2.3 Disease burden: generating evidence, guiding policy

Authors

Shuhei Nomura, Department of Health Policy and Management, Keio University, Tokyo, Japan;
Department of Global Health Policy, The University of Tokyo, Tokyo, Japan.

Aya Ishizuka, Department of Global Health Policy, The University of Tokyo, Tokyo, Japan.

2.3.1 Learning objectives

To understand the basic concept of disease burden and its potential in identifying and understanding the health issues surrounding a disaster, in particular:

1. The strength of the burden of disease concept.
2. How to quantify the burden of disease from mortality and disability.
3. The content of three case studies using the burden of disease concept.

2.3.2 Introduction

A pivotal foundation to prioritizing policy planning and interventions for health emergency and disaster risk management (Health EDRM) is the availability of comprehensive and comparable evidence of mortality and disability, and the risk factors that may contribute to them (see Chapter 3.2). The burden of disease is a globally recognized concept that provides a methodological framework to quantify and compare population health using a summary measure of both mortality and disability: the disability-adjusted life year (DALY) *(1–2)*.

A major strength of the burden of disease concept is that it allows comparisons to be made between health losses due to mortality and disability, and those due to different diseases or injuries. DALY combines in one measure the time lost due to individuals' premature death from each disease or injury and the time lived with disability, taking into account the degree of severity of disability associated with different states of poor health caused by each disease and injury *(3)*. DALYs are therefore a useful measure for examining which diseases and injuries make the largest contribution to health loss in a given population group (by age, gender, location and so on) at a given time, as well as for identifying and understanding key health problems and prioritizing health policy concerns, such as resource allocation, interventions, service providing, research, and advocacy.

Disasters and hazards are major causes of injuries which lead to mortality and disability. The threat of both natural and human-induced health emergencies and disasters adds an even greater sense of urgency to the need to hasten efforts for risk management on an 'all hazards' basis *(4)*. Rapid and unplanned urbanization, along with climate change, widespread poverty and insecurity, social inequality, political instability, and economic stagnation, have all helped to increase the risks and harmful consequences of health emergencies and disasters. For example, more than 50% of the world's population now lives in urban areas, and this is expected to increase to 66% by 2050 *(5)*. These heavily urbanized areas are frequently also located in disaster prone regions, with 80% of the world's largest cities vulnerable to earthquakes and 60% at risk from storm surges and tsunamis *(6)*. Today, natural disasters cause annual economic losses of US$ 520 billion worldwide, and cause about 26 million people to fall into poverty *(7)*. Investing in disaster risk management can reduce the disaster impact in terms of both economic losses and burden of diseases, conserve resources, and protect development progress. Some studies have estimated that for every dollar spent on well-targeted and effective DRR, approximately US$ 7 will be saved from a reduction in economic losses *(8)*.

The adoption in 2015 of the Sendai Framework, the SDGs, and the Paris Agreement (with DRR interlinked between them) reflects national, regional, and global commitments to disaster risk management, presenting an unparalleled opportunity for action. The burden of disease concept is a powerful research tool in this context – for generating evidence, guiding policy, planning, and investing strategically on disaster risk management. This chapter provides a guide as to how DALYs are defined and calculated, describes their use in practice, gives a snapshot of the Global Burden of Disease Study (GBD) (the world's largest systematic, scientific effort to produce comparable estimates of disease burden), and concludes with three case studies illustrating how the burden of disease concept has been used in professional practice.

2.3.3 Quantifying the burden of disease from mortality and disability

The DALY measures the difference between the actual situation and an ideal situation in which everyone lives to the standard life expectancy and is in perfect health. DALYs associated with hazards as health risks include not only direct injuries and deaths, but also indirect health effects and their spillover effects due to the deterioration of health resources and social capital *(9)*. One DALY represents a one-year loss of 'healthy' life due to disease or injury. DALYs for a specific cause of disease or injury are calculated as the sum of the Years of Life Lost (YLL) due to premature death from that cause and the Years Lived with Disability (YLD) for people living in states of less than perfect health resulting from a specific cause:

DALY = YLL + YLD

The YLLs metric essentially corresponds to the number of deaths multiplied by the standard life expectancy at the age at which death occurs. The basic formula for YLL for a given cause, age, and gender is the following:

YLL = N x L

where N denotes the number of deaths and L is standard life expectancy at age of death (in years). The standard life table (on which the standard life expectancy calculation is based) is a key component of the burden of disease concept. It corresponds to the ideal or aspirational life span for an individual in perfect health, but is not necessarily the actual life table of the population of interest. For example, a standard life table can be constructed from the lowest observed mortality rate in the latest year among all countries for each age and gender *(10)* or might be based on the life tables for countries with the highest longevity.

There are two methods of calculating the YLD for a particular cause in a particular time period: the incidence-based or prevalence-based approaches *(11)*. Prevalence looks at existing cases, while incidence looks at new cases. For incidence-based YLD, the number of incident cases in a given period is multiplied by the average duration of the disease or injury and a disability weight. This weight factor reflects the severity of the disease or injury on a scale from 0 (perfect health) to 1 (dead). The basic formula for incidence-based YLD is:

YLD = I x DW x L

where I denotes the number of incident cases, DW is the disability weight and L is average duration of the case to remission or death (in years). For prevalence-based YLD, the number of prevalent cases during a given period is also multiplied by a weight factor and the basic formula is:

YLD = P x DW

where P is the number of prevalent cases and DW is disability weight. The disability weights for YLD are based on subjective measures. The conceptual and methodological basis for estimation of disability weights have been developed through various iterations *(12-14)*, and there is debate over their validity *(15-17)*. A large set of global disability weights estimated by the Global Burden of Disease and for the European population by Haagsma and colleagues can be found elsewhere *(13- 14)*. Further details of the methods used for estimating YLLs, YLDs, and DALYs are provided in the Global Burden of Disease study *(10, 18)*.

2.3.4 Use of DALYs in Health EDRM

By quantifying the burden of disease associated with health emergencies and disasters, DALYs are a valuable metric for setting disaster research and policy priorities. If the data allow, DALYs can be calculated for different socioeconomic groups (by gender and age group) or geographic areas (by country and region), providing a more detailed perspective on the impact of emergencies and disasters. For example, by regularly updating DALYs estimates based on the best available data, trends in DRR policies can be monitored over time to assess the impact of macro-level policy interventions. As a result, DALY can be an important tool to support Health EDRM policies aimed at improving the resilience of the general population and particular population groups and reducing disparity in damage.

2.3.5 GBD 2017 reporting: a snapshot

The Global Burden of Disease (GBD), which has been affiliated with WHO and the World Bank and is now housed in the Institute for Health Metrics and Evaluation (IHME) at the University of Washington in the USA, is produced by a global network of more than 3600 collaborators from universities, research institutes and government units. Most of these are in low- and middle-income countries *(19)*. Using published studies and available data worldwide, the most recent study as of 2019 *(18)*, GBD 2017, covered 195 countries and territories, with subnational assessments for 16 countries (Brazil, China, Federal Democratic Republic of Ethiopia, India, Islamic Republic of Iran, Japan, Kenya, United Mexican States, New Zealand, Norway, the Russian Federation, South Africa, Sweden, United Kingdom and USA), and calculated DALYs and other health metrics for each year from 1990 until 2017. Data are disaggregated by age, gender, location and year. The study assessed 359 diseases and injuries, and 84 risk factors or combinations of risks *(20)*.

Table 2.3.1 shows seven hazards addressed in GBD 2017. The grouping of diseases and injuries used by the GBD is based on the International Statistical Classification of Diseases and Related Health Problems (ICD-10).

Table 2.3.1 Hazards currently covered in the GBD projects

WHO classification of hazards	GBD cause group	ICD10 codes mapped to GBD causes
Natural	Exposure to forces of nature	X33-X38
Natural	Environmental heat and cold exposure	L55-L55.9, L56.3, L56.8-L56.9, L58-L58.9, W88-W99, X30-X32, X39
Human-induced	Fire, heat, and hot substances	X00-X06, X08-X19
Human-induced	Exposure to mechanical forces	W20-W38, W40-W43, W45-W46, W49-W52
Human-induced	Interpersonal violence	X85-Y08, Y87
Human-induced	Conflict and terrorism	Y36-Y36.9, Y89.1
Human-induced	Executions and police conflict	Y35-Y35.9, Y89.0

The GBD synthesizes a large number of data sources to estimate burden of diseases. Country vital registration data are the primary data source for mortality due to these hazards. The Centre for Research on the Epidemiology of Disasters' International Disaster Database (EM-DAT) (see also Chapter 2.1) served as the GBD's primary non-vital registration source of mortality data due to exposure to forces of nature, and to fire, heat, and hot substances *(21)*. Data sources for conflict and terrorism include the Uppsala Conflict Data Program (UCDP) *(22)*, International Institute for Strategic Studies *(23)*, Robert S. Strauss Center for International Security and Law *(24)*, the Global Terrorism Database (GTD) *(25)*, and the RAND Database of Worldwide Terrorism Incidents *(26)*. Other data sources can be explored via the Institute for Health Metrics and Evaluation's GBD 2017 Data Input Sources Tool *(27)*.

2.3

The case studies below illustrate how the burden of disease concept can be interpreted and used for Health EDRM, using data from the GBD 2017. The data in Case Study 2.3.1 can be compared with that for another case of a major natural disaster in Japan, the Great Hanshin Earthquake in Kobe (magnitude 7.3), in January 1995. This shows a similar picture. The earthquake killed 6434 people, of whom 99.5% were residents of Hyogo Prefecture. Many structures were irreparably damaged by the earthquake, including nearly 400 000 buildings *(30)*. The most frequent cause of death was asphyxia due to direct compression of the chest or from being buried under the debris of houses *(30)*. The second most frequent cause of death was severe crush injury.

Figure 2.3.2 shows the age-specific mortality rate (per 100 000) due to natural disasters in 1995 in Hyogo Prefecture. As with the 2011 data for Miyagi Prefecture, the highest mortality rate was observed in the older population at the age of 90–94 years, at 487 (95% uncertainty intervals: 319 to 711) per 100 000 people, 5 to 10 times higher than among those aged under 50 years. However, as with the tsunami in Miyagi, when the burden of the earthquake was measured as a DALYs rate, the burden was highest among both the older population and young children.

These findings imply that, although mortality captures the likelihood (or risk) of dying due to a particular cause, DALYs capture the magnitude of health losses caused by a particular cause. Using a metric of DALYs in measuring the health impact of a disaster, it is clear that young children are more prominently affected. This is in part due to the fact that the burden of a disaster disproportionately affects younger populations, who lose greater healthy lifetime than the older population.

Case Study 2.3.1
DALYs produce a different picture of health impact of a disaster

The devastating magnitude 9.0 Great East Japan Earthquake that struck north-eastern Japan on 11 March 2011 and the subsequent tsunami killed more than 16 000 people. There was no major structural damage due to the earthquake itself. In Miyagi, the earthquake is said to have been directly responsible for the deaths of at least four people, but the largest number of tsunami deaths were recorded in this coastal prefecture, accounting for about 60% of total deaths. The nature of a tsunami is such that it usually causes fewer non-fatal injuries than an earthquake, but, rather, is a matter of life-or-death for those who live on the coastline in its path.

Many previous studies indicate that the older population are more likely to die or suffer serious injuries when involved in hazardous events *(28)*. The 2011 disaster in Japan is no exception. Figure 2.3.1 shows the age-specific mortality rate (per 100 000) due to 'exposure to forces of nature' (that is, natural disasters) in 2011 in Miyagi Prefecture. The highest mortality rate was observed in the age group over 90 years of age, at 1913 (95% uncertainty intervals 1249 to 2840) per 100 000 people. This is 5 to 10 times higher than among those aged under 50 years. DALYs produce a different picture of the burden of the natural disaster than that the mortality rates: in terms of DALYs rate, the highest burden of the natural disaster was observed in children under five years of age, followed by older age groups (Figure 2.3.1).

Figure 2.3.1 Age-specific mortality and DALYs rate per 100 000 people due to natural disaster in Miyagi Prefecture in 2011 (Source: *(27)*)

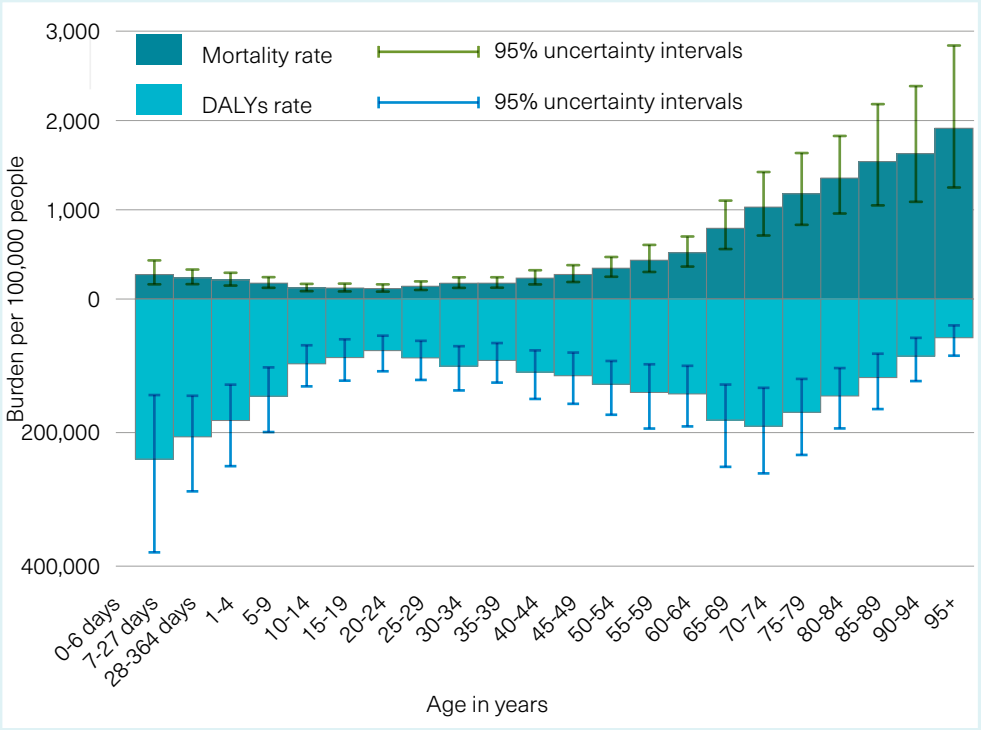
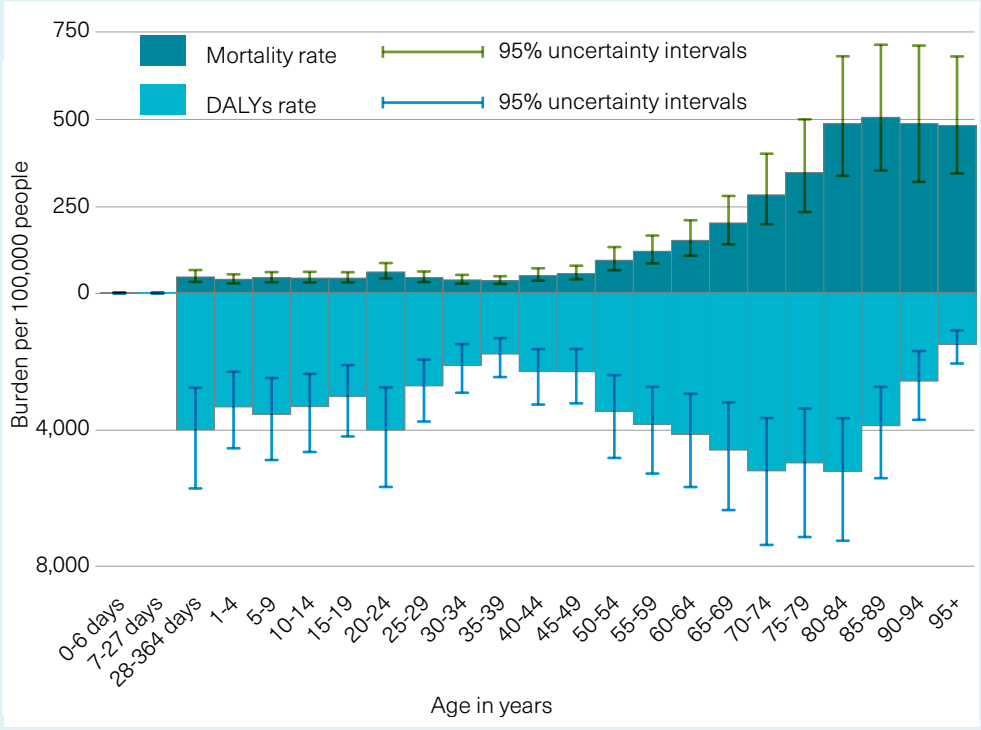


Figure 2.3.2 Age-specific mortality and DALYs rate per 100 000 people due to natural disaster in Hyogo Prefecture in 1995 (Source: *(27)*)

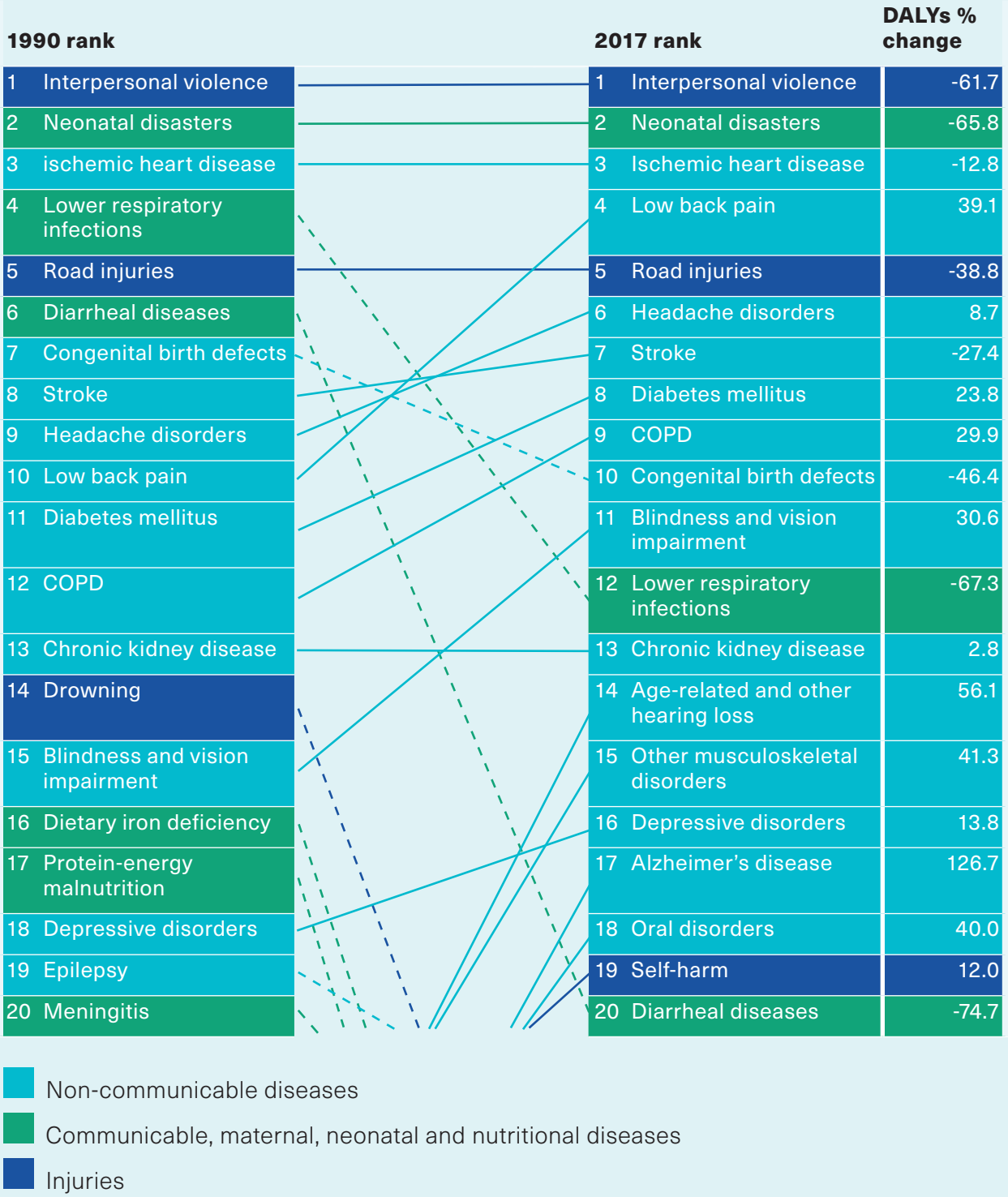


Case Study 2.3.2

Political violence has persisted in the Republic of Colombia despite several peace processes

In Colombia, the top three causes of DALYs in 2017 were interpersonal violence, neonatal disorders and ischemic heart disease (Figure 2.3.3). These rankings have not changed since 1990, although DALYs due to these causes have decreased by 61.7%, 65.8%, and 12.3%, respectively.

Figure 2.3.3 Ranking of DALYs in Colombia in 1990 and 2017 for both sexes combined, all ages *(27)*



Interpersonal violence, the leading cause of DALYs in 2017, is mainly attributed to homicides related to drug trafficking, illegal firearms and alcohol. The violence primarily affects the younger population, which leads to higher numbers of YLLs and YLDs. Young males in particular suffer from a high mortality rate due to interpersonal violence. It is worth noting that, although rates in Colombia remain high, from 1990 to 2017 DALYs declined by 61.7%, in part due to militaristic and social economic policies aimed at ending armed conflict and eradicating drug trafficking *(31)* which resulted, in 2016, in the end of a 53 year-long civil war through a peace agreement between the Colombian Government and the Revolutionary Armed Forces of Colombia (FARC). Other notable initiatives include banning of carry permits for guns, which started out as a time and occasion specific ban in major cities in the early 1990s, and a general ban in the capital, Bogotá, in 2012 and became nationwide in 2015 *(32-34)*. Furthermore, given the complexity of the relationship between police, crime and communities in Columbia, addressing interpersonal violence through means such as alcohol regulation, which was associated with a lower risk of homicide in the city of Cali, may be an effective intervention *(35)*.

Research points to violence repeating itself, in that children who experience abuse or violence as they grow up are prone to demonstrating and solving conflict with violence as adults *(36)*. In order to halt this cycle of violence, the mayor of Cali, Rodrigo Guerrero, who is a public health expert, stressed the need for Colombia to pursue a profound cultural change, beginning from the very earliest stages of life, so that violence ceases to be a culturally accepted way of resolving conflicts.

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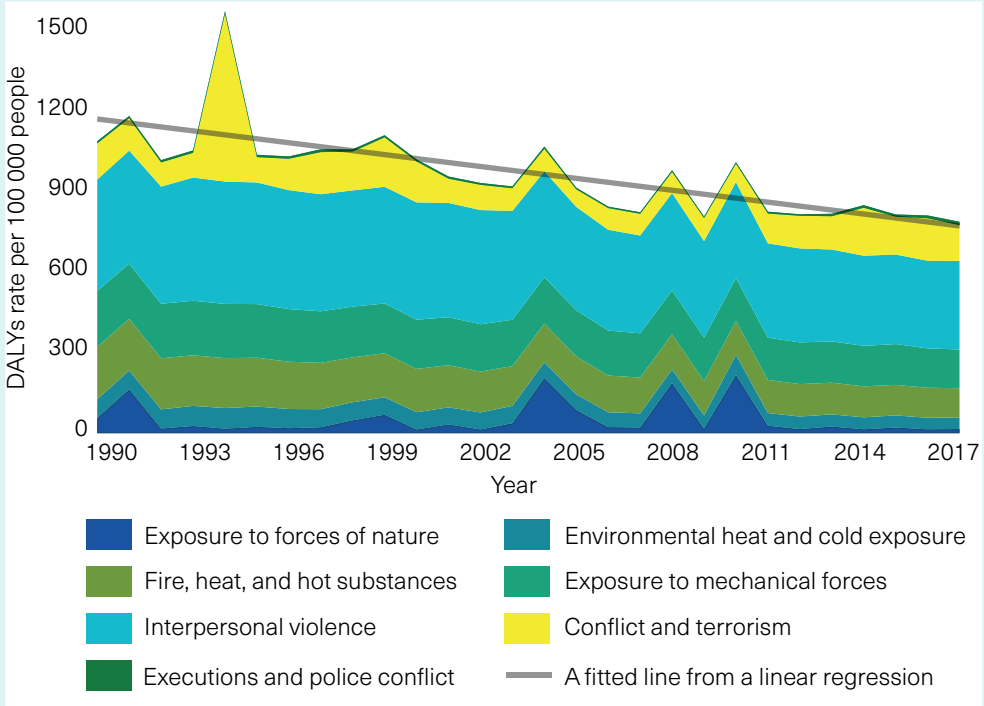
Case Study 2.3.3
Global DALYs due to the seven hazards are declining

Figure 2.3.4 shows stacked cumulative age-standardized DALY rates per 100 000 people globally due to the seven hazards defined in Table 2.3.1. Among these seven hazards considered in GBD 2017, interpersonal violence has been the main cause of DALYs in recent decades (41.0% on average between 1990 and 2017), followed by exposure to mechanical forces (18.3%); fire, heat, and hot substances (15.4%); conflict and terrorism (13.1%); environmental heat and cold exposure (6.2%); exposure to forces of nature (5.1%); and executions and police conflict (0.8%).

Figure 2.3.4 Trends in age-standardized DALYs rate per 100 000 people due to exposure to the seven hazards in Table 2.3.1 (Source: *(27)*)



The grey line on Figure 2.3.4 is an ordinary least squares regression line based on the total age-standardized DALYs rate from 1990 and 2017. This shows a temporal trend in DALYs due to the seven hazards. Between 1990 and 2017, there was a large reduction in the age-standardized DALYs rate, which fell by 34%. The peaks on the figure represent shock events: the 1991 Bangladesh cyclone (exposure to forces of nature), the 1994 Rwandan genocide (conflict and terrorism), the 2004 Indian Ocean earthquake and tsunami (exposure to forces of nature), the 2008 Cyclone Nargis in the Republic of the Union of Myanmar (exposure to forces of nature), and the 2010 Haiti Earthquake (exposure to forces of nature).

2.3.6 Conclusions

Disasters and other health emergencies cause substantial mortality and disability. Reliable evidence on the scale of this mortality and disability and how different populations groups are affected is vital to policy planning and the prioritization of interventions in Health EDRM. Using the burden of disease concept helps to provide the comprehensive and comparable data necessary for this. The burden of disease concept is globally recognized as a methodological framework to quantify and compare population health, using the DALY as a summary measure of both mortality and disability. When used in Health EDRM, burden of disease and DALYs allow policy makers and researchers to compare and contrast the health impacts of different events across countries and regions, and over time. This provides them with a foundation for the assessment of programmes and policies and for the planning and analysis of research.

2.3.7 Key messages

- **A key foundation for prioritizing policy planning and interventions in Health EDRM is comprehensive and comparable evidence on mortality and disability.**
- **A burden of disease approach quantifies and compares health loss due to mortality and disability for different diseases and injuries.**
- **DALY is a summary measure of population health that integrates mortality and disability.**
- **DALY allows comparisons between different health hazards and offers the ability to assess the impact of DRR strategies.**

2.3.8 Further reading

Haagsma JA, Polinder S, Cassini A, Colzani E, Havelaar AH. Review of disability weight studies: comparison of methodological choices and values. Population Health Metrics 2004: 12: 20.

Murray CJ. Quantifying the burden of disease: the technical basis for disability-adjusted life years. Bulletin of the World Health Organization. 1994: 72(3): 429-45.

Murray CJ, Lopez AD. The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries and risk factors in 1990 and projected to 2020. Cambridge: Harvard University Press. 1996.

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2.3.9 References

1. Murray CJ, Lopez AD. The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries and risk factors in 1990 and projected to 2020. Cambridge: Harvard University Press. 1996.
2. World Bank. World Development Report 1993: Investing in Health. New York: Oxford University Press. 1993.
3. Murray CJ. Quantifying the burden of disease: the technical basis for disability-adjusted life years. Bulletin of the World Health Organization 1994: 72(3): 429-45.
4. Official statements. In: Proceedings of the Forth Session of the Global Platform for Disaster Risk Reduction and World Reconstruction Conference; Geneva: United Nations International Strategy for Disaster Reduction. 2013.
5. How to Make Cities More Resilient: A Handbook for Local Government Leaders : a Contribution to the Global Campaign 2010-2020, Geneva, UNISDR. 2017.
6. Chafe. Reducing natural disaster risk in cities. State of the World 2007: Our Urban Future. Washington, DC: The World watch Institute. 2007.
7. Hallegatte S, Vogt-Schilb AC, Bangalore M, Rozenberg J. Unbreakable: Building the Resilience of the Poor in the Face of Natural Disasters, World Bank Group. 2016.
8. Act Now, Save Later: new UN social media campaign launched [Online]. New York: UNDP. 2012 https://www.undp.org/content/undp/en/home/presscenter/articles/2012/07/02/act-now-save-later-new-un-social-media-campaign-launched-.html (accessed 20 November 2019).
9. Fothergill L, Peek LA. Poverty and Disasters in the United States: A Review of Recent Sociological Findings. Natural Hazards. 2004: 32(1): 89-110.
10. GBD 2017 Causes of Death Collaborators. Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 2018: 392(10159): 1736-88.
11. Park B, Park B, Lee WK, Kim YE, Yoon SJ, Park H. Incidence-based versus prevalence-based approaches on measuring disability-adjusted life years for injury. Journal of Korean Medical Science 2019: 34 (Suppl 1): e69.
12. Salomon JA, Vos T, Hogan DR, Gagnon M, Naghavi M, Mokdad A, et al. Common values in assessing health outcomes from disease and injury: disability weights measurement study for the Global Burden of Disease Study 2010. Lancet 2012: 380(9859): 2129-43.
13. Salomon JA, Haagsma JA, Davis A, de Noordhout CM, Polinder S, Havelaar AH, et al. Disability weights for the Global Burden of Disease 2013 study. Lancet Global Health. 2015: 3(11): e712-23.

14. Haagsma JA, Maertens de Noordhout C, Polinder S, Vos T, Havelaar AH, Cassini A, et al. Assessing disability weights based on the responses of 30,660 people from four European countries. Population Health Metrics 2015: 13: 10.

15. Arnesen T, Nord E. The value of DALY life: problems with ethics and validity of disability adjusted life years. BMJ. 1999: 319(7222): 1423-5.

16. Polinder S, Haagsma JA, Stein C, Havelaar AH. Systematic review of general burden of disease studies using disability-adjusted life years. Population Health Metrics. 2012: 10(1): 21.

17. Haagsma JA, Polinder S, Cassini A, Colzani E, Havelaar AH. Review of disability weight studies: comparison of methodological choices and values. Population Health Metrics. 2014: 12: 20.

18. GBD 2017 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018: 392(10159): 1789-858.

19. GBD 2017: a fragile world. Lancet. 2018: 392(10159): 1683.

20. Global Burden of Disease (GBD) 2017. Study findings. IHME. 2018. http://www.healthdata.org/presentation/global-burden-disease-gbd-2017-study-findings (accessed 18 May 2019).

21. Centre for Research on the Epidemiology of Disasters. EM-DAT: the International Disaster Database. 2019. https://www.emdat.be/. (accessed 18 May 2019).

22. Uppsala Conflict Data Program. Uppsala University. 2019. https://www.pcr.uu.se/research/ucdp/ (accessed 18 May 2019).

23. International Institute for Strategic Studies. 2019. https://www.iiss.org/ (accessed 18 May 2019).

24. University of Texas at Austin. Robert S. Strauss Center for International Security and Law. 2019 https://www.strausscenter.org/ (accessed 18 May 2019).

25. University of Maryland. Global Terrorism Database. 2019. https://www.start.umd.edu/gtd/ (accessed on 18 May 2019).

26. RAND Database of Worldwide Terrorism Incidents. RAND Corporation. 2019 http://smapp.rand.org/rwtid/search_form.php (accessed 18 May 2019).

27. Institute for Health Metrics and Evaluation. Global Burden of Disease Study 2017 (GBD 2017) Data Results Tool. 2019. http://ghdx.healthdata.org/gbd-results-tool. (accessed 18 May 2019).

28. Nomura S, Parsons AJQ, Hirabayashi M, Kinoshita R, Liao Y, Hodgson S. Social determinants of mid- to long-term disaster impacts on health: a systematic review. International Journal of Disaster Risk Reduction 2016: 16: 53-67.

29. GBD 2016 SDG Collaborators. Measuring progress and projecting attainment on the basis of past trends of the health-related Sustainable Development Goals in 188 countries: an analysis from the Global Burden of Disease Study 2016. Lancet 2017: 390(10100): 1423-59.

30. Ukai T. The Great Hanshin-Awaji Earthquake and the problems with emergency medical care. Renal Failure. 1997: 19(5): 633-45.

31. Vallejo K, Tapias J, Arroyave I. Trends of rural/urban homicide in Colombia, 1992-2015: internal armed conflict and hints for postconflict. BioMed Research International. 2018: 6120909.

32. Villaveces A, Cummings P, Espitia VE, Koepsell TD, McKnight B, Kellermann AL. Effect of a ban on carrying firearms on homicide rates in 2 Colombian cities. JAMA. 2000: 283(9): 1205-9.

33. Rosenberg T. Colombia's data-driven fight against crime. 2014. https://opinionator.blogs.nytimes.com/2014/11/20/colombias-data-driven-fight-against-crime/ (accessed 4 June 2019).

34. Gacs D, Glickhouse R, Zissis C. Explainer: gun laws in Latin America's six largest economies. 2013. https://www.as-coa.org/articles/explainer-gun-laws-latin-americas-six-largest-economies#colombia (accessed 4 June 2019).

35. Sanchez AI, Villaveces A, Krafty RT, Park T, Weiss HB, Fabio A, et al. Policies for alcohol restriction and their association with interpersonal violence: a time-series analysis of homicides in Cali, Colombia. International Journal of Epidemiology. 2011: 40(4): 1037-46.

36. Norman RE, Byambaa M, De R, Butchart A, Scott J, Vos T. The long-term health consequences of child physical abuse, emotional abuse, and neglect: a systematic review and meta-analysis. PLoS Medicine 2012: 9(11): e1001349.