WHO methods and data sources for country-level causes of death 2000-2021

Department of Data and Analytics (DNA)
Division of Data, Analytics and Delivery for Impact (DDI)
WHO, Geneva

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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 Child and Adolescent Causes of Death Estimation (CA CODE) project, the Maternal Mortality Expert and Interagency Group (MMEIG), the International Agency for Research on Cancer, 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 Beatriz Galatas Andrade, Sébastien Antoni, Mathieu Bastard, Kelly Bienhoff, Bob Black, Freddie Bray, Zoe Brillantes, Jenny Cresswell, Juliana Daher, Patrick Gerland, , Kacem Iaych, Eline Louise Korenromp, Mathieu Laversanne, Li Liu, Rafael Lozano, Mary Mahy, Anna Minta, Mohsen Naghavi, Vladimir Poznyak, Ahmed Shady 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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Contents

1 Introduction

Global, regional, and country statistics on population and health indicators are critical for assessing development and health progress and for guiding resource allocation. Specifically, these data are used to monitor progress towards the health-related targets within the Sustainable Development Goals (SDGs) and WHO's 13th General Programme of Work (GPW13), 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.

Previous WHO time series estimates of deaths by cause, age and sex for its Member States[1–3] have now been updated for years 2000-2021 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 (GHE2021) for years 2000-2021. Annex Table A lists the cause of death categories and their definitions in terms of the International Classification of Diseases, Tenth Revision (ICD-10).[4] These estimates are available for years 2000, 2010, 2015, 2019, 2020 and 2021 for Member States and for selected regional groupings of countries, areas and territories, defined in Annex Table B, at

https://www.who.int/data/global-health-estimates

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 the Child and Adolescent Causes of Death Estimation (CA CODE) project to estimate child causes of death.

Estimates of mortality and causes of death were recently released in April 2024 by the Institute of Health Metrics and Evaluation (IHME) as part of the Global Burden of Disease 2021 study (GBD2021).[5] WHO has drawn on the GBD2021 analyses for selected causes for Member States without comprehensive death registration data as described in Section 9 below.

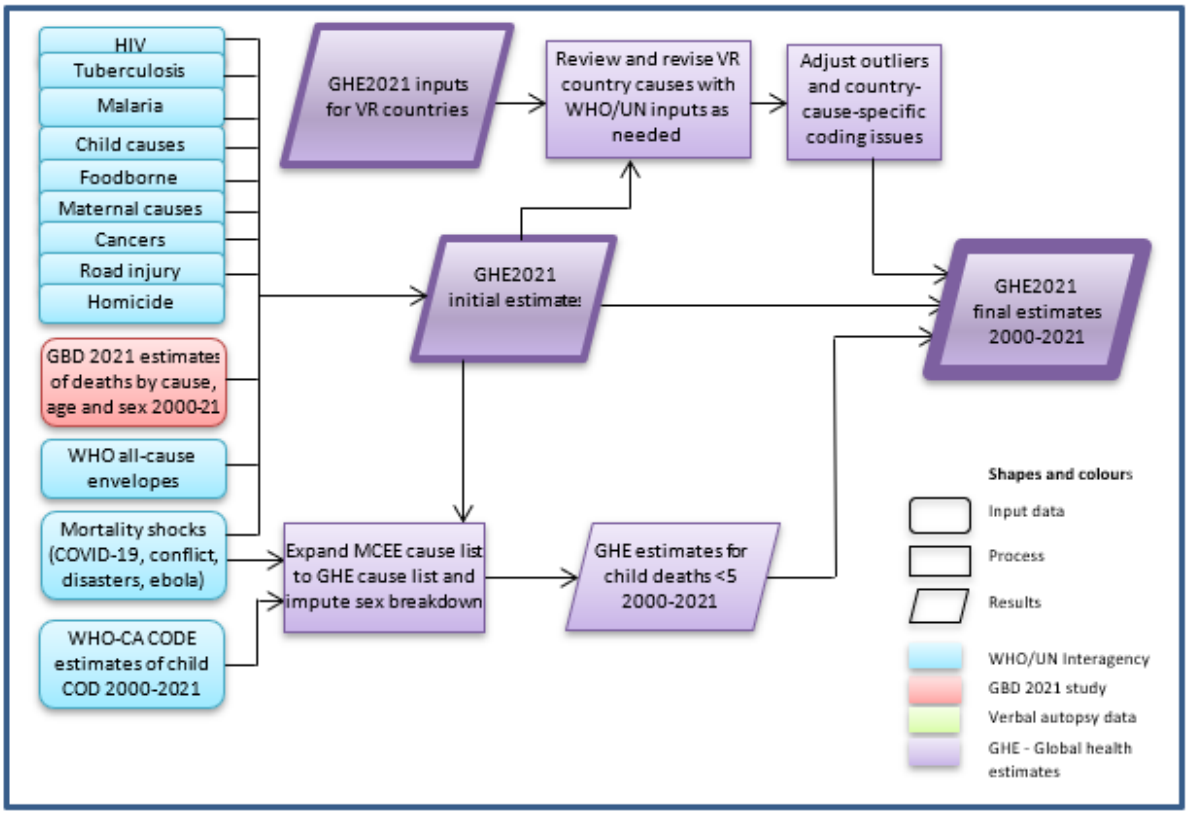
These WHO Global Health Estimates provide a comprehensive and comparable set of cause of death estimates from year 2000 onwards, consistent with and incorporating UN agency, interagency and WHO estimates for population, births, all-cause deaths and specific causes of death, including:

- most recent vital registration (VR) data for all countries submitting VR data to the WHO Mortality Database (WHO MDB), where the VR data meets certain criteria for completeness and quality;
- 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; and
- Global Burden of Disease 2021 (GBD2021) 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 GBD2021 study, and there have been substantial revisions to methods for many causes, these estimates for the years 2000-2021 are not directly comparable with previous WHO estimates for 2000-2019 or earlier versions. These Global Health Estimates represent the best estimates of WHO, based on the evidence available to it up until May 2024, 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).[6] 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 GHE2021 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 GHE2021 dataset for causes of death in 183 WHO Member States for years 2000-2021. Refer also to Figure 4.1 for a more detailed summary of the processes involved in the use of death registration data submitted to the WHO Mortality Database and to Figure 7.1 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 2000-2021

WHO life tables have been revised and updated for Member States for years 2000-2021, drawing on estimates of deaths and population from the recently released UN World Population Prospects 2024 revision (WPP2024),[7] recent UNAIDS/WHO analyses of HIV mortality for countries with high HIV prevalence,[8] vital registration data,[9] UN-IGME estimates of levels and trends for child mortality under 15 years,[10] as well as all-cause mortality estimates for adults based on the GBD model life table systems.[11]

Annex Table D summarizes the methods used for preparing life tables. Data sources are documented in more detail in GHE Technical Paper 2024.1.[12] The WHO life tables are available in the Global Health Observatory at https://www.who.int/data/gho/data/indicators/indicator-details/GHO/gho-ghe-life-tables-by-country

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 2022 revision.[7] 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 2021. The 11 WHO Member States excluded are: Andorra, Cook Islands, Dominica, Marshall Islands, Monaco, Nauru, Niue, Palau, Saint Kitts and Nevis, San Marino, and Tuvalu. Additionally, estimates are made for the following territories or areas: Puerto Rico; Taiwan, China; occupied Palestinian territory, including east Jerusalem, which are also included in the relevant regional and global totals as appropriate.

3.2 Age groups

The analysis of deaths by cause is carried out for 5-year age groups from 5-9, through to the final open-ended age group 85+. Deaths under age 5 are estimated for the following age groups: neonatal (0-27 days), post-neonatal (1-11 months), and 1-4 years. Cause of death estimates are released in tabular form for age groups 0-27 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 from previous WHO cause of death estimates have been used, with the addition of categories for COVID-19 and other pandemic-related mortality. The cause list is given in Annex Table A, together with corresponding ICD-10 codes.

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] For these estimates, a total of 66 countries or territories had data that met our inclusion criteria, of which 60 countries had data for years 2020 or 2021. For 48 countries, data were included for both 2020 and 2021.

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 detail of the data in the WHO Mortality Database);
3) redistribution of deaths of unknown sex/age and deaths assigned to ill-defined (garbage) codes;
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 2000-2021.

Figure 4.1 provides an overview of the steps involved in preparing the complete dataset for GHE causes and categories for years 2000 to 2021 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 mid-2020:

- The data are for a country/territory included in this analysis (see Section 3.1);
- The data are available for 5-year age groups to ages 85 and over;
- Data were reported to WHO were coded using ICD-9 or ICD-10 (*vs*. a prior version of ICD);
- At least five years of data were provided by ICD code (*vs.* a condensed list);
- Both early (1998-2006) and recent (2015-2021) data were reported to WHO;
- The average prevalence of HIV among adults aged 15 to 49 was 1.5% or lower during 2000-2018; and
- The country/territory's vital registration data were assessed as medium or high quality[13], as described below.

The concept of "usability" has been developed by WHO in order to assess the overall quality of death registration data. Usability is defined as the percentage of all deaths which are registered with meaningful cause-of-death information. Usability is calculated as completeness (i.e. the percentage of all deaths in a geographic area that are registered with medical certification of cause of death) multiplied by the proportion of registered deaths that are assigned a meaningful cause of death:

Usability (%) = Completeness (%) x (1-Deaths assigned to a garbage code (%))

Note that the completeness used to calculate usability is based on the deaths registered with cause of death and reported to the WHO Mortality Database. This may differ from estimated completeness of all registered deaths (with or without cause) used in the development of WHO life tables.[12]

Together with information on reporting status, WHO has used data on usability to categorize national death registration data reported to WHO as very low, low, medium or high quality, as described in Section 10. Briefly, data are considered high quality if the country has reported at least 5 years of data from 2010 or later to WHO, reports the latest year of data by ICD code, and has average usability from 2010-latest ≥ 80%. Data are considered medium quality if the country reports at least 5 years of data from 2010 or later to WHO, reports the latest year of data by ICD code, and has average usability during the period 2010-latest ≥

60% and < 80%. Data may also be considered medium quality if at least 5 years' data are reported using a shortlist and the average usability during the period 2010-latest is ≥ 80%.

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. Data from Suriname were excluded because of because of implausible trends implied by the data. Data from Guatemala, Kazakhstan, Kyrgyzstan, and Uzbekistan were excluded because the cause of death patterns implied by the data were implausible. Finally, data from Venezuela were excluded because the country situation has changed since data were last provided (2016) and it was not appropriate to project trends to 2021.

For countries which did not meet the criteria for directly using death registration data to estimate causes of death, we have drawn on the GBD2021 study, as described in Section 9. Note that the GBD 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. The country-specific GBD input data and estimates can be viewed on their website.[14,15]

Figure 4.1 Overview of the processes involved in the preparation of the GHE2021 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 GHE2021 estimates.

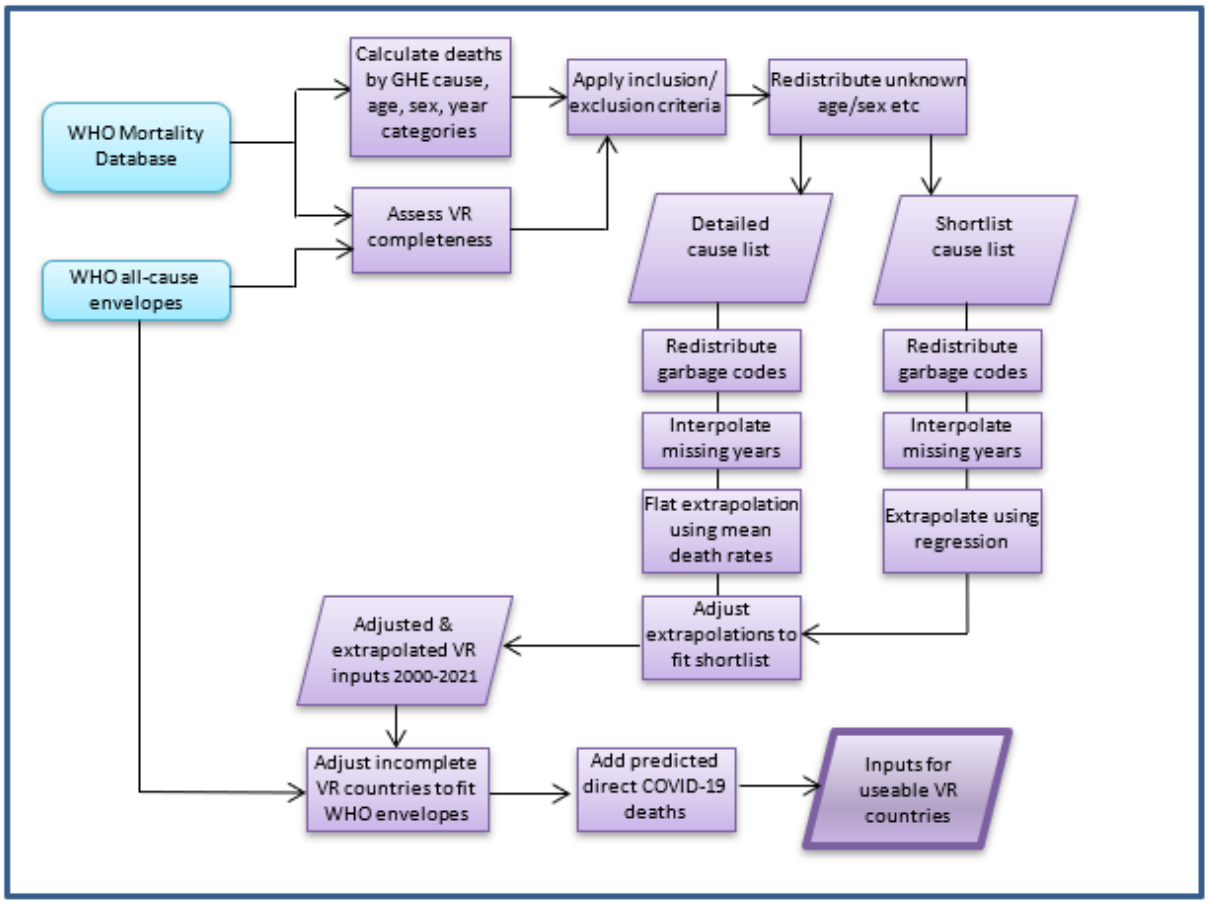


Table 4.1. *Characteristics[a] of country vital registration data and inclusion/exclusion[b]*

Country, territory, or area	Years of data in the WHO mortality database	Years of data used to compute the GHE	Quality	Completeness (ages 15 and over)		Usability[c]		Were data used for GHE?	Reason data or data-years were excluded	Notes
				Minimum	Maximum	Minimum	Maximum			
Albania	1998-2010		low	100%	100%			no	Low quality	
Antigua and Barbuda	1998-2021	1998-2021	medium	94%	100%	65%	84%	yes		
Argentina	1998-2021	1998-2021	medium	100%	100%	66%	75%	yes		
Armenia	1998-2003, 2006-2021	1998-2003, 2006-2021	high	100%	100%	80%	95%	yes		d, e
Australia	1998-2004, 2006-2021	1998-2004, 2006-2021	high	100%	100%	90%	92%	yes		
Austria	1998-2021	1998-2021	high	100%	100%	84%	90%	yes		
Azerbaijan	1998-2004, 2007		very low	79%	82%	45%	45%	no	Low quality	
Bahamas	1998-2015		medium	81%	83%	65%	76%	no	High HIV	
Bahrain	1998-2014		low	69%	72%	37%	46%	no	Low quality	
Barbados	2000-2013		low	100%	100%	70%	84%	no	Low quality	
Belarus	1998-2003, 2007-2011, 2013-2014, 2018		high	100%	100%	90%	90%	no	Fewer than five years by ICD code	
Belgium	1998-2020	1998-2020	high	100%	100%	81%	85%	yes		
Belize	1998-2016		high	92%	100%	68%	91%	no	High HIV	
Bolivia (Plurinational State of)	2000-2003		very low	55%	56%	19%	24%	no	Low quality	
Bosnia and Herzegovina	2011, 2014, 2016-2021		medium	90%	100%	64%	75%	no	Insufficient trend data	
Brazil	1998-2021	1998-2021	high	100%	100%	73%	86%	yes		
Brunei Darussalam	1998-2019	1998-2019	high	98%	100%	86%	88%	yes		d
Bulgaria	1998-2021	1998-2021	medium	100%	100%	65%	80%	yes		d, e
Cabo Verde	2011-2012		low	100%	100%	69%	71%	no	Low quality	

Canada	1998-2021	1998-2021	high	100%	100%	90%	92%	yes		
Chile	1998-2021	1998-2021	high	100%	100%	86%	91%	yes		
Colombia	1998-2021	1998-2021	high	100%	100%	88%	94%	yes		
Costa Rica	1998-2020	1998-2020	high	99%	100%	89%	93%	yes		
Croatia	1998-2021	1998-2021	high	100%	100%	81%	93%	yes		
Cuba	1998-2021	2000-2021	high	100%	100%	89%	93%	yes	Unusable ICD version or shortlist	
Cyprus[f]	1999-2000, 2004-2021	2004-2021	high	100%	100%	70%	87%	yes	Data not available by 5-year age group	
Czech Republic	1998-2021	1998-2021	high	100%	100%	83%	89%	yes		
Denmark	1998-2021	1998-2021	high	100%	100%	82%	86%	yes		
Dominican Republic	1998-2018		low	66%	73%	51%	58%	no	Low quality	
Ecuador	1998-2021	1998-2021	medium	81%	89%	56%	77%	yes		e
Egypt	2000-2019		low	100%	100%	42%	54%	no	Low quality	
El Salvador	1998-2018		low	100%	100%	54%	71%	no	Low quality	
Estonia	1998-2021	1998-2021	high	100%	100%	91%	95%	yes		
Fiji	1999, 2001-2009, 2011-2012		low	86%	95%	44%	69%	no	Low quality	
Finland	1998-2021	1998-2021	high	100%	100%	96%	98%	yes		
France	1998-2021	1998-2021	medium	100%	100%	78%	82%	yes		
Georgia	1998-2001, 2004-2007, 2009-2021	1998-2001, 2004-2007, 2009-2021	medium	95%	100%	30%	91%	yes		
Germany	1998-2021	1998-2021	high	100%	100%	83%	86%	yes		
Greece	1998-2021	1998-2021	medium	100%	100%	67%	80%	yes		
Grenada	2001-2021	2001-2021	medium	87%	90%	67%	78%	yes		
Guatemala	1998-2021		high	100%	100%	73%	84%	no	Ad-hoc exclusion (see text)	
Guyana	1998-1999, 2001-2019	1998-1999, 2001-2019	medium	90%	92%	66%	83%	yes		
Haiti	1999, 2001-2004		very low	12%	14%	6%	8%	no	Low quality	
Honduras	2008-2013		very low	26%	27%	23%	25%	no	Low quality	

Hungary	1998-2021	1998-2021	high	100%	100%	91%	94%	yes		
Iceland	1998-2021	1998-2021	high	97%	100%	88%	94%	yes		
Iran (Islamic Republic of)	2013-2017		medium	83%	89%	70%	76%	no	Insufficient trend data	
Iraq	2008, 2015-2016		low	90%	100%	53%	60%	no	Low quality	
Ireland	1998-2020	1998-2020	high	100%	100%	92%	94%	yes		d
Israel	1998-2021	1998-2021	high	100%	100%	79%	83%	yes		
Italy	1998-2020	1998-2020	high	100%	100%	85%	88%	yes		
Jamaica	2000-2006, 2009-2014		high	100%	100%	70%	90%	no	High HIV	
Japan	1998-2021	1998-2021	high	100%	100%	75%	87%	yes		
Jordan	2008-2012, 2015-2018		medium	73%	78%	58%	61%	no	Insufficient trend data	
Kazakhstan	1998-2021		high	100%	100%	86%	90%	no	Ad-hoc exclusion (see text)	
Kiribati	1998-2001		very low	51%	52%	31%	35%	no	Low quality	
Kuwait	1998-2019		low	51%	59%	41%	47%	no	Low quality	
Kyrgyzstan	1998-2019		high	94%	100%	86%	97%	no	Ad-hoc exclusion (see text)	
Latvia	1998-2021	1998-2021	high	100%	100%	88%	95%	yes		
Lebanon	2019-2021		low	85%	94%	51%	62%	no	Low quality	
Libya	2016-2017		very low	74%	74%	38%	39%	no	Low quality	
Lithuania	1998-2021	1998-2021	high	100%	100%	94%	97%	yes		
Luxembourg	1998-2021	1998-2021	high	100%	100%	78%	86%	yes		
Malaysia	2000-2020		low	66%	71%	43%	56%	no	Low quality	
Maldives	2000-2005, 2007-2008, 2010-2021		low	83%	93%	15%	62%	no	Low quality	
Malta	1998-2021	1998-2021	high	85%	100%	77%	90%	yes		
Mauritius	1998-2021	1998-2021	high	100%	100%	77%	90%	yes		
Mexico	1998-2021	1998-2021	high	100%	100%	89%	94%	yes		e
Micronesia (Federated States of)	2018-2021		low	67%	67%	50%	54%	no	Low quality	
Mongolia	2016-2021		high	100%	100%	96%	96%	no	Insufficient trend data	

Montenegro	2000-2009, 2017, 2019		low	96%	100%	63%	74%	no	Low quality	
Morocco	2000-2004, 2007-2016, 2020		very low	31%	41%	13%	24%	no	Low quality	
Netherlands	1998-2021	1998-2021	high	100%	100%	82%	86%	yes		
New Zealand	1998-2016	1998-2016	high	98%	100%	93%	95%	yes		
Nicaragua	1998-2021	1998-2021	high	77%	100%	66%	89%	yes		e
Norway	1998-2021	1998-2021	high	100%	100%	84%	87%	yes		
Oman	2009-2010, 2014, 2016-2021		very low	61%	65%	16%	32%	no	Low quality	
Panama	1998-2019, 2021	1998-2019, 2021	high	96%	100%	79%	86%	yes		
Paraguay	1998-2021	1998-2021	medium	72%	86%	49%	75%	yes		
Peru	1998-2020	1999-2020	medium	75%	92%	51%	83%	yes	Unusable ICD version or shortlist	
Philippines	1998-2003, 2006-2011, 2014, 2016-2019	2000-2001, 2003, 2006-2011, 2014, 2016-2019	medium	88%	95%	73%	80%	yes	Ad-hoc exclusion (see text)	
Poland	1999-2021	1999-2021	medium	100%	100%	68%	83%	yes		
Portugal	1998-2003, 2007-2019	1998-2003, 2007-2019	high	100%	100%	75%	83%	yes		d
Puerto Rico	1998-2017, 2021	1999-2017, 2021	high	100%	100%	85%	88%	yes	Unusable ICD version or shortlist	
Qatar	2001, 2004-2017, 2019-2021		very low	42%	52%	28%	34%	no	Low quality	
Republic of Korea	1998-2021	1998-2021	high	100%	100%	76%	85%	yes		
Republic of Moldova	1998-2018, 2021	1998-2018, 2021	high	89%	100%	83%	98%	yes		
Romania	1998-2019	1998-2019	high	100%	100%	81%	88%	yes		
Russian Federation	1998-2019		medium	100%	100%			no	Fewer than five years by ICD code	
Saint Lucia	1998-2006, 2008-2020	1998-2006, 2008-2020	high	100%	100%	65%	89%	yes		

Saint Vincent and the Grenadines	1998-2021	2000-2021	high	100%	100%	75%	91%	yes	Unusable ICD version or shortlist	
Saudi Arabia	2009, 2012, 2021		high	57%	100%	24%	80%	no	Insufficient trend data	
Serbia	1998-2021	1998-2021	medium	100%	100%	77%	84%	yes		
Seychelles	2001-2017, 2019-2021		medium	100%	100%			no	Fewer than five years by ICD code	
Singapore	1998-2021	1998-2021	high	100%	100%	93%	96%	yes		
Slovakia	1998-2010, 2012-2014, 2016-2021	1998-2010, 2012-2014, 2016-2021	high	100%	100%	86%	93%	yes		e
Slovenia	1998-2020	1998-2020	high	100%	100%	86%	91%	yes		
Solomon Islands	2017-2018		low	53%	53%	47%	48%	no	Low quality	
South Africa	1998-2018		medium	80%	89%	52%	67%	no	High HIV	
Spain	1998-2021	1998-2021	high	100%	100%	83%	89%	yes		
Sri Lanka	1998-2007, 2009-2015, 2019		medium	100%	100%	59%	65%	no	Insufficient trend data	
Suriname	1998-2014		medium	79%	90%	57%	73%	no	Ad-hoc exclusion (see text)	
Sweden	1998-2021	1998-2021	high	100%	100%	85%	88%	yes		
Switzerland	1998-2021	1998-2021	high	98%	99%	83%	86%	yes		
Syrian Arab Republic	1998-2010		low	81%	87%	48%	48%	no	Low quality	
Tajikistan	1998-2005, 2016-2017		low	83%	84%	63%	63%	no	Low quality	
Thailand	1998-2000, 2002-2019		low	82%	100%	31%	65%	no	Low quality	
The former Yugoslav Republic of Macedonia	1998-2013, 2015-2021	1998-2013, 2015-2021	medium	100%	100%	69%	84%	yes		d, e
Trinidad and Tobago	1998-2012		low	100%	100%	90%	92%	no	Low quality	
Tunisia	2009, 2013, 2017, 2020-2021		low	63%	64%	41%	50%	no	Low quality	
Türkiye	1998-2002, 2004-2019		medium	71%	100%	57%	80%	no	Insufficient trend data	

Turkmenistan	1998-2015		very low	58%	67%			no	Low quality	
Ukraine	1998-2012, 2014-2015, 2017-2019		medium	100%	100%			no	Fewer than five years by ICD code	
United Arab Emirates	2005-2010, 2018-2020		low	80%	100%	55%	61%	no	Low quality	
United Kingdom	1998-2020	1998-2020	high	96%	97%	87%	90%	yes		
United States of America	1998-2021	1998-2021	high	98%	99%	86%	89%	yes		
Uruguay	1998-2010, 2012-2020	1998-2010, 2012-2020	medium	100%	100%	76%	80%	yes		
Uzbekistan	1998-2005, 2009-2019		medium	61%	81%	57%	75%	no	Ad-hoc exclusion (see text)	
Venezuela (Bolivarian Republic of)	1998-2016		high	100%	100%	87%	90%	no	Ad-hoc exclusion (see text)	

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

b) Only country/territories included in this analysis are listed here (see Section 3.1).

c) Usability range is shown for data years available by ICD code.

d) Summarized cause list used for some years.

e) Lower respiratory deaths were reassigned to COVID-19 for one or more years 2020-2021 due to suspected COVID-19 misclassification.

f) Data pertain only to government-controlled areas.

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 4.5 (hereafter "shortlist"). In some cases, counts of deaths were not available for specific causes of death. 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.

Adjustments made to all countries, territories or areas

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.

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[16,17] have proposed that these deaths be reassigned mainly to ischemic heart disease (IHD; cause 1130), 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. These destination causes are 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 4.2-4.5.

Most deaths coded to essential hypertension (I10) are likely to have been caused by ischemic heart disease, stroke or kidney disease. These deaths were redistributed pro-rata to these three target diseases (GHE causes 1130, 1140 and 1270).

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

The majority of deaths assigned an ICD code for accidental poisoning are assigned ICD codes for poisoning by drugs and alcohol (ICD10 codes X40-X45). Most of these deaths are a result of overdose deaths among individuals with a drug or alcohol use disorder, and therefore should have been assigned the ICD code for the relevant drug use disorders. ICD10 codes associated with alcohol and commonly misused drugs (X41-X42, X44-X45) were assigned to the drug or alcohol use disorder category, while the codes associated with medications that are not commonly misused (X40,X43) were assigned to the poisoning category.

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.[18] Pneumonitis due to food and vomit (J69) and unspecified respiratory failure (J96) were also redistributed pro-rata to all non-injury causes of death.

Adjustments made to all countries for which ICD9 data were used

Chlamydia is not included among the 4-digit ICD-9 codes. To estimate chlamydia deaths when they were not available, the mean fraction of other sexually transmitted disease deaths caused by chlamydia was calculated for each country-sex group for the years it was available (i.e., years coded with ICD10), and applied to all years of data coded using ICD-9 for that country. If there were no deaths coded to other sexually transmitted diseases with ICD10 in a given country, the mean fraction for all other countries was used.

It was not possible to carry out the mapping discussed above for misused prescription medications for data coded using ICD9 (about 5% of country-years in the dataset). This resulted in artificial discontinuities in the estimated number of poisoning and drug use deaths in some countries. To better estimate poisoning, alcohol and drug use deaths, the percentage of drug use and poisoning deaths assigned to poisoning was computed for each country using all data coded using ICD10. This percentage was applied to all years of data coded using ICD9.

Table 4.2. *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							
	1130	1150	1180	1440	1130	1150	1180	1440
Age	Redistribution fractions for males				Redistribution fractions for females			
0	0%	6%	1%	93%	0%	6%	1%	93%
1-4	2%	18%	4%	76%	2%	22%	3%	73%
5-9	4%	26%	4%	66%	3%	31%	4%	61%
10-14	6%	34%	4%	56%	5%	33%	3%	58%
15-19	14%	42%	3%	40%	12%	37%	4%	47%
20-24	31%	41%	3%	25%	22%	41%	4%	33%
25-29	47%	36%	3%	15%	34%	39%	4%	23%
30-39	62%	27%	2%	8%	48%	32%	5%	15%
35-39	74%	19%	3%	4%	60%	25%	6%	9%
40-44	80%	14%	4%	2%	68%	17%	10%	5%
45-49	83%	11%	5%	1%	70%	13%	14%	3%
50-54	91%	0%	9%	0%	76%	0%	24%	0%
55-59	87%	0%	13%	0%	71%	0%	29%	0%
60-64	83%	0%	17%	0%	68%	0%	32%	0%
65-69	79%	0%	21%	0%	67%	0%	33%	0%

70-74	75%	0%	25%	0%	69%	0%	31%	0%
75-79	73%	0%	27%	0%	72%	0%	28%	0%
80-84	73%	0%	27%	0%	77%	0%	23%	0%
85+	76%	0%	24%	0%	84%	0%	16%	0%

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

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 eastern European and central Asian countries*[a]

	GHE target cause							
	1130	1150	1180	1440	1130	1150	1180	1440
Age	Redistribution fractions for males				Redistribution fractions for females			
0	0%	3%	1%	96%	0%	3%	0%	96%
1-4	0%	11%	3%	86%	0%	14%	3%	84%
5-9	1%	21%	5%	73%	2%	25%	4%	69%
10-14	4%	32%	5%	59%	3%	28%	7%	63%
15-19	16%	37%	8%	39%	11%	30%	8%	52%
20-24	40%	36%	7%	18%	29%	29%	10%	32%
25-29	52%	33%	6%	10%	43%	29%	8%	20%
30-39	64%	28%	4%	4%	53%	29%	8%	11%
35-39	72%	22%	4%	2%	65%	22%	7%	6%
40-44	78%	17%	5%	1%	73%	17%	7%	3%
45-49	81%	13%	6%	0%	76%	14%	9%	1%
50-54	93%	0%	7%	0%	88%	0%	12%	0%
55-59	91%	0%	9%	0%	88%	0%	12%	0%
60-64	88%	0%	12%	0%	88%	0%	12%	0%
65-69	87%	0%	13%	0%	89%	0%	11%	0%
70-74	85%	0%	15%	0%	91%	0%	9%	0%
75-79	85%	0%	15%	0%	92%	0%	8%	0%
80-84	86%	0%	14%	0%	93%	0%	7%	0%
85+	89%	0%	11%	0%	95%	0%	5%	0%

a) Armenia, Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Republic of Moldova, Romania, Serbia, Slovakia, Slovenia, Republic of North Macedonia

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 all other countries*

	GHE target cause							
	1130	1150	1180	1440	1130	1150	1180	1440
Age	Redistribution fractions for males				Redistribution fractions for females			
0	0%	3%	1%	96%	0%	3%	1%	95%
1-4	1%	10%	4%	85%	1%	10%	3%	86%
5-9	3%	16%	5%	76%	2%	16%	3%	79%
10-14	9%	24%	5%	63%	7%	22%	4%	66%
15-19	42%	23%	5%	30%	33%	22%	5%	40%
20-24	61%	19%	5%	15%	46%	23%	6%	25%
25-29	70%	18%	5%	8%	56%	22%	6%	16%
30-39	76%	15%	5%	4%	66%	18%	7%	9%
35-39	80%	14%	5%	2%	73%	15%	7%	5%
40-44	83%	11%	5%	1%	78%	12%	8%	2%
45-49	84%	9%	7%	1%	79%	9%	10%	1%
50-54	90%	0%	10%	0%	85%	0%	15%	0%
55-59	87%	0%	13%	0%	83%	0%	17%	0%
60-64	82%	0%	18%	0%	80%	0%	20%	0%
65-69	78%	0%	22%	0%	78%	0%	22%	0%
70-74	73%	0%	27%	0%	76%	0%	24%	0%
75-79	69%	0%	31%	0%	75%	0%	25%	0%
80-84	67%	0%	33%	0%	74%	0%	26%	0%
85+	68%	0%	32%	0%	76%	0%	24%	0%

Adjustments made to specific countries

COVID-19 deaths may have been misclassified to other causes of death due to regulatory incentives, lack of diagnostic information, or other factors (and vice versa). An additional screening was carried out to identify countries with extensive misclassification of COVID-19 deaths to other causes of death in 2020 and/or 2021. The screening was carried out as follows:

1. Countries where estimated excess mortality less direct COVID-19 mortality comprised more than 7% of all deaths were identified, and
2. The age pattern of lower respiratory infections (LRIs) in 2018-2019, 2020, and 2021 were compared

with the age pattern of COVID-19 mortality.

Based on these factors, each country-year of data was classified as having no suspected COVID-19 misclassification, or suspected misclassification of COVID-19. Countries with suspected misclassification are noted in Table 4.1.

In countries without suspected COVID-19 misclassification, age-standardized LRI mortality in 2020-2021 fell by a median of 24% (interquartile range 36% to 9%). For the countries with suspected misclassification of COVID-19 to LRIs, the mean LRI mortality rate from 2017-2019 was computed. This was adjusted by the median age-specific decline in LRI mortality in 2020 and 2021 in countries without suspected misclassification. The excess LRI mortality in countries with suspected misclassification was assigned to COVID-19.

It is possible that COVID-19 was misclassified to causes of death other than LRIs in these countries. In fact, large increases in cardiovascular and other NCD mortality rates were observed in some of these countries. For example, among men in Cuba, the age-standardized rate of cardiovascular mortality increased from 218 per 100,000 in 2019 to 327 per 100,000 in 2021. Although these death certificate data were analyzed as usual, all estimates for 2020 and 2021 from countries with suspected COVID misclassification should be used with caution.

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 .[19] 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.

In Mauritius, the introduction of ICD10 in 2005 resulted in a shift of deaths from ischemic heart disease and stroke to diabetes, which resulted in a more than tripling the number of diabetes deaths recorded and a simultaneous reduction in the cardiovascular causes. To generate a consistent time-series, the percentage of deaths from these three causes that were assigned to diabetes from 2005-2010 (50.5%) was applied to the years 2004 and prior. Also in Mauritius, the ICD10 code J98.8 (other specified respiratory disorders) is frequently used as a cause of death. As chest infection is often noted on the death certificate, these were reassigned to lower respiratory infections.

In Finland, an exceptionally high proportion of deaths among older adults are assigned to Alzheimer's and other dementias. For each age and sex category, we capped the dementia mortality rate at the 95th percentile mortality rate from all other included country-years, and assigned the excess deaths pro-rata to all non-injury causes of death.

In Greece, a large number of deaths were assigned upper respiratory infection as an underlying cause of death during years coded using ICD-9. The ratio of upper respiratory infection deaths to lower respiratory infection deaths from years coded using ICD-10 was applied to years coded using ICD-9.

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, we interpolated mortality rates for each country and cause, and then extrapolated at the beginning and end of the data series. Our interpolation and extrapolation methods are not appropriate for mortality shocks, such as natural disasters or epidemics. Prior to interpolation and extrapolation, we excluded COVID-19 and other causes of death that shifted systematically in 2020 and 2021. To do this, we projected age-

standardized mortality from 2015-2019 to 2020 and 2021 and compared reported data to our counterfactual (business-as-usual) projections. We considered causes of death at all levels of the GHE cause hierarchy (*e.g.*, ischemic heart disease as well as all cardiovascular diseases together). We considered that causes of death changed systematically if:

- Projected mortality was greater than observed mortality in 75% of country years, or projected mortality was less than observed mortality in 75% of country-years;
- The absolute median difference between projected and observed cause-specific mortality was >1 per 100,000.

We found that LRI and chronic obstructive pulmonary disease mortality systematically decreased during 2020-2021, and that diabetes and cerebrovascular disease systematically increased during 2020-2021. The higher-level causes chronic respiratory diseases and cardiovascular diseases were also affected. These causes of death, plus COVID-19, respiratory infections, and all group 1 mortality, were considered pandemic-affected causes of death. All other causes of death from 2020-2021 and all data from before 2020 were used for interpolation/extrapolation as described below.

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 12 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).

4.5 Adjustment of specific causes

Estimates for HIV deaths were compared with UNAIDS/WHO estimates.[8] In general, the VR-based estimates were used. For five countries the UNAIDS/WHO estimates were used: El Salvador, Nicaragua, Panama, Saint Lucia, Venezuela. For another five countries, an average of the UNAIDS-based and VR-based deaths was used: Armenia, Barbados, Paraguay, the Republic of Moldova, Sri Lanka.

WHO estimates for maternal deaths include an upwards adjustment for under-recording of maternal deaths in death registration data.[20] Maternal deaths were adjusted using these country-specific factors, and all other causes adjusted pro-rata.

Where necessary, road injury deaths were adjusted upwards to take account of additional surveillance data provided by countries (see Section 6.9). Homicide deaths were similarly adjusted where relevant to take account of homicide data from the police/justice sector (see Section 6.10).

Estimates of deaths due to conflicts (see Section 6.12) 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.

***Table 4.5**. 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
380	B. Respiratory infections
420	C. Maternal conditions
490	D. Neonatal conditions
540	E. Nutritional deficiencies
600	**II. Noncommunicable diseases**
610	A. Malignant neoplasms
800	C. Diabetes mellitus
820	E. Mental and neurological disorders

1100	H. Cardiovascular diseases
1170	I. Respiratory diseases
1210	J. Digestive disorders
1260	K. Genitourinary diseases
1400	N. Congenital anomalies
	Other noncommunicable diseases
1510	**III. Injuries**
1520	A. Unintentional injuries
1600	B. Intentional injuries

5 Causes of death for children under age 5 years

The CA CODE project prepares estimates of deaths for children under age 5 for 16 cause categories using methods described elsewhere.[21] and a previously published technical paper .[22] For causes for which WHO technical programmes have updated estimates after the release of the CA CODE estimates, those updates were incorporated. Additionally, CA CODE estimates for children under age 5 years are not sex-specific and grouped into neonatal (0-27 days) and post-neonatal (1-59 months) that are not disaggregated the same way as GHE, i.e., sex-specific rates for three age categories under age of 5-years, namely 0-27 days, 1-11 months, and 1-4 years. Therefore, sex and age splits were performed using the all-cause mortality envelope based on complete VR data or IGME estimates, population estimates from WPP2024, and age and sex distribution by cause from GBD2021.

At the time of the GHE analysis, the latest available CA CODE estimates were also for the reference period 2000-2021. The CA CODE analysis employs a new multinomial Bayesian Lasso model with updated national vital registration data, new country-based studies and revisions to single cause of death estimates from a variety of sources.

The 16 cause categories used for the CA CODE estimates of under 5 deaths for years 2000-2021 (see Annex Table E) include all the major causes of neonatal (0-27 days) and post-neonatal (1-59 months) and two residual categories containing all remaining causes of death ("Other Group 1" and "Other noncommunicable"). Cause groups such as "Congenital anomalies" 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 GBD2021 estimates.[5]

6 Methods for specific causes with additional information

6.1 Tuberculosis

For countries without useable death registration data, total tuberculosis deaths were derived from latest published WHO estimates,[23] together with more detailed unpublished age distributions based on the VR data and notifications data. For the countries with useable death registration data, the VR-based estimates were generally somewhat higher than the WHO estimates, as the GHE cause category for tuberculosis includes the ICD code for deaths due to late effects of tuberculosis.

6.2 HIV/AIDS and sexually transmitted diseases

(a) Countries with useable vital registration data

For countries with useable death registration data, estimates for HIV deaths were compared with UNAIDS/WHO estimates.[8] In general, the VR-based estimates were used. For five countries the UNAIDS/WHO estimates were used: El Salvador, Nicaragua, Panama, Saint Lucia, Venezuela. For another five countries, an average of the UNAIDS-based and VR-based deaths was used: Armenia, Barbados, Paraguay, the Republic of Moldova, Sri Lanka.

(b) Other countries

For other countries, estimates were based on UNAIDS estimated HIV/AIDS mortality.[8] The current UNAIDS data does not have estimates of HIV deaths for the following countries: Antigua and Barbuda, Grenada, Iraq, Kiribati, Micronesia, Saint Lucia, Saint Vincent and the Grenadines, Samoa, Sao Tome and Principe, Seychelles, Solomon Islands, Tonga and Vanuatu. HIV estimates for these countries were based on previous WHO GHE2019 estimates with projections.

6.3 Malaria

WHO publishes updates for malaria deaths (total, and under 5 years) by country for years from 2000 onwards in its annual World Malaria Report.[24] The under 5 deaths are prepared in collaboration with the CA CODE collaborative group and also reported in the CA CODE child cause of death estimates.[21,22] For Member States without useable death registration data, these WHO malaria mortality estimates are used in GHE2019. The methods remain identical to those used for GHE2016 with updated data inputs, and are summarized in the following sections.

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 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[25–27]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.[28] 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.[29,30]

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.[31]

6.4 Measles

Estimates of measles deaths were prepared using a statistical model which firstly estimates measles cases by country and year using surveillance data and then makes explicit projections about dynamic transitions over time as well as overall patterns in incidence. Age-specific case fatality ratios are then applied for each country to estimate deaths.[32,33] Measles deaths have been updated to take into account trends in case notifications and vaccine coverage up to and including the year 2021.[34]

6.5 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 (45, 46). The GBD2021 time series estimates of deaths for these three diseases were scaled to match the underlying FERG estimates of deaths by country in 2010.

6.6 Cancers

Cause-specific estimates for cancer deaths in 2021 were derived as an average of estimates from Globocan 2020 and Globocan 2022.[35,36] For countries without useable death registration data, site-specific deaths were projected back to year 2000 using trend estimates from the GBD2021. 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.

6.7 Maternal causes of death

Country-specific estimates for maternal mortality were based on the most recent Interagency estimates for years 2000-2020.[20] 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 data.

Because the WHO life tables, and hence the total female deaths in the maternal age range, have been revised, 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 although regional and global totals have changed little.

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.

6.8 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). This mapping is complicated by the need to distribute the accidental poisoning category for “other and unspecified drugs, medicaments and biological substances” (X44) to the specific categories for drug use disorders (opioids, cocaine, amphetamines, cannabis and “other drugs”). Additionally, there is a category F19 in the mental health chapter for “multiple drug use and unspecified drug use disorders” which is used to code deaths in some countries and also must be redistributed appropriately.

GHE drug dependence deaths have been updated for all countries drawing on GBD2021 cause fractions. Additionally, estimates for the USA have been updated using US death registration data together with published analyses of drug-specific overdose deaths in the USA.[37] Drug overdose and dependence deaths for Australia and Canada were also revised to take into account latest published statistics and death registration data.[38,39]

6.9 Road injuries

For the third WHO *Global status report on road safety*, updated estimates of road injury deaths were prepared for 182 Member States for the years 2000-2021.[40] These estimates drew on death registration data and on reported road traffic deaths from official road traffic surveillance systems (collected in a WHO survey of Member States for the report).

6.10 Homicide

Updated estimates of homicide deaths for WHO Member States were published by WHO for years 2000-2019 in the GHE2019.[3] These were projected forward to 2021 using recent trends in death registration data, UNODC data [41]and GBD data where available.

6.11 Natural disasters

Estimated deaths for major natural disasters were obtained from estimates of GBD2019 which are based on information from the EM-DAT/CRED International Disaster Database .[42] These data were used to supplement the VR data as described in the previous WHO Life Tables Technical Paper.[12]

6.12 Conflict

Similar to natural disasters, we used GBD2019 data for conflict and terrorism which were primarily estimated using data from the Uppsala Conflict Data Program (UCDP), International Institute for Strategic Studies (IISS), Armed Conflict Location & Event Data Project (ACLED), Global Terrorism Database (GTD), supplemented by vital registration systems and other relevant data sources. Deaths were assigned for each event according to the source's cause coding and any description from available notes. When the deaths due to a certain event are reported across multiple locations and estimates by side were not provided, deaths were split between the population from both locations.

6.13 COVID-19

Estimated deaths directly due to COVID-19 come from three sources: 1. VR data adjusted for completeness and misclassification as described in above sections. 2. Weekly counts of confirmed COVID-19 deaths on WHO COVID-19 dashboard reported by countries, based on which annual total deaths were aggregated. This is used for informing the imputation of VR data when COVID-19 deaths were available in 2020 but not in 2021, by multiplying the ratio of COVID-19 deaths in the adjusted VR data to COVID-19 dashboard data in 2020 to the reported deaths in 2021 from the COVID-19 dashboard. This is based on the assumption that the under-reporting of COVID-19 deaths from the dashboard data relative to adjusted VR data is constant in 2020 and 2021. 3. For countries where VR data are not available, a relationship between directed COVID-19 deaths and total excess deaths was established by regressing the COVID-19 deaths from the adjusted VR data on WHO's excess mortality.[43] This relationship is thus extrapolated to non-VR countries using available estimated excess deaths to predict the underlying direct COVID-19 deaths.

6.14 Other Pandemic related mortality

GBD2021 introduced a measure of other pandemic related mortality (OPRM) to capture captures all deaths due to the pandemic which were not specifically caused by COVID-19 or the indirect COVID causes.[5] It is equal to the difference between excess mortality and the sum of COVID-19 specific deaths, measles, lower respiratory infection (LRI), and pertussis. Measles, LRI, and pertussis were referred to as indirect COVID causes as mortality from these diseases was affected by the pandemic. To reconcile this with WHO's estimates of COVID-19 excess deaths and direct COVID-19 deaths for countries where estimates draw on GBD data, OPRM estimates from GBD2021 were rescaled using the ratio of COVID-19 excess deaths less direct COVID-19 deaths from WHO to those from GBD.

7 Other causes of death for countries without useable data

The Institute for Health Metrics and Evaluation (IHME) has 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.[44] For this update of WHO Global Health Estimates for 2000-2021, we have similarly drawn on updated IHME single-cause analyses for the GBD2021 study,[5] as described below.

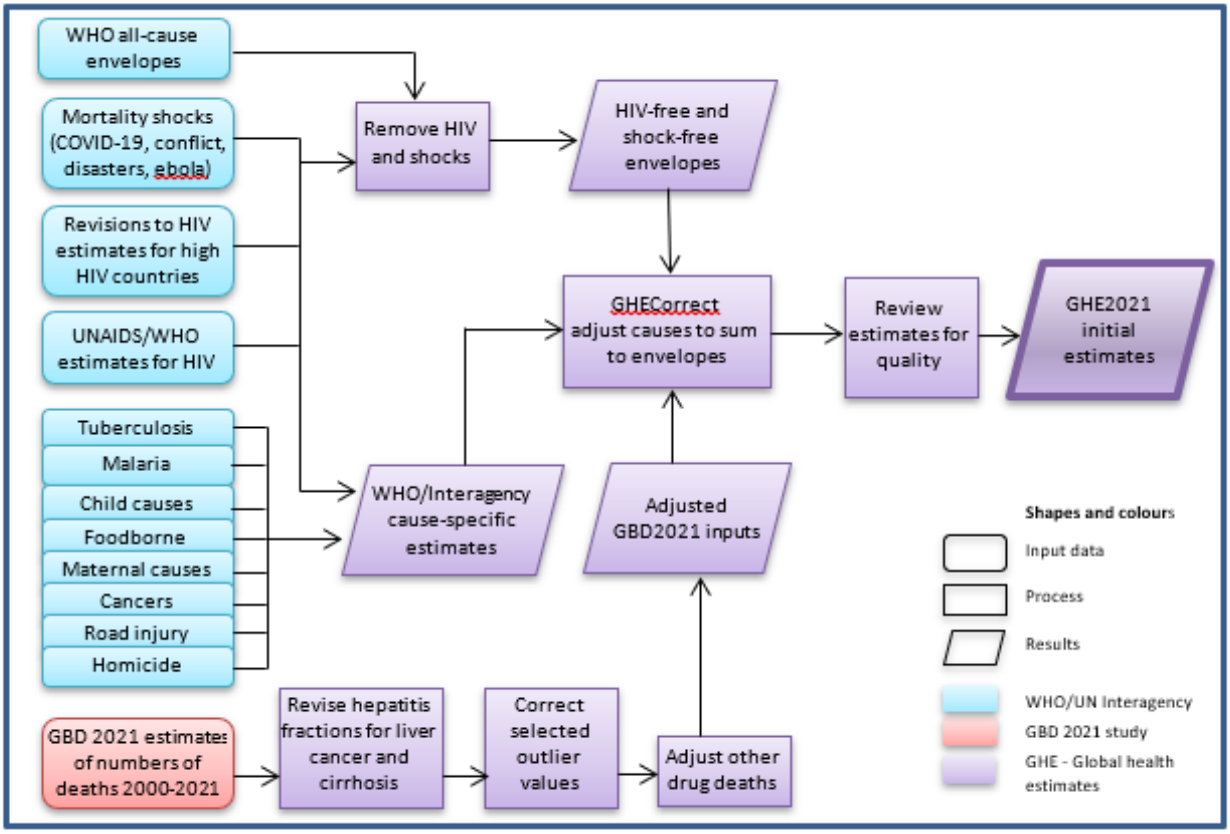
To ensure that the results of all the single-cause models summed to the all-cause mortality estimate for each age-sex-country-year group, IHME applied a final step called CoDCorrect to rescale the cause-specific estimates. This was done using repeated random draws from the uncertainty distributions of 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.

GBD2021 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 6) were not available. For this set of causes, GBD 2021country-level estimates for death rates at ages 5 and over for years 2000-2021 were used. For each year 2000 to 2021, 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.

GBD 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 GBD2021, 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. This is described in more detail in the GHE2015 technical paper.[1]

The overall process of preparing the "prior" set of estimates for all countries for years 2000-2021 for the complete GHE cause list ensuring that inputs from WHO/UN sources and GBD2021 were consistent with the WHO all-cause envelopes is summarized in Figure 7.1. 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, under 5 deaths and inputs for specific detailed cause breakdowns for certain cause groups for countries with death registration data.

Figure 7.1 Overview of the processes involved in the preparation of the GHE2021 "prior" estimates for all countries. Refer also to Figure 1.1 for further steps involved in the inclusion of this dataset in the final GHE2021 estimates.



8 Uncertainty of estimates

Many of the inputs to the GHE2021 estimates have explicit uncertainty ranges. However, there are some specific cause inputs from WHO and UN sources which do not yet estimate disaggregated uncertainty ranges by age and sex. 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 8.1). In addition, quantitative uncertainty ranges are available as part of the comprehensive GHE2021 estimates dataset to be made available on the WHO website. Methods for these uncertainty ranges, as well as an overview of the quality of the uncertainty analysis, were described in the previous Technical Paper[2] and are based on quantitative 95% uncertainty rates for cause-specific WHO/UN estimates together with 95% uncertainty ranges for other causes based on the broad variations of uncertainty in the GBD2021 estimates across cause categories and countries, with the latter grouped by data sources and methods.

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.

8.1 Guidance on underlying data quality

General guidance on the level of evidence available for death estimates 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 recent years of data available in the WHO mortality database, and
3. the average usability of the available data in the period 2010-present.

Usability is calculated as the product of the proportion of deaths assigned to a set of ill-defined cause of death codes[1] 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.

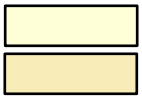
[1] ICD10 codes A40-A41, C76, C80, C97, D65, E86, I10, I26.9, I46, I47.2, I49.0, I50, I51.4-I51.6, I51.9, I70.9, I99, J81, J96, K72, N17-N19, P28.5, Y10-Y34, Y87.2

Table 8.1 Criteria for classification of countries by quality of death registration data

Quality assessment	Color	Number of years of data reported to WHO since 2010	Average usability for years 2010-latest (countries reporting data to WHO by ICD code)	Average usability for years 2010-latest (countries reporting data to WHO by a shortlist)
high	green	at least 5 years	usability >= 80%	n/a
medium	light yellow	at least 5 years	usability >= 60%	usability >= 80%
low	dark yellow	at least 1 year	usability >= 40%	usability >= 60%
very low	pink	no minimum	does not qualify for any other category (usability < 40%)	does not qualify for any other category (usability < 60%)

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.

9 Conclusions

GHE2021 presents results for 183WHO Member States and 3 selected territories or areas, encompassing all those with a population of 90,000 or greater in 2021. The GHE2021 estimates of causes of death by country, region and world for years 2000-2021 confirm and expand previous WHO analyses of global health trends and improvements. In particular, these GHE2021 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 taken place in March-April 2024 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,[6] documentation of data inputs, methods, and results, including uncertainty, has improved (Annex C provides the location of each GATHER reporting item).

Estimates of mortality by cause of death differ among estimates produced by different researchers and between revisions from the same agency or research group. 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; and
- Complete facility recording and reporting with regular quality control.

9.1 Reasons for changes in GHE estimates in this revision

As with previous revisions of WHO GHE and specific-cause time series estimates, GHE2021 provides an update for the entire time series from 2000 to 2021 incorporating data sources and specific WHO/interagency and IHME estimates released since GHE2019. 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. This resulted in changes in the estimates of overall mortality rates for a number of countries, thus also affecting the estimates of causes of death..
- The revision of methods for assessing the completeness of VR data. The adoption of a more advanced death distribution method has led to changes in the completeness estimates for VR data in some countries.[12]

- 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 the recently published GBD 2021 study for GHE2021. There were substantial changes in GBD 2021 estimates for some causes and countries compared to the previous GBD 2019 estimates used for GHE2019.
- Improvements to the GHECorrect process (Section 7.2) used to ensure that cause-specific estimates summed to WHO all-cause mortality estimates derived from WHO life tables.
- Additional years of death registration data were used for many countries.
- Updated methods for ill-defined causes of death, most notably for ill-defined respiratory mortality (Section 4.3).
- .

9.2 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 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.
- The COVID-19 pandemic caused unprecedented increases in mortality worldwide. The attribution of these increases to direct COVID-19 mortality vs. other causes of death, e.g. from healthcare disruption, is an ongoing effort. In this round of GHE, excess mortality is attributed to COVID-19 and other causes of death for countries with high-quality vital registration data. These estimates may be affected by misclassification of COVID-19 in some countries. In countries without high-quality vital registration, GBD2021 estimates were used. These estimates included a category, “other pandemic-related mortality”, which comprises all causes of death other than COVID-19 which increased during the pandemic. Cardiovascular and other NCD mortality were likely underestimated in these countries, meaning that global NCD mortality estimates for 2020-2021 were likely underestimated. Future rounds of GBD and GHE will aim to assign other pandemic-related mortality to its constituent causes.
- 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 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 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 GBD 2019 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 GBD2021 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, U07, U09-U10
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, A63-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. 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

GHE code	GHE cause name	ICD-10 codes
350	b. Trichuriasis	B79
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, U07, U09-U10
390	1. Lower respiratory infections	J09-J22, P23, U04
395	2. COVID-19*	U07, U09-U10
400	3. Upper respiratory infections	J00-J06
410	4. 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, G31.2), H00-H61, H68-H93, I00-I99, J30-J98 (minus J69, J96) , K00-K92, L00-L98, M00-M99, N00-N64, N75-N98, Q00-Q99, X41-X42, X44, X45, R95
610	**A.** Malignant neoplasms[c]	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	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[d]	C53
720	11. Corpus uteri cancer[d]	C54
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	C17, C26-C31, C37-C41, C46-C49, C51, C52, C57-C60, C63, C68, C69, C74-C75, C77-C79
790	**B. Other neoplasms**	D00-D48
800	**C. Diabetes mellitus**	E10-E14 (minus E10.2, E11.2, E12.2, E13.2, 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, G31.2, G72.1, Q86.0, X45
870	5. Drug use disorders[e]	F11-F16, F18-F19[d], X41-X42, X44[d]
871	a. Opioid use disorders	F11, X42
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, 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
940	**F. Neurological conditions**	F01-F03, G06-G98 (minus G14, G31.2, G72.1)
950	1. Alzheimer disease and other dementias	F01-F03, G30-G31 (minus G31.2)
960	2. Parkinson disease	G20-G21
970	3. Epilepsy	G40-G41

GHE code	GHE cause name	ICD-10 codes
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[f,g]**	I00-I99
1110	1. Rheumatic heart disease	I01-I09
1120	2. Hypertensive heart disease	I11-I15
1130	3. Ischaemic heart disease[f,g]	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 (minus J69, J96)
1180	1. Chronic obstructive pulmonary disease[f]	J40-J44
1190	2. Asthma	J45-J46
1200	3. Other respiratory diseases	J30-J39, J47-J98 (minus J69, J96)
1210	**J. Digestive diseases**	K20-K92
1220	1. Peptic ulcer disease	K25-K27
1230	2. Cirrhosis of the liver	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[g]	N00-N19, E10.2,E11.2,E12.2,E13.2,E14.2
1271	a. Acute glomerulonephritis	N00-N01
1272	b. Chronic kidney disease due to diabetes	E10.2, E11.2, E12.2, E13.2, E14.2
1273	c. Other chronic kidney disease	N02-N19
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

GHE code	GHE cause name			ICD-10 codes
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[f]	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[h]**			V01-Y89 (minus X41-X42, X44, X45)
1520	**A.**	**Unintentional injuries**		V01-X40, X43, X46-59, Y40-Y86, Y88, Y89, V99, Y85
1530		1.	Road injury[i]	V01-V04, V06, V09-V80, V87, V89, V99, Y85
1540		2.	Poisonings	X40, X43, X46-X48, X49
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	X33-X39
1590		8.	Other unintentional injuries	Rest of V, W39, W44, W53-W64, W77-W99, X20-X32, X50-X59 (minus X59.4), Y40-Y86 (minus Y85), 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
1700	**IV. Other pandemic-related****			

—, not available

[a] Deaths coded to "Symptoms, signs and ill-defined conditions" (R00-R94, R96-R99), J69 and J96 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] 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 other than liver, pancreas, ovary and lung within each age–sex group, so that the category "Other malignant neoplasms" includes only malignant neoplasms of other specified sites.

[d] Deaths assigned to ICD code C55, cancer of the uterus, part unspecified, and distributed pro-rata to cervix uteri cancer and corpus uteri cancer.

[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.

[f] Deaths assigned to a number of so-called cardiovascular “garbage” codes are reassigned to other underlying causes of death. These include heart failure, ventricular dysrhythmias, generalized atherosclerosis and ill-defined descriptions and complications of heart disease. Relevant ICD-10 codes are I46, I47.2, I49.0, I50, I51.4, I51.5, I51.6, I51.9 and I70.9. These are reassigned mainly to ischemic heart disease, but also to cardiomyopathy, myocarditis, endocarditis, chronic obstructive pulmonary disease, congenital heart anomalies, as described in Section 4.

[g] Deaths assigned to essential hypertension (I10) were redistributed to ischemic heart disease, stroke, and kidney diseases.

[h] Injury deaths where the intent is not determined (Y10-Y34, Y87.2) are distributed proportionately to all causes below the group level for injuries.

[j] For countries with 3-digit ICD10 data, for “Road injury” use: Y85, 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, X59.4, and Y85.

* Deaths directly caused by COVID-19, with ICD-10 codes including U07, U09-U10.

** To reconcile deaths associated with COVID-19 excess mortality and cause-specific pandemic-related deaths, GBD2021 introduced a measure of other pandemic related mortality (OPRM) to capture all deaths due to the pandemic which were not specifically caused by COVID-19 or the indirect COVID causes. It is equal to the difference between excess mortality and the sum of COVID-19 specific deaths, measles, lower respiratory infection (LRI), and pertussis.

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, Eswatini, 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, occupied Palestinian territory, including east Jerusalem, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Puerto Rico, Qatar, Republic of Korea, Republic of Moldova, Republic of North Macedonia, 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, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Thailand, Timor-Leste, Togo, Tonga, Trinidad and Tobago, Tunisia, Türkiye, 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, 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, Eswatini, 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, 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, Puerto Rico, 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, Republic of North Macedonia, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tajikistan, Türkiye, Turkmenistan, Ukraine, United Kingdom, Uzbekistan

WHO Eastern Mediterranean Region

Afghanistan, Bahrain, Djibouti, Egypt, Iran (Islamic Republic of), Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, occupied Palestinian territory, including east Jerusalem, 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 Member States with a population of less than 90 000 population in 2021 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, Burkina Faso, Burundi, Central African Republic, Chad, Democratic People's Republic of Korea, Democratic Republic of the Congo, Eritrea, Ethiopia, Gambia, Guinea-Bissau, Liberia, Madagascar, Malawi, Mali, Mozambique, Niger, Rwanda, Sierra Leone, Somalia, South Sudan, Sudan, Syrian Arab Republic, Togo, Uganda, Yemen

Lower middle income

Angola, Bangladesh, Benin, Bhutan, Bolivia (Plurinational State of), Cabo Verde, Cambodia, Cameroon, Comoros, Congo, Côte d'Ivoire, Djibouti, Egypt, Eswatini, Ghana, Guinea, Haiti, Honduras, India, Jordan, Kenya, Kiribati, Kyrgyzstan, Lao People's Democratic Republic, Lebanon, Lesotho, Mauritania, Micronesia (Federated States of), Mongolia, Morocco, Myanmar, Nepal, Nicaragua, Nigeria, occupied Palestinian territory, including east Jerusalem, Pakistan, Papua New Guinea, Philippines, Samoa, Sao Tome and Principe, Senegal, Solomon Islands, Sri Lanka, Tanzania, Tajikistan, Timor-Leste, Tunisia, Uzbekistan, Vanuatu, Viet Nam, Zambia, Zimbabwe

Upper middle income

Albania, Algeria, Argentina, Armenia, Azerbaijan, Belarus, Belize, Bosnia and Herzegovina, Botswana, Brazil, China, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Equatorial Guinea, Fiji, Gabon, Georgia, Grenada, Guatemala, Indonesia, Iran, Iraq, Jamaica, Kazakhstan, Libya, Malaysia, Maldives, Marshall Islands , Mauritius, Mexico, Moldova, Montenegro, Namibia, Paraguay, Peru, Republic of North Macedonia, Saint Lucia, Saint Vincent and the Grenadines, Serbia, South Africa, Suriname, Thailand, Tonga, Türkiye, Turkmenistan, Tuvalu, Ukraine

High income

Andorra, Antigua and Barbuda, Australia, Austria, Bahamas, Bahrain, Barbados, Belgium, Brunei Darussalam, Bulgaria, Canada, Chile, Taiwan, China; Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Guyana, Hungary, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Oman, Panama, Poland, Portugal, Puerto Rico, Qatar, Republic of Korea, Romania, Russian Federation, 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 2023 Atlas gross national income per capita estimates (World Bank list of economies, June 2024).

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
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 5, 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.	https://www.who.int/data/global-health-estimates
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.	https://www.who.int/data/global-health-estimates
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
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, 2000-2019

All-cause mortality method groups:

VR:	Life tables based on death rates computed from vital registration data.
VR-adj:	Life tables based on mortality estimates for adults (age 15+ years) informed by completeness-adjusted vital registration data and child mortality estimates for ages under 15 years from the UN-IGME, with.
Non-VR:	Life tables based on child mortality estimates for ages under 15 years from the UN-IGME and adult mortality estimates based on model life tables

Child cause of death methods:

VR data	Death registration data from the WHO Mortality Database
Sample VR	Cause of death data from the China Maternal and Child Surveillance System (MCMSS)
VRMCM	Multi-cause models based on death registration data
VAMCM	Multi-cause models based on verbal autopsy data
IndiaVAVR	Multi-cause models based on India state-level verbal autopsy and death registration data

Cause of death (COD) methods for ages 5+

Useable VR	See Section 4.
GBD2019+WHO	WHO/UNAIDS estimates for HIV deaths and all-cause deaths, GBD2019 study estimates, and WHO and UN Interagency cause-specific estimates (see Section 8 above)

Completeness

Note: (a) Completeness estimated for death registration data with cause of death for ages 15+ from the WHO Mortality Database. This estimate may differ from the completeness assessed for total registered deaths used in the development of WHO life tables (9).

Country, territory or area	All-cause mortality method	Neonatal method	1-59 month method	COD method for ages 5+
Afghanistan	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Albania	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Algeria	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Angola	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Antigua and Barbuda	VR-adj	VR data	VR data	Useable VR
Argentina	VR-adj	VR data	VR data	Useable VR
Armenia	VR-adj	VRMCM	VRMCM	Useable VR
Australia	VR	VR data	VR data	Useable VR
Austria	VR	VR data	VR data	Useable VR
Azerbaijan	VR-adj	VAMCM	VAMCM	GBD2021+WHO
Bahamas	NON-VR	VR data	VR data	GBD2021+WHO
Bahrain	VR-adj	VR data	VR data	GBD2021+WHO
Bangladesh	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Barbados	NON-VR	VR data	VR data	GBD2021+WHO
Belarus	VR-adj	VRMCM	VRMCM	GBD2021+WHO
Belgium	VR	VR data	VR data	Useable VR
Belize	NON-VR	VR data	VR data	GBD2021+WHO
Benin	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Bhutan	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Bolivia (Plurinational State of)	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Bosnia and Herzegovina	VR-adj	VRMCM	VRMCM	GBD2021+WHO
Botswana	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Brazil	VR-adj	VR data	VR data	Useable VR
Brunei Darussalam	VR-adj	VR data	VR data	Useable VR
Bulgaria	VR	VR data	VR data	Useable VR
Burkina Faso	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Burundi	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Cabo Verde	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Cambodia	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Cameroon	NON-VR	VAMCM	VAMCM	GBD2021+WHO

Country, territory or area	All-cause method	Neonatal method	1-59 month method	COD method for ages 5+
Canada	VR	VR data	VR data	Useable VR
Central African Republic	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Chad	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Chile	VR-adj	VR data	VR data	Useable VR
China	NON-VR	Sample VR	Sample VR	GBD2021+WHO
Colombia	VR-adj	VR data	VR data	Useable VR
Comoros	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Congo	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Costa Rica	VR-adj	VR data	VR data	Useable VR
Cote d'Ivoire	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Croatia	VR	VR data	VR data	Useable VR
Cuba	VR-adj	VR data	VR data	Useable VR
Cyprus	VR-adj	VR data	VR data	Useable VR
Czechia	VR	VR data	VR data	Useable VR
Democratic People's Republic of Korea	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Democratic Republic of the Congo	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Denmark	VR	VR data	VR data	Useable VR
Djibouti	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Dominican Republic	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Ecuador	VR-adj	VR data	VR data	Useable VR
Egypt	VR-adj	VRMCM	VRMCM	GBD2021+WHO
El Salvador	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Equatorial Guinea	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Eritrea	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Estonia	VR	VR data	VR data	Useable VR
Ethiopia	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Fiji	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Finland	VR	VR data	VR data	Useable VR
France	VR	VR data	VR data	Useable VR
Gabon	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Gambia	NON-VR	VAMCM	VAMCM	GBD2021+WHO

Country, territory or area	All-cause method	Neonatal method	1-59 month method	COD method for ages 5+
Georgia	VR-adj	VRMCM	VRMCM	Useable VR
Germany	VR	VR data	VR data	Useable VR
Ghana	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Greece	VR	VR data	VR data	Useable VR
Grenada	VR-adj	VR data	VR data	Useable VR
Guatemala	VR-adj	VAMCM	VAMCM	GBD2021+WHO
Guinea	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Guinea-Bissau	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Guyana	VR-adj	VR data	VR data	Useable VR
Haiti	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Honduras	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Hungary	VR	VR data	VR data	Useable VR
Iceland	VR	VR data	VR data	Useable VR
India	NON-VR	IndiaVAVR	IndiaVAVR	GBD2021+WHO
Indonesia	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Iran (Islamic Republic of)	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Iraq	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Ireland	VR	VR data	VR data	Useable VR
Israel	VR	VR data	VR data	Useable VR
Italy	VR	VR data	VR data	Useable VR
Jamaica	NON-VR	VR data	VR data	GBD2021+WHO
Japan	VR	VR data	VR data	Useable VR
Jordan	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Kazakhstan	VR-adj	VAMCM	VAMCM	GBD2021+WHO
Kenya	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Kiribati	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Kuwait	NON-VR	VR data	VR data	GBD2021+WHO
Kyrgyzstan	VR-adj	VR data	VR data	GBD2021+WHO
Lao People's Democratic Republic	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Latvia	VR	VR data	VR data	Useable VR
Lebanon	NON-VR	VRMCM	VRMCM	GBD2021+WHO

Country, territory or area	All-cause method	Neonatal method	1-59 month method	COD method for ages 5+
Lesotho	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Liberia	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Libya	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Lithuania	VR-adj	VR data	VR data	Useable VR
Luxembourg	VR	VR data	VR data	Useable VR
Madagascar	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Malawi	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Malaysia	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Maldives	VR-adj	VRMCM	VRMCM	GBD2021+WHO
Mali	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Malta	VR	VR data	VR data	Useable VR
Mauritania	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Mauritius	VR	VR data	VR data	Useable VR
Mexico	VR-adj	VR data	VR data	Useable VR
Micronesia (Federated States of)	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Mongolia	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Montenegro	VR-adj	VR data	VR data	GBD2021+WHO
Morocco	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Mozambique	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Myanmar	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Namibia	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Nepal	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Netherlands	VR	VR data	VR data	Useable VR
New Zealand	VR	VR data	VR data	Useable VR
Nicaragua	NON-VR	VR data	VR data	Useable VR
Niger	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Nigeria	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Norway	VR	VR data	VR data	Useable VR
occupied Palestinian territory, including east Jerusalem	NON-VR	GBD2021	GBD2021	GBD2021+WHO
Oman	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Pakistan	NON-VR	VAMCM	VAMCM	GBD2021+WHO

Country, territory or area	All-cause method	Neonatal method	1-59 month method	COD method for ages 5+
Panama	VR-adj	VR data	VR data	Useable VR
Papua New Guinea	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Paraguay	NON-VR	VRMCM	VRMCM	Useable VR
Peru	NON-VR	VRMCM	VRMCM	Useable VR
Philippines	VR-adj	VAMCM	VAMCM	Useable VR
Poland	VR	VR data	VR data	Useable VR
Portugal	VR	VR data	VR data	Useable VR
Puerto Rico	VR-adj	VR data	VR data	Useable VR
Qatar	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Republic of Korea	VR-adj	VR data	VR data	Useable VR
Republic of Moldova	VR-adj	VR data	VR data	Useable VR
Romania	VR	VR data	VR data	Useable VR
Russian Federation	VR	VRMCM	VRMCM	GBD2021+WHO
Rwanda	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Saint Lucia	VR-adj	VR data	VR data	GBD2021+WHO
Saint Vincent and the Grenadines	VR-adj	VR data	VR data	Useable VR
Samoa	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Sao Tome and Principe	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Saudi Arabia	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Senegal	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Serbia	VR-adj	VR data	VR data	Useable VR
Seychelles	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Sierra Leone	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Singapore	VR-adj	VR data	VR data	Useable VR
Slovakia	VR	VR data	VR data	Useable VR
Slovenia	VR	VR data	VR data	Useable VR
Solomon Islands	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Somalia	NON-VR	VAMCM	VAMCM	GBD2021+WHO
South Africa	NON-VR	VR data	VAMCM	GBD2021+WHO
South Sudan	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Spain	VR	VR data	VR data	Useable VR

Country, territory or area	All-cause method	Neonatal method	1-59 month method	COD method for ages 5+
Sri Lanka	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Sudan	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Suriname	VR-adj	VR data	VR data	GBD2021+WHO
Swaziland	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Sweden	VR	VR data	VR data	Useable VR
Switzerland	VR	VRMCM	VR data	Useable VR
Syrian Arab Republic	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Taiwan, China	NON-VR	GBD2021	GBD2021	GBD2021
Tajikistan	VR-adj	VAMCM	VAMCM	GBD2021+WHO
Thailand	NON-VR	VRMCM	VRMCM	GBD2021+WHO
The former Yugoslav Republic of Macedonia	VR	VR data	VR data	Useable VR
Timor-Leste	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Togo	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Tonga	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Trinidad and Tobago	VR-adj	VR data	VR data	GBD2021+WHO
Tunisia	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Türkiye	NON-VR	VR data	VR data	GBD2021+WHO
Turkmenistan	VR-adj	VAMCM	VAMCM	GBD2021+WHO
Uganda	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Ukraine	VR-adj	VRMCM	VRMCM	GBD2021+WHO
United Arab Emirates	NON-VR	VRMCM	VRMCM	GBD2021+WHO
United Kingdom	VR	VR data	VR data	Useable VR
United Republic of Tanzania	NON-VR	VAMCM	VAMCM	GBD2021+WHO
United States of America	VR	VR data	VR data	Useable VR
Uruguay	VR	VR data	VR data	Useable VR
Uzbekistan	VR-adj	VAMCM	VAMCM	GBD2021+WHO
Vanuatu	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Venezuela (Bolivarian Republic of)	VR-adj	VR data	VR data	GBD2021+WHO
Viet Nam	NON-VR	VRMCM	VRMCM	GBD2021+WHO
Yemen	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Zambia	NON-VR	VAMCM	VAMCM	GBD2021+WHO
Zimbabwe	NON-VR	VAMCM	VAMCM	GBD2021+WHO

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"