, case definitions, or diagnostic technology. Nested super-region, region, and country random intercepts are also included. A map of regions and super-regions is published elsewhere.[86] Where appropriate, DisMod-MR uses data on incidence, prevalence, remission, excess mortality, and cause-specific mortality to generate prevalence estimates assuming these rates are stable over time. Using data on multiple epidemiological parameters to estimate prevalence is especially important when prevalence data are sparse. Where rates are changing rapidly, DisMod-MR can be used to undertake meta-regression without assuming equilibrium rates. Alternative strategies have been used for the prevalence of selected sequelae (see elsewhere for details).[93] DisMod-MR and alternative methods generate uncertainty distributions for the prevalence of each sequela by age, sex, country, and year. For nine residual cause categories such as other mental and behavioural disorders, YLDs have been approximated with the relation between YLLs and YLDs reported for similar disease groupings.

For the GBD 2010, disability weights have been measured for 220 unique health states that encompass the 1160 disease and injury sequelae. The number of health states is lower than the number of sequelae because the same health status such as anaemia appears in the cause sequela list multiple times (eg, mild anaemia from malaria, or mild anaemia from chronic kidney diseases). Disparate outcomes across some diseases have been grouped into a small number of more homogeneous outcomes. For example, disability from all acute infectious disease episodes was captured by a mild, moderate, or severe health state. Disability weights have been generated using data collected from more than 31000 respondents through population-based surveys in five countries—USA, Peru, Tanzania, Bangladesh, and Indonesia—and an open internet survey. The primary elicitation method used was pairwise comparisons of two randomly selected health states where the respondent selects which health state represents the higher level of health. Results for health-state severities were consistent across levels of educational attainment and cultural groups.[3] Uncertainty in the disability weight for each sequela has been propagated into the estimates of YLDs for each disease and injury. Salomon and colleagues[3] provide detail on the methods used to analyse the results of pairwise comparisons to yield disability weights.

Ranking lists

For presentation of the leading causes of DALYs, we need to choose the level in the cause hierarchy at which we rank disorders. Because the leading causes of burden tend to have some influence on the perception of disease-control priorities, the choice of aggregation is at once important and subject to debate. To help convey the complexity of the burden of disease results, we show information at the second level of the GBD cause hierarchy (21 causes); we have also identified a ranking list with 176 causes selected to distinguish and cluster disorders that might have programmatic or public-health significance. We aggregated detailed causes within the broader categories of maternal disorders, diarrhoeal diseases, lower respiratory infections, stroke, and road injury for this reason. The full ranking list is included in the report by Murray and colleagues.[86] Results in the tables are provided for all 291 causes; the ranking list is used only for the figures illustrating the leading cause of DALYs. The 176 causes do not include residual categories such as other parasitic or other cardiovascular diseases because these categories represent complex aggregations of detailed causes for which no clear public health programme exists. The 176 causes along with the excluded residual categories are also mutually exclusive and collectively exhaustive.

Regional ordering and uncertainty

For figures where we present information by region, we order regions by the mean age of death.[90] Mean age of death reflects both population age-structure and age-specific death rates and is a simple summary measure of the demographic and epidemiological transition. Mean age of death is a particularly useful metric because average age of the population and age-specific death rates are negatively correlated.

The models used to generate estimates of YLLs and YLDs produce uncertainty intervals that include correlation of uncertainty across age, sex, and time for a given outcome. In the absence of data and a method that would allow one to estimate the correlation of uncertainty between YLLs and YLDs, we had to assume that, for estimating DALYs in an age-sex-country-year-cause, YLL and YLD uncertainty distributions were independent. We computed many different aggregations of DALYs, for example global and regional DALYs for an age group or aggregations for developed or developing regions. For all geographic aggregates, we assumed that uncertainty distributions of the components across countries were independent. In practice, uncertainty from all inputs into the calculations of YLLs, YLDs, and DALYs are propagated with Monte Carlo techniques where 1000 samples are from the posterior distribution. Aggregations are made at the level of the 1000 draws for all estimates that are being summarised. The uncertainty interval (UI) around each quantity of interest is presented as the 2·5th and 97·5th centile values. These ranges can be interpreted as a 95% UI.

Decomposition of change from 1990 to 2010

To help understand the drivers of change in the numbers of DALYs by cause, we have decomposed change from 1990 to 2010 into growth in total population, change in population age-structure and sex-structure, and change in age-specific and sex-specific rates. We compute two counterfactual sets of DALY numbers: (1) a population growth scenario computed as the number of DALYs expected in 2010 if only total population numbers increased to the level of 2010 but the age-sex structure of population stayed the same as in 1990 and age-specific and sex-specific rates remained at 1990 levels and (2) a population growth and population ageing scenario computed as the number of DALYs expected in 2010, using 1990 age-specific and sex-specific rates and 2010 age-specific and sex-specific population numbers. The difference between 1990 numbers and the population growth scenario is the change in DALY numbers due strictly to the growth in total population. The change from the population growth scenario to the population growth and ageing scenario is the number of deaths due to ageing of the population. The difference between 2010 DALYs and the population growth and ageing scenario is the difference in DALY numbers due to epidemiological change in age-specific and sex-specific death rates. Each of these three differences is also presented as a percentage change with reference to the 1990 observed death number.

Further details on the data and methods used for specific diseases and injuries are available on request.

Drug and Alcohol Research Centre (B Calabria BPsych, Prof L Degenhardt, P K Nelson MHSc, J Singleton MIPH), **University of New South Wales, Sydney, NSW, Australia** (C Bucello BPsyc, Prof P B Mitchell MD); **Vision and Eye Research Unit, Anglia Ruskin University, Cambridge, UK** (Prof R Bourne MD); **Institut de Recherche pour le Développement, Martinique, France** (M Boussinesq MD, S Pion PhD); **Moorfields Eye Hospital, London, UK** (T Braithwaite BMBCh); **University of Cambridge, Cambridge, UK** (Prof C Brayne MD, K Richardson MSc); **University of Leicester, Leicester, UK** (Prof T S Brugha MD); **Flinders University, Adelaide, SA, Australia** (C Bryan-Hancock BPsych, Prof J E Harrison MBBS, L Flood MBBS, T Lathlean MA, Prof K Pesudovs PhD); **Cabrini Institute, Malvern, VIC, Australia** (Prof R Buchbinder MBBS); **Department of Epidemiology and Preventive Medicine** (B J Gabbe PhD), **Monash University, Melbourne, VIC, Australia** (Prof R Buchbinder MBBS, D Hoy PhD); **Bloomberg School of Public Health** (G Buckle MPH, S Manivannan ScM), **Johns Hopkins University, Baltimore, MD, USA** (E R Dorsey MD, R Shivakoti BA); **Texas A&M University, College Station, TX, USA** (C M Budke PhD); **Great Ormond Street Hospital, London, UK** (M Burch MD); **Washington University, St Louis, MO, USA** (Prof C E Canter MD); **University of Oklahoma Health Sciences Center, Oklahoma City, OK, USA** (Prof H Carabin PhD); **Telethon Institute for Child Health Research, Centre for Child Health Research** (Prof J Carapetis MBBS), **University of Western Australia, Perth, WA, Australia** (Prof P Norman MD); **Universidad Camilo Jose Cela, Villanueva de la Cañada, Spain** (Loreto Carmona MD); **Mario Negri Institute for Pharmacological Research, Bergamo, Italy** (C Cella PharmChemD, M Cortinovis BiotechD, F Gaspari ChemD, V Miglioli, N Perico MD, Prof G Remuzzi MD); **National Institute of Environmental Health Sciences,**

Research Triangle Park, NC, USA (H Chen PhD); Institute of Biomedical Sciences, Academia Sinica, Taipei, Taiwan (Prof A T-A Cheng MD); Heart Institute (R Havmoeller MD), Cedars-Sinai Medical Center, Los Angeles, CA, USA (Prof S S Chugh MD); Department of Public Health (S Polinder PhD), Erasmus MC, University Medical Center Rotterdam, Rotterdam, Netherlands (L E Coffeng MD, J Haagsma PhD, W A Stolk PhD); Menzies School of Health Research, Darwin, NT, Australia (S Colquhoun MPH, J Condon PhD); National Health Services, Fife, Edinburgh, Scotland, UK (M D Connor PhD); University of Edinburgh, Edinburgh, Scotland, UK (M D Connor, E M Fèvre PhD, Prof F G R Fowkes FRCPE); University of the Witwatersrand, Johannesburg, South Africa (M D Connor); Loyola University Medical School, Chicago, IL, USA (Prof L T Cooper MD); School of Public Health Sciences, Wake Forest University, Winston-Salem, NC, USA (M Corriere MD); Hospital Dr Gustavo N Collado, Puerto Chitre, Panama (K Courville de Vaccaro MD); Victorian Infectious Diseases Reference Laboratory, Melbourne, VIC, Australia (B C Cowie MBBS); University of California, San Diego, San Diego, CA, USA (Prof M H Criqui MD, J Denenberg MA); University of Pennsylvania, Philadelphia, PA, USA (N Dahodwala MD, Prof D J Margolis MD);

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Results

In 2010, there were a total of 2·490 billion DALYs, or 361 DALYs per 1000 population. Globally, 31·2% of DALYs in 2010 were from YLDs and 68·8% from YLLs. YLDs make very little contribution to the burden in the neonatal age groups but increase to a peak in age group 10–14 years when mortality rates are generally the lowest (figure 1). In nearly all age groups, YLDs make up a larger share of DALYs in women than in men. Globally, YLDs in women caused 50% or more of DALYs up until age 45 years and then declined slowly but still caused about 30% of DALYs over the age of 70 years.

Across broad cause groups, the distribution of DALYs in 2010 reflected a predominance of NCDs globally, with 54% of all DALYs due to non-communicable diseases, compared with 35% due to communicable, maternal, neonatal, and nutritional disorders, and 11% due to injuries. The composition of global DALYs in 2010 shows the diversity of causes that make major contributions to the burden of disease. Cancers and circulatory diseases accounted for 19% of global DALYs, while about a third of the global burden of disease was from other NCDs including chronic respiratory, digestive, neurological, mental and behavioural, endocrine, kidney, musculoskeletal, and other disorders. In the early and late neonatal age groups, neonatal disorders, diarrhoea, lower respiratory infections, and the category other NCDs, which includes congenital anomalies, were most common (figure 2). For children older than the age of 1 month, the cluster of diarrhoea, lower respiratory infections and other infections, nutritional deficiencies, malaria and neglected tropical diseases, and a diverse set of other causes start to play an increasing part. For young adult men from 15–39 years of age, the main causes of DALYs were HIV/AIDS and tuberculosis, mental and behavioural disorders, road injuries, unintentional injuries other than transport, intentional injuries, and wars or disasters. In young women, the same set of causes plus deaths and YLDs due to maternal disorders occurred. At older ages, cancers, cardiovascular diseases, musculoskeletal disorders, chronic respiratory diseases, digestive diseases, and diabetes are important.

The wide range of causes making up the burden of disease is borne out by examining the cumulative burden as a function of a rank list of specific causes. The top ten causes account for 37% of DALYs, the top 25 account for 61% of DALYs, and the top 50 causes account for 78%. Results for all 20 GBD age groups, by male, female, and combined sexes are shown in the appendix. While the results for many causes have public health significance, we highlight causes that lead to more than 15 million DALYs. Tuberculosis accounts for 2·0% of all DALYs, HIV/AIDS 3·3% of DALYs, and malaria 3·3% (table 1). Diarrhoea and lower respiratory infections were very large causes of burden accounting for 3·6% and 4·6% of global DALYs, respectively. Within the broad group of communicable, maternal, neonatal, and nutritional disorders, meningitis (1·2%), maternal disorders (0·6%), protein-energy malnutrition (1·4%), and iron-deficiency anaemia (1·8%) were all substantial causes. Neonatal disorders collectively caused 8·1% of all DALYs because of the large number of deaths at young ages and some lifelong disability. Each of the four causes in neonatal disorders was a major cause: preterm birth complications (3·1%), neonatal encephalopathy (birth asphyxia and birth trauma; 2·0%), sepsis and other infectious disorders of the newborn baby (1·8%), and other neonatal disorders (1·2%).

Several diseases within the NCD group caused more than 15 million DALYs in 2010. All neoplasms accounted for 7·6% of global DALYs. Of the 28 categories of cancer

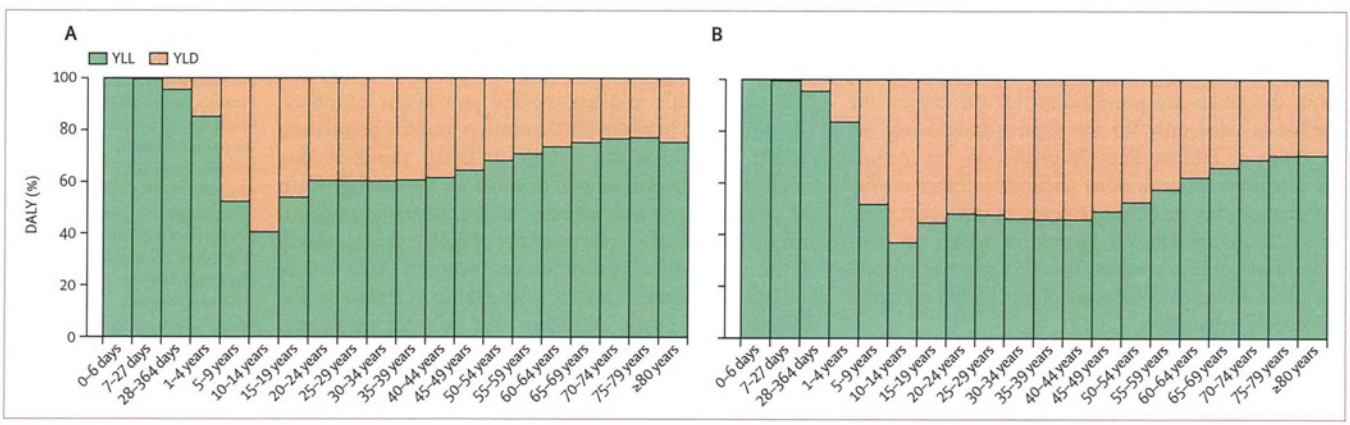

Figure 1: **Years of life lost due to premature mortality and years lived with disability composition of total disability-adjusted life years by age and sex, 2010**
Composition in male individuals (A) and female individuals (B). DALY=disability-adjusted life years. YLD=years lived with disability. YLL=years of life lost due to premature mortality.

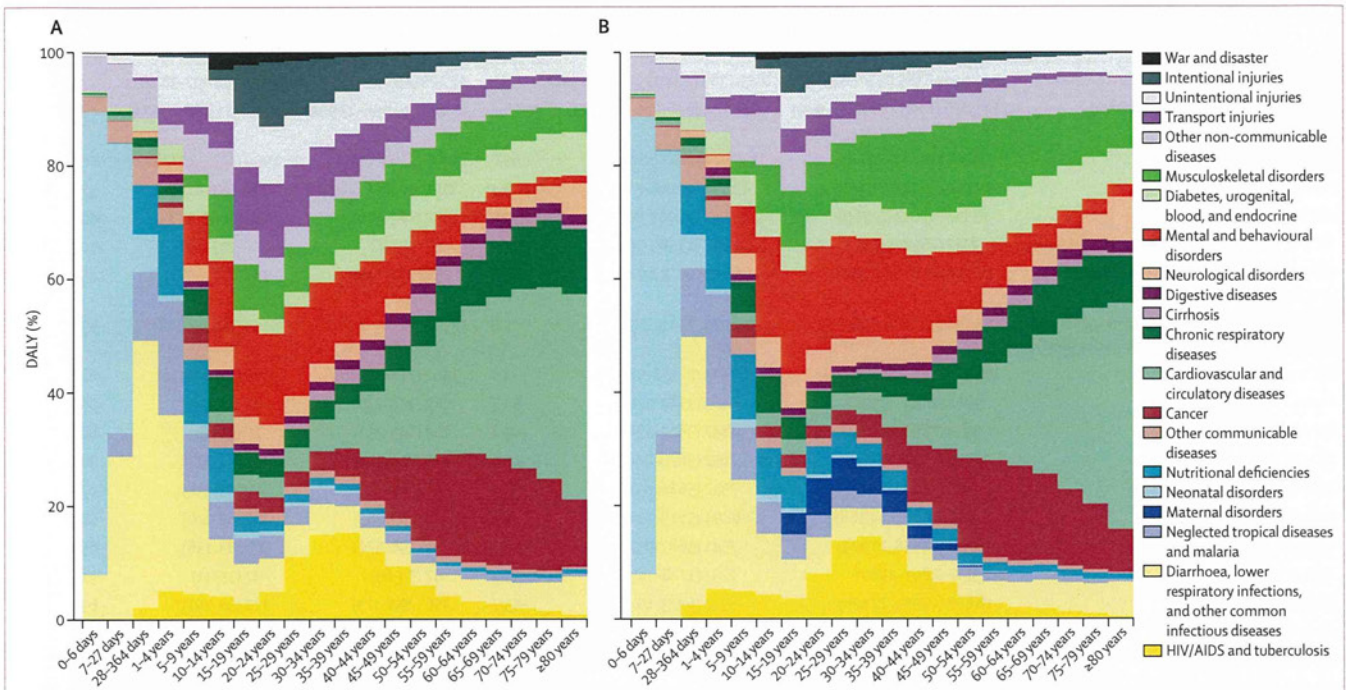

Figure 2: **Percentage of global disability-adjusted life years by age, sex, and cause in 2010**
Distribution of DALYs for male individuals (A) and female individuals (B). DALY=disability-adjusted life years. An interactive version of this figure is available online at http://healthmetricsandevaluation.org/gbd/visualizations/regional.

included in the analysis, four caused more than 15 million DALYs each: stomach cancer (0·7%), other neoplasms (0·7%), liver cancer (0·8%), and trachea, bronchus, and lung cancers (1·3%). Cardiovascular and circulatory diseases accounted for 11·8% of global DALYs; the major diseases within this group are ischaemic heart disease (5·2%), haemorrhagic stroke (2·5%), ischaemic stroke (1·6%), and hypertensive heart disease (0·6%). The larger burden of haemorrhagic stroke compared with ischaemic stroke is mostly a function of the younger average age of death for this form of stroke and consequently more YLLs per death. Chronic respiratory diseases as a group accounted for 4·7% of global DALYs, with chronic obstructive pulmonary disease (COPD) making up two-thirds of the total and asthma nearly a fifth of the total. Surprisingly, cirrhosis accounted for 1·2% of global DALYs with a nearly equal share related to hepatitis B, hepatitis C, and alcohol. 3·0% of global DALYs were from neurological disorders; of which a quarter were due to epilepsy and nearly a third were from migraine. While in some regions dementias were a major cause, at the global level they accounted for 11·3 million DALYs. Mental and behavioural disorders accounted for 7·4% of DALYs; within this large grouping five different diseases caused more than 15 million DALYs each. In order of importance, the main causes were major depressive disorder (2·5%), anxiety disorders (1·1%), drug use disorders (0·8%), alcohol use disorders (0·7%), and schizophrenia (0·6%). Nearly 5·0% of all DALYs were from diseases in the diabetes, urogenital, blood, and endocrine group: the most important diseases were diabetes mellitus (1·9%), chronic kidney diseases (0·8%), and the group of haemoglobinopathies and haemolytic anaemias (0·6%). Musculoskeletal disorders accounted for 6·8% of total DALYs. Of this large total, low back pain accounted for nearly half, neck pain a fifth, and osteoarthritis about 10·0%. A further 5·1% of the GBD was due to causes in the category other NCDs; roughly 30% of which was due each to congenital anomalies, skin diseases, and sense organ diseases.

Injuries collectively caused 11·2% of DALYs with many different injuries making important contributions. The largest was road injuries, which accounted for 27% of the injury total. Within road injuries, nearly equal shares were due to pedestrian injuries, injuries sustained by occupants of three or more wheeled vehicles, and the rest of road injuries. The next most important injury was self-harm (1·5%) followed by falls (1·4%) and interpersonal violence (1·0%). Drowning and fires each accounted for just over 19 million DALYs.

An important innovation in the GBD 2010 is the quantification of uncertainty from all sources entering the estimation of DALYs. Figure 3 shows how the first and second ranked disorders, ischaemic heart disease and lower respiratory infections, have nearly overlapping uncertainty distributions but do not overlap with any of the lower ranked causes. There are many examples of

Building and Road Research Institute, Kumasi, Ghana (J Damsere-Derry MPH); **MRC Hearing and Communication Group, Manchester, UK** (Prof A Davis PhD); **School of Dentistry and Oral Health (Prof R Lalloo PhD), Population and Social Health Research Program** (Prof R Lalloo), **Griffith University, Brisbane, QLD, Australia** (Prof D De Leo DSc, N J C Stapelberg MBBS); **Denver VA Medical Center, Denver, CO, USA** (R Dellavalle MD); **University of Otago, Dunedin, New Zealand** (S Derrett PhD, R Grainger PhD, T R Merriman PhD, W J Taylor PhD, Prof W M Thomson PhD); **Beth Israel Medical Center, New York City, NY, USA** (D C Des Jarlais PhD); **University of Peradeniya, Peradeniya, Sri Lanka** (Prof S D Dharmaratne); **The University of Liverpool, Liverpool, UK** (M Dherani PhD); **Hospital de la Santa Creu i Sant Pau, Barcelona, Spain** (C Diaz-Torne MD); **University of Ulster, Ulster, UK** (Prof H Dolk DrPH, M Loane MSc); **Federal Ministry of Health, Khartoum, Sudan** (S Eltahir Ali Mcs); **Hospital**

	All ages DALYs (thousands)			DALYs (per 100 000)		
	1990	2010	%Δ	1990	2010	%Δ
All causes	**2 502 601 (2 389 053–2 639 606)**	**2 490 385 (2 349 250–2 637 538)**	**–0·5**	**47 205 (45 063–49 789)**	**36 145 (34 097–38 281)**	**–23·4**
Communicable maternal, neonatal, and nutritional disorders	**1 181 610 (1 113 122–1 268 900)**	**868 024 (818 934–921 489)**	**–26·5**	**22 288 (20 996–23 934)**	**12 598 (11 886–13 374)**	**–43·5**
HIV/AIDS and tuberculosis	79 368 (72 264–90 448)	130 944 (119 310–141 121)	65·0	1497 (1363–1706)	1900 (1732–2048)	26·9
Tuberculosis	61 250 (55 443–71 077)	49 396 (40 065–56 071)	–19·4	1155 (1046–1341)	717 (581–814)	–37·9
HIV/AIDS	18 117 (15 012–22 260)	81 547 (75 003–88 367)	350·1	342 (283–420)	1184 (1089–1283)	246·3
HIV disease resulting in mycobacterial infection	3281 (2658–4135)	14 948 (13 589–16 410)	355·5	62 (50–78)	217 (197–238)	250·5
HIV disease resulting in other specified or unspecified diseases	14 836 (12 246–18 359)	66 600 (60 517–72 845)	348·9	280 (231–346)	967 (878–1057)	245·4
Diarrhoea, lower respiratory infections, meningitis, and other common infectious diseases	543 168 (491 308–624 755)	282 982 (254 312–317 466)	–47·9	10 245 (9267–11 784)	4107 (3691–4608)	–59·9
Diarrhoeal diseases	183 538 (168 790–198 052)	89 513 (77 572–98 906)	–51·2	3462 (3184–3736)	1299 (1126–1436)	–62·5
Cholera	9802 (7834–12 198)	4463 (3344–5787)	–54·5	185 (148–230)	65 (49–84)	–65·0
Other salmonella infections	9550 (7690–11 625)	4847 (3819–5949)	–49·2	180 (145–219)	70 (55–86)	–60·9
Shigellosis	13 575 (11 325–16 120)	7052 (5676–8466)	–48·1	256 (214–304)	102 (82–123)	–60·0
Enteropathogenic *E coli* infection	17 808 (14 243–21 647)	7542 (5686–9524)	–57·6	336 (269–408)	109 (83–138)	–67·4
Enterotoxigenic *E coli* infection	12 629 (10 768–14 968)	6894 (5619–8286)	–45·4	238 (203–282)	100 (82–120)	–58·0
Campylobacter enteritis	16 611 (13 558–19 924)	7541 (5687–9374)	–54·6	313 (256–376)	109 (83–136)	–65·1
Amoebiasis	3577 (2861–4389)	2237 (1728–2832)	–37·5	67 (54–83)	32 (25–41)	–51·9
Cryptosporidiosis	18 897 (15 579–22 426)	8372 (6473–10 401)	–55·7	356 (294–423)	122 (94–151)	–65·9
Rotaviral enteritis	42 224 (35 313–48 745)	18 650 (14 431–22 746)	–55·8	796 (666–919)	271 (209–330)	–66·0
Other diarrhoeal diseases	38 865 (28 644–51 813)	21 916 (16 031–28 760)	–43·6	733 (540–977)	318 (233–417)	–56·6
Typhoid and paratyphoid fevers	9256 (1281–17 123)	12 239 (1702–23 043)	32·2	175 (24–323)	178 (25–334)	1·7
Lower respiratory infections	206 460 (183 340–222 982)	115 227 (102 282–126 985)	–44·2	3894 (3458–4206)	1672 (1485–1843)	–57·1
Influenza	32 428 (28 369–36 097)	19 244 (16 906–21 451)	–40·7	612 (535–681)	279 (245–311)	–54·3
Pneumococcal pneumonia	43 371 (38 585–47 618)	26 906 (23 723–29 865)	–38·0	818 (728–898)	391 (344–433)	–52·3
H influenzae type B pneumonia	43 895 (38 426–48 914)	21 315 (18 581–24 305)	–51·4	828 (725–923)	309 (270–353)	–62·6
Respiratory syncytial virus pneumonia	44 970 (38 833–51 176)	20 472 (17 193–24 136)	–54·5	848 (732–965)	297 (250–350)	–65·0
Other lower respiratory infections	41 796 (36 198–47 564)	27 289 (23 757–30 811)	–34·7	788 (683–897)	396 (345–447)	–49·8
Upper respiratory infections	1695 (1007–2797)	1866 (1049–3189)	10·1	32 (19–53)	27 (15–46)	–15·3
Otitis media	4171 (2521–8188)	4680 (2946–7589)	12·2	79 (48–154)	68 (43–110)	–13·7
Meningitis	37 815 (33 840–45 081)	29 399 (25 584–33 328)	–22·3	713 (638–850)	427 (371–484)	–40·2
Pneumococcal meningitis	9442 (8322–11 429)	8024 (6946–9065)	–15·0	178 (157–216)	116 (101–132)	–34·6
H influenzae type B meningitis	10 142 (8793–12 574)	6611 (5661–7851)	–34·8	191 (166–237)	96 (82–114)	–49·8
Meningococcal infection	5796 (5126–7055)	5163 (4397–5890)	–10·9	109 (97–133)	75 (64–85)	–31·4
Other meningitis	12 401 (11 069–14 632)	9563 (8108–10 858)	–22·9	234 (209–276)	139 (118–158)	–40·7
Encephalitis	10 157 (8828–12 143)	7141 (6148–8274)	–29·7	192 (167–229)	104 (89–120)	–45·9
Diphtheria	514 (0–4351)	236 (0–2016)	–54·1	10 (0–82)	3 (0–29)	–64·7
Whooping cough	14 331 (236–69 476)	7018 (149–33 926)	–51·0	270 (4–1310)	102 (2–492)	–62·3
Tetanus	21 815 (13 557–34 348)	4663 (2569–7588)	–78·6	411 (256–648)	68 (37–110)	–83·6
Measles	52 570 (15 757–124 079)	10 420 (3453–24 535)	–80·2	992 (297–2340)	151 (50–356)	–84·7
Varicella	847 (106–4875)	581 (145–2773)	–31·4	16 (2–92)	8 (2–40)	–47·2
Neglected tropical diseases and malaria	103 808 (86 028–123 663)	108 739 (87 846–137 588)	4·7	1958 (1623–2333)	1578 (1275–1997)	–19·4
Malaria	69 138 (54 532–85 576)	82 685 (63 426–109 836)	19·6	1304 (1029–1614)	1200 (921–1594)	–8·0
Chagas disease	584 (322–966)	546 (271–1054)	–6·5	11 (6–18)	8 (4–15)	–28·1
Leishmaniasis	5877 (3416–9458)	3317 (2180–4890)	–43·6	111 (64–178)	48 (32–71)	–56·6
African trypanosomiasis	2034 (630–4370)	560 (76–1766)	–72·5	38 (12–82)	8 (1–26)	–78·8
Schistosomiasis	2125 (1052–4230)	3309 (1705–6260)	55·7	40 (20–80)	48 (25–91)	19·8
Cysticercosis	514 (398–650)	503 (379–663)	–2·1	10 (8–12)	7 (5–10)	–24·7
Echinococcosis	152 (60–359)	144 (69–286)	–5·1	3 (1–7)	2 (1–4)	–27·0
Lymphatic filariasis	2368 (1551–3399)	2775 (1807–4000)	17·2	45 (29–64)	40 (26–58)	–9·9
Onchocerciasis	512 (361–687)	494 (360–656)	–3·5	10 (7–13)	7 (5–10)	–25·7

(Continues on next page)

	All ages DALYs (thousands)			DALYs (per 100 000)		
	1990	2010	%Δ	1990	2010	%Δ
(Continued from previous page)						
Trachoma	144 (104–189)	334 (243–438)	132·5	3 (2–4)	5 (4–6)	78·9
Dengue	712 (226–1513)	825 (344–1412)	15·9	13 (4–29)	12 (5–20)	−10·8
Yellow fever	<0·5 (0–0·5)	<0·5 (0–0·5)	15·1	<0·5 (0–0·5)	<0·5 (0–0·5)	−11·4
Rabies	3234 (1866–6509)	1462 (852–2659)	−54·8	61 (35–123)	21 (12–39)	−65·2
Intestinal nematode infections	9008 (4993–15 391)	5184 (2979–8811)	−42·5	170 (94–290)	75 (43–128)	−55·7
Ascariasis	4217 (2291–7148)	1315 (713–2349)	−68·8	80 (43–135)	19 (10–34)	−76·0
Trichuriasis	857 (465–1420)	638 (349–1061)	−25·5	16 (9–27)	9 (5–15)	−42·7
Hookworm disease	3934 (2056–6983)	3231 (1695–5732)	−17·9	74 (39–132)	47 (25–83)	−36·8
Food-borne trematodiases	2394 (635–8501)	1875 (708–4837)	−21·7	45 (12–160)	27 (10–70)	−39·7
Other neglected tropical diseases	5012 (3656–7226)	4724 (3525–6351)	−5·7	95 (69–136)	69 (51–92)	−27·5
Maternal disorders	21 582 (18 000–25 720)	16 104 (12 972–18 912)	−25·4	407 (340–485)	234 (188–274)	−42·6
Maternal haemorrhage	4784 (3923–5713)	3289 (2619–3860)	−31·2	90 (74–108)	48 (38–56)	−47·1
Maternal sepsis	2043 (1701–2508)	1309 (1059–1585)	−35·9	39 (32–47)	19 (15–23)	−50·7
Hypertensive disorders of pregnancy	4108 (3406–4986)	2797 (2254–3357)	−31·9	77 (64–94)	41 (33–49)	−47·6
Obstructed labour	1891 (1451–2625)	1792 (1249–2806)	−5·2	36 (27–50)	26 (18–41)	−27·1
Abortion	3218 (2668–3945)	2138 (1731–2592)	−33·6	61 (50–74)	31 (25–38)	−48·9
Other maternal disorders	5538 (4576–6538)	4778 (3819–5512)	−13·7	104 (86–123)	69 (55–80)	−33·6
Neonatal disorders	273 711 (239 733–300 723)	201 959 (182 138–221 901)	−26·2	5163 (4522–5672)	2931 (2644–3221)	−43·2
Preterm birth complications	105 969 (88 149–120 926)	76 982 (66 233–88 295)	−27·4	1999 (1663–2281)	1117 (961–1282)	−44·1
Neonatal encephalopathy (birth asphyxia/trauma)	60 592 (50 207–75 034)	50 150 (40 521–59 841)	−17·2	1143 (947–1415)	728 (588–869)	−36·3
Sepsis and other infectious disorders of the newborn baby	46 029 (25 147–70 357)	44 236 (27 349–72 418)	−3·9	868 (474–1327)	642 (397–1051)	−26·1
Other neonatal disorders	61 121 (46 110–74 451)	30 591 (25 603–37 360)	−50·0	1153 (870–1404)	444 (372–542)	−61·5
Nutritional deficiencies	111 787 (94 423–134 793)	85 341 (68 823–106 945)	−23·7	2109 (1781–2543)	1239 (999–1552)	−41·3
Protein-energy malnutrition	60 543 (50 360–71 685)	34 874 (27 975–41 628)	−42·4	1142 (950–1352)	506 (406–604)	−55·7
Iodine deficiency	3273 (2143–5008)	4027 (2594–6279)	23·0	62 (40–94)	58 (38–91)	−5·3
Vitamin A deficiency	740 (565–941)	806 (612–1037)	9·0	14 (11–18)	12 (9–15)	−16·1
Iron-deficiency anaemia	46 792 (32 598–66 122)	45 338 (30 977–64 551)	−3·1	883 (615–1247)	658 (450–937)	−25·4
Other nutritional deficiencies	439 (384–552)	295 (218–327)	−32·8	8 (7–10)	4 (3–5)	−48·3
Other communicable, maternal, neonatal, and nutritional disorders	48 186 (39 071–58 574)	41 957 (36 061–49 095)	−12·9	909 (737–1105)	609 (523–713)	−33·0
Sexually transmitted diseases excluding HIV	18 314 (11 399–28 213)	10 978 (6821–16 989)	−40·1	345 (215–532)	159 (99–247)	−53·9
Syphilis	17 014 (10 026–26 765)	9578 (5650–15 409)	−43·7	321 (189–505)	139 (82–224)	−56·7
Sexually transmitted chlamydial diseases	621 (332–1085)	714 (369–1271)	15·0	12 (6–20)	10 (5–18)	−11·5
Gonococcal infection	230 (137–381)	282 (156–481)	22·8	4 (3–7)	4 (2–7)	−5·5
Trichomoniasis	182 (0–549)	167 (0–493)	−8·4	3 (0–10)	2 (0–7)	−29·5
Other sexually transmitted diseases	267 (181–351)	236 (177–339)	−11·5	5 (3–7)	3 (3–5)	−31·9
Hepatitis	10 447 (9780–11 134)	13 258 (11 364–15 855)	26·9	197 (184–210)	192 (165–230)	−2·4
Acute hepatitis A	4945 (2942–7350)	4351 (2412–9026)	−12·0	93 (55–139)	63 (35–131)	−32·3
Acute hepatitis B	2877 (1910–3596)	4674 (3189–6052)	62·5	54 (36–68)	68 (46–88)	25·0
Acute hepatitis C	276 (169–394)	518 (378–713)	87·7	5 (3–7)	8 (5–10)	44·4
Acute hepatitis E	2349 (1339–3675)	3715 (1552–7470)	58·1	44 (25–69)	54 (23–108)	21·7
Leprosy	26 (12–48)	6 (3–11)	−76·6	<0·5 (0–1)	<0·5 (0–0·5)	−82·0
Other infectious diseases	19 399 (13 847–23 286)	17 715 (13 382–21 539)	−8·7	366 (261–439)	257 (194–313)	−29·7
Non-communicable diseases	**1 075 297 (1 001 607–1 159 673)**	**1 343 696 (1 239 973–1 456 773)**	**25·0**	**20 283 (18 893–21 874)**	**19 502 (17 997–21 143)**	**−3·8**
Neoplasms	148 078 (136 775–158 256)	188 487 (174 452–199 037)	27·3	2793 (2580–2985)	2736 (2532–2889)	−2·1
Oesophageal cancer	8139 (6608–10 115)	8943 (6698–10 822)	9·9	154 (125–191)	130 (97–157)	−15·5
Stomach cancer	18 453 (14 113–24 068)	16 413 (12 290–21 537)	−11·1	348 (266–454)	238 (178–313)	−31·6
Liver cancer	13 187 (10 746–15 056)	19 111 (16 655–22 911)	44·9	249 (203–284)	277 (242–333)	11·5
Liver cancer secondary to hepatitis B	6152 (5031–6999)	8938 (7729–10 877)	45·3	116 (95–132)	130 (112–158)	11·8
Liver cancer secondary to hepatitis C	2628 (2194–2937)	4141 (3542–4859)	57·6	50 (41–55)	60 (51–71)	21·3

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	All ages DALYs (thousands)			DALYs (per 100 000)		
	1990	2010	%Δ	1990	2010	%Δ
(Continued from previous page)						
Liver cancer secondary to alcohol use	2645 (2167–2999)	3782 (3295–4488)	42·9	50 (41–57)	55 (48–65)	10·0
Other liver cancer	1762 (1430–2003)	2250 (1964–2687)	27·7	33 (27–38)	33 (29–39)	–1·7
Larynx cancer	2055 (1101–3338)	2367 (1281–3818)	15·1	39 (21–63)	34 (19–55)	–11·4
Trachea, bronchus, and lung cancers	23 850 (18 835–29 845)	32 405 (24 400–38 334)	35·9	450 (355–563)	470 (354–556)	4·5
Breast cancer	8845 (8571–9295)	12 018 (11 514–12 704)	35·9	167 (162–175)	174 (167–184)	4·5
Cervical cancer	5570 (3570–7639)	6440 (4111–8758)	15·6	105 (67–144)	93 (60–127)	–11·0
Uterine cancer	1016 (588–1744)	1272 (630–1825)	25·2	19 (11–33)	18 (9–26)	–3·7
Prostate cancer	2352 (1438–3486)	3787 (2189–5623)	61·0	44 (27–66)	55 (32–82)	23·9
Colon and rectum cancers	10 640 (8967–11 798)	14 422 (12 774–16 571)	35·5	201 (169–223)	209 (185–241)	4·3
Mouth cancer	2224 (1859–2401)	3228 (2718–3538)	45·1	42 (35–45)	47 (39–51)	11·7
Nasopharynx cancer	1486 (980–1925)	2007 (1311–2611)	35·1	28 (18–36)	29 (19–38)	3·9
Cancer of other part of pharynx and oropharynx	2094 (1211–2579)	2742 (1577–3413)	30·9	39 (23–49)	40 (23–50)	0·8
Gallbladder and biliary tract cancer	2046 (1374–2812)	3034 (1966–4061)	48·3	39 (26–53)	44 (29–59)	14·1
Pancreatic cancer	4188 (3186–5376)	6161 (4644–7694)	47·1	79 (60–101)	89 (67–112)	13·2
Malignant melanoma of skin	841 (539–1231)	1169 (744–1694)	39·1	16 (10–23)	17 (11–25)	7·0
Non-melanoma skin cancer	515 (350–746)	798 (557–1068)	54·9	10 (7–14)	12 (8–16)	19·2
Ovarian cancer	2987 (2146–3606)	4118 (2930–5115)	37·9	56 (40–68)	60 (43–74)	6·1
Testicular cancer	282 (172–364)	313 (202–405)	11·2	5 (3–7)	5 (3–6)	–14·4
Kidney and other urinary organ cancers	2132 (1554–2806)	3676 (2857–4922)	72·5	40 (29–53)	53 (41–71)	32·7
Bladder cancer	2388 (1904–2858)	3015 (2336–3563)	26·2	45 (36–54)	44 (34–52)	–2·9
Brain and nervous system cancers	4602 (3053–6493)	6060 (3669–7455)	31·7	87 (58–122)	88 (53–108)	1·3
Thyroid cancer	579 (446–714)	836 (625–997)	44·4	11 (8–13)	12 (9–14)	11·1
Hodgkin's disease	751 (474–1035)	647 (430–920)	–13·8	14 (9–20)	9 (6–13)	–33·7
Non-Hodgkin lymphoma	4509 (3577–5210)	5860 (4610–6450)	30·0	85 (67–98)	85 (67–94)	0·0
Multiple myeloma	1029 (724–1452)	1475 (969–2002)	43·3	19 (14–27)	21 (14–29)	10·2
Leukaemia	8950 (7078–11 042)	9556 (7662–11 232)	6·8	169 (134–208)	139 (111–163)	–17·8
Other neoplasms	12 366 (9438–15 506)	16 615 (11 928–19 888)	34·4	233 (178–292)	241 (173–289)	3·4
Cardiovascular and circulatory diseases	240 667 (227 084–257 718)	295 036 (273 061–309 562)	22·6	4540 (4283–4861)	4282 (3963–4493)	–5·7
Rheumatic heart disease	14 418 (13 170–16 236)	10 150 (9058–11 308)	–29·6	272 (248–306)	147 (131–164)	–45·8
Ischaemic heart disease	100 473 (96 503–108 966)	129 820 (119 174–138 044)	29·2	1895 (1820–2055)	1884 (1730–2004)	–0·6
Cerebrovascular disease	86 010 (81 022–94 811)	102 232 (90 428–107 989)	18·9	1622 (1528–1788)	1484 (1312–1567)	–8·5
Ischaemic stroke	32 128 (29 567–36 615)	39 389 (36 906–45 504)	22·6	606 (558–691)	572 (536–660)	–5·7
Haemorrhagic and other non-ischaemic stroke	53 882 (45 237–63 351)	62 843 (54 386–72 540)	16·6	1016 (853–1195)	912 (789–1053)	–10·3
Hypertensive heart disease	11 152 (9216–13 691)	15 324 (12 835–18 433)	37·4	210 (174–258)	222 (186–268)	5·7
Cardiomyopathy and myocarditis	9148 (7463–10 970)	11 151 (9759–12 882)	21·9	173 (141–207)	162 (142–187)	–6·2
Atrial fibrillation and flutter	1854 (1377–2429)	3598 (2756–4578)	94·1	35 (26–46)	52 (40–66)	49·3
Aortic aneurysm	2349 (1629–3220)	3163 (2280–4235)	34·6	44 (31–61)	46 (33–61)	3·6
Peripheral vascular disease	505 (342–748)	995 (703–1445)	97·1	10 (6–14)	14 (10–21)	51·7
Endocarditis	1489 (1215–1828)	1582 (1245–1839)	6·2	28 (23–34)	23 (18–27)	–18·3
Other cardiovascular and circulatory diseases	13 266 (11 425–15 212)	17 021 (15 191–19 188)	28·3	250 (216–287)	247 (220–278)	–1·3
Chronic respiratory diseases	119 153 (107 917–132 391)	117 945 (102 924–135 608)	–1·0	2248 (2036–2497)	1712 (1494–1968)	–23·8
Chronic obstructive pulmonary disease	78 283 (70 391–87 044)	76 731 (65 654–90 111)	–2·0	1477 (1328–1642)	1114 (953–1308)	–24·6
Pneumoconiosis	3503 (1799–6097)	2582 (1667–4295)	–26·3	66 (34–115)	37 (24–62)	–43·3
Asthma	21 469 (16 117–28 161)	22 459 (17 184–29 189)	4·6	405 (304–531)	326 (249–424)	–19·5
Interstitial lung disease and pulmonary sarcoidosis	1547 (1043–2156)	2233 (1547–2978)	44·4	29 (20–41)	32 (22–43)	11·1
Other chronic respiratory diseases	14 352 (10 700–19 695)	13 940 (11 167–17 190)	–2·9	271 (202–371)	202 (162–249)	–25·3
Cirrhosis of the liver	24 327 (20 693–27 179)	31 027 (25 965–34 645)	27·5	459 (390–513)	450 (377–503)	–1·9
Cirrhosis of the liver secondary to hepatitis B	7088 (5842–7961)	8990 (7728–10 912)	26·8	134 (110–150)	130 (112–158)	–2·4
Cirrhosis of the liver secondary to hepatitis C	5629 (4813–6421)	7452 (6370–8553)	32·4	106 (91–121)	108 (92–124)	1·9
Cirrhosis of the liver secondary to alcohol use	6350 (5128–7602)	8575 (6840–10 177)	35·0	120 (97–143)	124 (99–148)	3·9

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