WHO methods and data sources for country-level causes of death 2000-2015

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Many of the inputs to these estimates result from collaborations with Interagency Groups, expert advisory groups and academic groups. These include the Interagency Group on Child Mortality Estimation (UN-IGME), the UN Population Division, the Maternal and Child Epidemiology Estimation Group (MCEE), the Maternal Mortality Expert and Interagency Group (MMEIG), the International Agency for Research on Cancer, WHO QUIVER, the Institute of Health Metrics and Evaluation (IHME) at the University of Washington, and various experts collaborating in the IHME Global Burden of Disease Study. While it is not possible to name all those who provided advice, assistance or data, both inside and outside WHO, we would particularly like to note the assistance and inputs provided by Bob Black, Ties Boerma, Phillipe Boucher, Freddie Bray, Zoe Brillantes, Doris Chou, Richard Cibulskis, Simon Cousens, Louisa Degenhardt, Brecht Devleesschauwer, Jeffrey Eaton, Jacques Ferlay, Marta Gacic-Dobo, Patrick Gerland, Arie Havelaar, Stephane Helleringer, Yvan Hutin, Philippe Glaziou, Kacem Iaych, Robert Jakob, Prabhat Jha, Joy Lawn, Li Liu, Mary Mahy, Bruno Masquelier, Shefali Oza, Minal Patel, Margie Peden, Francois Pelletier, Juergen Rehm, Florence Rusciano, Lale Say, Charalampos Sismanidis, John Stover, Peter Strebel, Paul Torgerson and Danzhen You. The World Health Organization funded this work.

Estimates and analysis are available at:
http://www.who.int/gho/mortality_burden_disease/en/index.html

For further information about the estimates and methods, or to obtain computer codes, please contact healthstat@who.int

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1 Introduction

Global, regional, and country statistics on population and health indicators are important for assessing development and health progress and for guiding resource allocation. The demand is growing for timely data to monitor progress on life expectancy and age- and cause-specific mortality rates. This is perhaps best reflected in the indicators selected to monitoring progress towards the health-related targets within the Sustainable Development Goals (SDGs), which will require regular reporting on child mortality, maternal mortality and mortality due to non-communicable diseases, suicide, pollution, road traffic injuries, homicide, natural disasters and conflict.

In 2014, WHO published time series estimates of deaths by cause, age and sex for years 2000-2012 for its Member States (1). These have now been updated for years 2000-2015 drawing on more recent data as summarized below. This technical paper documents the data sources and methods used for preparation of these country-level Global Health Estimates (GHE) for years 2000-2015. Annex Table A lists the cause of death categories and their definitions in terms of the International Classification of Diseases, Tenth Revision (ICD-10) (2). These estimates are available for years 2000, 2005, 2010 and 2015 for Member States and for selected regional groupings of countries, areas and territories (3), defined in Annex Table B, at http://www.who.int/healthinfo/global_health_estimates/en/.

One of the six core functions of WHO is monitoring of the health situation, trends and determinants in the world. Over the years it has cooperated closely with other UN partner agencies like UNICEF, UNAIDS, UNFPA and the UN Population Division to collect and compile global health statistics. There are a number of established UN multi-agency expert group mechanisms for cross cutting topics such as child mortality (the UN-IGME including UNICEF/WHO/UN Population Division/World Bank), and specific diseases such as HIV/AIDS (UNAIDS Reference Group), maternal mortality (MMEIG including WHO/UNICEF/UNFPA/World Bank), tuberculosis (WHO STAG), malaria (Malaria Reference Group and Roll Back Malaria- Malaria Monitoring and Evaluation Reference Group). Additionally, WHO collaborates with a network of academics (MCEE) to estimate child causes of death. This collaboration succeeds the former Child Health Epidemiology Reference Group (CHERG) of WHO and UNICEF.

Estimates of mortality, causes of death, DALYs for diseases, injuries and risk factors were released in 2016 (4-6) by the Institute of Health Metrics and Evaluation (IHME) as part of the Global Burden of Disease 2015 study (GBD2015). WHO has drawn on the GBD2015 analyses for selected causes for Member States without comprehensive death registration data as described in Section 9 below.

These WHO Global Health Estimates provide a comprehensive and comparable set of cause of death estimates from year 2000 onwards, consistent with and incorporating UN agency, interagency and WHO estimates for population, births, all-cause deaths and specific causes of death, including:

- most recent vital registration (VR) data for all countries where the VR data quality is assessed as useable;
- updated and additional information on levels and trends for child and adult mortality in many countries without good death registration data
- improvements in methods used for the estimation of causes of child deaths in countries without good death registration data.
- Updated assessments of levels and trends for specific causes of death by WHO programs and interagency groups. These include:
    - Tuberculosis –WHO
    - HIV – UNAIDS and WHO

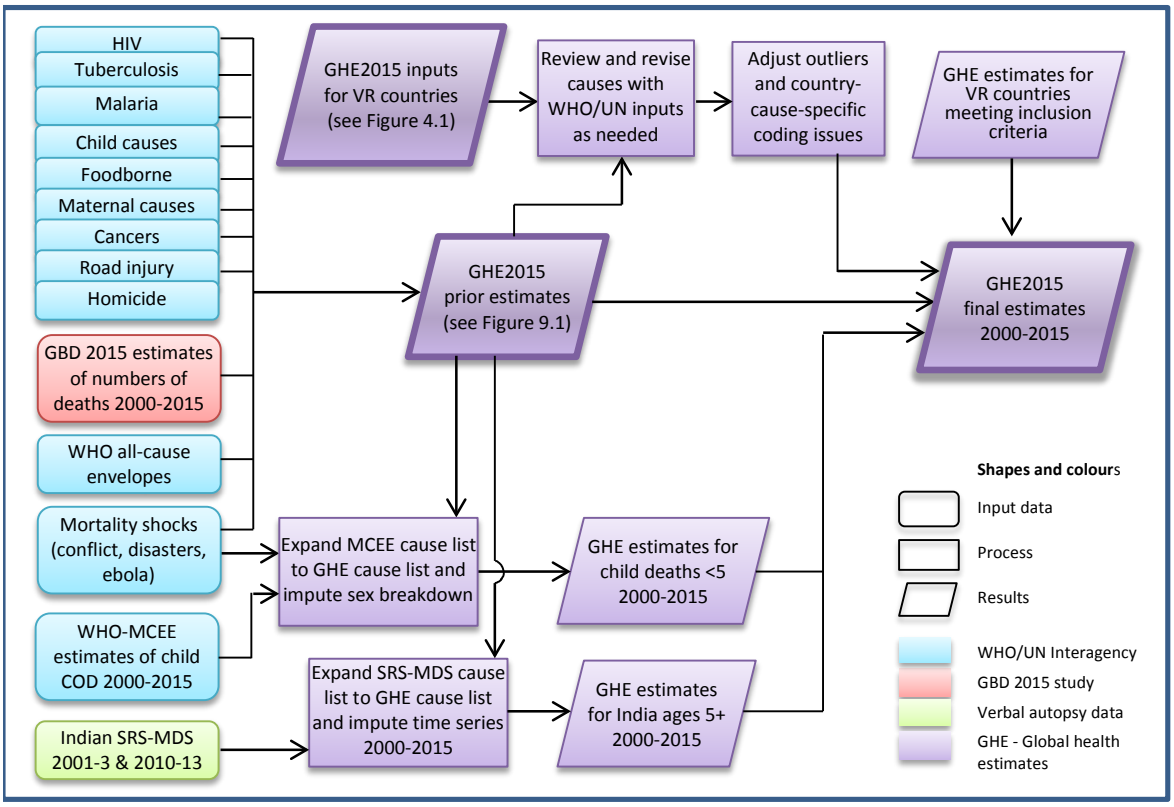
- Malaria – WHO
- Vaccine-preventable child causes – WHO
- Other major child causes – WHO and CHERG
- Maternal mortality –MMEIG
- Cancers – IARC
- Road traffic accidents – WHO
- Homicide – WHO
- Conflict and natural disasters – WHO and the Collaborating Center for Research on the Epidemiology of Disasters (CRED)

o GBD2015 study estimates for other causes in countries without useable VR data or other nationally representative sources of information on causes of death.

Because these estimates draw on new data and on the result of the GBD2015 study, and there have been substantial revisions to methods for many causes, these estimates for the years 2000-2015 are not directly comparable with previous WHO estimates for 2000-2012 or earlier versions. These Global Health Estimates represent the best estimates of WHO, based on the evidence available to it up until October 2016, rather than the official estimates of Member States, and have not necessarily been endorsed by Member States. They have been computed using standard categories, definitions and methods to ensure cross-national comparability and may not be the same as official national estimates produced using alternate, potentially equally rigorous methods. The following sections of this document provide explanatory notes on data sources and methods for preparing mortality estimates by cause.

These estimates have been documented following the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) (7). The location where GATHER reporting items are reported are given in Annex Table C. Figure 1.1 provides an overview of the overall process of preparing the GHE2015 estimates from the input data sources. Input data and processes are described in more detail in the following Sections.

Figure 1.1 Overview of the processes involved in the preparation of the GHE2015 dataset for causes of death in 183 WHO Member States for years 2000-2015. Refer also to Figure 4.1 for more a more detailed summary of the processes involved in the use of death registration data submitted to the WHO Mortality Database and to Figure 9.1 for a summary of the data and processes involved in the preparation of the GHE "prior" estimates dataset.



2 Population and all-cause mortality estimates for years 2000-2015

WHO life tables have been revised and updated for all Member States for years 1990-2015, drawing on the recently released UN World Population Prospects 2015 revision (8), recent and unpublished analyses of all-cause and HIV mortality for countries with high HIV prevalence, vital registration data (9), and UN-IGME estimates of levels and trends for under-5 mortality (10). Annex Table D summarizes the methods used for preparing life tables. Data sources are documented in more detail in GHE Technical Paper 2016.2 (11). The WHO life tables are available in the Global Health Observatory at http://apps.who.int/gho/data/node.main.LIFECOUNTRY?lang=en

In recent years, WHO has liaised more closely with the UN Population Division (on life tables for countries, in order to maximize the consistency of UN and WHO life tables, and to minimize differences in the use and interpretation of available data on mortality levels. For countries where WHO previously predicted levels of adult mortality from estimated levels of child mortality, this update has taken into

account additional country-specific sources of information on levels of adult mortality as reflected in the life tables prepared by the UN Population Division for its World Population Prospects (WPP).

Total deaths by age and sex were estimated for each country by applying the WHO life table death rates to the estimated de facto resident populations prepared by the UN Population Division in its 2015 revision (8). They may thus differ slightly from official national estimates for corresponding years.

3 Analysis categories

3.1 Countries

Estimates are made for 183 WHO Member States with populations greater than 90,000 in 2015. The 11 Member States excluded are: Andorra, Cook Islands, Dominica, Marshall Islands, Monaco, Nauru, Niue, Palau, Saint Kitts and Nevis, San Marino, and Tuvalu. This is fewer than the 22 Member States excluded for the previous GHE2013 cause of death estimates. Additionally, estimates are made for the three largest populations in non-Member State territories: Puerto Rico; Taiwan, China; West Bank and Gaza Strip. These are not released at country level, but are included in the relevant regional and global totals.

3.2 Age groups

The analysis of deaths by cause is carried out for 5-year age groups from 5-9, though to the final open-ended age group 85+. Deaths under age 5 are estimated for the following age groups: neonatal (0-29 days), postneonatal (1-11 months), and 1-4 years. Cause of death estimates are released in tabular form for age groups 0-28 days, 1-59 months, 5-14 years, 15-29, 30-49, 50-59, 60-69, 70+ years.

3.3 Cause of death categories

The cause of death categories used in the previous WHO cause of death estimates have been expanded to include a number of additional causes and to provide a more detailed breakdown for a several causes. The revised GHE2015 cause list is given in Annex Table A, together with corresponding ICD-10 codes.

New cause categories include:

- Acute hepatitis A
- Acute hepatitis E
- Cysticercosis
- Echinococcosis
- Yellow fever
- Food-borne trematodosis
- Testicular, kidney, brain, gallbladder, larynx, thyroid cancers and mesothelioma
- Thalassaemias and sickle cell disorders
- Additional digestive disease categories
- Sudden infant death syndrome
- Injuries resulting from unintentional exposure to mechanical forces

More detailed subcategories have been included for liver cancer and liver cirrhosis, and for five categories of drug use disorders. The subcategories for liver cancer and liver cirrhosis relate to causes including alcohol use and hepatitis infection earlier in life.

4 Countries with useable death registration data

4.1 Data and estimates

Cause-of-death statistics are reported to WHO on an annual basis by country, year, cause, age and sex. These statistics can be accessed in the WHO Mortality Database (9). The number of countries reporting data using ICD-10 has continued to increase. For these estimates, a total of 69 countries had data that met our inclusion criteria, of which 66 countries were reporting data coded to the third or fourth character of ICD-10 and 61 countries had data for years 2013 or later. Fourteen countries had reported data from 2015.

For countries with a high-quality vital registration system including information on cause of death, we used the vital registration data recorded in the WHO Mortality Database to estimate cause-specific deaths. We analyzed the data using the following steps:

1) application of inclusion criteria to select countries with high-quality vital registration data;
2) extraction of deaths by cause group, with a short cause list and, if possible, a detailed cause list (depending on the cause tabulation used in each country-year);
3) redistribution of deaths of unknown sex/age and deaths assigned to ill-defined (garbage) codes and adjustment for incomplete registration of deaths in some countries;
4) interpolation/extrapolation of number of deaths for missing country-years;
5) adjustments to take into account additional information for specific causes of death; and
6) scaling of total deaths by age and sex to previously estimated WHO all-cause envelopes for years 2000-2015.

Figure 4.1 provides an overview of the involved in preparing the complete dataset for GHE causes and categories for years 2000 to 2015 for the countries with death registration data reported to the WHO Mortality Database and which meet inclusion criteria. Details are provided below.

4.2 Inclusion criteria for countries with high quality death registration data

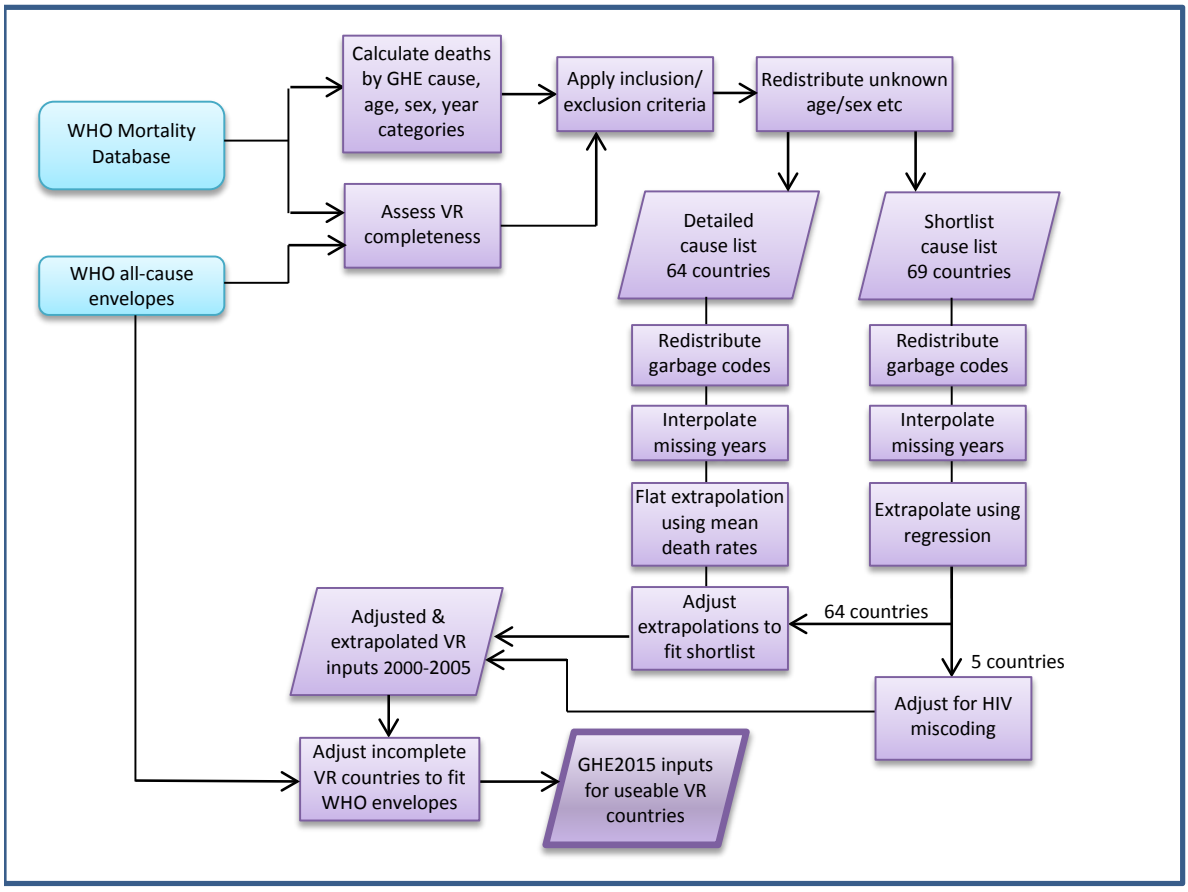
We applied the following inclusion criteria to data in the WHO mortality database received as of end October 2016:

- The data are for a country that is currently a WHO Member State;
- The data are for a country whose population in 2015 was greater than 90,000;
- The data are available for 5-year age groups to ages 85 and over;
- At least five years of data are available during 2005-present;
- The data fulfill quality criteria pertaining to garbage codes and completeness, as described below.

Completeness of death registration data was assessed against estimated total deaths for the population as described in the GHE Technical Paper 2016.2 (11). We then calculated the proportion of deaths with underlying cause coded to a short list of so-called “garbage” codes:

- symptoms, signs and ill-defined conditions (ICD10 codes R00-R99),
- injuries undetermined whether intentional or unintentional (ICD10 Y10-Y34, Y87.2),
- ill-defined cancers (C76, C80, and C97), and
- ill-defined cardiovascular diseases (I47.2, I49.0, I46, I50, I51.4, I51.5, I51.6, I51.9 and I70.9).

Figure 4.1 Overview of the processes involved in the preparation of the GHE2015 dataset for Member States with death registration data meeting inclusion criteria. Refer also to Figure 1.1 for further steps involved in the inclusion of this dataset in the final GHE2015 estimates.



A summary usability score was calculated as follows:

(Percent Usable) = Completeness (%) * (1 - Proportion Garbage)

All countries with a mean percent usable below 65% during the period 2000 to latest available year were excluded (see Table 4.1).

The quality of cause-of-death coding was further investigated in the remaining countries. The proportion of deaths assigned to an expanded list of ill-defined causes (Table 4.2) was calculated for each year in the period 2005-2014 (or latest available), and the mean proportion garbage during the period was calculated. Data from a country were excluded if the average proportion of ill-defined causes was above 25%. Based on this analysis, data from Argentina, Bulgaria, Fiji, Greece, Montenegro, Poland, and Syrian Arab Republic were excluded (Table 4.1).

Some data were excluded despite fulfilling our inclusion criteria: from the Philippines, the years 1998-1999 and 2002 were excluded because the trends in specific causes were implausible, and data from Armenia for the years 2006 and 2008-2011 were excluded because it was not possible to map the data provided to WHO to the shortlist cause list (Table 4.6). Data from South Africa were excluded because of

high levels of miscoding of HIV deaths to other causes, not captured by the useability index. The estimation of HIV deaths for South Africa is described in Section 8.2.

For countries which did not meet the criteria for directly using death registration data to estimate causes of death, we have drawn on updated IHME single-cause analyses from the GBD2015 study (4-6), as described in Section 9. Note that the IHME modelling strategies do make use of the available death registration data (9) as well as other sources of information on deaths, covariate regression modelling and also draw on patterns of causes of death for similar countries. The country-specific data and IHME analyses can be viewed on their website (12).

Table 4.1. *Characteristics[a] of country vital registration data and inclusion/exclusion*

Country[b]	Years Available	Average usability 2000-latest year	Range of completeness		Range of garbage fraction[c]		Notes
Albania	1998-2009	60%	76%	85%	18%	28%	Excluded: low usability
Antigua and Barbuda	1998-2009, 2012-2014	78%	81%	95%	5%	18%	
Argentina	1998-2014	77%	98%	99%	19%	22%	Excluded: high proportion garbage
Armenia	1998-2003, 2012-2015	95%	91%	103%	4%	7%	Excluded: fewer than five years' data since 2005
Australia	1998-2004, 2006-2014	95%	100%	100%	5%	6%	
Austria	1998-2014	91%	100%	100%	1%	14%	
Azerbaijan	1998-2004, 2007	87%	94%	97%	2%	34%	Excluded: fewer than five years' data since 2005
Bahamas	1998-2013	87%	81%	103%	2%	8%	
Bahrain	2001, 2010-2014	61%	81%	100%	25%	33%	Excluded: low usability
Barbados	2000-2003, 2005-2013	68%	71%	80%	8%	13%	
Belarus	1998-2003, 2007-2011, 2013-2014	80%	88%	95%	10%	15%	Summarized cause list used for all years
Belgium	1998-2013	87%	100%	100%	12%	15%	
Belize	1998-2014	76%	74%	90%	4%	13%	
Bolivia (Plurinational State of)	2000-2003	17%	35%	41%	48%	58%	Excluded: fewer than five years' data since 2005
Bosnia and	2011, 2014	73%	95%	95%	21%	24%	Excluded: fewer

Herzegovina							than five years' data since 2005
Brazil	1998-2014	83%	93%	100%	10%	21%	
Brunei Darussalam	1998-2014	91%	92%	103%	4%	9%	Summarized cause list used for all years
Bulgaria	1998-2013	76%	93%	98%	16%	28%	Excluded: high proportion garbage
Cabo Verde	2011	73%	95%	95%	23%	23%	Excluded: fewer than five years' data since 2005
Canada	1998-2012	94%	100%	100%	6%	8%	
Chile	1998-2014	94%	99%	100%	5%	11%	
Colombia	1998-2013	84%	80%	91%	5%	8%	
Costa Rica	1998-2014	87%	91%	98%	4%	7%	
Croatia	1998-2015	89%	100%	100%	6%	17%	
Cuba	1998-2014	92%	98%	100%	1%	9%	
Cyprus[d]	2004-2013	58%	66%	76%	10%	24%	
Czechia	1998-2015	89%	100%	100%	7%	15%	
Denmark	1998-2014	87%	100%	100%	12%	14%	
Dominican Republic	1998-2012	45%	50%	61%	8%	21%	Excluded: low usability
Ecuador	1998-2014	69%	79%	93%	14%	23%	
Egypt	2000-2011	56%	89%	94%	32%	41%	Excluded: low usability
El Salvador	1998-2013	63%	75%	84%	18%	26%	Excluded: low usability
Estonia	1998-2014	94%	100%	100%	5%	8%	
Fiji	2001-2009, 2011-2012	81%	103%	103%	9%	37%	Excluded: high proportion garbage
Finland	1998-2014	97%	100%	100%	2%	3%	
France	1998-2013	85%	100%	100%	14%	16%	
Georgia	1998-2001, 2004-2007, 2009-2014	61%	81%	100%	7%	69%	Excluded: low usability
Germany	1998-2014	88%	100%	100%	11%	14%	
Greece	1998-2013	74%	97%	100%	24%	27%	Excluded: high proportion garbage
Grenada	2001-2015	88%	87%	100%	5%	15%	
Guatemala	1998-2014	79%	90%	96%	9%	22%	
Guyana	1998-1999, 2001-2012	86%	76%	93%	6%	22%	
Haiti	1999, 2001-2004	6%	3%	15%	32%	52%	Excluded: fewer than five years'

							data since 2005
Honduras	2008-2013	13%	13%	15%	3%	7%	Excluded: low usability
Hungary	1998-2014	95%	100%	100%	4%	7%	
Iceland	1998-2015	94%	100%	100%	5%	10%	
Iraq	2008	54%	75%	75%	28%	28%	Excluded: fewer than five years' data since 2005
Ireland	1998-2013	95%	100%	100%	4%	8%	Summarized cause list used for some years
Israel	1998-2014	91%	100%	100%	8%	14%	
Italy	1998-2003, 2006-2012	91%	100%	100%	8%	12%	
Jamaica	2000-2006, 2009-2011	73%	73%	92%	5%	25%	
Japan	1998-2014	89%	100%	100%	9%	15%	
Jordan	2008-2011	61%	59%	86%	9%	10%	Excluded: fewer than five years' data since 2005
Kazakhstan	1998-2015	81%	84%	90%	3%	22%	Summarized cause list used for all years
Kiribati	1998-2001	51%	68%	79%	25%	35%	Excluded: fewer than five years' data since 2005
Kuwait	1998-2014	65%	63%	86%	8%	16%	Excluded: low usability
Kyrgyzstan	1998-2015	90%	92%	97%	3%	8%	
Latvia	1998-2014	90%	95%	98%	5%	11%	
Lithuania	1998-2015	92%	91%	99%	2%	6%	
Luxembourg	1998-2014	86%	100%	100%	12%	16%	
Malaysia	2000-2008	40%	46%	58%	21%	24%	Excluded: fewer than five years' data since 2005
Maldives	2000-2005, 2007-2008, 2010-2011	58%	84%	102%	13%	77%	Excluded: low usability
Malta	1998-2014	92%	100%	100%	5%	12%	
Mauritius	1998-2014	88%	96%	97%	7%	15%	
Mexico	1998-2014	95%	100%	100%	4%	6%	
Montenegro	2000-2009	67%	89%	94%	23%	29%	Excluded: high proportion garbage
Morocco	2008-2012	12%	21%	24%	46%	51%	Excluded: low usability
Netherlands	1998-2015	86%	100%	100%	13%	15%	
New Zealand	1998-2012	97%	100%	100%	3%	4%	
Nicaragua	1998-2013	60%	49%	72%	4%	11%	Excluded: low usability

Norway	1998-2014	88%	100%	100%	11%	13%	
Oman	2009-2010	49%	81%	84%	34%	46%	Excluded: fewer than five years' data since 2005
Panama	1998-2014	80%	86%	93%	8%	14%	
Paraguay	1998-2014	61%	66%	83%	14%	27%	Excluded: low usability
Peru	1998-2014	57%	61%	68%	5%	24%	Excluded: low usability
Philippines	2000-2001, 2003, 2006-2011	78%	85%	90%	9%	10%	
Poland	1999-2014	72%	98%	100%	25%	31%	Excluded: high proportion garbage
Portugal	1998-2003, 2007-2014	82%	100%	100%	14%	22%	Summarized cause list used for some years
Qatar	2001, 2004-2012	60%	65%	97%	22%	35%	Excluded: low usability
Republic of Korea	1998-2013	85%	97%	100%	13%	21%	
Republic of Moldova	1998-2015	83%	80%	90%	2%	7%	
Romania	1998-2015	92%	100%	100%	0%	8%	
Russian Federation	1998-2011	89%	91%	96%	4%	6%	Summarized cause list used for all years
Saint Lucia	1998-2006, 2008-2014	75%	76%	94%	6%	27%	
Saint Vincent and the Grenadines	1998-2015	93%	92%	104%	2%	10%	
Saudi Arabia	2009, 2012	21%	39%	39%	46%	48%	Excluded: fewer than five years' data since 2005
Serbia	1998-2014	80%	93%	96%	12%	18%	
Singapore	1998-2015	71%	68%	82%	1%	4%	
Slovakia	1998-2010, 2012-2014	94%	100%	100%	4%	11%	
Slovenia	1998-2013, 2015	89%	100%	100%	9%	12%	
South Africa	1998-2014	70%	81%	97%	19%	32%	Special methods used
Spain	1998-2014	90%	100%	100%	8%	12%	
Sri Lanka	1998-2003, 2006	72%	79%	102%	23%	32%	Excluded: fewer than five years' data since 2005
Suriname	1998-2014	64%	66%	79%	12%	22%	Excluded: low usability
Sweden	1998-2015	89%	100%	100%	10%	12%	
Switzerland	1998-2013	89%	100%	100%	10%	13%	

Syrian Arab Republic	1998-2010	72%	79%	103%	10%	35%	Excluded: high proportion garbage
Tajikistan	1998-2005	78%	78%	83%	4%	9%	Excluded: fewer than five years' data since 2005
Thailand	1998-2000, 2002-2014	52%	79%	95%	31%	54%	Excluded: low usability
The former Yugoslav Republic of Macedonia	1998-2013	87%	96%	103%	9%	16%	Summarized cause list used for some years
Trinidad and Tobago	1998-2010	84%	81%	100%	2%	5%	
Tunisia	2009, 2013	22%	28%	30%	18%	27%	Excluded: fewer than five years' data since 2005
Turkey	1999-2002, 2004-2013	58%	47%	91%	8%	15%	Excluded: low usability
Turkmenistan	1998, 2012-2013	67%	77%	94%	3%	13%	Excluded: fewer than five years' data since 2005
Ukraine[d]	1998-2012, 2014	90%	89%	97%	2%	6%	Summarized cause list used for all years
United Arab Emirates	2005-2010	56%	59%	82%	18%	26%	Excluded: low usability
United Kingdom	1998-2014	93%	100%	100%	6%	8%	
United States of America	1998-2014	93%	100%	100%	7%	10%	
Uruguay	1998-2010, 2012-2014	83%	100%	100%	16%	18%	
Uzbekistan	1998-2005, 2009-2014	85%	81%	99%	2%	6%	Summarized cause list used for some years
Venezuela (Bolivarian Republic of)	1998-2013	82%	86%	90%	7%	9%	

a) Characteristics on data sources that are common to all sources are not listed in this table. Specifically, all data sources cover the national area unless otherwise noted, are death registration data based on medical certification of death, and cover all ages and both sexes.

b) Only data fulfilling the first three inclusion criteria listed above, e.g. member state, minimum population and detailed age grouping, are included in this table.

c) ICD-10 codes included in the "garbage" category are given in the text above. Additional codes in Table 4.2 are not considered in this column.

d) Data are for areas under government control.

Table 4.2. *Expanded list of garbage codes*

ICD-10 code(s)	Description
A40-A41	Streptococcal and other septicaemia
C76, C80, C97	Ill-defined cancer sites
D65	Disseminated intravascular coagulation [defibrination syndrome]
E86	Volume depletion
I10	Essential (primary) hypertension
I269	Pulmonary embolism without mention of acute cor pulmonale
I46	Cardiac arrest
I472	Ventricular tachycardia
I490	Ventricular fibrillation and flutter
I50	Heart failure
I514	Myocarditis, unspecified
I515	Myocardial degeneration
I516	Cardiovascular disease, unspecified
I519	Heart disease, unspecified
I709	Generalized and unspecified atherosclerosis
I99	Other and unspecified disorders of circulatory system
J81	Pulmonary oedema
J96	Respiratory failure, not elsewhere classified
K72	Hepatic failure, not elsewhere classified
N17	Acute renal failure
N18	Chronic renal failure
N19	Unspecified renal failure
P285	Respiratory failure of newborn
Y10-Y34, Y872	External cause of death not specified as accidentally or purposely inflicted

4.3 Mapping to the GHE cause lists and redistribution of unknown age/sex or ill-defined cause of death

Included vital registration data were coded according to ICD9, ICD10, or one of several abbreviated cause lists derived from ICD9 or ICD10. Total deaths by cause, age and sex were mapped to the GHE cause list (Annex Table A). We used the complete cause list in Annex Table A if the data were coded using 3- or 4-digit ICD-10 codes or 4-digit ICD-9 codes. For all included data, we extracted the number of deaths by cause, age and sex, using the broad cause categories listed in Table 4.6 (hereafter "shortlist"). In some cases, counts of deaths were not available for specific causes of death. Specifically, chlamydia deaths were not available in the 4-digit ICD-9 codes. The mean fraction of other sexually transmitted disease deaths caused by chlamydia was calculated for each country-sex group and applied to all years of data for that country. If there were no deaths coded to other sexually transmitted diseases in a given country, the mean fraction for all other countries was used. Several causes of death are not available in death registration data coded using ICD10 at the 3-digit level: hepatitis C (acute infections), lymphatic

filariasis, Japanese encephalitis, panic disorder, age-related vision disorders, congenital abdominal wall defect, and congenital oesophageal atresia. Deaths for all of these causes were assumed to be zero in the countries with data coded to ICD10 at the 3-digit level.

Deaths of unknown sex were redistributed pro-rata within cause-age groups of known sexes, and then deaths of unknown age were redistributed pro-rata within cause-sex groups of known ages. We redistributed deaths coded to symptoms, signs and ill-defined conditions (ICD10 codes R00-R94,R96-R99) pro-rata to all non-injury causes of death, and injuries with undetermined intent (ICD10 codes Y10-Y34) pro-rata to all injury causes of death, following previously published methods (13). Cancers with unspecified site (ICD10 codes C76, C80, C97) were redistributed pro-rata to all sites excluding liver, pancreas, ovary, and lung. Additionally, we redistributed cancer of uterus, part unspecified (C55) pro-rata to cervix uteri (C53) and corpus uteri (C54).

Previously published analyses of heart failure (14, 15) have proposed that these deaths be reassigned mainly to to ischemic heart disease (IHD; cause 1100), chronic obstructive pulmonary disease (COPD; cause 1180) in older adults, and to IHD, COPD, cardiomyopathy, myocarditis, and endocarditis (cause 1150) and congenital heart anomalies (cause 1440) in children, adolescents and young adults (destination causes for ill-defined deaths may be called target causes). Following these analyses, we redistributed heart failure and other ill-defined cardiovascular causes of death to IHD and COPD in adults over age 50 and to the four target causes—IHD, COPD, cardiomyopathy, myocarditis, endocarditis, and congenital heart anomalies in people under age 50. As these conditions have strong age and sex patterns, redistribution fractions were calculated by age and sex. We combined available data from three epidemiologically relevant regions, the traditional high-income countries, Eastern Europe and Central Asia, and other countries with usable death registration data, and calculated fractions for each target disease based on their relative frequency in the data. The redistribution fractions are shown in Tables 4.3-5.

The ICD-10 code ranges mapped to hypertensive heart disease (HHD) include codes for essential hypertension (I10), secondary hypertension (I15) and hypertensive renal disease (I12). Most deaths coded to essential hypertension are likely to be due to ischaemic heart disease, and additionally it is likely that a proportion of deaths coded to HHD are actually due to ischaemic heart disease in people who also had essential hypertension.

Based on a regression analysis of the logit of the proportion of deaths in the HHD category that were coded to essential hypertension against the crude HHD death rate, the predicted fraction of HHD deaths to be redistributed to IHD was estimated. It was set to 30% for country-years with HHD death rate less than 20 per 100,000. For certain outlier countries, it was set to country-specific values derived directly from the VR data: 50% (Brazil), 40% (France) and 37% (Argentina). Based on a similar analysis, 10% of HHD deaths were redistributed to “other chronic kidney disease”, with specific higher values for Japan (18%), Mexico (30%) and the USA (15%).

Table 4.3. *Redistribution fractions for ill-defined cardiovascular causes of death (ICD10 4-digit codes I472, I490, I46, I50, I514, I515, I516, I519, and I709) for the traditionally high-income countries*[a]

	GHE target cause							
	1100	1150	1180	1440	1100	1150	1180	1440
Age	Redistribution fractions for males				Redistribution fractions for females			
0	1%	6%	1%	93%	1%	7%	1%	92%
1-4	2%	19%	4%	75%	2%	22%	3%	73%
5-9	4%	26%	4%	66%	4%	32%	4%	60%
10-14	6%	35%	3%	55%	5%	34%	4%	57%
15-19	14%	42%	3%	41%	11%	37%	5%	48%
20-24	29%	42%	3%	26%	20%	41%	4%	35%
25-29	46%	35%	3%	16%	33%	37%	4%	25%
30-39	63%	27%	2%	8%	48%	31%	5%	16%
35-39	74%	19%	3%	4%	61%	24%	6%	9%
40-44	81%	14%	4%	2%	69%	17%	10%	5%
45-49	83%	10%	5%	1%	70%	13%	14%	3%
50-54	91%		9%		78%		22%	
55-59	88%		12%		73%		27%	
60-64	84%		16%		71%		29%	
65-69	80%		20%		70%		30%	
70-74	76%		24%		71%		29%	
75-79	74%		26%		75%		25%	
80-84	74%		26%		79%		21%	
85+	77%		23%		86%		14%	

a) Andorra, Australia, Austria, Belgium, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, Malta, Monaco, Netherlands, New Zealand, Norway, Portugal, Republic of Korea, San Marino, Singapore, Spain, Sweden, Switzerland, United Kingdom, United States of America

Table 4.4. *Redistribution fractions for ill-defined cardiovascular causes of death (ICD10 4-digit codes I472, I490, I46, I50, I514, I515, I516, I519, and I709) for eastern European and central Asian countries*[a]

	GHE target cause							
	1100	1150	1180	1440	1100	1150	1180	1440
Age	Redistribution fractions for males				Redistribution fractions for females			
0	0%	2%	0%	97%	0%	3%	0%	97%
1-4	2%	9%	3%	86%	2%	12%	2%	84%
5-9	4%	20%	5%	71%	2%	23%	4%	71%
10-14	5%	29%	8%	57%	5%	27%	11%	57%
15-19	21%	34%	9%	37%	18%	26%	10%	46%
20-24	50%	27%	10%	14%	47%	19%	14%	20%
25-29	59%	26%	8%	7%	58%	21%	10%	11%
30-39	66%	25%	7%	3%	59%	23%	11%	7%
35-39	72%	21%	6%	1%	66%	21%	9%	4%
40-44	76%	17%	6%	1%	73%	17%	8%	2%
45-49	80%	13%	7%	0%	76%	14%	9%	1%
50-54	92%		8%		89%		11%	
55-59	90%		10%		89%		11%	
60-64	88%		12%		90%		10%	
65-69	87%		13%		91%		9%	
70-74	86%		14%		92%		8%	
75-79	86%		14%		92%		8%	
80-84	87%		13%		93%		7%	
85+	90%		10%		94%		6%	

a) Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czechia, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Mongolia, Montenegro, Poland, Republic of Moldova, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Tajikistan, The former Yugoslav Republic of Macedonia, Turkmenistan, Ukraine, Uzbekistan

Table 4.5. *Redistribution fractions for ill-defined cardiovascular causes of death (ICD10 4-digit codes I472, I490, I46, I50, I514, I515, I516, I519, and I709) for all other countries*

	GHE target cause							
	1100	1150	1180	1440	1100	1150	1180	1440
Age	Redistribution fractions for males				Redistribution fractions for females			
0	0%	3%	1%	95%	0%	3%	1%	95%
1-4	1%	9%	5%	84%	1%	9%	4%	85%
5-9	4%	15%	5%	76%	3%	15%	4%	77%
10-14	9%	23%	5%	63%	7%	22%	5%	66%
15-19	38%	23%	6%	33%	30%	22%	6%	42%
20-24	59%	20%	5%	15%	44%	23%	6%	26%
25-29	69%	18%	5%	8%	54%	22%	7%	17%
30-39	75%	16%	5%	4%	65%	18%	7%	9%
35-39	79%	14%	5%	2%	72%	15%	8%	5%
40-44	82%	11%	6%	1%	76%	12%	9%	2%
45-49	83%	9%	7%	1%	78%	10%	11%	1%
50-54	89%		11%		85%		15%	
55-59	86%		14%		82%		18%	
60-64	81%		19%		80%		20%	
65-69	76%		24%		77%		23%	
70-74	71%		29%		75%		25%	
75-79	68%		32%		74%		26%	
80-84	66%		34%		74%		26%	
85+	66%		34%		75%		25%	

In a number of countries, the deaths coded to the GHE category “other infectious diseases” result in unusually high death rates for this category. The GHE category includes a number of within-infectious-disease garbage codes: A49 Bacterial infection, unspecified; A89 Unspecified viral infection of the CNS; B34 Viral infection of unspecified site; B94 Sequelae of other and unspecified infectious disease; and B99 Other and unspecified infectious diseases. However, the numbers of deaths coded to these categories are insufficient to explain the outlier levels. Based on a regression the death rate for this category against the death rate for lower respiratory infections, fractions of the “other infectious

disease" deaths were shifted to lower respiratory infections for all except shortlist countries. The average fraction was 13% with 20th percentile 4% and 80th percentile 29%. Countries with average fractions of 30% or more included Antigua and Barbuda, Belgium, Barbados, Grenada, Israel, Saint Lucia, Luxembourg, Norway, Sweden, Switzerland and St. Vincent and the Grenadines.

GHE categories 950 "Alzheimer disease and other dementias" and 1010 "Other neurological conditions" contain 84% of the deaths coded to neurological causes in the death registration data for 2000-2015. "Other neurological conditions" accounted for 15% on average, but in some countries accounted for much higher proportions of deaths, eg. Uzbekhistan 63%, Guatemala 59%, Singapore 52%, Colombia 52%, Philippines 46%, Mexico 44%, Brazil 30%. Based on a regression of the log of the "Other neurological conditions" death rate against the log of the death rate for dementias, excess "other neurological" deaths above the predicted rate were shifted to the dementia category.

Similar issues occurred for chronic respiratory disease categories, with high proportions of deaths coded to "other respiratory diseases" in some countries. Denoting the fraction chronic respiratory disease deaths in the "other respiratory diseases" category as rfrac, for countries where rfrac exceeded the initial average value of 0.15, it was rescaled to fall in the range 0.15 to 0.5 (one standard deviation above the mean). The excess deaths in the "other" category were shifted pro-rata by age and sex to COPD and asthma cause categories.

4.4 Interpolation and extrapolation for missing country-years

For many countries, data were missing for some years. In order to create a continuous time-series of data from 2000 to 2015, we interpolated mortality rates for each country and cause, and then extrapolated up to six years of data at the beginning and end of the data series. Interpolation and extrapolation was carried out separately for the detailed cause list and the short cause list. All shortlist interpolations and extrapolations were carried out using all available data meeting the inclusion criteria. A description of the methods follows.

For each country-age-sex-cause group of the detailed cause list:

1) We interpolated by calculating the mean death rate of all available data in a seven-year window (three years on either side, no earlier than 1998).
2) We extrapolated up to six years from the first/last year of data by applying the mean death rate from the first three or last three years of data to the missing data-years.

For each country-age-sex-cause group of the shortlist cause list:

1) We interpolated by fitting a logistic regression for each missing country-age-sex-cause group, using death rates six years prior (but no earlier than 1998) and six years after the missing data year as the dependent variable and year as the independent variable. In some cases, few deaths were recorded for a specific country-age-sex-cause group and the logistic regression did not converge. In that case, the death rate was estimated as the average rate in the three years prior and three years following the missing data year (as was done for the detailed cause list).
2) Extrapolation method depended on mean number of deaths in the first/last three years of data:

a. If there were an average of more than 250 deaths, a logistic regression was fitted to the first or the final six years of data (including interpolated estimates) for each country-sex-cause.

b. If there were an average 250 or fewer deaths, we extrapolated up to six years from the first/last year of data by applying the mean death rate from the first three or last three years of data to the missing data-years (as was done for the detailed cause list).

Because more shortlist data were available than detailed list data, and shortlist data were interpolated and extrapolated using regression methods that reflect trends in death rates, deaths by cause according to the detailed cause list were adjusted to sum to the totals in the filled-in shortlist dataset. This implied no change when the detailed cause list data were available (most country-years).

For five countries, only data grouped by the shortlist in Table 4.6 were used, either because too few years' (Brunei Darussalam and Kazakhstan) or no data (Russian Federation, Ukraine and Belarus) were reported by ICD code. Shortlist categories were expanded by using the cause-fraction distribution within each shortlist category by year, age, sex from the GBD2013 study results (4-6). For Russia, Belarus and Ukraine, HIV deaths recorded in the death registration data were substantially miscoded to tuberculosis (cause 30), lower respiratory infections (390), other infectious diseases (370), lymphomas and multiple myeloma (760), other malignant neoplasms (780), and endocrine, blood and immune disorders (810). Deaths in these categories falling in the characteristic HIV age pattern were recoded to HIV (100), according to the age-sex-specific HIV mortality estimates from UNAIDS (Section 8.2).

4.5 Adjustment of specific causes

Estimates for tuberculosis deaths were compared with the WHO estimates (also based on an analysis of death registration data and surveillance data) and where the death registration numbers were lower, an average of the two sets of estimates was used. This affected mainly small countries (Antigua and Barbuda, Barbados, Grenada, Iceland, Kuwait, and Luxembourg.

Estimates for HIV deaths were compared with UNAIDS/WHO estimates. For seven mainly small countries, an average of the two sets of estimates were used: Bahamas, Barbados, Guatemala, Jamaica, Saint Lucia, The Former Yugoslav Republic of Macedonia, and Saint Vincent and the Grenadines.

Estimates for malaria deaths were compared with WHO estimates (see Section 8.3) and replaced by WHO estimates for seven countries where the WHO estimates summed across all years were lower than those from the death registration data. This affected malaria deaths for Brazil, Columbia , Ecuador, Guatemala, the Republic of Korea, Panama and the Philippines.

WHO estimates for maternal deaths include an upwards adjustment for under-recording of maternal deaths in death registration data (16). Maternal deaths were adjusted using these country-specific factors, and all other causes adjusted pro-rata.

An adjustment was made for estimates of deaths due to cancer of the colon and rectum for Australia. In Australia, the term "bowel cancer" is often used as a synonym for large intestine on death certificates (17). However, as the bowel does not refer to a specific site in the digestive tract, the ICD-10 directs the coding of the term "bowel cancer" to C260. The GHE grouping for colon and rectum cancers is C18-C21. As many codes in C260 are a cancer of the colon or rectum, there will be an under estimate in this GHE grouping, as C26 is included in "other malignant neoplasms". For Australia, deaths coded to C260 were included in the GHE cause category 650 for colon and rectal cancers.

***Table 4.6**. Short cause list used for vital registration data coded using ICD-9 or ICD-10 abbreviated cause lists*

GHE code	Shortlist cause category
10	**I. Communicable, maternal, perinatal and nutritional conditions**
20	A. Infectious and parasitic diseases
30	A1. Tuberculosis
100	A3. HIV/AIDS
220	A9a. Malaria
380	B. Respiratory infections
390	B1. Lower respiratory infections
420	C. Maternal conditions
490	D. Neonatal conditions
540	E. Nutritional deficiencies
600	**II. Noncommunicable diseases**
610	A. Malignant neoplasms
620	A1. Mouth and oropharynx cancers
630	A2. Oesophagus cancer
640	A3. Stomach cancer
650	A4. Colon and rectum cancers
660	A5. Liver cancer
680	A7. Trachea, bronchus and lung cancers
700	A9. Breast cancer
710	A10. Cervix uteri cancer
740	A13. Prostate cancer
800	C. Diabetes mellitus
820/ 940	E/F. Mental and neurological disorders
1100	H. Cardiovascular diseases
1130	H3. Ischaemic heart disease
1140	H4. Stroke
1170	I. Respiratory diseases
1180	I1. Chronic obstructive pulmonary disease
1190	I2. Asthma
1200	I3. Other respiratory diseases
1210	J. Digestive disorders
1230	J2. Liver cirrhosis
1260	K. Genitourinary diseases
1400	N. Congenital anomalies
1510	**III. Injuries**
1520	A. Unintentional injuries
1530	A1. Road injury
1600	B. Intentional injuries
1610	B1. Self-harm
1620	B2. Interpersonal violence
1630	B3. Collective violence and legal intervention

Relatively small numbers of deaths coded to depression in some countries were re-assigned to suicide.

Deaths due to alcohol and drug use disorders include alcohol and drug poisoning deaths coded to the injury chapter of ICD (see Annex Table A). These were adjusted as described in Section 8.14 to re-allocate unspecified drug dependence, multiple drug use, and unspecified poisoning.

Where necessary, road injury deaths were adjusted upwards to take account of additional surveillance data provided by countries (see Section 8.15). Homicide deaths were similarly adjusted where relevant to take account of homicide data from the police/justice sector (see Section 8.16)

Estimates of deaths due to conflicts (see Section 8.17) were compared with estimates from the death registration data year by year and added "outside-the-envelope" for country-years where they are not included in death registration data.

Death rates for some specific conditions were extreme outliers in a few countries. These outliers were adjusted as follows:

- Death rates for skin disease for Barbados were replaced by the average of rates for Antigua and Barbuda, Trinidad and Tobago, Saint Lucia and Saint Vincent and the Grenadines,
- Death rates for otitis media for Saint Vincent and the Grenadines were replaced by the average of rates for Antigua and Barbuda, Trinidad and Tobago, and Saint Lucia,
- Death rates for eating disorders for Guatemala were adjusted using rates for Mexico
- Death rates for upper respiratory tract infections for Kyrgystan were replaced by estimates based on those in GBD2015, which were somewhat higher than the rates for Tajikistan
- Death rates for upper respiratory tract infections for Uzbekistan were replaced by estimates based on the rates for Kazakhstan
- Death rates for neurological disorders in Kazakhstan were reduced by 75% to bring them into line with other countries in the region.

5 Causes of death for children under age 5 years

5.1 Child deaths

Cause-specific estimates of deaths for children under age 5 were estimated for 15 cause categories using methods described elsewhere by Liu et al. (18) and a companion technical paper in this series (19). Previously published estimates for years 2000-2013 (20) have been updated to take account of revisions in child mortality levels (10), as well as cause-specific estimates as described in Section 8. Inputs to the multivariate cause composition models are also updated. The specific methods used for child causes of death for China and India are described in Sections 5.2 and 5.3.

The fifteen cause categories used for the WHO-MCEE estimates of under 5 deaths for years 2000-2015 (see Annex Table E) include all the major causes of neonatal (0-27 days), postneonatal (1-59 months) and 1-4 year deaths and two residual categories containing all remaining causes of death. These residual categories ("Other Group 1" and "Other Group 2"). Cause groups such as "Congenital malformations" and "Injuries" were expanded to the full GHE cause list (Annex Table A) for neonatal and under 5 deaths using sub-cause distributions derived from the GBD2015 estimates (4-6).

Note that the WHO-MCEE cause estimates and the GBD2105 sub-cause distributions are derived from death registration data for those countries with useable death registration data. Modest differences

between WHO-MCEE estimates published in February 2016 and these GHE2015 estimates are mainly due to new estimates for deaths due to measles and crises, as well as some revisions to malaria deaths in low-burden countries.

5.2 Child deaths in China

Estimates of causes of death under age 5 were based on a separate analysis of the China Maternal and Child Surveillance System (MCMSS). Cause-specific estimates of deaths for children under age 5 were estimated for 15 cause categories using data obtained from China Maternal and Child Surveillance System (MCMSS) for years 2000-2015 by age-sex-residency-region strata. The methods used are described in more detail in a technical paper in this series (19). The fifteen cause categories used for the WHO-MCEE estimates of under 5 deaths for years 2000-2015 (see Annex Table E) include all the major causes of neonatal deaths (0-27 days), and deaths at ages 1-59 months and two residual categories containing all remaining causes of death. These residual categories ("Other Group 1" and "Other Group 2") and cause groups such as "Congenital malformations" and "Injuries" were expanded to the full GHE cause list (Annex Table A) for neonatal and under 5 deaths using cause distributions derived from the GBD2015 estimates for child causes.

Total number of deaths were estimated based on subnational live births and MCMSS strata-specific mortality rates smoothed using a three-year moving average, and normalized to fit IGME all-cause number of death estimates. Cause-specific death proportions from MCMSS, smoothed using a 7-year moving average, were applied to the estimated total number of deaths to obtain the estimated number of deaths by cause by strata prior to summing to obtain national estimates.

5.3 Child deaths in India

In order to estimate trends in under 5 causes of death for India, the previously developed subnational analyses were further refined and used to develop national estimates for years 2000-2015. For neonates, a verbal autopsy multi-cause model (VAMCM) based on 37 sub-national Indian community-based VA studies was used to predict the cause distribution of deaths at state level. The resulting cause-specific proportions were applied to the estimated total number of neonatal deaths to obtain the estimated number of deaths by cause at state level prior to summing to obtain national estimates.

For children who died in the ages of 1-59 months in India, the previously developed multi-cause model (21) was rerun for years 2000-2015 after an updated systematic review was conducted to identify 27 new study data points of sub-national community-based VA studies, plus 22 sets of observations for the Indian states derived from the Million Death Study (22). Nine cause categories were specified, including measles plus the eight specified in the post-neonatal VAMCM for other countries. State-level measles deaths were then normalized to fit the national measles estimates produced by the WHO IVB. State-level AIDS and malaria estimates were provided by UNAIDS and WHO malaria program, respectively. All cause fractions were adjusted to sum to one. The state-level estimates were collapsed to obtain national estimates at the end.

6 Causes of death for China 2000-2015

6.1 Data sources for causes of death

Cause-specific mortality data for China were available from three sources – the sample vital registration (VR) system data for years 1987 to 2012 (23), summary deaths tabulations from the Diseases Surveillance Points (DSP) system for years 1995-1998 and 2004-2012 (24, 25) and the newly merged and expanded VR and DSP system for 2013, referred to as the Death Registration (DR) system (26). The Death Registration system also includes larger numbers of in-hospital deaths so that the total deaths recorded in the system reached 4 million deaths in 2012 (27). The numbers of deaths recorded in the sample representative sites for DSP, VR and DR systems is summarized in Table 6.1 below.

Table 6.1 *Total deaths and population covered by the Chinese vital registration system (VR) , the Disease Surveillance Points system (DSP) and the newly merged Death Registration system (DR).*

	Number of deaths			Population		
Year	VR	DSP	DR	VR	DSP	DR
2000	711,946	…	…	117,183,678	…	…
2001	…	…	…	…	…	…
2002	…	…	…	…	…	…
2003	626,392	…	…	102,889,945	…	…
2004	295,906	430,994	…	55,288,841	71,173,205	…
2005	310,826	437,490	…	57,272,144	71,487,277	…
2006	379,057	347,057	…	72,240,261	66,012,299	…
2007	475,289	401,008	…	79,101,646	71,476,477	…
2008	471,219	424,683	…	…	73,928,499	…
2009	505,021	437,550	…	…	75,020,489	…
2010	558,915	453,211	…	90,158,748	78,766,626	…
2011	775,458	437,490	…	124,960,668	77,396,478	…
2012	929,249	459,836	…	147,969,227	77,215,997	…
2013	…	…	1,463,851	…	…	227,236,284

… data not available.

These sets of data were assessed and compared for suitability in estimating 2000-2015 cause-specific mortality for China at the national level. The VR and DSP datasets gave quite similar cause distributions at major cause group level by age, across the period 2000-2010. Additionally, comparison for more detailed major causes of death did not give any clear indication that one data set was of systematically higher quality than the other. We therefore based the previous 2000-2012 cause of death estimates for China on an average of the estimates from the two systems (1).

With the merger of the two systems in 2013, and the expansion of urban sample sites, the urban-rural composition of the sampled populations changed to be more nationally representative. For earlier years, WHO analyses had re-weighted urban and rural samples from DSP and VR to give approximate national representativeness. However, the DR dataset for 2013 also uses a different set of cause categories, not entirely consistent with the earlier datasets. We mapped cause categories from the three datasets to GHE cause categories and examined the resulting cause-specific time trends. There were inconsistencies between the DSP+VR based results and the 2013 results which were not resolvable given the available cause-specific information.

6.2 Estimation of deaths by cause for ages 5 and over

We also compared these results with the GBD2015 national cause-specific trends for China (4-6) and found reasonable consistency for the 2015 results for most but not all causes. For causes for which WHO has specific estimates as described in Section 8 below, these estimates were used. For other causes, cause fractions from the GBD2015 estimates were used, adjusted to the WHO envelope for these causes. The GBD2015 estimates were derived from available Chinese data on causes of death at national and sub-national levels, with major inputs coming from the DSP and VR sample systems for years 2000-2012, with additional data on deaths in Chinese hospitals (27).

The DR 2013 data were used to make the following adjustments to WHO and GBD2015 inputs:

(1) 2011-2015 estimates for road injury deaths were revised based on analysis of the DR 2013 data. The estimated total road injury deaths for China in 2013 was revised upwards from 261,000 to 272,000, which is still somewhat lower than the 310,000 estimated by GBD2015.

(2) The following GBD2015 cause fractions were adjusted based on comparisons with 2013 data:
    a. Diabetes 17% increase
    b. Epilepsy 17% increase
    c. Other neurological 53% increase
    d. COPD increase in 2000 of 6%, dropping to 0% in 2010 and beyond (based on trend in VR/DSP data for 2000-2010
    e. Other respiratory: increase in 2000 of 20%, dropping to 0% in 2010 and beyond (based on trend in VR/DSP data for 2000-2010
    f. Suicide: approximately 5% increase across all years

Other adjustments for specific causes are described in Section 8 below.

6.3 Comparison of GHE estimates with death registration data and GBD2015

GBD2015 results were used as inputs to estimate cause fractions by country, age, sex and year for causes of death at ages five years and above for which death registration data and/or WHO and UN Interagency analyses were not available. For this set of causes, GBD2015 national estimates for death rates at ages 5 and over for China in years 2000-2015 were used. For each year 2000 to 2015, cause fraction distributions were then computed for the set of causes excluding WHO/Interagency cause-specific estimates. For countries where these cause fractions were used, they were applied to the country-level residual mortality envelopes by age and sex after the WHO/Interagency cause-specific estimates were subtracted from the WHO all-cause envelopes.

Table 6.2 summarizes and compares the estimates for total deaths in 2015 for selected causes from the DR 2013 (scaled to the China all-cause envelope), from GHE2015 and from GBD2015.

Table 6.2 Estimated total deaths ('000s) for China in 2013, selected causes from DR2013 (rescaled to total deaths by age and sex), GHE2015 and GBD2015.

Cause	DR2013	GHE2015	GBD2015
Tuberculosis	32.2	33.6	48.9
HIV	6.4	23.1	41.8
Diarrheal diseases	4.6	9.2	5.9
Malaria	0.0	0.0	0.2
Lower respiratory infections	215.9	217.1	205.1
other infectious diseases	117.6	53.4	t
Maternal causes	3.1	4.8	2.9
Neonatal causes	81.6	68.8	75.4
Cancers	2,290.3	2,309.6	2,343.8
Oesophagus cancer	242.9	196.6	202.0
Stomach cancer	265.0	326.5	334.7
Lung cancer	455.3	635.6	580.0
breast cancer	30.2	49.0	69.2
Cardiovascular diseases	4,105.3	4224.0	3,829.6
Chronic respiratory diseases	1,084.3	1,061.2	957.8
Other noncommunicable diseases	1,058.2	1,196.5	8221.6
Road injury	281.5	268.1	310.5
Poisoning	34.6	22.4	22.3
Suicide	135.2	138.6	135.7
Homicide	9.9	11.9	20.0
Other injury	289.2	255.3	777.2

Source for GBD2015 (4-6)

7 Causes of death for India 2000-2015

7.1 Sample Registration System data

Analysis of causes of death for India was based on data from the Sample Registration system (SRS) for the periods 2001-2003 (28, 29) and 2010-2013 (30, 31). These data were derived from representative samples of deaths in the SRS sampling areas, for which verbal autopsy methods were used to assign cause of death. The Sample Registration System monitors a representative sample population of over 6 million people in over 1 million homes in India. In 2013, a total of 7,597 sample units covered a total population of 7.5 million people, of whom 2.0 million were in urban areas and 5.5 million in rural areas.

In 2001 the Indian Registrar General Surveyor introduced an enhanced form of verbal autopsy for assessing the cause of death. Verbal autopsy is a method of ascertaining the cause of death by interviewing a family member or caretaker of the deceased to obtain information on the clinical signs, symptoms and general circumstances that preceded the death. Details of methods and validation have been reported elsewhere (29, 30). Verbal autopsy reports were independently coded to ICD-10 categories by at least two of a total of 130 physicians trained in ICD-10 coding. In case of disagreement on the ICD-10 codes at the chapter level, reconciliation between reports was conducted, followed by a third senior physician's adjudication.

A total of 122,848 deaths between January 2001 and December 2003, and a total of 182,827 deaths for 2010-2013 were assigned causes of death by verbal autopsy. Verbal autopsies could not be conducted for around 10% of the deaths for reasons such as family migration or change of residence.

The cause-specific proportion of deaths in each five-year age category from 0 to 79 years and for people aged 80 years and over was weighted by the inverse probability of a household being selected within rural and urban subdivisions of each state to account for the sampling design. National estimates for deaths and mortality rates were based on reweighted urban and rural estimates for India, by age, sex and area.

The GHE analysis is based on the resulting national-level cause-specific mortality proportions derived for GHE cause categories from the SRS data. GBD2015 cause fractions were used to redistribute deaths to detailed sub-cause categories in cases where the SRS cause categories were broader than the GHE cause categories.

7.2 Comparison of GHE estimates with SRS and GBD2015

For causes for which full time series estimates for years 2000-2015 were not available from WHO technical programs and UNAIDS (see Section 8), the trends for the full period 2000-2015 were estimated as follows. We made use of the trends estimated by IHME in the GBD2015 study (2). The India data sources used by IHME can be inspected on their website (12). The GBD2015 estimates for years 2000-2015 were rescaled for consistency with the total deaths across all such causes estimated from WHO life tables and cause-specific estimates. Age-sex-cause specific ratios of SRS-based deaths to rescaled GBD2015 deaths were calculated from the SRS data for period 2002 (2001-2003) and 2011.5 (2010-2013). The scale factors were linearly interpolated for years 2003-2011 and extrapolated to year 2000 and 2015. They were then applied to the GBD2015 estimates to generate full time series for these causes consistent with the WHO analyses of the SRS data for 2001-2003 and 2010-2013. The remaining cause-specific estimates were based on information from WHO technical programmes and UNAIDS on specific causes as described in Section 8.

8 Methods for specific causes with additional information

8.1 Tuberculosis

For countries with death registration data, tuberculosis mortality estimates were generally based on the most recently available vital registration data. For other countries, total tuberculosis deaths were derived from latest published WHO estimates (32), together with more detailed unpublished age distributions based on the VR data and notifications data.

8.2 HIV/AIDS and sexually transmitted diseases

(a) High HIV countries

For 43 countries with significant HIV epidemics, explicit efforts were made to ensure consistency of all-cause and HIV mortality estimates across the period 2000-2015 in the 2016 revision of WHO life tables and all-cause mortality "envelopes" (11). These countries are identified in Annex Table D. For these countries, HIV mortality estimates from either UN Population Division (8) or UNAIDS (33) were revised using updated Spectrum models for 1985-2015. These models took into account the WPP 2015 revisions to demographic data and all-cause mortality, as well as 2015 UNAIDS files with a range of 2016 updates to the Spectrum/AIM software including new patterns of adult mortality on ART and age at ART initiation among pediatric patients and the re-fitting of all the EPP curves (11, 34).

(b) Countries with useable vital registration data

For countries with death registration data, HIV/AIDS mortality estimates were generally based on the most recently available vital registration data except where there was evidence of misclassification of HIV/AIDS deaths. In such cases, a time series analysis of causes where there was likely misclassified HIV/AIDS deaths was carried out to identify and re-assign such deaths.

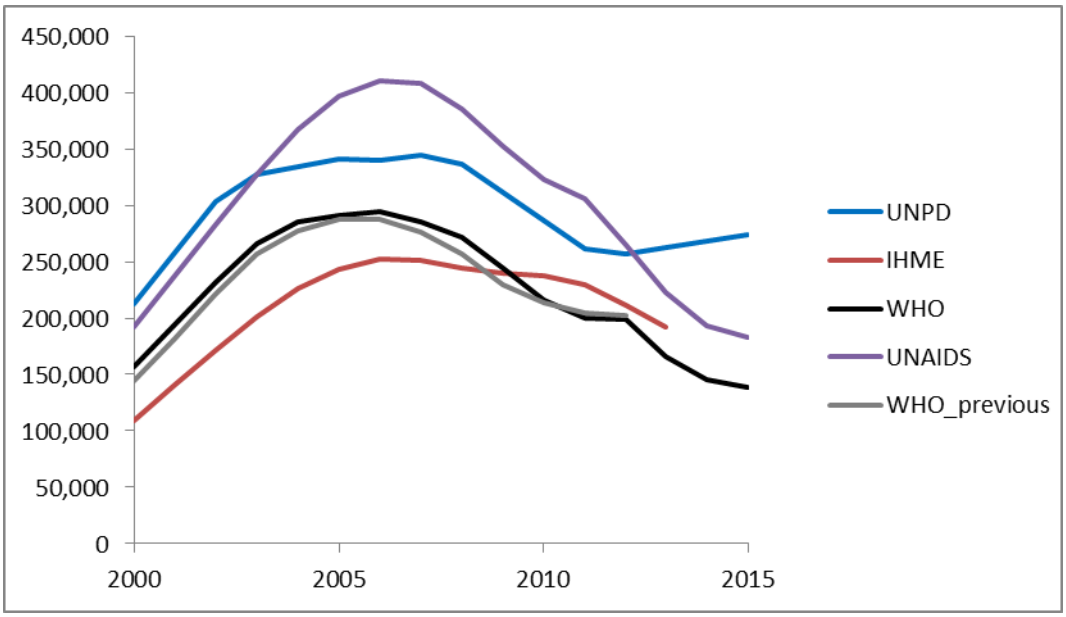
(c) Other countries

For other countries, estimates were based on UNAIDS estimated HIV/AIDS mortality (33). UNAIDS does not estimate HIV deaths for the following countries: Comoros, Libya, Micronesia, Samoa, Seychelles, Solomon Islands, Tonga and Vanuatu. HIV estimates for these countries were based on previous WHO GHE2013 estimates with projections. It was assumed based on advice from UNAIDS that 1% of HIV deaths under age 5 occurred in the neonatal period.

(d) South Africa

For development of previous WHO life tables, South Africa was classified as "high HIV" and explicit efforts made to ensure consistency of all-cause and HIV mortality estimates. For the WPP 2015, UN Population Division used Spectrum (34) with input assumptions consistent with those of UNAIDS in mid-2014 to model all-cause mortality for South Africa. This resulted in estimates for HIV deaths that were not consistent with the most recent estimates by UNAIDS (33). Figure 8.1 shows total HIV deaths by year as estimated by UN Population Division for the WPP2015 life tables, UNAIDS revision in 2016, IHME estimates from GBD2013, and current WHO draft estimates along with the WHO previous GHE2013 estimates for 2000-2012 (1).

Figure 8.1. *Comparison of estimates of total HIV deaths 2000-2015, South Africa*



During the 2016 revision of WHO life tables drawing on inputs from WPP2015, it was realized that use of either the UNPD or UNAIDS estimates of HIV mortality would either result in implausibly low levels of non-HIV mortality, or high levels of all-cause mortality not consistent with available estimates of completeness of death registration data. Figure 8.2 compares estimates of non-HIV mortality and total all-cause mortality from the various agencies, and Figure 8.3 compares the implied completeness estimates of South African death registration data (calculated by dividing total registered deaths by estimated total deaths from all causes).

Figure 8.2. *Comparison of estimates of total non-HIV deaths and all-cause deaths, 2000-2015, South Africa*

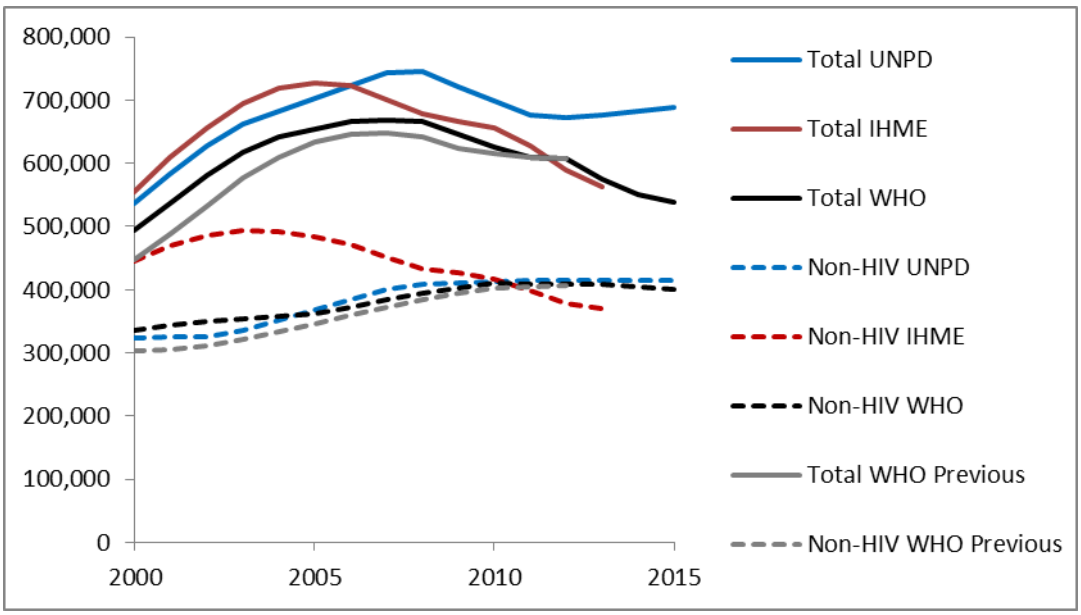
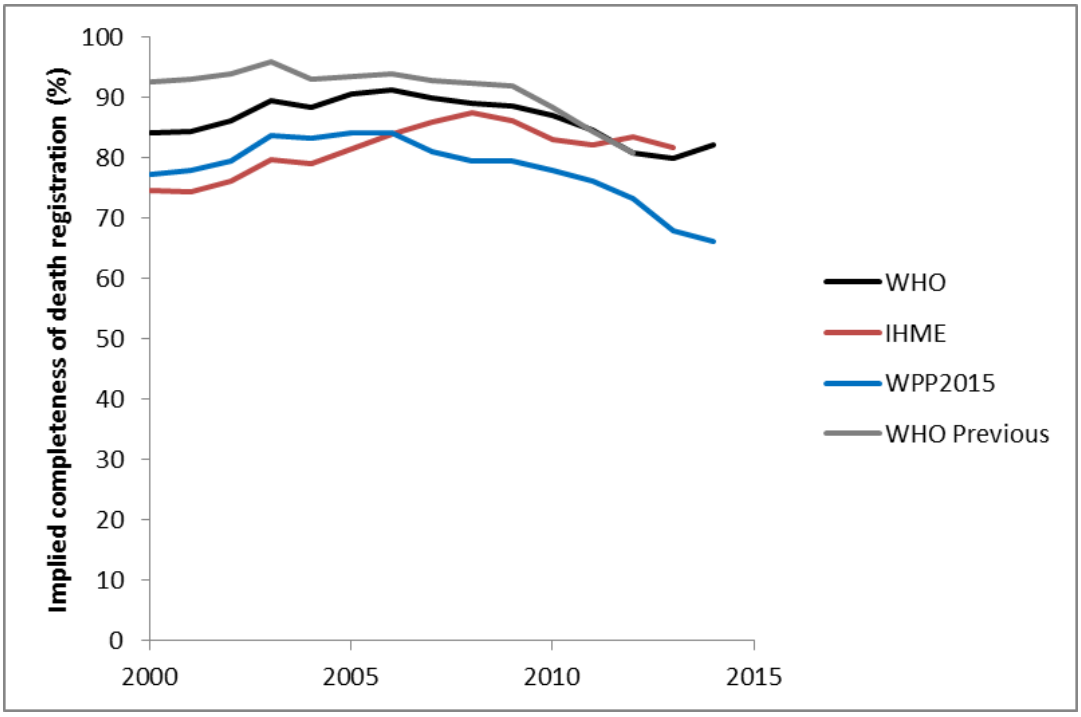


Figure 8.3. *Comparison of estimates of completeness of death registration, 2000-2014, South Africa*



Given the inconsistencies between the HIV mortality estimates, all-cause mortality estimates and implied completeness of death registration, we decided to maximise consistency with the previous WHO estimates of HIV and non-HIV mortality for years 2000-2012 (1) released in 2014. Estimates of both non-HIV and HIV mortality were adjusted upwards for earlier years near 2000, as the implied completeness of death registration was too high for the previous WHO estimates. Non-HIV mortality rates were projected forwards drawing on the trend estimates from UNPD and HIV mortality rates were projected forwards based on the trends in the UNAIDS estimates for HIV deaths.

8.3 Malaria

Under 5 deaths in countries with high quality VR data

For countries in which death reporting is estimated to capture > 50% of all deaths and a high proportion of malaria cases are parasitologically confirmed, reported malaria deaths are adjusted for completeness of death reporting. For countries in elimination programme phase, reported malaria deaths are adjusted for completeness of case reporting.

Under 5 deaths in countries outside the WHO African Region and low transmission countries in Africa

For countries (i) outside the African Region in which death reporting is estimated to capture ≤ 50% of all deaths or a high proportion of malaria cases are *not* parasitologically confirmed, or (ii) in the African Region where estimates of case incidence were derived from routine reporting systems and where malaria comprises less than 5% of all deaths in children under 5,[1] case fatality rates are used to derive

[1] Algeria, Botswana, Cape Verde, Comoros, Eritrea, Ethiopia, Madagascar, Namibia, Sao Tome and Principe, South Africa, Swaziland, and Zimbabwe

number of deaths from case estimates. A case fatality rate of 0·256% is applied to the estimated number of *P. falciparum* cases, being the average of case fatality rates reported in the literature (35-37) and unpublished data from Indonesia, 2004-2009 (*correspondence with Dr. Ric Price, Menzies School of Health Research*). A case fatality rate of 0.0375% is applied to the estimated number of *P. vivax* cases, representing the mid-point of the range of reported case fatality rates (38). The number of cases reported by a Ministry of Health is adjusted to take into account (i) incompleteness in reporting systems (ii) patients seeking treatment in the private sector, self-medicating or not seeking treatment at all, and (iii) potential over-diagnosis through the lack of laboratory confirmation of cases.

Under 5 deaths in South Sudan and high transmission countries in the WHO African Region.

For countries in the African Region where malaria comprises 5% or more of all deaths in children under 5, malaria deaths were estimated using a multinomial logistic regression model fitted to available verbal autopsy data sets. This model is described in more detail elsewhere and draws on geospatial estimates of parasite prevalence rates produced by the Malaria Atlas Project at Oxford University in close collaboration with WHO (39).

Malaria deaths at ages 5 and over.

The estimated malaria mortality rate in children under 5 years for a country was used to determine malaria transmission intensity and the corresponding malaria-specific mortality rates in older age groups (53).

These estimates for malaria deaths 2000-2015 are consistent with those published in the World Malaria Report 2016 (39), except for some slight differences resulting mainly from malaria deaths coded in death registration data for some countries.

8.4 Whooping cough

Recognizing the limited data to support modelling of pertussis mortality, the World Health Organization's Department of Immunization Vaccines and Biologicals' Quantitative Immunization and Vaccines Related Research (QUIVER), recommended in 2009 that a revised pertussis model be developed to specifically address uncertainty in the model inputs and parameter values. Inputs to the current model are country- and year-specific estimates of population by single year of age and estimated pertussis immunization coverage (40). Age-, country-, and immunization history- specific estimates of the probability of initial infection, probability that an infected individual develops typical symptoms of a case of pertussis and the probability that a case of pertussis will die were estimated using structured expert judgment (41, 42*)*. Annual deaths attributable to pertussis infection during the neonatal period (5% of estimated pertussis deaths 0-11 months of age), from age 1-11 months of age (estimated as 95% of deaths 1-11 months of age) and 12-59 months of age were estimated for each country for the years 2000 – 2012. The pertussis cause fraction was assumed to be constant to extrapolate forwards to 2015. Pertussis deaths at ages 5 and over were estimated from useable death registration data or GBD2015 analyses.

8.5 Measles

To estimate deaths attributable to measles, a new model of measles mortality developed by WHO Department of Immunization, Vaccines and Biologicals (IVB) was used to first estimate country-and-year-specific cases using surveillance data (43, 44). The improved statistical model firstly estimates measles cases by country and year using surveillance data and making explicit projections about dynamic transitions over time as well as overall patterns in incidence.

The cases are then stratified by age classes based on a model fitted to data stratified by national GDP and vaccine coverage. The results are applied to age-specific case fatality ratios for each country (45-47) and then aggregated again to produce overall measles deaths. The estimates used here are from an update to take into account trends in case notifications and vaccine coverage up to and including the year 2015 (48).

Measles deaths at ages 5 and over were estimated from useable death registration data or GBD2015 analyses.

8.6 Hepatitis-attributable deaths

For liver cancer and cirrhosis of the liver, the GBD2015 estimated deaths for four aetiological categories: hepatitis B virus (HBV) infection, hepatitis C virus (HCV) infection, alcohol, and "other causes". DisMod-MR 2.1 was used to model the proportions of liver cancers and liver cirrhosis due to these four sub-causes using data derived from systematic reviews of literature on the aetiology of liver cancers and liver cirrhosis (5). Relevant covariates used in DisMod-MR 2.1 were apparent alcohol consumption (litres per capita), hepatitis B surface antigen (HBsAg) seroprevalence, and hepatitis C (anti-HCV IgG) seroprevalence, and a binary covariate indicating countries with a predominantly Muslim population (associated with low alcohol consumption).

To ensure coherent results between the cirrhosis and the liver cancer etiologies, the results from the liver cancer etiology models were transformed into covariates that were then used in the cirrhosis etiology models. The results from the cirrhosis etiology models were then used in the liver cancer proportion models. The DisMod proportions for the underlying liver cancer and cirrhosis etiologies were then squeezed to 100% and these final proportions were applied to the total liver cancer and liver cirrhosis to derive the estimates for the four etiologies.

IARC has also carried out an analysis of the hepatitis B and hepatitis C fractions of total liver cancer cases. Estimates for 50 countries have been published (49) and regional and global estimates are in preparation (50). Since there is considerable time lag between hepatitis infection and death from liver cancer, the proportions attributable to HBV and HCV infection relate to hepatitis seroprevalence distributions in the past, when hepatitis C was less prevalent than in recent years. The time series used in the IARC paper vary from country to country depending on available data, but typically contain data ranging from the early 1990s to the early 2000s, in some cases out to 2010. The data for China are for the range 1954-2010. Details of the time periods for the data used in the IHME analyses are not available. On the other hand, the IHME analyses included a complete set of subcause categories as they are also estimating alcohol and other causes as well as hepatitis infection (ensuring that all cause fractions add to 100%). The IARC analyses address only hepatitis B and C with the potential for over-estimation of causal fractions.

Table 8.1 summarizes the global attributable fractions for HBV and HCV caused liver cancer and liver cirrhosis from WHO, IARC and IHME, together with the GHE2015 final estimates, derived as described below. In estimating the sub-causes of liver cancer and cirrhosis for GHE2015, we drew on the GBD2015, GBD2013 and IARC analyses as follows. The GBD2015 cause fractions for liver cancer were revised pro-rata to adjust the HBC fraction of HBV+HCV caused liver cancer by country/region group to the IARC estimates shown in Table 8.2. We also revised the "other" category downwards to the proportions estimated in GBD2013, shifting the excess deaths to HBV and HCV. This resulted in an overall estimate of the fraction of liver cancer attributable to hepatitis (HBV or HCV) similar to the IARC estimates. Cirrhosis death attributions were similarly adjusted drawing on the HCV/HBV proportions estimated for liver cancer.

Table 8.1 Global attributable fractions for liver cancer and cirrhosis, latest year, WHO, IARC and GHE.

	WHO (51)	IARC (49,50)	GBD2013	GBD2015	GHE2015
Liver cancer					
HBV	53	53	37	33	43
HCC	25	20	42	21	17
Alcohol			11	30	30
Other			10	16	10
Cirrhosis					
HBV	30		26	29	40
HCC	27		29	25	22
Alcohol			32	27	25
Other			13	19	13
HBV+HCV percent of					
Liver ca	78	73	79	53	60
Cirrhosis	57		55	54	62

Table 8.2 Fractions of liver cancer caused by HBV and HPC estimated by IARC (49, 50) and IHME (4). IHME GBD2015 results shown are for year 2015.

	HBV %of (HBV+HVC)		(HBV+HCV) %	
Region	IARC	GBD2015	IARC	GBD2015
Eastern Asia	42	57	89	58
Latin America	56	69	64	54
China	7	18	74	49
India	24	29	69	63
Russia	29	61	51	39
Northern Africa	85	81	88	75
Northern America	73	76	45	40
Northern Europe	78	69	36	54
Oceania	29	62	70	51
Rest of Europe	71	76	62	54
Sub-Saharan Africa	30	29	71	57
Western-Central Asia	47	57	74	67
World	73	62	73	53

8.7 Schistosomiasis

For the WHO update of burden of disease for year 2004 (52), the incidence and prevalence of cases of schistosomiasis infection were separately estimated by country for *S. mansoni*, *S. haematobium* and *S. japonicum* plus *S. mekongi.* The GBD 2004 estimated that schistosomiasis was responsible for around 41 000 deaths globally (excluding attributable cancer deaths) and 36 000 in sub-Saharan Africa, although others have argued that the figure should be much higher (53). Van der Werf et al (54), using limited data from Africa, estimated that schistosomiasis caused 210 000 deaths annually. For the GBD 2004 update, very limited available data was used to conservatively estimate annual case fatality rates for prevalent cases at 0.01% for *S. mansoni,* 0.02% for *S. haematobium,* and 0.03% for *S. japonicum* and *S. mekongi*. There were estimated to be 261 million prevalent cases of schistosomiasis infection in 2004.

The GBD2015 study estimated that there 252 million prevalent cases of schistosomiasis infection in 2015, and 4,365 deaths due to schistosomias, giving an implied average case fatality rate of 0.002%, an order of magnitude lower than earlier WHO estimates. The GBD2015 implied case fatality rates for the Middle East and North Africa, for Latin America, and for Southeast Asia, East Asia and the Pacific are 0.009%, 0.017% and 0.08% respectively. These are substantially higher than the implied African case fatality rate of 0.001%. Revised case fatality rates of 0.0075% for *S. mansoni,* 0.015% for *S. haematobium* were applied to the prevalence rates estimated by GBD2015 (6) to revise the estimates of schistosomiasis deaths for GHE. This resulted in an estimate of 21,170 deaths in sub-Saharan Africa and 24,067 deaths globally in 2015.

8.8 Cycsticercosis, echinococcosis and food-borne trematodes

In 2007, the World Health Organization (WHO) established the Foodborne Disease Burden Epidemiology Reference Group (FERG) to estimate global and regional burdens of foodborne disease. Included among the parasitic foodborne diseases analysed were cysticercosis, echinococcis, and food-borne trematodosis. In 2015, the FERG published regional and global estimates of deaths and DALYs for these diseases for the year 2010 (55, 56). The GBD2015 time series estimates of deaths for these three diseases were scaled to match the underlying FERG estimates of deaths by country in 2010.

8.9 Rabies

GHE2015 estimates of rabies deaths for years 2000-2015 were updated as follows. Total rabies deaths for years 2011-2015 were based on more recent data on reported human rabies deaths from the Chinese Center for Disease Control and Prevention (57, 58). Rabies deaths for India were revised based on the reported deaths in the Indian SRS data for years 2001-2003 and 2010-2013 (see Section 7). For other countries with more than 10 estimated rabies deaths per year, years 2013 to 2015 were projected assuming an average annual rate of decline of 4% based on the trend in the GHD2013 estimates.

8.10 Leprosy

The GBD2015 estimated that there were 514,200 prevalent cases of leprosy in 2015, with 35% of these in India. Although cause of death data for both India and China contained leprosy deaths, the GBD2015 estimated zero deaths globally. The implied case fatality rate for India of 2% was applied to GBD2015 estimates of leprosy cases across all countries. Resulting global deaths for leprosy in 2015 were just over 15,900.

8.11 Ebola

Deaths directly resulting from Ebola virus infection in 2014 and 2015 in Liberia, Sierra Leone and Guinea were estimated using the "medium" scenario estimates of Helleringer and Noymer (59). They estimated Ebola deaths for three scenarios as follows: a "low" scenario where they consider that no cases went unrecorded, and a high scenario where they consider that there 2.5 times more cases than recorded. The medium scenario considers 70% more cases than recorded. There have been new estimates recently that suggest that there could be up to 3.5 times more cases than recorded, but these were focused on a small locality, so Helleringer and Noymer did not extend the range all the way to 3.5.

The Ebola outbreak overwhelmed the healthcare systems of Guinea, Liberia, and Sierra Leone, reducing access to health services for diagnosis and treatment for the major diseases that are endemic to the region: malaria, HIV/AIDS, and tuberculosis. Parpia et al. (60) modelled the impact of reduced access to health services on the mortality rates for these three diseases. We took their modelled impact of a 50% reduction in treatment coverage to estimate the additional deaths for malaria (under 5), HIV(ages 15 +) and tuberculosis (all ages). Their estimates related to March 2014 to March 2015, and we assumed the coverage collapse would have covered half a year in 2014 and half a year in 2015. For Liberia, there were very few Ebola deaths in 2015 compared to 2014, so we reduced the coverage collapse to 1/3 of 2015.

Takashi et al (61) estimated the likely increase in measles deaths resulting from disruption of childhood vaccinations during the Ebola outbreak. They projected that after 6 to 18 months of disruptions, a large cluster of children unvaccinated for measles would have accumulated across the three countries, increasing the expected sizes of regional measles outbreaks and resulting in an additional 5,200 deaths (range 2,000 – 16,000).

Data reported to WHO from the case-based measles surveillance systems for all three countries to 31 March 2016 confirmed that there were outbreaks of measles in 2015 in all three countries, although it is likely that reported cases do not accurately reflect the magnitude of the outbreaks. We conservatively adjusted the 2015 measles deaths to include outbreaks of the same magnitude as those estimated for 2014 for deaths under age 5, and to increase the 2015 deaths over age 5 so they were 10% higher than those in 2014.

We explored options for estimating other impacts of health system collapse during the Ebola epidemic, but decided to limit the estimates to those outlined above, for two reasons. First, the impact on HIV, TB, malaria and measles may be higher because of the direct impact on interventions with a big effect on mortality (ART, DOTs, antimalarials, vaccination) and second, it's not clear that there would have been much pre-Ebola health system impact on other causes (particularly for adults).

The estimated direct and indirect mortality impacts of the Ebola epidemic, included in GHE2015, are summarized in the following Table 8.3.

Table 8.3 Estimated direct and indirect additional deaths associated with the West African Ebola outbreak of 2014-2015.

	2014	2015	Under5	Over5	Total
Guinea					
Ebola	2,635	1,105	324	3,416	3,740
TB	849	847	336	1,361	1,697
HIV	339	288	-	627	627
Measles	-	550	450	100	550
Malaria	2,197	2,082	4,199	80	4,279
Total	**6,021**	**4,872**	**5,309**	**5,583**	**10,892**
Liberia					
Ebola	5,412	155	307	5,260	5,567
TB	830	560	215	1,175	1,390
HIV	112	73	-	186	186
Measles	-	145	119	25	145
Malaria	420	253	627	46	673
Total	**6,774**	**1,186**	**1,268**	**6,693**	**7,961**
SierraLeone					
Ebola	9,025	1,580	952	9,653	10,605
TB	787	803	324	1,267	1,590
HIV	106	94	-	199	199
Measles	-	4,533	4,532	1	4,533
Malaria	1,576	1,347	2,844	78	2,923
Total	**11,493**	**8,357**	**8,652**	**11,198**	**19,851**
Total					
Ebola	17,072	2,840	1,583	18,329	19,912
TB	2,466	2,211	875	3,802	4,677
HIV	557	455	-	1,012	1,012
Measles	-	5,228	5,101	127	5,228
Malaria	4,193	3,682	7,670	204	7,875
Total	**24,288**	**14,415**	**15,229**	**23,474**	**38,703**

8.12 Maternal causes of death

Country-specific estimates for maternal mortality were based on the most recent Interagency estimates for years 2000-2015 (16). A multilevel regression model for the proportion of total female deaths in the age range 15-49 that were due to maternal causes (PM) was developed using available national-level data from surveys, censuses, surveillance systems and death registration. This regression model included national income per capita, the general fertility rate and the presence of a skilled attendant at birth (as a proportion of total births) as covariates to predict trends in maternal mortality.

Because the WHO life tables, and hence the total female deaths in the maternal age range, were revised in 2016, the interagency PM estimates have been applied to the new envelopes to estimate numbers of maternal deaths. This has resulted in changes in the estimates of maternal deaths for some countries with substantial revisions to all-cause mortality, and small changes to regional and global total maternal deaths.

Note that the maternal mortality estimates include those HIV deaths occurring in pregnant women or within 42 days of end of pregnancy which were considered to be indirect maternal deaths rather than incidental. These HIV maternal deaths were subtracted from total HIV deaths as estimated by UNAIDS.

8.13 Cancers

Cause-specific estimates for cancer deaths in 2012 were derived from Globocan 2012 (62). For countries without useable death registration data, site-specific deaths were projected back to year 2000 using trend estimates from the GBD2015. For countries with useable death registration data, cancer deaths by site were estimated from the death registration data directly with the various adjustments and redistributions described in Section 4.

Karposi sarcoma was excluded from the Globocan estimates as this is almost entirely a manifestation of HIV/AIDS, already included in the estimates for HIV/AIDS deaths.

8.14 Alcohol use and drug use disorders

The injury codes for accidental poisoning by alcohol and by opioids are now used to code acute intoxication deaths from alcohol and acute overdose deaths by opioids. These deaths have been remapped to alcohol use disorders and drug use disorders respectively (see Annex Table A). GBD2015 estimates for alcohol and drug use disorder deaths, and for accidental poisoning deaths, were used as the starting points for the WHO GHE as described in Section 9 below.

The GBD2013 attributed deaths coded to the ICD-10 code X49 “Accidental poisoning due to other and unspecified chemicals” pro-rata to the GBD drug-type cause categories for drug use disorders, based on the similarity of the age patterns for unspecified poisoning to those for drug overdose. This resulted in a relatively large proportion of drug use disorder deaths for the “other drug use disorders” category. Based on a literature review that identified opioid-dependecy as a large contributor to the deaths in the “other drug use disorders” category, particularly where multiple drug use was involved (5, page 150), the GBD2015 redistributed a large [but undocumented] proportion of the “other drug use” deaths to the “opioid use disorder” category.

An analysis of the age pattern of “Other drug use disorders” for Australia and the USA and comparison with the age patterns for “Opioid drug use disorders” and for accidental poisoning by prescription drugs, also confirmed that the resulting GBD2015 “Other drug use disorders” should be re-attributed in part to opioid use disorders. Analysis of detailed Australian data for deaths coded to ICD-10 code F19 “Multiple

drug use, other and unknown drug use" has shown that around 77% of these deaths involve opioid drugs (63). Based on the adjustment needed to match this result, 24.3% of "other drug use" deaths were re-attributed to opioid use disorders.

The resulting global deaths for opioid use disorders of 127,373 in 2015 is thus somewhat higher than the 122,048 estimated by the GBD2015 for the year 2015. The GHE estimates are also more consistent with the CDC estimates of opioid-caused deaths in the USA (64, 65). Note that these are deaths directly caused by opioid use. The total attributable deaths for opioid use are much higher as they include deaths due to infectious diseases transmitted via re-use of injecting equipment, as well as deaths due to road injury and suicide. The UNODC's World Drug Report 2015 estimated there were 187,100 (98,300-231,400) drug-related deaths globally in 2013, based on reports from its Member States (66). This is surprisingly close to the WHO estimate of 160,946 for drug use disorder deaths in 2013, but less than half of WHO draft estimates for total deaths from all causes attributable to drug use.

8.15 Road injuries

For the third WHO *Global status report on road safety* (67), updated estimates of road injury deaths were prepared for 182 Member States for the years 2000-2013. These estimates drew on death registration data, on reported road traffic deaths from official road traffic surveillance systems (collected in a WHO survey of Member States for the report), and on a revised regression model for countries without useable death registration data. Road injury deaths were projected forward to 2015 using recent trends in death registration data where available, or the trend for recent years to 2015 from the GBD2015. Road injury deaths for Libya reported in the third WHO *Global status report on road safety* were considerably higher than for any other country (based on country-reported surveillance data) and were revised downwards using the road injury regression model estimates predicted for Libya from relevant covariates such as vehicle ownership.

8.16 Homicide

Updated estimates of homicide deaths for WHO Member States were published by WHO for years 2000-2012 in the Global status report on violence prevention 2014 (68), drawing on data from vital registration and criminal justice systems. These were projected forward to 2015 using recent trends in death registration data where available, or the trend for recent years to 2015 from the GBD2015.

8.17 Conflict and natural disasters

Estimated deaths for major natural disasters were obtained from the EM-DAT/CRED International Disaster Database (69). These data were used to adjust age-sex specific total as described in the WHO Life Tables Technical Paper (11).

Country-specific estimates of war and conflict deaths were updated for the entire period 1990-2015 using revised methods documented previously which draw on information on conflict intensity, time trends, and mortality obtained from a number of war mortality databases. The revised WHO country-specific estimates of war and conflict deaths for the period 1990-2015 make use of estimates of direct deaths from three datasets: *Battle-Related Deaths (version 5), Non-State* Conflict *Dataset (UCDP version 5),* and *One-sided Violence Dataset (UCDP version 5)* from 1989 to 2014 (70-72). Using these three datasets, instead of focusing solely on battle-related deaths, reduces the likelihood that overall direct conflict deaths are underestimated.

However, it is likely that a degree of undercounting still occurs in the count-based datasets, and a revised adjustment factor of 1.91 is applied to the annual battle death main estimates for state-state

conflicts. No adjustments were applied to estimated conflict deaths (main estimates) for non-state conflict deaths, and one-sided violence. Note that the application of a single adjustment factor for all state-state conflicts may result in deaths for specific conflicts being over- or under-estimated.

For several conflicts where more specific sources of information are available, these were used to revise estimated deaths:

Iraq — Latest counts of reported deaths in Iraq by the Iraq Body Count (73) were compared with conflict deaths for the period 2003-2006 estimated from the Iraq Family Health Survey 2006 (74). This nationally representative survey of 9,345 households included questions on deaths of adult siblings of respondents, and deaths in the household. Sibling deaths were used to estimate adult mortality rates using the Gakidou-King method (75). Calendar year adjustment factors for under-reporting in the Iraq Body Count data ranged from 3.3 (2003) and 3.4 (2004) to 2.3 (2006) and 2.2 (2007). An average adjustment factor of 2.17 was applied to Iraq Body Count data for more recent years to derive a time series of estimated total conflict deaths in Iraq.

Syria — For Syria, excess mortality in 2011 and 2012 due to the conflict was taken into account based on UN estimates of overall conflict deaths by month and age distribution of deaths (76, 77), as well as estimates by various human rights organizations (78, 79).

West Bank and Gaza Strip. — Estimates of Israeli and Palestinian deaths were derived from statistics published by the Office for the Coordination of Humanitarian Affairs (OCHA) - Occupied Palestinian Territory (OPT) (80) and the Israeli Center for Human Rights in the Occupied Territories (81).

Deaths due to landmines and unexploded ordinance, terrorist events and legal execution were estimated as described in the 2016 Technical Paper on WHO life table methods ().Deaths from terrorist events were separately estimated for many countries without ongoing general conflict using data from the Global Terrorism Database (82). Terrorism deaths from this database were not added to conflict deaths for Iraq, Pakistan, Afghanistan and a number of African countries to avoid potential double counting.

Legal execution deaths are included in this cause category for GHE2015. Estimated execution deaths were added for the main countries using capital punishment regularly (China, Iran, Iraq, DPR Korea, Saudi Arabia, USA and Yemen), from UN Human Rights Reports, with additional information from Amnesty International reports, Human Rights Watch reports and Wikipedia.

9 Other causes of death for countries without useable data

9.1 Cause of death estimates from the GBD2015 study

The IHME developed covariate based estimation models for a large number of single causes as inputs to its overall estimation of numbers of deaths by country, cause, age and sex for years 1990-2010 in the GBD2010 study (83). Results from these models were used as inputs to WHO Global Health Estimates 2000-2012 for causes of death not addressed by WHO and UN Interagency estimation processes and where death registration data did not provide sufficient detail or did not meet quality criteria for direct use for estimating deaths by cause.

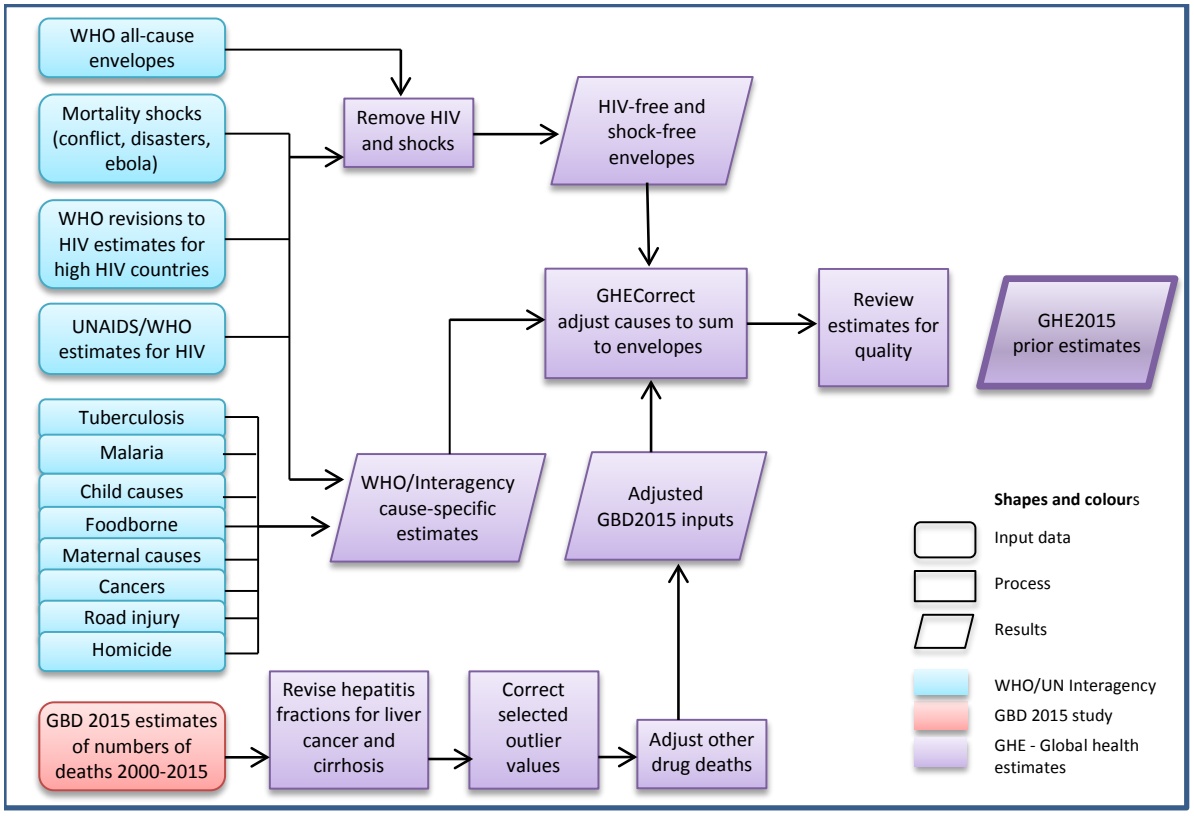
For detailed cause-of-death subcategories not directly derivable from the death registration data in the WHO Mortality Database, we have drawn on updated IHME analyses from the GBD2015 study (4-6), as described below. For example, deaths in the full ICD cause list categories and the short list categories were used to impute more detailed cause distributions for some GHE cause categories (for example, cerebrovascular disease type) using relevant cause fractions from the GBD2015 analyses. Note that the IHME modelling strategies do make use of the available death registration data as well as other sources of information on deaths, covariate regression modelling and also draw on patterns of causes of death for similar countries.

A number of modelling strategies were used by IHME for causes of death depending on the availability of data and the epidemiology of the disease (5). For most major causes of death except HIV/AIDS and measles, IHME used ensemble modelling to create a weighted average of many individual covariate-based models (ranging from hundreds to thousands in some cases) for each specific cause. IHME cause of death estimation methods are thus complex and highly computer-intensive. The overall out-of-sample predictive validity of the ensemble is usually not much different to that of the top-ranked model, but uncertainty ranges are generally much wider and more plausible than for single models.

To ensure that the results of all the single-cause models summed to the all-cause mortality estimate for each age-sex-country-year group, IHME applied a final step called CoDCorrect to rescale the cause-specific estimates (5). This was done using repeated random draws from the uncertainty distributions of each single cause and from the all-cause envelope, and proportionately rescaling each single cause estimate so they collectively summed to the envelope estimate. The overall effect is to “squeeze” or “expand” causes with wider uncertainty ranges more than those with narrower uncertainty ranges.

The overall process of preparing the “prior” set of estimates for all countries for years 2000-2015 for the complete GHE cause list ensuring that inputs from WHO/UN sources and GBD2015 were consistent with the WHO all-cause envelopes is summarized in Figure 9.1. These “prior” estimates were used “as is” for causes of death at ages 5 and over for countries without death registration data meeting inclusion criteria, and also provided inputs to the preparation of GHE2015 estimates for India, under 5 deaths and inputs for specific detailed cause breakdowns for certain cause groups for countries with death registration data.

Figure 9.1 Overview of the processes involved in the preparation of the GHE2015 "prior" estimates for all countries. Refer also to Figure 1.1 for further steps involved in the inclusion of this dataset in the final GHE2015 estimates.



9.2 GHECorrect process

GBD2015 results, post-CoDCorrect, were used as inputs to estimate cause fractions by country, age, sex and year for causes of death at ages five years and above for which death registration data and/or WHO and UN Interagency analyses (described in Sections 4 to 8) were not available. IHME results for priority causes such as HIV, TB, malaria, cancers, maternal mortality, child mortality differ to varying degrees from those of WHO and UN agency partners. In part, this reflects differences in modelling strategies, but also the inclusion by IHME of data from verbal autopsy (VA) studies which has been mapped to ICD categories using IHME-developed computer algorithms. As was done for GBD2015, we carried out a "GHECorrect process to ensure that cause fractions across all causes added to 1 by age, sex, country and year, meaning that estimated numbers of deaths added across causes to the estimated total deaths by age, sex, country and year.

Since WHO and IHME all-cause envelopes (death rates, life tables) differed significantly for some age groups and countries, the first step was to rescale estimated deaths for all cause categories excluding disasters and conflict (referred to as mortality shocks) in the GBD2015 to match the estimated WHO all-cause deaths excluding shocks:

$$CG_{lysac} = G_{lysac}(E_{lysa}) \Big/ \sum_{c \notin shock} G_{lysac}$$

where CG_{lysac} is the corrected number of GBD2015 deaths for location l, year y, sex s, age a, cause c, G_{lysac} is the corresponding uncorrected number of GBD2015 deaths, and E_{lysa} is the estimated GHE total deaths excluding shocks for location l, year y, sex s, and age a.

Causes were divided into three groups:

- W WHO/interagency causes with estimates (tuberculosis, HIV, malaria, rabies, maternal causes, cancers, road injuries and homicide)
- S mortality shocks (natural disasters and conflicts)
- R other causes

The adjustment factor required for corrected GBD estimates for group R is:

$$\alpha_{lysa} = \left(E_{lysa} - \sum_{c \in W} D_{lysac}\right) \Big/ \sum_{cc \in R} CG_{lysac}$$

The adjustment factor α was less than 0.5 for 3.4% of location-year-sex-age-specific estimates and between 0.5 and 0.75 for another 5.7%. To reduce the need for substantial squeezing of GBD2015 inputs, adjustments were made to the age distribution of deaths for causes in group W' (apart from HIV and maternal causes) as follows. Where α_{lysa} was <0.5, deaths D_{lysac} for causes c in cause group W' were adjusted downwards by the factor 0.5*($D_{lysaW'}$ + $CG_{lysaW'}$)/ ($D_{lysaW'}$) and the excess deaths redistributed pro-rata across other ages for that location l, year y, and sex s. After these adjustments to age distributions of causes in W', the adjustment factor α was less than 0.5 for 1.7% of location-year-sex-age-specific estimates and between 0.5 and 0.75 for another 3.3%.

GBD2015-derived estimates for causes in group R were squeezed up to 25% using an alpha value

$$\alpha'_{lysa} = \max(\alpha_{min}, \alpha_{lysa})$$

where $\alpha_{\min}$ =0.75. Where further squeezing was required to match the WHO envelope, estimates were squeezed in both groups R and W', with a differential squeezing factor δ = 1.5 (causes in group R squeezed by factor δxβ and those in group W' by factor β) where β was calculated as:

$$\beta_{lysa} = \left[\left(\sum_{cc \in R} \alpha'_{lysa} CG_{lysac}\right) - \left(E_{lysa} - \sum_{c \in W} D_{lysac}\right)\right] \Big/ \left(\delta \sum_{cc \in R} \alpha'_{lysa} CG_{lysac} + \sum_{c \in W} D_{lysac}\right)$$

Some additional adjustments were carried out for age distributions of group W' causes for Zimbabwe, due to large differences between GBD2015 and GHE non-HIV envelopes. For Zimbabwe, $\alpha_{\min}$ was set to 0.9 and δ to 1. The squeeze factor β was capped at a maximum value of 0.5/ δ (0.5 for Zimbabwe, 0.333 for other countries). There were 10 countries where β initially exceeded 0.5/ δ for some age-sex categories, seven of these were high HIV countries, and the others were small islands. This mostly occurred at younger adult ages and for years before 2010. In these cases, a further pro-rata squeeze was applied to groups W (including and maternal now) and R to match the WHO envelope for 161 country-

year-sex-age categories (an average of 1 age-sex category in each year for each of 10 countries). For these cases, the average additional adjustment was 16% downwards.

9.3 Other adjustments for specific causes in certain countries

As described in a previous technical paper, HIV mortality rates and non-HIV mortality rates were explicitly estimated for 43 high HIV prevalence countries (11). The resulting non-HIV mortality envelopes differed substantially from those in GBD2015 for 4 countries, resulting in Group I (infectious, maternal, neonatal and nutritional causes) and Group II (non-communicable diseases) fractions and age patterns substantially different in GHE2015 from those of neighboring countries with similar non-HIV mortality levels. For this reason, the GBD2015 Group I and Group II inputs were further adjusted for Côte d'Ivoire, Nigeria, Sierra Leone and Zimbabwe, based on group fractions for other countries in the region with similar non-HIV mortality levels..

The numbers of liver cancer deaths and liver cirrhosis deaths attributable to hepatitis B, hepatitis C and alcohol derived from the GBD2015 corrected estimates were further revised as described in Section 8.6. Estimates of deaths attributable to drug use disorders derived from GBD2015 corrected estimates were further revised to account for opioid-related deaths included in the "other and multiple drug use" category as described in Section 8.14. Various other adjustments were also made for specific causes as described in Section 8.

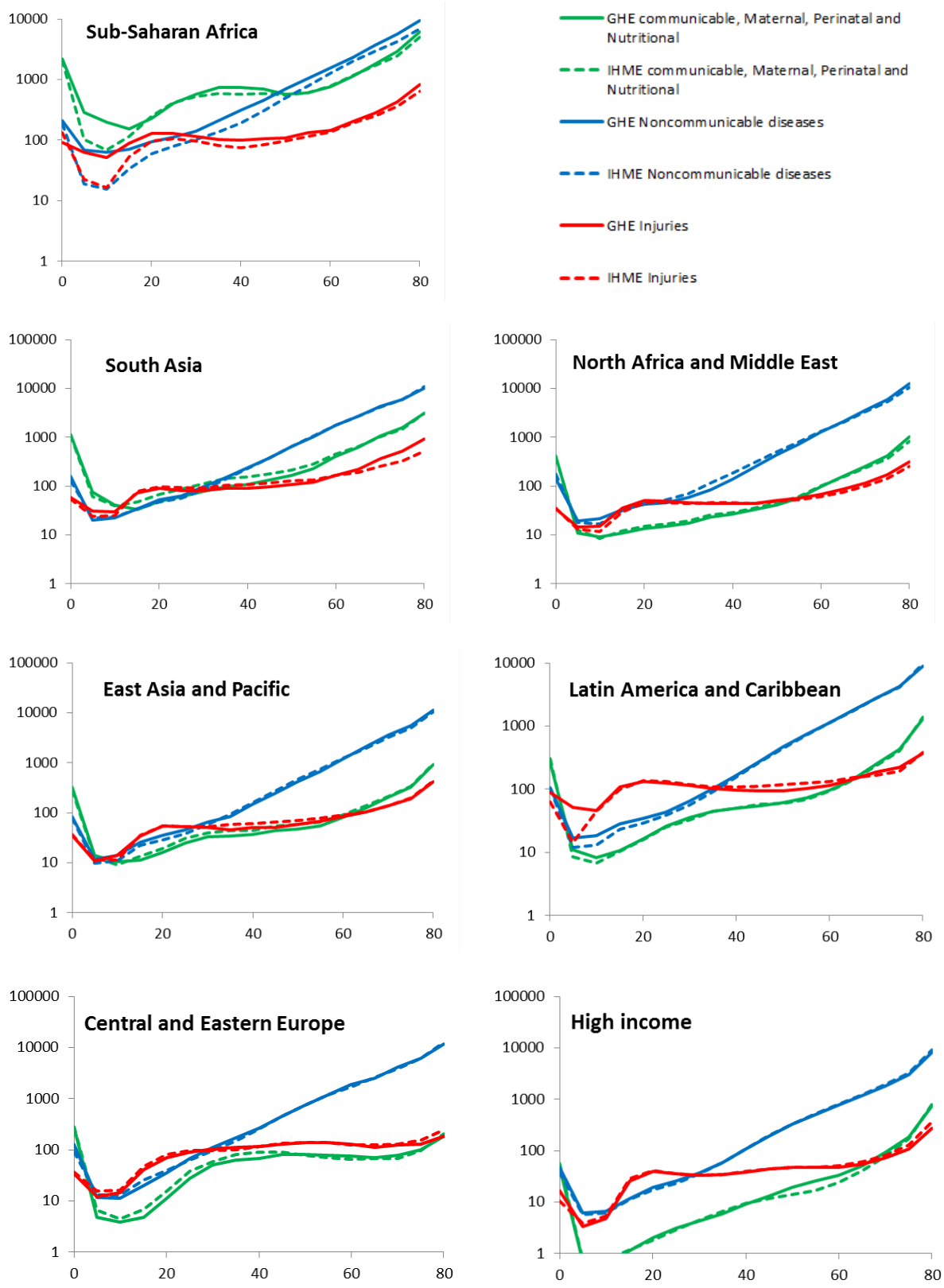
Based on the GBD2015 inputs, there were also a number of extreme outliers for specific causes in some countries. These were adjusted as follows:

- Deaths due to meningitis and encephalitis in Nepal and Bhutan were revised downwards by a factor based on the ratio of GBD2015 estimated death rate to that for India applied to the GHE2015 revised meningitis and encephalitis deaths derived from the Indian SRS data.
- Chronic respiratory disease deaths for Papua New Guinea (the highest in the world in GBD2015) were revised downwards to a level 20% above the average for Vanuatu, Micronesia and Fiji.
- Accidental poisoning deaths in Somalia were revised downward by 60% based on the difference between GBD2013 and GBD2015 estimates.
- Skin disease deaths were revised downwards in Bahrein based on the average of the death rates for United Arab Emirates, Kuwait, Oman, Qatar and Saudi Arabia.
- Endocrine disease death rates were adjusted downwards in Tajikistan using GBD2013-based rates, which are similar to those for Afghanistan and Pakistan in GBD2015.
- GBD2015 death rates for chronic respiratory diseases in Montenegro were extremely low, unlike those in the surrounding countries (Serbia, Bosnia and Herzegovina, Croatia, Albania, and the Former Yugoslav Republic of Macedonia). In contrast, both smoking rates and air pollution levels were similar for Montenegro and these countries. The CRD death rates for Montenegro were adjusted to match those of Serbia.

9.4 Comparisons of major cause groups and differences

Figure 9.2 provides a comparison of major cause group death rates for the GBD2015 and WHO GHE results for year 2015 for seven broad regional groupings, after the GHECorrect process and the other cause- and country-specific adjustments.

Figure 9.2 *Comparison of GHE and IHME death rates per 100,000 population, major cause groups, 2015.*



10 Uncertainty of estimates

Many of the inputs to the GHE2015 estimates have explicit uncertainty ranges. However, there are some exceptions: WHO life tables are based on the UN Population Division's World Population Prospects 2015 life tables and these do not yet have explicit uncertainty ranges estimated. Additionally, there are some specific cause inputs from WHO and UN sources which do not yet estimate quantitative uncertainty ranges. Given the challenges associated with calculating coherent quantitative uncertainty intervals with the available input data, guidance to users on the quality of underlying death registration data is available together with country estimates, using methods described below (section 10.1). In addition, quantitative uncertainty ranges are available as part of the comprehensive GHE2015 estimates dataset on the WHO website. Methods for these uncertainty ranges, as well as an overview of the quality of the uncertainty analysis, are below (section 10.2).

10.1 Guidance on underlying data quality

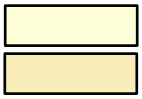
General guidance on the level of evidence available for death estimates for years 2000-2015 is based on the quality of death registration data available in the WHO Mortality Database. Countries are classified into five levels, with descending quality of death registration data, as described in Table 10.1. Classification is based on three characteristics: 1) whether the data are reported by ICD code or with a summarized cause list, 2) the number of years of data available in the WHO mortality database, and 3) the average usability of the available data in the period 2000-present. Usability is calculated as the product of the proportion of deaths assigned to a set of ill-defined cause of death codes (Table 4.2) and 100 less the percentage completeness. Because it is not possible to obtain the full number of deaths assigned to ill-defined causes of death when countries report death registration data using a summarized cause list, a more stringent set of usability cutoffs were defined for these countries.

Table 10.1 Criteria for classification of countries by quality of death registration data

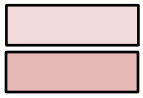
Category	Countries reporting data by ICD code	Countries reporting data with a summarized cause list
Green (highest)	Average usability for all available years from 2000 equal or greater than 80% At least 5 years' data available from 2005	N/A
Light yellow	Average usability for all available years from 2000 equal or greater than 60% At least 5 years' data available from 2005	Average usability for all available years from 2000 equal or greater than 80% At least 5 years' data available from 2005
Dark yellow	Average usability for all available years from 2000 equal or greater than 40%	Average usability for all available years from 2000 equal or greater than 60%
Light pink	No/unusable death registration data Low HIV country	
Dark pink (lowest)	No/unusable death registration High HIV country	

The following guidance to users is provided together with the country data download:

Multiple years of national death registration data with high completeness and quality of cause-of-death assignment are available. Estimates for these countries may be compared and time series may be used for priority setting and policy evaluation.



Multiple years of death registration data are available. Data have low completeness and/or issues with cause-of-death assignment which likely affect estimated deaths by cause and time trends. Estimates may be used for priority setting. Use estimates for programme evaluation with caution, as improvements in the vital registration system may affect the estimated trends in cause-specific mortality. Comparisons among countries should be interpreted with caution. Light yellow denotes moderate quality issues and dark yellow denotes severe quality issues.



Death registration data are unavailable or unusable due to quality issues. Estimates of mortality by cause should be interpreted with caution. Estimates may be used for priority setting, however, they are not likely to be informative for policy evaluation or comparisons among countries. Dark pink denotes countries with high HIV prevalence.

10.2 Uncertainty ranges

Additionally, quantitative uncertainty ranges have been released for the following WHO/UN cause-specific estimates:

- UN-IGME estimates of neonatal, infant and child mortality (10)
- WHO-MCEE estimates of neonatal and child causes of death (84)
- Tuberculosis (32, 85)
- Malaria (39, 86)
- HIV (UNAIDS estimates) (33)
- Maternal deaths (16)
- Road injury (67)
- Homicide (68)

In addition, the IARC Globocan database provides information on data sources and quality of inputs for seven categories of incidence data and six categories of mortality data, as well as six estimation methods for mortality (87).

Uncertainty intervals for global health estimates frequently underestimate total uncertainty. Calculated uncertainty ranges depend on the assumptions and methods used. These methods typically reflect some, but not all, sources of uncertainty (7). Most methods for estimation of uncertainty rely on statistical techniques to assess variations across observations and/or take into account sampling error but are less successful in dealing with unknown systematic bias in observations, such as systematic misspecification of cause of death. Uncertainty around model specification and data pre-processing steps are also frequently omitted when uncertainty intervals are quantified.

The GBD2015 estimates of deaths by cause, age, sex, year and country also include estimates of 95% uncertainty ranges that take account of some, but not all sources of uncertainty. Their uncertainty estimates include uncertainties that arise from sample sizes of data, adjustments to sources of all-cause

mortality, all-cause and cause-specific model specifications, and the CoDCorrect process. The GBD2015 uncertainty ranges do not include uncertainty in garbage code redistribution algorithms, uncertainty in covariates used in cause of death models, uncertainty in the attribution of underlying cause of death through the death registration and coding process, or uncertainty in the attribution of cause of death from verbal autopsy data.

The most common way of understanding how well uncertainty intervals perform is to withhold data, fit the model, and compare the withheld data to the uncertainty interval for the same country, cause and year (usually called cross-validation). This method may overstate the performance of uncertainty intervals, since it weights data-rich regions most heavily and does not take into account data pre-processing. Another method is to calculate how often the results of a methodologically sound estimation method fits within the confidence interval of another methodologically sound estimation method. To this end, we compared GBD2015 results to the uncertainty intervals calculated for GBD2013, by country, sex, and cause for a shortlist of causes (Table 4.6). We found that 65% of total deaths by country, cause and sex for the year 2013 from GBD2015 fell within the 95% intervals presented with GBD2013 (Table 10.2).

This indicates that the GBD2013 confidence intervals performed quite poorly, given that the two estimation exercises share the same methodological framework. As expected, the GBD2013 confidence intervals were most likely to contain the GBD2015 estimate for the data-rich regions. The GBD2013 uncertainty intervals performance also varied by cause of death, with only 28% of GBD2015 total malaria deaths by country and sex falling within the GBD2013 uncertainty interval, likely due to methodological revisions between the two rounds of GBD.

Table 10.2 Percentage of GBD2015 country-sex results for 2013 falling within GBD2013 uncertainty intervals, selected causes available in both rounds, by indicator.

Number of deaths by cause	65%
Rate by cause	64%
Percentage of deaths by cause	58%

Nevertheless, the GBD enterprise is the only source of comprehensive uncertainty estimates for mortality by cause. These intervals may be interpreted as a minimum uncertainty level. As a source of guidance on uncertainty in the GHE, we summarize the broad variations of uncertainty in the GBD2015 estimates across cause categories and countries, with the latter grouped by data sources and methods. The following tables summarize relative uncertainty intervals by cause, country size and data class. Separate upper and lower uncertainty intervals are given as per cent values. Thus for example upper and lower uncertainty estimates of 12% and 14% for an estimate of 1000 deaths would correspond to a 95% uncertainty range of (880,1140).

Table 10.3 Average relative uncertainty (%) for all-cause all-ages mortality, by country size and data class

	VR 90+**		VR 80-90**		China/India		Other		High HIV	
Size*	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Small	4.5	4.7	7.8	8.3			11.9	13.9	27.4	42.0
Medium	1.7	1.8	4.4	4.7			11.9	13.9	20.8	28.6
Large	0.9	0.9	3.3	3.4	4.0	4.1	11.9	13.9	15.7	19.5

* Size categories based on average deaths per year 2000-2015 tertiles: small <30,000, large>150,000 deaths/year

** VR = Death registration data, completeness 80% to <90% and 90% or more

Table 10.3 summarizes average GBD2015 estimated uncertainty ranges for all-cause mortality estimates (total for all ages). Table 10.4 summarizes relative average for all-age estimates of cause-specific mortality for four categories of causes. GBD2015 relative uncertainty ranges correlate quite strongly with the magnitude of the number of deaths estimate, indicating the size of the uncertainty interval is driven stochastic error rather than systematic biases which would be less correlated with the total number of deaths. Thus Table 10.4 presents summary uncertainty estimates for a selection of magnitudes ranging from 10 deaths per year to 1 million deaths per year.

Uncertainty ranges for age-specific mortality estimates are wider than those for all-cause mortality, except for older age groups in countries with useable death registration data. Relative uncertainty multipliers for specific age groups are given in Table 10.5 by cause category and data class. These multipliers are applied to the all-age uncertainty ranges given in Tables 10.3 and 10.4 to produce age-specific uncertainty estimates.

These averaged uncertainty levels by country size, data class, and cause category were used to impute 95% uncertainty intervals for GHE estimates by country, region, cause, age group, sex and year. Available estimates of uncertainty intervals for WHO/UN cause-specific estimates and for child causes of death were also taken into account. The resulting uncertainty ranges are included in full datasets downloadable from the Global Health Estimates webpage on the WHO website as zipped csv files.

These uncertainty intervals do not include all sources of uncertainty, and may not fully reflect uncertainty arising from differences in WHO/UN and IHME approaches to estimation for specific causes or countries. However, they do provide some minimal guidance to avoid over-interpretation of differences in death rates across causes or countries. In particular, care should be taken not to over-interpret detailed rankings of deaths by cause or country.

Table 10.4 Average relative uncertainty (%) for all-ages mortality, by cause category, magnitude of deaths and data class

Cause	Deaths per year	VR 90+*		VR 80-90*		Other		High HIV	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Uncertainty category 1 Includes 1st level cause groups I, II, III as well as 2nd level cause groups totals for malignant neoplasms, mental disorders and substance use, cardiovascular diseases	10	18	19	18	20	25	32	72	136
	100	11	12	13	14	21	27	52	89
	1,000	7	7	9	10	18	22	38	58
	10,000	4	4	7	7	16	18	28	38
	100,000	3	3	5	5	14	15	20	25
	1,000,000	2	2	3	3	12	13	15	16
Uncertainty category 2. Includes 2nd level causes neonatal, neurological, chronic respiratory, digestive, musculoskeletal, unintentional injuries, intentional injuries, and 3rd level causes in the unintentional injuries (except poisoning), cancers, neurological disorders (except dementia), cardiovascular conditions (except hyper-tensive heart disease), and COPD, alcohol and drug use disorder (total)	10	16	18	18	22	29	38	50	83
	100	13	14	15	17	26	33	42	64
	1,000	10	10	13	14	23	28	36	50
	10,000	8	8	11	11	21	24	30	38
	100,000	6	6	9	9	19	21	25	30
	1,000,000	5	5	7	7	17	18	22	23
Uncertainty category 3. Includes 2nd level causes meingitis, encephalitis, hepatitis,parasitic/vector diseases, other infectious diseases, endocrine, blood and immune disorders, congenital anomalies and 3rd level causes in the digestive, genitourinary, musculoskeletal and intentional injury groups as well as eating disorders, dementia,hypertensive heart disease, asthma and specific drug use disorders	10	21	25	24	31	34	48	51	92
	100	17	19	20	24	31	43	46	75
	1,000	14	15	18	19	29	38	41	62
	10,000	12	11	15	15	27	34	37	50
	100,000	10	9	13	12	26	30	33	41
	1,000,000	8	7	11	9	24	27	30	34
Uncertainty category 4. Includes 3rd level causes in the following 2nd level cause groups: STDs, childhood-cluster, hepatitis, parasitic/vector, intestinal nematode, neonatal conditions, nutritional deficiencies, endocrine**,** blood and immune disorders, congenital anomalies, as well as leprosy, upper respiratory tract infections, SIDS and poisoning	10	32	43	41	61	53	97	65	137
	100	25	31	37	51	51	89	61	120
	1,000	20	22	34	42	50	83	57	105
	10,000	16	15	32	35	49	77	54	92
	100,000	13	11	29	29	48	71	50	80
	1,000,000	10	8	27	24	47	65	47	70

* VR = Death registration data, completeness 80% to <90% and 90% or more

Table 10.5 Relative uncertainty multipliers of all-ages uncertainty for specific age groups, by cause category, and data class

Cause categories	Age group (years)*	VR 90+**		VR 80-90**		Other		High HIV	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
All causes	5-14	3.32	3.61	2.56	2.96	1.19	1.24	1.05	1.10
	15-29	1.56	1.63	1.49	1.67	1.47	1.51	1.93	1.86
	30-49	1.40	1.44	1.31	1.35	1.59	1.69	1.75	1.85
	50-59	1.23	1.25	1.16	1.15	1.51	1.56	2.00	2.28
	60-69	1.15	1.15	1.06	1.03	1.34	1.34	1.90	2.02
	70+	0.89	0.88	0.82	0.80	1.00	1.00	1.42	1.32
Uncertainty category 1 Includes 1st level cause groups I, II, III as well as 2nd level cause groups totals for malignant neoplasms, mental disorders and substance use, cardiovascular diseases	5-14	3.99	4.31	3.20	3.70	1.80	1.92	1.03	1.05
	15-29	2.97	3.19	2.43	2.71	1.74	1.91	1.49	1.60
	30-49	2.23	2.36	2.01	2.13	1.67	1.83	1.46	1.68
	50-59	1.88	2.00	1.75	1.84	1.52	1.65	1.44	1.64
	60-69	1.72	1.82	1.61	1.68	1.40	1.48	1.33	1.40
	70+	1.68	1.75	1.51	1.58	1.26	1.29	1.12	1.08
Uncertainty category 2. Includes 2nd level causes neonatal, neurological, chronic respiratory, digestive, musculoskeletal, unintentional injuries, intentional injuries, and 3rd level causes in the unintentional injuries (except poisoning), cancers, neurological disorders (except dementia), cardiovascular conditions (except hyper-tensive heart disease), and COPD, alcohol and drug use disorder (total)	Neonatal	2.36	2.51	2.58	3.03	1.91	2.59	1.49	1.99
	1-59 months	3.43	4.15	3.36	4.43	2.41	3.52	1.74	2.43
	5-14	2.62	3.05	2.58	3.14	1.74	2.06	1.22	1.29
	15-29	2.55	2.96	2.41	2.88	1.73	2.06	1.40	1.63
	30-49	2.28	2.59	2.17	2.47	1.71	1.98	1.39	1.71
	50-59	2.10	2.35	2.03	2.27	1.58	1.81	1.34	1.59
	60-69	2.00	2.22	1.96	2.18	1.51	1.69	1.26	1.38
	70+	1.97	2.17	1.92	2.16	1.47	1.63	1.16	1.20

(continued on next page)

Table 10.5 (continued) Relative uncertainty multipliers of all-ages uncertainty for specific age groups, by cause category, and data class

Cause categories	Age group (years)	VR 90+**		VR 80-90**		Other		High HIV	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Uncertainty category 3. Includes 2nd level causes meningitis, encephalitis, hepatitis, parasitic/vector diseases, other infectious diseases, endocrine, blood and immune disorders, congenital anomalies and 3rd level causes in the digestive, genitourinary, musculoskeletal and intentional injury groups as well as eating disorders, dementia,hypertensive heart disease, asthma and specific drug use disorders	Neonatal	2.11	2.32	1.99	2.32	1.70	2.10	1.44	1.71
	1-59 months	2.45	2.93	2.43	3.06	1.99	2.75	1.57	2.10
	5-14	2.32	2.74	2.22	2.64	1.58	1.79	1.21	1.25
	15-29	2.11	2.54	2.07	2.47	1.55	1.78	1.33	1.49
	30-49	1.96	2.28	1.93	2.26	1.58	1.82	1.36	1.64
	50-59	1.91	2.20	1.89	2.18	1.53	1.76	1.35	1.60
	60-69	1.85	2.10	1.85	2.12	1.50	1.70	1.30	1.46
	70+	1.79	2.01	1.82	2.11	1.47	1.66	1.22	1.31
Uncertainty category 4. Includes 3rd level causes in the following 2nd level cause groups: STDs, childhood-cluster, hepatitis, parasitic/vector, intestinal nematode, neonatal conditions, nutritional deficiencies, endocrine**,** blood and immune disorders, congenital anomalies, as well as leprosy, upper respiratory tract infections, SIDS and poisoning	Neonatal	1.43	1.53	1.27	1.40	1.26	1.43	1.20	1.28
	1-59 months	1.65	1.89	1.56	1.93	1.42	1.97	1.32	1.79
	5-14	1.66	1.89	1.52	1.86	1.24	1.38	1.14	1.22
	15-29	1.80	2.02	1.67	2.03	1.30	1.52	1.24	1.47
	30-49	1.73	1.89	1.58	1.91	1.34	1.63	1.28	1.60
	50-59	1.71	1.90	1.65	1.99	1.32	1.61	1.28	1.58
	60-69	1.64	1.83	1.62	1.94	1.32	1.60	1.27	1.53
	70+	1.62	1.77	1.56	1.90	1.28	1.51	1.22	1.42

* Uncertainty ranges for total neonatal and under 5 deaths are given elsewhere (10), as are uncertainty ranges for major causes of child death (84)

** VR = Death registration data, completeness 80% to <90% and 90% or more

11 Conclusions

GHE2015 presents results for 183 WHO Member States, encompassing all those with a population of 90,000 or greater in 2015. The GHE2015 estimates of causes of death by country, region and world for years 2000-2015 confirm and expand previous WHO analyses of global health trends and improvements. In particular, WHO published an assessment of progress towards and achievement of the UN Millenium Development Goals at the end of 2015 (88) and followed this by the World Health Statistics 2016 (89), which focused on progress and challenges for the UN Sustainable Development Goals and Targets for year 2030.

The Sustainable Development Goals expand the focus of health targets from the unfinished agenda for child and maternal mortality, and infectious diseases to a broader agenda also including non-communicable diseases, injuries, health emergencies and health risk factors, as well as a strong focus on universal health care (UHC) (90, 91). These GHE2015 estimates of trends and levels of mortality by cause will contribute to WHO and UN monitoring and reporting of the health SDG goal and targets.

WHO's adoption of health estimates is affected by a number of factors, including a country consultation process for country-level health estimates, existing multi-agency and expert group collaborative mechanisms, and compliance with standards around reporting data and methods. More detailed information on quality of data sources and methods, as well as estimated uncertainty intervals, is provided in in this document and in other referenced sources. As required by the GATHER guidelines (7), documentation of data inputs, methods, and results, including uncertainty, has improved (Annex C provides the location of each GATHER reporting item).

The type and complexity of models used for global health estimates varies widely by research/institutional group and health estimate. More complex models are necessary to generate more accurate uncertainty intervals. As expected, these require greater researcher expertise and time and computational resources to run. Where data are available and of high quality, estimates from different institutions are generally in agreement. Discrepancies are more likely to arise for countries where data are poor and for conditions where data are sparse and potentially biased. This is best addressed through improving the primary data.

Country health information systems, including vital registration, need to be strengthened as a matter of priority, in order to provide a more solid empirical basis for monitoring health situation and trends. Such data are also crucial for Member States' monitoring of national and sub-national trends in order to respond to the changing needs of their populations.

To improve monitoring of mortality, morbidity and risk factors health information systems should focus on strengthening:

- Death registration through civil registration and vital statistics systems (CRVS), local health and demographic studies and other sources
- Cause of death data collection through vital registration and verbal autopsy in communities
- Regular household health surveys that include biological and clinical data collection
- Complete facility recording and reporting with regular quality control

11.1 Leading causes of death in 2015

Of the 56.4 million deaths worldwide in 2015, more than half (54%) were due by the following 10 causes (Figure 11.1). Ischaemic heart disease and stroke killed 15 million people in 2015 – these two diseases have remained the biggest killers globally in the last 15 years.

Chronic lung disease claimed 3.2 million lives in 2015, while lung cancer (along with trachea and bronchus cancers) caused 1.7 million deaths. Diabetes killed 1.6 million people in 2015, up from less than 1 million in 2000. Deaths due to dementias more than doubled between 2000 and 2015, making it the 7th leading cause of global deaths in 2015.

Lower respiratory infections remained the most deadly communicable disease, causing 3.2 million deaths worldwide in 2015. Diarrhoea death rate almost halved between 2000 and 2015, but the disease still caused a large number of deaths (1.4 million) in 2015. Similarly, tuberculosis death rate decreased during the same period, but the disease was still among the top 10 causes of death in 2015 with a death toll of 1.4 million.

Road injury killed 1.3 million people in 2015, three-quarter of which were men and boys.

Figure 11.1 The 10 leading causes of death in the world, 2015

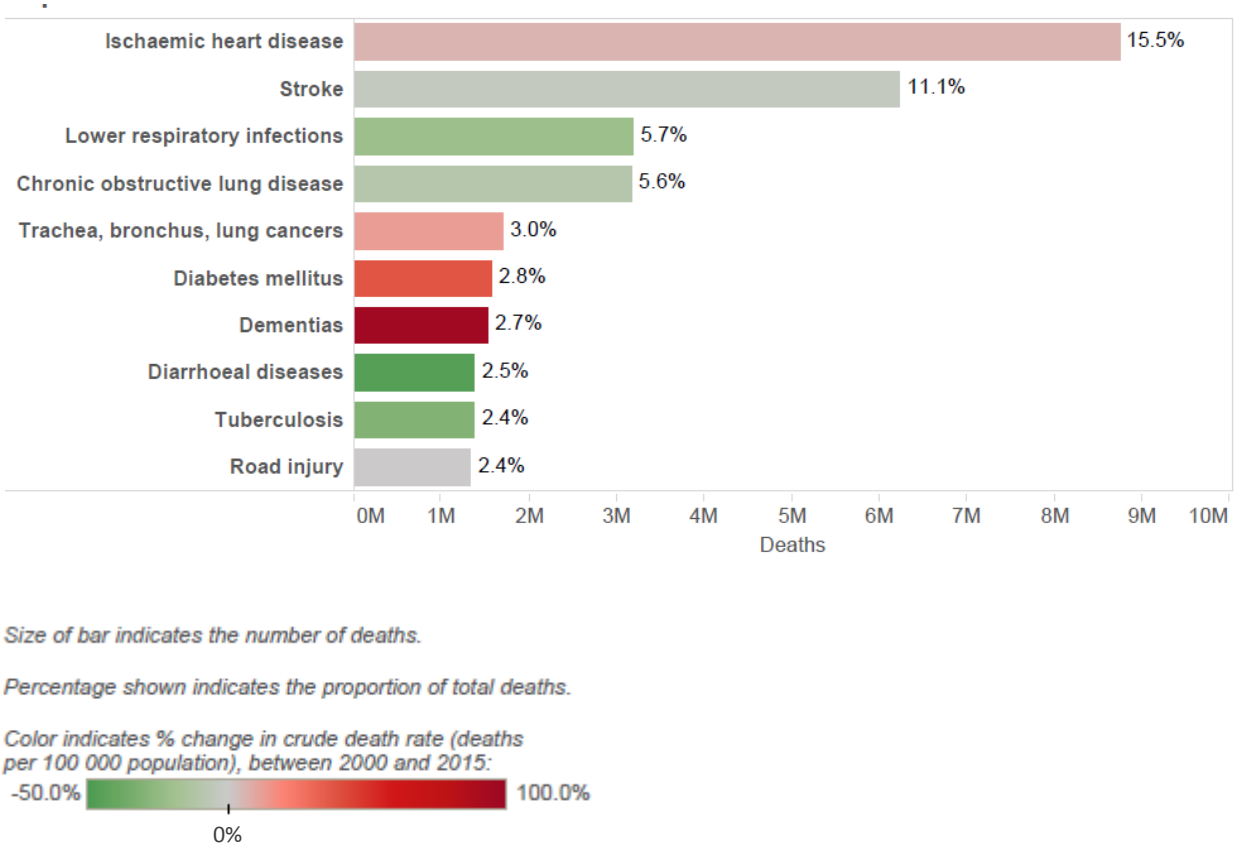
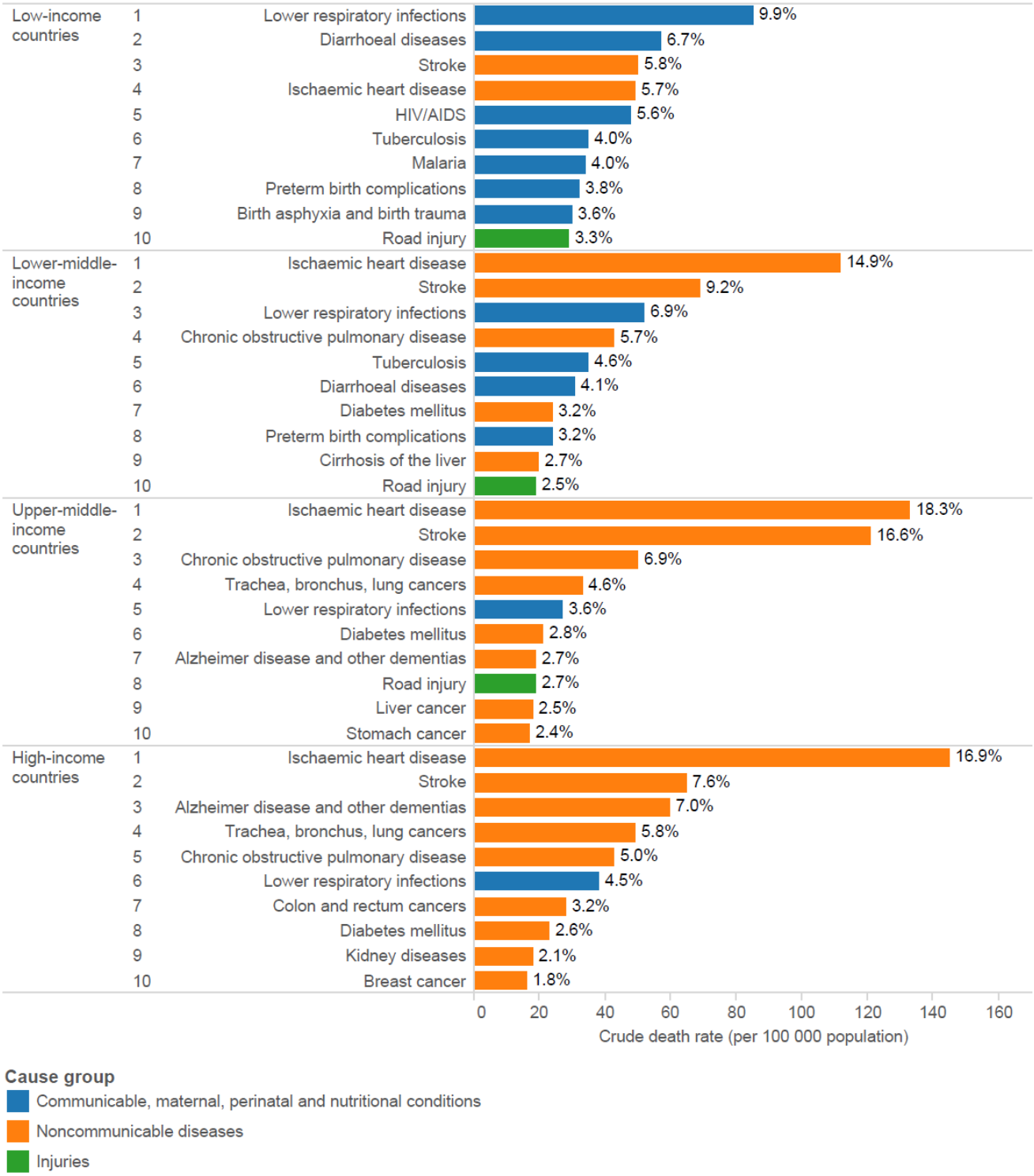


Figure 11.2 Leading causes of death by country income group, 2015



More than half (52%) of all deaths in low-income countries in 2015 were caused by the so-called "Group I" conditions, which include communicable diseases, maternal causes, conditions arising during the perinatal period, and nutritional deficiencies. By contrast, less than 7% of deaths in high-income countries were due to such causes. Lower respiratory infections were among the leading causes of death across all income groups (Figure 11.2).

Noncommunicable diseases (NCDs) caused 70% of deaths globally, with regional figures ranging from 37% in low-income countries to 88% in high-income countries. Almost all of the 10 leading causes of death in the latter group of countries were NCDs. In terms of absolute number of deaths, however, 78% of global NCD deaths occurred in low- and middle-income countries.

Injuries claimed nearly 5 million lives in 2015. Over a quarter (27%) of these deaths were due to road traffic injuries. Low-income countries had the highest mortality rate due to road traffic injuries with 28.5 deaths per 100 000 population – the global rate was 18.3. Road injuries were also among the leading 10 causes of death in both lower-middle- and upper-middle-income countries.

11.2 Reasons for changes in GHE estimates in this revision

As with previous revisions of WHO GHE and specific-cause time series estimates, GHE2015 provides an update for the entire time series from 2000 to 2015 incorporating data sources and specific WHO/interagency and IHME estimates released since GHE2013. This time series supercedes previous GHE time series, and differences between revision series should not be interpreted as time trends.

Major causes of significant changes in estimates or trends for individual countries or for specific causes at country, regional or global level include the following:

- The revision of WHO life table time series for Member States to align more closely with the UN WPP 2015 life table time series (8). This resulted in substantial changes for some countries, and also for some high HIV countries due to significant changes in UN WPP and UNAIDS modelling of the HIV epidemics in these countries.
- Significant updates to time series estimates for WHO and UN interagency estimates for specific causes such as HIV, tuberculosis, and malaria, as well as incorporation of new WHO estimates for causes such as homicide and road injury.
- Revision of maternal mortality estimates to take account of revisions to all-cause mortality envelopes in the reproductive age range 15-49 years.
- Use of more recent SRS data on causes of death in India, allowing the estimation of time trends from the two data sets for 2001-2003 and 2010-2013.
- Use of the recently published IHME GBD 2015 study for GHE2015. There were substantial changes in GBD 2015 estimates for some causes and countries compared to the previous GBD 2010 estimates used for GHE2013.
- Improvements to the GHECorrect process (Section 9.2) used to ensure that cause-specific estimates summed to WHO all-cause mortality estimates derived from WHO life tables.
- Substantial improvements in the availability of death registration data for many countries, together with improvements in the mapping of ICD-based cause groups to the GHE cause groups.

- Substantial revision of the garbage code redistribution algorithms used for ill-defined cardiovascular diseases and hypertensive heart disease, plus additional adjustments to deal with high proportions of deaths coded to “other” categories for certain ICD chapters in some countries.
- Greater reliance on estimates derived from death registration data to supercede older WHO estimates for selected causes, particularly for cancers.

11.3 Limitations of GHE estimates

Here we highlight some broad cross-cutting limitations to the GHE mortality and cause of death analysis. Comparable information about death numbers and rates by age, sex, cause, year, and country provides important information for priority setting discussions and for monitoring and evaluating progress towards global health goals. Major limitations and challenges are summarized below.

- All-cause mortality estimates in countries without well-functioning death registration systems relies heavily on census and survey data sources (particularly sibling survival data) and the use of model life tables. There is not yet consensus on the methods for analyzing sibling survival data or assessing levels of under-reporting of deaths in surveys or censuses.
- Demographic methods for the assessment of completeness of death registration all involve strong assumptions or information about migration and are prone to error resulting from age mis-statement in registration or census data, and to differential completeness of successive censuses.
- Estimation of HIV mortality relies on imputation of deaths from seroprevalence data using limited information on survival curves for HIV-positive persons not receiving or receiving anti-retroviral treatment (ART), and on the coverage of ART in populations. This results in large uncertainty for countries with high prevalence of HIV, as disease progression rates may well vary across countries.
- Although death registration data is generally the best form of information available on causes of death, it has considerable limitations, even in well-functioning systems with medical certification of cause of death. The so-called garbage codes represent a substantial proportion of deaths in some countries, and methods for re-assigning these deaths to valid causes are highly uncertain and generally are not based on empirical data. The assignment of underlying cause of death is limited by the information provided on the death certificate and quite sensitive to the order in which diagnoses are written. For most causes of death, variability (due to differences in physician practice when certifying a death) in assignment of valid causes of underlying death has not been addressed to date. Additionally, some diseases and injuries have specific problems associated with difficulty in making causal judgments of underlying cause (eg. diabetes and heart disease, or Alzheimer’s disease and heart disease, drug or alcohol overdose). Finally, HIV and other stigmatized causes of death, such as suicide, are routinely miscoded; the miscoding rate varies by setting.
- For many countries without functioning death registration systems, particularly in Africa, there is strong reliance on verbal autopsy studies, most of which are not nationally representative samples. Until recently there has been considerable variation in verbal autopsy instruments, and in analysis and cause assignment methods. Validation studies are challenging, and difficult to generalize to other settings. The Indian SRS data included in the Million Death Study use a form of physician-assignment of underlying cause that may be subject to different biases and limitations than the statistical algorithms used in InterVA or Tariff analyses.
- The WHO GHE estimates bring together single cause analyses from a number of WHO departments, interagency collaborations, and other sources, together with estimates drawn from the IHME GBD2015 study. These estimates are updated on differing time tables, and using different methods

and assumptions in some cases, and it is more difficult to ensure consistency across causes, than is the case for large comprehensive estimates such as GBD2015 prepared by a single study group. In addition, separate preparation of estimates of total mortality and cause-specific mortality can lead to incompatible cause-specific and total mortality estimates. In some cases, WHO/UN estimates are prepared only for all-age deaths, and age patterns imputed from available sometimes limited evidence.

- Estimates of deaths associated with mortality shocks (mainly conflict and disasters, but also some epidemics) are highly uncertain, and age patterns are generally imputed from limited data for other shocks. Additionally, in countries without functioning death registration systems or high quality censuses, it is very difficult to take account of, and to estimate, indirect mortality associated with mortality shocks, with increases in non-injury mortality rates associated with disruption to health and other social systems.
- While the uncertainty estimates discussed in Section 10 provide some guidance on the limitations of interpretation of the results, it should be kept in mind that these estimates reflect a subset of sources of uncertainty, and true uncertainty is higher.

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Annex Table A GHE cause categories and ICD-10 codes

GHE code	GHE cause name	ICD-10 codes
10	**I. Communicable, maternal, perinatal and nutritional conditions**[a]	A00-B99, D50-D53, D64.9, E00-E02, E40-E46, E50-E64, G00-G04, G14, H65-H66, J00-J22, N70-N73, O00-O99, P00-P96, U04
20	**A. Infectious and parasitic diseases**	A00-B99, G00-G04, G14, N70-N73, P37.3, P37.4
30	1. Tuberculosis	A15-A19, B90
40	2. STDs excluding HIV	A50-A64, N70-N73
50	a. Syphilis	A50-A53
60	b. Chlamydia	A55-A56
70	c. Gonorrhoea	A54
80	d. Trichomoniasis	A59
85	e. Genital herpes	A60
90	f. Other STDs	A57-A58, A61-A64, N70-N73
100	3. HIV/AIDS	B20-B24
101	a. HIV resulting in TB	B20.0
102	b. HIV resulting in other diseases	B20-B24 (minus B20.0)
110	4. Diarrhoeal diseases[b]	A00, A01, A03, A04, A06-A09
120	5. Childhood-cluster diseases	A33-A37, B05
130	a. Whooping cough	A37
140	b. Diphtheria	A36
150	c. Measles	B05
160	d. Tetanus	A33-A35
170	6. Meningitis[b]	A39, G00, G03
180	7. Encephalitis[b]	A83-A86, B94.1, G04
185	8. Hepatitis	B15-B19 (minus B17.8)
186	a. Acute hepatitis A	B15
190	b. Acute hepatitis B	B16-B19 (minus B17.1, B17.2, B18.2, B18.8)
200	c. Acute hepatitis C	B17.1, B18.2
205	d. Acute hepatitis E	B17.2, B18.8
210	9. Parasitic and vector diseases	A71, A82, A90-A91, A95, B50-B57, B65, B67, B69, B73, B74.0-B74.2, P37.3-P37.4
220	a. Malaria	B50-B54, P37.3, P37.4
230	b. African trypanosomiasis	B56
240	c. Chagas disease	B57
250	d. Schistosomiasis	B65
260	e. Leishmaniasis	B55
270	f. Lymphatic filariasis	B74.0-B74.2
280	g. Onchocerciasis	B73
285	h. Cysticercosis	B69
295	i. Echinococcosis	B67
300	j. Dengue	A90-A91
310	k. Trachoma	A71
315	l. Yellow fever	A95
320	m. Rabies	A82
330	10. Intestinal nematode infections	B76-B81
340	a. Ascariasis	B77
350	b. Trichuriasis	B79

GHE code	GHE cause name	ICD-10 codes
360	c. Hookworm disease	B76
362	d. Food-bourne trematodes	B78, B80, B81
365	11. Leprosy	A30
370	12. Other infectious diseases	A02, A05, A20-A28, A31, A32, A38, A40-A49, A65-A70, A74-A79, A80-A81, A87-A89, A92-A99, B00-B04, B06-B09, B17.8, B25-B49, B58-B60, B64, B66, B68, B70-B72, B74.3-B74.9, B75, B82-B89, B91-B99 (minus B94.1), G14
380	**B. Respiratory infectious**[b]	H65-H66, J00-J22, P23, U04
390	1. Lower respiratory infections	J09-J22, P23, U04
400	2. Upper respiratory infections	J00-J06
410	3. Otitis media	H65-H66
420	**C. Maternal conditions**	O00-O99
490	**D. Neonatal conditions**	P00-P96 (minus P23, P37.3, P37.4)
500	1. Preterm birth complications[b]	P05, P07, P22, P27-P28
510	2. Birth asphyxia and birth trauma[b]	P03, P10-P15, P20-P21, P24-P26, P29
520	3. Neonatal sepsis and infections	P35-P39 (minus P37.3, P37.4)
530	4. Other neonatal conditions	P00-P02, P04, P08, P50-P96
540	**E. Nutritional deficiencies**	D50-D53, D64.9, E00-E02, E40-E46, E50-E64
550	1. Protein-energy malnutrition	E40-E46
560	2. Iodine deficiency	E00-E02
570	3. Vitamin A deficiency	E50
580	4. Iron-deficiency anaemia	D50, D64.9
590	5. Other nutritional deficiencies	D51-D53, E51-E64
600	**II. Noncommunicable diseases**[a]	C00-C97, D00-D48, D55-D64 (minus D 64.9), D65-D89, E03-E07, E10-E34, E65-E88, F01-F99, G06-G98 (minus G14), H00-H61, H68-H93, I00-I99, J30-J98, K00-K92, L00-L98, M00-M99, N00-N64, N75-N98, Q00-Q99, X41-X42, X44, X45, R95
610	**A.** Malignant neoplasms	C00-C97
620	1. Mouth and oropharynx cancers	C00-C14
621	a. Lip and oral cavity	C00-C08
622	b. Nasopharynx	C11
623	c. Other pharynx	C09-C10, C12-C14
630	2. Oesophagus cancer	C15
640	3. Stomach cancer	C16
650	4. Colon and rectum cancers	C18-C21
660	5. Liver cancer[c]	C22
670	6. Pancreas cancer	C25
680	7. Trachea, bronchus, lung cancers	C33-C34
690	8. Melanoma and other skin cancers	C43-C44
691	a. Malignant skin melanoma	C43
692	b. Non-melanoma skin cancer	C44
700	9. Breast cancer	C50
710	10. Cervix uteri cancer	C53
720	11. Corpus uteri cancer	C54-C55
730	12. Ovary cancer	C56
740	13. Prostate cancer	C61
742	14. Testicular cancer	C62
745	15. Kidney, renal pelvis and ureter cancer	C64-C66

GHE code	GHE cause name	ICD-10 codes
750	16. Bladder cancer	C67
751	17. Brain and nervous system cancers	C70-C72
752	18. Gallbladder and biliary tract cancer	C23-C24
753	19. Larynx cancer	C32
754	20. Thyroid cancer	C73
755	21. Mesothelioma	C45
760	22. Lymphomas, multiple myeloma	C81-C90, C96
761	a. Hodgkin lymphoma	C81
762	b. Non-Hodgkin lymphoma	C82-C86, C96
763	c. Multiple myeloma	C88, C90
770	23. Leukaemia	C91-C95
780	24. Other malignant neoplasms[d]	C17, C26-C31, C37-C41, C46-C49, C51, C52, C57-C60, C63, C68, C69, C74-C80, C97
790	**B. Other neoplasms**	D00-D48
800	**C. Diabetes mellitus**	E10-E14 (minus E10.2-E10.29, E11.2-E11.29, E12.2, E13.2-E13.29, E14.2)
810	**D. Endocrine, blood, immune disorders**	D55-D64 (minus D64.9), D65-D89, E03-E07, E15-E34, E65-E88
811	1. Thalassaemias	D56
812	2. Sickle cell disorders and trait	D57
813	3. Other haemoglobinopathies and haemolytic anaemias	D55, D58-D59
814	4. Other endocrine, blood and immune disorders	D60-D64 (minus D64.9), D65-D89, E03-E07, E15-E34, E65-E88
820	**E. Mental and substance use disorders**	F04-F99, G72.1, Q86.0, X41-X42, X44, X45
830	1. Depressive disorders	F32-F33, F34.1
831	a. Major depressive disorder	F32-F33
832	b. Dysthymia	F34.1
840	2. Bipolar disorder	F30-F31
850	3. Schizophrenia	F20-F29
860	4. Alcohol use disorders	F10, G72.1, Q86.0, X45
870	5. Drug use disorders[e]	F11-F16, F18-F19[e], X41-X42, X44[e]
871	a. Opioid use disorders	F11, X42, X44[e]
872	b. Cocaine use disorders	F14
873	c. Amphetamine use disorders	F15
874	d. Cannabis use disorders	F12
875	e. Other drug use disorders	F13, F16, F18, F19[e], X41
880	6. Anxiety disorders	F40-F44
890	7. Eating disorders	F50
900	8. Autism and Asperger syndrome	F84
910	9. Childhood behavioural disorders	F90-F92
911	a. Attention deficit/hyperactivity syndrome	F90
912	b. Conduct disorder	F91-F92
920	10. Idiopathic intellectual disability	F70-F79
930	11. Other mental and behavioural disorders	F04-F09, F17, F34-F39 (minus F34.1), F45-F48, F51-F69, F80-F83, F88-F89, F93-F99

GHE code	GHE cause name	ICD-10 codes
940	**F. Neurological conditions**	F01-F03, G06-G98 (minus G14, G72.1)
950	1. Alzheimer disease and other dementias	F01-F03, G30-G31
960	2. Parkinson disease	G20-G21
970	3. Epilepsy	G40-G41
980	4. Multiple sclerosis	G35
990	5. Migraine	G43
1000	6. Non-migraine headache	G44
1010	7. Other neurological conditions	G06-G12, G23-G25, G36-G37, G45-G98 (minus G72.1)
1020	**G. Sense organ diseases**	H00-H61, H68-H93
1030	1. Glaucoma	H40
1040	2. Cataracts	H25-H26
1050	3. Uncorrected refractive errors	H49-H52
1060	4. Macular degeneration	H35.3
1070	5. Other vision loss	H30-H35 (minus H35.3), H53-H54
1080	6. Other hearing loss	H90-H91
1090	7. Other sense organ disorders	H00-H21, H27, H43-H47, H55-H61, H68-H83, H92-H93
1100	**H. Cardiovascular diseases**	I00-I99
1110	1. Rheumatic heart disease	I01-I09
1120	2. Hypertensive heart disease	I10-I15
1130	3. Ischaemic heart disease[f]	I20-I25
1140	4. Stroke[g]	I60-I69
1150	5. Cardiomyopathy, myocarditis, endocarditis	I30-I33, I38, I40, I42
1160	6. Other circulatory diseases	I00, I26-I28, I34-I37, I44-I51, I70-I99
1170	**I. Respiratory diseases**	J30-J98
1180	1. Chronic obstructive pulmonary disease	J40-J44
1190	2. Asthma	J45-J46
1200	3. Other respiratory diseases	J30-J39, J47-J98
1210	**J. Digestive diseases**	K20-K92
1220	1. Peptic ulcer disease	K25-K27
1230	2. Cirrhosis of the liver[h]	K70, K74
1240	3. Appendicitis	K35-K37
1241	4. Gastritis and duodenitis	K29
1242	5. Paralytic ileus and intestinal obstruction	K56
1244	6. Inflammatory bowel disease	K50-K52, K58.0
1246	7. Gallbladder and biliary diseases	K80-K83
1248	8. Pancreatitis	K85-K86
1250	9. Other digestive diseases	K20-K22, K28, K30-K31, K38, K40-K46, K55, K57, K58.9, K59-K66, K71-K73, K75-K76, K90-K92
1260	**K. Genitourinary diseases**	E10.2-E10.29,E11.2-E11.29,E12.2,E13.2-E13.29,E14.2, N00-N64, N75-N76, N80-N98
1270	1. Kidney diseases	N00-N19, E10.2-E10.29,E11.2-E11.29,E12.2,E13.2-E13.29,E14.2
1271	a. Acute glomerulonephritis	N00-N01
1272	b. Chronic kidney disease due to diabetes	E10.2-E10.29, E11.2-E11.29, E12.2, E13.2-E13.29, E14.2
1273	c. Other chronic kidney disease	N02-N19

GHE code	GHE cause name	ICD-10 codes
1280	2. Benign prostatic hyperplasia	N40
1290	3. Urolithiasis	N20-N23
1300	4. Other urinary diseases	N25-N39, N41-N45, N47-N51
1310	5. Infertility	N46, N97
1320	6. Gynecological diseases	N60-N64, N75-N76, N80-N96, N98
1330	**L. Skin diseases**	L00-L98
1340	**M. Musculoskeletal diseases**	M00-M99
1350	1. Rheumatoid arthritis	M05-M06
1360	2. Osteoarthritis	M15-M19
1370	3. Gout	M10
1380	4. Back and neck pain	M45-M48, M50-M54
1390	5. Other musculoskeletal disorders	M00, M02, M08, M11-M13, M20-M43, M60-M99
1400	**N. Congenital anomalies**	Q00-Q99 (minus Q86.0)
1410	1. Neural tube defects	Q00, Q05
1420	2. Cleft lip and cleft palate	Q35-Q37
1430	3. Down syndrome	Q90
1440	4. Congenital heart anomalies	Q20-Q28
1450	5. Other chromosomal anomalies	Q91-Q99
1460	6. Other congenital anomalies	Q01-Q04, Q06-Q18, Q30-Q34, Q38-Q89 (excluding Q86.0)
1470	**O. Oral conditions**	K00-K14
1480	1. Dental caries	K02
1490	2. Periodontal disease	K05
1500	3. Edentulism	-
1502	4. Other oral disorders	K00, K01, K03, K04, K06-K14
1505	**P. Sudden infant death syndrome**	R95
1510	**III. Injuries**[i]	V01-Y89 (minus X41-X42, X44, X45)
1520	**A. Unintentional injuries**	V01-X40, X43, X46-59, Y40-Y86, Y88, Y89
1530	1. Road injury[j]	V01-V04, V06, V09-V80, V87, V89, V99
1540	2. Poisonings[e]	X40, X43, X46-X48, X49[e]
1550	3. Falls	W00-W19
1560	4. Fire, heat and hot substances	X00-X19
1570	5. Drowning	W65-W74
1575	6. Exposure to mechanical forces	W20-W38, W40-W43, W45, W46, W49-W52, W75, W76
1580	7. Natural disasters	X30-X39
1590	8. Other unintentional injuries	Rest of V, W39, W44, W53-W64, W77-W99, X20-X29, X50-X59, Y40-Y86, Y88, Y89
1600	**B. Intentional injuries**	X60-Y09, Y35-Y36, Y870, Y871
1610	1. Self-harm	X60-X84, Y870
1620	2. Interpersonal violence	X85-Y09, Y871
1630	3. Collective violence and legal intervention	Y35-Y36

—, not available

[a] Deaths coded to “Symptoms, signs and ill-defined conditions” (R00-R94. R96-R99) are distributed proportionately to all causes within Group I and Group II.

[b] For deaths under age 5, refer to classification in Annex Table E.

[c] For liver cancer secondary to hepatitis B, hepatitis C, and alcohol use, proportions derived from GBD2013 analyses.

[d] Cancer deaths coded to ICD categories for malignant neoplasms of other and unspecified sites including those whose point of origin cannot be determined, and secondary and unspecified neoplasms (C76, C80, C97) were redistributed pro-rata across malignant neoplasm categories within each age–sex group, so that the category "Other malignant neoplasms" includes only malignant neoplasms of other specified sites.

[e] Deaths coded to F19 (Multiple and other drug use) and X44 (Accidental poisoning by other and unspecified drugs and medicines) have been redistributed to the GHE drug categories as described in Section 8.14. Deaths coded to X49 (Accidental poisoning by other and unspecified chemicals) have been redistributed to GHE accidental poisoning and GHE opioid use disorders categories as described in Section 8.14.

[f] Ischaemic heart disease deaths may be miscoded to a number of so-called cardiovascular "garbage" codes. These include heart failure, ventricular dysrhythmias, generalized atherosclerosis and ill-defined descriptions and complications of heart disease. Proportions of deaths coded to these causes were redistributed to ischaemic heart disease as described in Mathers CD, Lopez AD, Murray CJL, Ezzati M, Jamison DT. *The burden of disease and mortality by condition: data, methods and results for 2001. Global burden of disease and risk factors.* New York, Oxford University Press, 2006. p. 45–240. Relevant ICD-10 codes are I46, I47.2, I49.0, I50, I51.4, I51.5, I51.6, I51.9 and I70.9.

[g] For ischaemic stroke and haemorrhagic stroke, proportions derived from GBD2013 analyses.

[h] For cirrhosis due to hepatitis B, hepatitis C, and alcohol use, proportions derived from GBD2013 analyses.

[i] Injury deaths where the intent is not determined (Y10-Y34, Y872) are distributed proportionately to all causes below the group level for injuries.

[j] For countries with 3-digit ICD10 data, for "Road injury" use: V01-V04, V06, V09-V80, V87, V89 and V99. For countries with 4-digit ICD10 data, for "Road injury" use:

V01.1-V01.9, V02.1-V02.9, V03.1-V03.9, V04.1-V04.9, V06.1-V06.9, V09.2, V09.3, V10.3-V10.9, V11.3-V11.9, V12.3-V12.9, V13.3-V13.9, V14.3-V14.9, V15.4-V15.9, V16.4-V16.9, V17.4-V17.9, V18.4-V18.9, V19.4-V19.9, V20.3-V20.9, V21.3-V21.9, V22.3-V22.9, V23.3-V23.9, V24.3-V24.9, V25.3-V25.9, V26.3-V26.9, V27.3-V27.9, V28.3-V28.9, V29.4-V29.9, V30.4-V30.9, V31.4-V31.9, V32.4-V32.9, V33.4-V33.9, V34.4-V34.9, V35.4-V35.9, V36.4-V36.9, V37.4-V37.9, V38.4-V38.9, V39.4-V39.9, V40.4-V40.9, V41.4-V41.9, V42.4-V42.9, V43.4-V43.9, V44.4-V44.9, V45.4-V45.9, V46.4-V46.9, V47.4-V47.9, V48.4-V48.9, V49.4-V49.9, V50.4-V50.9, V51.4-V51.9, V52.4-V52.9, V53.4-V53.9, V54.4-V54.9, V55.4-V55.9, V56.4-V56.9, V57.4-V57.9, V58.4-V58.9, V59.4-V59.9, V60.4-V60.9, V61.4-V61.9, V62.4-V62.9, V63.4-V63.9, V64.4-V64.9, V65.4-V65.9, V66.4-V66.9, V67.4-V67.9, V68.4-V68.9, V69.4-V69.9, V70.4-V70.9, V71.4-V71.9, V72.4-V72.9, V73.4-V73.9, V74.4-V74.9, V75.4-V75.9, V76.4-V76.9, V77.4-V77.9, V78.4-V78.9, V79.4-V79.9, V80.3-V80.5, V81.1, V82.1, V82.8-V82.9, V83.0-V83.3, V84.0-V84.3, V85.0-V85.3, V86.0-V86.3, V87.0-V87.9, V89.2-V89.3, V89.9, V99 and Y850.

Annex Table B Groupings of countries, areas and territories used for global and regional tabulations

B.1 Global

Afghanistan, Albania, Algeria, Angola, Antigua and Barbuda, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bhutan, Bolivia (Plurinational State of), Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cabo Verde, Cambodia, Cameroon, Canada, Central African Republic, Chad, Chile, China; Taiwan, China; Colombia, Comoros, Congo, Costa Rica, Côte d'Ivoire, Croatia, Cuba, Cyprus, Czechia, Democratic People's Republic of Korea, Democratic Republic of the Congo, Denmark, Djibouti, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Estonia, Ethiopia, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hungary, Iceland, India, Indonesia, Iran (Islamic Republic of), Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kiribati, Kuwait, Kyrgyzstan, Lao People's Democratic Republic, Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Mauritania, Mauritius, Mexico, Micronesia (Federated States of), Mongolia, Montenegro, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Puerto Rico, Qatar, Republic of Korea, Republic of Moldova, Romania, Russian Federation, Rwanda, Saint Lucia, Saint Vincent and the Grenadines, Samoa, Sao Tome and Principe, Saudi Arabia, Senegal, Serbia, Seychelles, Sierra Leone, Singapore, Slovakia, Slovenia, Solomon Islands, Somalia, South Africa, South Sudan, Spain, Sri Lanka, Sudan, Suriname, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Thailand, The former Yugoslav Republic of Macedonia, Timor-Leste, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, United Kingdom, United Republic of Tanzania, United States of America, Uruguay, Uzbekistan, Vanuatu, Venezuela (Bolivarian Republic of), Viet Nam, West Bank and Gaza Strip, Yemen, Zambia, Zimbabwe

B.2 WHO Region*

WHO African Region

Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Africa, South Sudan, Swaziland, Togo, Uganda, United Republic of Tanzania, Zambia, Zimbabwe

WHO Region of the Americas

Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia (Plurinational State of), Brazil, Canada, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, United States of America, Uruguay, Venezuela (Bolivarian Republic of)

WHO South-East Asia Region

Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Indonesia, Maldives, Myanmar, Nepal, Sri Lanka, Thailand, Timor-Leste

WHO European Region

Albania, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tajikistan, The former Yugoslav Republic of Macedonia, Turkey, Turkmenistan, Ukraine, United Kingdom, Uzbekistan

WHO Eastern Mediterranean Region

Afghanistan, Bahrain, Djibouti, Egypt, Iran (Islamic Republic of), Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Qatar, Saudi Arabia, Somalia, Sudan, Syrian Arab Republic, Tunisia, United Arab Emirates, Yemen

WHO Western Pacific Region

Australia, Brunei Darussalam, Cambodia, China, Fiji, Japan, Kiribati, Lao People's Democratic Republic, Malaysia, Marshall Islands, Micronesia (Federated States of), Mongolia, New Zealand, Papua New Guinea, Philippines, Republic of Korea, Samoa, Singapore, Solomon Islands, Tonga, Vanuatu, Viet Nam

*WHO regional grouping as of 2015. WHO Member States with a population of less than 90 000 population in 2015 were not included in the analysis; these include: Andorra, Cook Islands, Dominica, Marshall Islands, Monaco, Nauru, Niue, Palau, Saint Kitts and Nevis, San Marino, Tuvalu.

B.3 World Bank income grouping*

Low income

Afghanistan, Benin, Burkina Faso, Burundi, Central African Republic, Chad, Comoros, Democratic People's Republic of Korea, Democratic Republic of the Congo, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Liberia, Madagascar, Malawi, Mali, Mozambique, Nepal, Niger, Rwanda, Senegal, Sierra Leone, Somalia, South Sudan, Togo, Uganda, United Republic of Tanzania, Zimbabwe

Lower middle income

Armenia, Bangladesh, Bhutan, Bolivia (Plurinational State of), Cabo Verde, Cambodia, Cameroon, Congo, Côte d'Ivoire, Djibouti, Egypt, El Salvador, Ghana, Guatemala, Honduras, India, Indonesia, Kenya, Kiribati, Kyrgyzstan, Lao People's Democratic Republic, Lesotho, Mauritania, Micronesia (Federated States of), Mongolia, Morocco, Myanmar, Nicaragua, Nigeria, Pakistan, Papua New Guinea, Philippines, Republic of Moldova, Samoa, Sao Tome and Principe, Solomon Islands, Sri Lanka, Sudan, Swaziland, Syrian Arab Republic, Tajikistan, Timor-Leste, Tonga, Tunisia, Ukraine, Uzbekistan, Vanuatu, Viet Nam, West Bank and Gaza Strip, Yemen, Zambia

Upper middle income

Albania, Algeria, Angola, Argentina, Azerbaijan, Belarus, Belize, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Equatorial Guinea, Fiji, Gabon, Georgia, Grenada, Guyana, Iran (Islamic Republic of), Iraq, Jamaica, Jordan, Kazakhstan, Lebanon, Libya, Malaysia, Maldives, Mauritius, Mexico, Montenegro, Namibia, Panama, Paraguay, Peru, Romania, Russian Federation, Saint Lucia, Saint Vincent and the Grenadines, Serbia, South Africa, Suriname, Thailand, The former Yugoslav Republic of Macedonia, Turkey, Turkmenistan, Venezuela (Bolivarian Republic of)

High income

Antigua and Barbuda, Australia, Austria, Bahamas, Bahrain, Barbados, Belgium, Brunei Darussalam, Canada, Chile, Taiwan, China; Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Hungary, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Oman, Poland, Portugal, Puerto Rico, Qatar, Republic of Korea, Saudi Arabia, Seychelles, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, Trinidad and Tobago, United Arab Emirates, United Kingdom, United States of America, Uruguay

* This regional grouping classifies countries, areas and territories according to the World Bank analytical income of economies based on the 2015 Atlas gross national income per capita estimates (World Bank list of economies, July 2016).

B.4 World Bank regions

East Asia and Pacific

Australia, Brunei Darussalam, Cambodia, China; Taiwan, China; Democratic People's Republic of Korea, Fiji, Indonesia, Japan, Kiribati, Lao People's Democratic Republic, Malaysia, Micronesia (Federated States of), Mongolia, Myanmar, New Zealand, Papua New Guinea, Philippines, Republic of Korea, Samoa, Singapore, Solomon Islands, Thailand, Timor-Leste, Tonga, Vanuatu, Viet Nam

Europe and Central Asia

Albania, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Luxembourg, Montenegro, Netherlands, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tajikistan, The former Yugoslav Republic of Macedonia, Turkey, Turkmenistan, Ukraine, United Kingdom, Uzbekistan

Latin America and Caribbean

Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia (Plurinational State of), Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela (Bolivarian Republic of)

Middle East and North Africa

Algeria, Bahrain, Djibouti, Egypt, Iran (Islamic Republic of), Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Malta, Morocco, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Tunisia, United Arab Emirates, West Bank and Gaza Strip, Yemen

North America

Canada, United States of America

South Asia

Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka

Sub-Saharan Africa

Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Swaziland, Togo, Uganda, United Republic of Tanzania, Zambia, Zimbabwe

Annex Table C GATHER checklist

Item #	Checklist item	Location reported
Objectives and funding		
1	Define the indicator(s), populations (including age, sex, and geographic entities), and time period(s) for which estimates were made.	Sections 2-3
2	List the funding sources for the work.	Acknowledgments
Data Inputs		
For all data inputs from multiple sources that are synthesized as part of the study:		
3	Describe how the data were identified and how the data were accessed.	Section 4.1
4	Specify the inclusion and exclusion criteria. Identify all ad-hoc exclusions.	Section 4.2
5	Provide information on all included data sources and their main characteristics. For each data source used, report reference information or contact name/institution, population represented, data collection method, year(s) of data collection, sex and age range, diagnostic criteria or measurement method, and sample size, as relevant.	Table 4.1: data with "Excluded" in the notes column were not used
6	Identify and describe any categories of input data that have potentially important biases (e.g., based on characteristics listed in item 5).	N/A
For data inputs that contribute to the analysis but were not synthesized as part of the study:		
7	Describe and give sources for any other data inputs.	
	Population by age and sex	Section 2
	Total number of deaths by age and sex	Section 2
	China/India	Sections 6-7
	Program estimates of cause of death	Section 8
	GBD2015 estimates for causes of death	Section 9
For all data inputs:		
8	Provide all data inputs in a file format from which data can be efficiently extracted (e.g., a spreadsheet rather than a PDF), including all relevant meta-data listed in item 5. For any data inputs that cannot be shared because of ethical or legal reasons, such as third-party ownership, provide a contact name or the name of the institution that retains the right to the data.	http://www.who.int/healthinfo/global_burden_disease/estimates/en/index1.html
Data analysis		
9	Provide a conceptual overview of the data analysis method. A diagram may be helpful.	Section 1
10	Provide a detailed description of all steps of the analysis, including mathematical formulae. This description should cover, as relevant, data cleaning, data pre-processing, data adjustments and weighting of data sources, and mathematical or statistical model(s).	Sections 4-10
11	Describe how candidate models were evaluated and how the final model(s)	N/A: statistical models

	were selected.	were not used to synthesize data
12	Provide the results of an evaluation of model performance, if done, as well as the results of any relevant sensitivity analysis.	N/A: statistical models were not used to synthesize data
13	Describe methods for calculating uncertainty of the estimates. State which sources of uncertainty were, and were not, accounted for in the uncertainty analysis.	Section 10
14	State how analytic or statistical source code used to generate estimates can be accessed.	Acknowledgments (available upon request from healthstat@who.int)
Results and Discussion		
15	Provide published estimates in a file format from which data can be efficiently extracted.	http://www.who.int/healthinfo/global_burden_disease/estimates/en/index1.html
16	Report a quantitative measure of the uncertainty of the estimates (e.g. uncertainty intervals).	Section 10
17	Interpret results in light of existing evidence. If updating a previous set of estimates, describe the reasons for changes in estimates.	Section 11, Annex Table D
18	Discuss limitations of the estimates. Include a discussion of any modelling assumptions or data limitations that affect interpretation of the estimates.	Section 11

Annex Table D Methods used for estimation of mortality levels and causes of death, by country, 2000-2015

All-cause mortality method groups:

A: Life tables based on death rates computed from vital registration data.

B: Life tables based on UNPD's World Population Prospects – the 2015 revision, and child mortality estimates from the UN-IGME.

C: Life tables based on UNPD's World Population Prospects – the 2015 revision, updated with the latest HIV/AIDS mortality from UNAIDS and child mortality estimates from the UN-IGME

D: WHO modelled HIV and non-HIV mortality.

Abbreviations

GBD2015	Global Burden of Disease 2015 study estimates (6)
GBD2015	GBD2015 study estimates drawing on WHO death registration data (VR) for the country
High HIV	WHO/UNAIDS/WPP2015 estimates for HIV deaths and all-cause deaths, GBD2015 study estimates (6)
VA/VR	Verbal autopsy and Verbal autopsy sample data plus sample death registration data
VR	Vital (death) registration
Note (a)	WHO and UN Interagency cause-specific estimates (see Section 8 above).
n.a.	Useability not assessed

Country	All-cause mortality method	Under 5 child cause of death method	Cause of death methods for ages 5+	Latest available year VR	Average useability 2000-latest
Afghanistan	B	VA MCM	GBD2015 plus (a)		
Albania	A	VR MCM	GBD2015	2009	60%
Algeria	B	VA MCM	GBD2015 plus (a)		
Angola	C	VA MCM	High HIV		
Antigua and Barbuda	B	VR data	VR data	2014	78%
Argentina	A	VR data	GBD2015	2014	77%
Armenia	A	VR MCM	GBD2015	2015	95%
Australia	A	VR data	VR data	2014	95%
Austria	A	VR data	VR data	2014	91%
Azerbaijan	A	VA MCM	GBD2015	2007	87%
Bahamas	D	VR data	VR data & High HIV	2013	87%
Bahrain	B	VR data	GBD2015	2014	61%
Bangladesh	B	VA MCM	GBD2015 plus (a)		

Country	All-cause mortality method	Under 5 child cause of death method	Cause of death methods for ages 5+	Latest available year VR	Average useability 2000-latest
Barbados	A	VR data	VR data	2013	68%
Belarus	A	VR MCM	VR data	2014	80%
Belgium	A	VR data	VR data	2013	87%
Belize	D	VR data	VR data & High HIV	2014	76%
Benin	D	VA MCM	High HIV		
Bhutan	B	VA MCM	GBD2015 plus (a)		
Bolivia (Plurinational State of)	A	VA MCM	GBD2015	2003	17%
Bosnia and Herzegovina	A	VR MCM	GBD2015	2014	73%
Botswana	C	VA MCM	High HIV		
Brazil	A	VR data	VR data	2014	83%
Brunei Darussalam	A	VR data	VR data	2014	91%
Bulgaria	A	VR data	GBD2015	2013	76%
Burkina Faso	D	VA MCM	High HIV		
Burundi	C	VA MCM	High HIV		
Cabo Verde	B	VR MCM	GBD2015	2011	73%
Cambodia	B	VA MCM	GBD2015 plus (a)		
Cameroon	C	VA MCM	High HIV		
Canada	A	VR MCM (0-27d), VR data (1-59m)	VR data	2012	94%
Central African Republic	C	VA MCM	High HIV		
Chad	D	VA MCM	High HIV		
Chile	A	VR data	VR data	2014	94%
China	B	Sample VR	VA/VR data	2013	n.a.
Colombia	A	VR data	VR data	2013	84%
Comoros	B	VA MCM	GBD2015 plus (a)		
Congo	C	VA MCM	High HIV		
Costa Rica	A	VR data	VR data	2014	87%
Côte d'Ivoire	D	VA MCM	High HIV		
Croatia	A	VR data	VR data	2015	89%
Cuba	A	VR data	VR data	2014	92%
Cyprus	B	VR MCM	VR data	2013	58%
Czechia	A	VR data	VR data	2015	89%
Democratic People's Republic of Korea	B	VA MCM	GBD2015 plus (a)		
Democratic Republic of the Congo	D	VA MCM	High HIV		
Denmark	A	VR data	VR data	2014	87%
Djibouti	D	VA MCM	High HIV		
Dominican Republic	A	VA MCM	GBD2015	2012	45%
Ecuador	A	VR MCM	VR data	2014	69%

Country	All-cause mortality method	Under 5 child cause of death method	Cause of death methods for ages 5+	Latest available year VR	Average useability 2000-latest
Egypt	A	VR MCM	GBD2015	2011	56%
El Salvador	A	VR MCM	GBD2015	2013	63%
Equatorial Guinea	C	VA MCM	High HIV		
Eritrea	D	VA MCM	High HIV		
Estonia	A	VR data	VR data	2014	94%
Ethiopia	C	VA MCM	High HIV		
Fiji	B	VR MCM	GBD2015	2012	81%
Finland	A	VR data	VR data	2014	97%
France	A	VR data	VR data	2013	85%
Gabon	C	VA MCM	High HIV		
Gambia	D	VA MCM	High HIV		
Georgia	A	VR MCM	GBD2015	2014	61%
Germany	A	VR data	VR data	2014	88%
Ghana	D	VA MCM	High HIV	2014	n.a.
Greece	A	VR data	GBD2015	2013	74%
Grenada	B	VR data	VR data	2015	88%
Guatemala	A	VA MCM	VR data	2014	79%
Guinea	D	VA MCM	High HIV		
Guinea-Bissau	D	VA MCM	High HIV		
Guyana	A	VR data	VR data	2012	86%
Haiti	D	VA MCM	High HIV	2004	6%
Honduras	B	VR MCM	GBD2015	2013	13%
Hungary	A	VR data	VR data	2014	95%
Iceland	A	VR data	VR data	2015	94%
India	B	State level	VA/VR data	2007	n.a.
Indonesia	B	VA MCM	GBD2015 plus (a)		
Iran (Islamic Republic of)	B	VA MCM	GBD2015 plus (a)	2014	n.a.
Iraq	B	VA MCM	GBD2015	2008	54%
Ireland	A	VR data	VR data	2013	95%
Israel	A	VR data	VR data	2014	91%
Italy	A	VR data	VR data	2012	91%
Jamaica	D	VR MCM	VR data & High HIV	2011	73%
Japan	A	VR data	VR data	2014	89%
Jordan	B	VR MCM	GBD2015	2011	61%
Kazakhstan	A	VA MCM	VR data	2015	81%
Kenya	C	VA MCM	High HIV	2015	n.a.
Kiribati	B	VA MCM	GBD2015	2001	51%
Kuwait	B	VR data	GBD2015	2014	65%
Kyrgyzstan	A	VA MCM	VR data	2015	90%

Country	All-cause mortality method	Under 5 child cause of death method	Cause of death methods for ages 5+	Latest available year VR	Average useability 2000-latest
Lao People's Democratic Republic	B	VA MCM	GBD2015 plus (a)		
Latvia	A	VR data	VR data	2014	90%
Lebanon	B	VR MCM	GBD2015 plus (a)	1999	n.a.
Lesotho	C	VA MCM	High HIV		
Liberia	D	VA MCM	High HIV		
Libya	B	VR MCM	GBD2015 plus (a)		
Lithuania	A	VR data	VR data	2015	92%
Luxembourg	A	VR data	VR data	2014	86%
Madagascar	B	VA MCM	GBD2015 plus (a)	2010	n.a.
Malawi	C	VA MCM	High HIV		
Malaysia	B	VR MCM	GBD2015	2008	40%
Maldives	A	VR MCM	GBD2015	2011	58%
Mali	D	VA MCM	High HIV		
Malta	A	VR data	VR data	2014	92%
Mauritania	B	VA MCM	GBD2015 plus (a)		
Mauritius	A	VR data	VR data	2014	88%
Mexico	A	VR data	VR data	2014	95%
Micronesia (Federated States of)	B	VA MCM	GBD2015 plus (a)		
Mongolia	A	VA MCM	GBD2015 plus (a)	2012	n.a.
Montenegro	A	VR data	GBD2015	2009	67%
Morocco	B	VA MCM	GBD2015	2012	12%
Mozambique	C	VA MCM	High HIV	2014	n.a.
Myanmar	B	VA MCM	GBD2015 plus (a)	2014	n.a.
Namibia	C	VA MCM	High HIV		
Nepal	B	VA MCM	GBD2015 plus (a)		
Netherlands	A	VR data	VR data	2015	86%
New Zealand	A	VR data	VR data	2012	97%
Nicaragua	A	VR MCM	GBD2015	2013	60%
Niger	B	VA MCM	GBD2015 plus (a)		
Nigeria	D	VA MCM	High HIV		
Norway	A	VR data	VR data	2014	88%
Oman	B	VR MCM	GBD2015	2010	49%
Pakistan	B	VA MCM	GBD2015 plus (a)		
Panama	A	VR data	VR data	2014	80%
Papua New Guinea	B	VA MCM	GBD2015 plus (a)		
Paraguay	B	VR MCM	GBD2015	2014	61%
Peru	A	VR MCM	GBD2015	2014	57%
Philippines	A	VA MCM	VR data	2011	78%
Poland	A	VR data	GBD2015	2014	72%

Country	All-cause mortality method	Under 5 child cause of death method	Cause of death methods for ages 5+	Latest available year VR	Average useability 2000-latest
Portugal	A	VR MCM (0-27d), VR data (1-59m)	VR data	2014	82%
Qatar	B	VR MCM	GBD2015	2012	60%
Republic of Korea	A	VR data	VR data	2013	85%
Republic of Moldova	A	VR data	VR data	2015	83%
Romania	A	VR data	VR data	2015	92%
Russian Federation	A	VR MCM	VR data	2011	89%
Rwanda	C	VA MCM	High HIV		
Saint Lucia	A	VR data	VR data	2014	75%
Saint Vincent and the Grenadines	B	VR data	VR data	2015	93%
Samoa	B	VR MCM	GBD2015 plus (a)		
Sao Tome and Principe	B	VA MCM	GBD2015 plus (a)		
Saudi Arabia	B	VR MCM	GBD2015	2012	21%
Senegal	B	VA MCM	GBD2015 plus (a)		
Serbia	A	VR data	VR data	2014	80%
Seychelles	B	VR MCM	GBD2015 plus (a)	2015	n.a.
Sierra Leone	D	VA MCM	High HIV		
Singapore	B	VR data	VR data	2015	71%
Slovakia	A	VR data	VR data	2014	94%
Slovenia	A	VR data	VR data	2015	89%
Solomon Islands	B	VA MCM	GBD2015 plus (a)		
Somalia	B	VA MCM	GBD2015 plus (a)		
South Africa	C	VR data (0-27d), VA MCM (1-59m)	High HIV	2014	70%
South Sudan	D	VA MCM	High HIV		
Spain	A	VR data	VR data	2014	90%
Sri Lanka	B	VR MCM	GBD2015	2006	72%
Sudan	B	VA MCM	GBD2015 plus (a)	2010	n.a.
Suriname	A	VR data	GBD2015	2014	64%
Swaziland	C	VA MCM	High HIV		
Sweden	A	VR data	VR data	2015	89%
Switzerland	A	VR MCM (0-27d), VR data (1-59m)	VR data	2013	89%
Syrian Arab Republic	B	VR MCM	GBD2015	2010	72%
Tajikistan	A	VA MCM	GBD2015	2005	78%
Thailand	D	VR MCM	High HIV	2014	52%
The former Yugoslav Republic of Macedonia	A	VR data	VR data	2013	87%
Timor-Leste	B	VA MCM	GBD2015 plus (a)		

Country	All-cause mortality method	Under 5 child cause of death method	Cause of death methods for ages 5+	Latest available year VR	Average useability 2000-latest
Togo	D	VA MCM	High HIV		
Tonga	B	VR MCM	GBD2015 plus (a)		
Trinidad and Tobago	A	VR data	VR data	2010	84%
Tunisia	B	VR MCM	GBD2015	2013	22%
Turkey	B	VR data	GBD2015	2013	58%
Turkmenistan	A	VA MCM	GBD2015	2013	67%
Uganda	C	VA MCM	High HIV		
Ukraine	A	VR MCM	VR data	2014	90%
United Arab Emirates	B	VR MCM	GBD2015	2010	56%
United Kingdom	A	VR data	VR data	2014	93%
United Republic of Tanzania	C	VA MCM	High HIV	2014	n.a.
United States of America	A	VR data	VR data	2014	93%
Uruguay	A	VR data	VR data	2014	83%
Uzbekistan	A	VA MCM	VR data	2014	85%
Vanuatu	B	VR MCM	GBD2015 plus (a)		
Venezuela (Bolivarian Republic of)	A	VR data	VR data	2013	82%
Viet Nam	B	VR MCM	GBD2015 plus (a)		
Yemen	B	VA MCM	GBD2015 plus (a)		
Zambia	C	VA MCM	High HIV	2014	n.a.
Zimbabwe	C	VA MCM	High HIV	2002	n.a.

Annex Table E First-level categories for analysis of child causes of death

GBD cause name	ICD-10 code	ICD-9 code
All causes	A00-Y89	001-999
I. Communicable, maternal, perinatal and nutritional conditions[a]	A00-B99, D50-D53, D64.9, E00-E02, E40-E64, G00-G09, H65-H66, J00-J22, J85, N30, N34, N390, N70-N73, O00-P96, U04	001-139, 243, 260-269, 279.5-279.6, 280, 281, 285.9, 320-326, 381-382, 460-466, 480-487, 513, 614-616, 630-676, 760-779
HIV/AIDS	B20-B24	279.5-279.6, 042
Diarrhoeal diseases	A00-A09	001-009
Pertussis	A37	033
Tetanus	A33-A35	037, 771.3
Measles	B05	055
Meningitis/encephalitis	A20.3, A32.1, A39.1, G00–G09	036, 320, 322-326
Malaria	B50-B54, P37.3, P37.4	084
Acute respiratory infections	H65-H66, J00-J22, J85, P23, U04	460-466, 480-487, 381-382, 513, 770.0
Prematurity	P01.0, P01.1, P07, P22, P25-P28, P52, P61.2, P77	761.0-761.1, 765, 769, 770.2-770.9, 772.1, 774.2, 776.6, 777.5-777.6,
Birth asphyxia & birth trauma[b]	P01.7-P02.1, P02.4-P02.6, P03, P10-P15, P20-P21, P24, P50, P90-P91	761.7-762.1, 762.4-762.6, 763, 767-768, 770.1, 772.2, 779.0-779.2
Sepsis and other infectious conditions of the newborn	P35-P39 (exclude P37.3, P37.4)	771.0-771.2, 771.4-771.8
Other Group I	Remainder	Remainder
II. Noncommunicable diseases[a]	C00-C97, D00-D48, D55-D64 (exclude D64.9), D65-D89, E03-E34, E65-E88, F01-F99, G10-G98, H00-H61, H68-H93, I00-I99, J30-J84, J86-J98, K00-K92, L00-L98, M00-M99, N00-N28, N31-N32, N35-N64 (exclude N39.0), N75-N98, Q00-Q99	140- 242, 244-259, 270-279, 282-285, 286-319, 330-380, 383-459, 470-478, 490- 512, 514-611, 617- 629, 680- 759 (exclude 279.5-279.6, 285.9)
Congenital anomalies	Q00-Q99	740-759
Other Group II	Remainder	Remainder
III. Injuries	V01-Y89	E800-E999

[a] Deaths coded to "Symptoms, signs and ill-defined conditions" (780-799 in ICD-9 and R00-R99 in ICD-10) are distributed proportionately to all for neonatal deaths, but exclusively to Group I and Group II for the postneonatal deaths.
[b] Also referred to as "intrapartum-related complications"