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Guidance version 1.2

ANACoD3 | Analysing Mortality and Cause of Death (version 3)

User Guidance

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Abbreviations

ANACoD3	Analysis of Cause of Death
ASDR	age-specific death rate (same as ASMR)
ASMR	age-specific mortality rate (same as ASDR)
CDR	crude death rate
CRVS	civil registration vital statistics
GBD	global burden of disease
ICD	International Statistical Classification of Diseases and Related Health Conditions
IMR	infant mortality rate
MCCD	Medical Certificate of Cause of Death
UN	United Nations
U5MR	under-5 mortality rate
UNPD	United Nations Population Division
WHO	World Health Organization

About ANACoD3

The ANACoD3 tool is a product of the World Health Organization. WHO makes it freely available for public use. Additional information about the tool, and requests for permission to translate or otherwise adapt the tool should be addressed to WHO, Division of Data, Analytics and Delivery for Impact, 20 Ave Appia, 1211 Geneva 27, Switzerland, mortality@who.int.

The user of the tool is solely responsibility for the interpretation of the results and is kindly requested to acknowledge using the ANACoD3 tool with the recommended citation below.

Recommended citation: World Health Organization (2021). Analysing Mortality and Causes of Death, version 3 (ANACoD3). Geneva Switzerland.

Objectives of ANACoD3

The objective of the Analysing Mortality and Causes of Death version 3 (ANACoD3) online tool is to help users to perform a comprehensive and systematic analysis of mortality and cause of death data. The intended result is to enhance the value and usability of these data for informing health policies and programmes.

The tool automatically tabulates data and presents basic mortality measures in the form of tables and figures. It highlights potential inconsistencies and errors in the data and estimates the completeness of reporting deaths with information on the cause of death. ANACoD3 generates indicators that reveal potential data quality issues, as well as an array of demographic and epidemiological indicators including sex- and age-specific mortality rates, crude death rates, life expectancy at birth, causes of death distributed by global burden of disease categories, leading causes of death, and the percentage of ill-defined causes of death. For ICD-10 data, the tool conducts an in-depth analysis of external causes of death.

Users may use ANACoD3 to analyse either their preliminary data or final datasets. Often, users will apply the tool to review results of a preliminary dataset, as a step towards reviewing data quality prior to finalizing the dataset. Except for the three sample datafiles available for upload in the tool, ANACoD3 does not store any datafiles that the user uploads or any results that ANACoD3 produces, thereby assuring the user that the data and results remain confidential. Moreover, WHO has had for many years an officially established channel for nationally designated authorities to submit final cause of death datasets annually upon an official written request from WHO. Countries may avail themselves of these publicly available cause-of-death datasets accessible on the WHO Mortality Database[1].

New features in version 3

This latest version allows for the analysis of cause-of-death data coded in either ICD-10 or ICD-11 formats. It analyses sub-national level data to reveal potential health equity issues or outbreak patterns; it also simultaneously analyses data over multiple time periods for trend analyses.

The tool is hosted in a web-operating environment with optimal performance. The maximum size of the file import is 5 MB, large enough to easily accommodate five years of national data. An array of visualizations enhances data interpretation. Detailed checks on the ICD codes, including matching individual codes in the dataset with those in the official list of ICD codes , further inform users on potential errors in the input data set. Furthermore, the tool's architecture allows for a further expansion of the tool to include more indicators and more specialized analyses by topic in the future.

To help users rapidly grasp the functioning of the tool, several sample data sets are readily available that offer users a complete tour of the analytical capabilities of the tool. Users just need to select one of the sample data sets and in a one click can begin viewing the breadth of analyses.

Structure of ANACoD3

ANACoD3 provides simple ways of assessing the *internal* validity and coherence of mortality data and shows how comparisons with *external* sources of mortality data can be used to evaluate data consistency and

[1] https://www.who.int/data/data-collection-tools/who-mortality-database

plausibility. By carrying out these simple checks, certifiers, coders and analysts will be able to identify shortcomings in the data.

Upon opening the ANACoD3 landing page, the user may choose 'Use sample dataset' or "Upload data' to being uploading a datafile. For the latter, a zipped folder automatically downloads containing detailed instructions, an example template, and a blank template for the user to complete in the required format. See further details in the 'Upload data files in ANACoD3' section below.

ANACoD3 analyses the data in four main parts:

Part 1. Check input data (step 1)

Step 1 checks totals and distributions of the population and mortality input data in a series of tables and figures. It also run checks on ICD codes, enumerating invalid codes (codes that do not match to those in the official list of ICD codes) as well as ICD codes that are inconsistent with recorded sex or age, and those not to be used for underlying cause of death according to ICD volume 2 rules and guidelines. Information shown in step 1 intends to reveal basic errors in the data, which the user may decide to correct in the original data file and then re-upload the revised data file before proceeding to the subsequent analysis steps. This step omits deaths for which sex is unknown (sex=9).

Part 2. Mortality levels analyses (steps 2-5)

Steps 2-5 assess levels of mortality. ANACoD3 compiles and formats the cause of death data for the user to view the distribution of death by age and sex (step 2); the completeness of recorded deaths, summary demographic indicators, and empirical life tables (step 3); sex- and age-specific mortality rates (step 4), and probabilities of early childhood mortality (step 5). The tool presents comparison indicators by income-level grouping, thereby assisting the user to identify potential irregularities in their own data due to incomplete or inaccurate data. These basic measures of mortality can provide insights into the health status trends of a population (if a multi-year dataset is uploaded). This type of information informs public health authorities to effectively allocate resources for health care provision. All these analysis steps omit deaths for which sex is unknown (sex=9), except for step 3 where the calculation includes the total number of recorded deaths, including unknown sex, to estimate completeness.

Part 3. Causes of death – Basic analyses (steps 6-10)

Steps 6-10 assess the causes of death. A well-functioning civil registration and vital statistics system not only registers demographic information about the decedent, but also integrates cause of death data from medical certifiers in the health sector. Medically certified causes of death are assigned according to International Statistical Classification of Diseases and Related Health Conditions (ICD) rules and guidelines. Only medically or authorized qualified personnel should certify the cause of death using the International Form of Medical Certificate of Cause of Death (MCCD), and a coder specially trained in the ICD rules and instructions should code all causes of death before selecting the underlying causes of death.

Causes of death analyses provide the following results, by year, for deaths with valid ICD codes and known sex:

- Distribution of deaths by the three major cause-of-death groups i.e., communicable, noncommunicable and injuries, and detailed causes of death by global burden of disease (GBD) categories (step 6);

- Distribution of deaths by cause-of-death groups, with income level group comparisons (step 7);
- Leading causes of death overall and for children, with income level group comparisons (step 8);
- Ratio of communicable to noncommunicable deaths, with income level group comparisons (step 9);
- Quality of cause-of-death data, including a usability index, numbers of ill-defined causes of death by ICD chapter, and frequency of specific ill-defined codes (step 10);
- Numbers of deaths and death rates, by age and sex, according to selected causes of death (step 11); and
- Trends in selected causes of death, numbers of deaths and death rates (step 12).

Part 4. Causes of death - Special analyses of external causes of death from injury (Ext 1-11)

The special analyses of external causes of death consist of 11 types of analysis for each year in the dataset:

1. Leading external causes of death codes (ext 1);
2. Ill-defined external causes of death (ext 2);
3. Distribution of external causes of death by GBD cause-of-death list (extracted from step 6) (ext 3);
4. Distribution of deaths by cause-of-death groups, by age and sex (from step 7) and selected external causes by age group and mechanism (ext 4)
5. Deaths from transport accidents, share of external causes and by mechanism (ext 5)
6. Deaths from suicide, share of external causes and by mechanism (ext 6)
7. Deaths from homicide, share of external causes and by mechanism (ext 7)
8. Deaths from firearms, share of external causes and by intent (ext 8)
9. Deaths from burns, share of external causes and by intent (ext 9)
10. Deaths from drowning, share of external causes and by intent, and additional deaths due to drowning in a water transport accident (ext 10)
11. Age-standardized death rates for external causes, overall and for selected causes, with income level group comparisons (ext 11)

Medical certification of cause of death

The quality of cause of death data depends on the accuracy of ***death certification*** and the reliability of ***coding***. Internationally established rules and guidance in the ICD govern these two separate but related functions. Death certification, which should be done by a qualified medical practitioner, involves accurately diagnosing the causes of death and correctly completing the International Medical Certificate of Cause of Death (MCCD) form. A qualified and trained coder then translates all the causes of death using an alpha-numeric ICD code, and then selects the underlying cause of death from among the thousands of codes that can be used as the underlying causes of death - approximately 10 000 ICD-10, 4-character codes, 2000 ICD-10 3-character codes, and 14 000 ICD-11 codes.

For primary tabulation purposes, the cause-of-death codes in the datafile uploaded in ANACoD3 must be those for the ***underlying*** cause of death, not the immediate or other antecedent causes of death. The underlying cause of death is defined by the World Health Organization (WHO) as ‘the disease or injury that initiated the train of events leading directly to death, or the circumstances of the accident or violence which produced the fatal injury’. The underlying cause of death provides information that is useful for public health interventions. ICD rules for selecting the underlying cause, with its corresponding ICD code, indicate that every death be attributed one (and only one) underlying cause based on information reported on the death certificate. The internationally agreed MCCD form is specially designed to facilitate the selection of the underlying cause of death when two or more causes are recorded on the death certificate (figure 1). This certificate is shown in Figure 1. WHO Member States should comply with WHO regulations in using this certificate to certify deaths (Twentieth World Health Assembly 1967, Article 2).

Figure 1: International Form of Medical Certificate of cause of death

FRAME A: ► Medical data: Part 1 and 2			
		► Cause of death	► Time interval from onset to death
1. Report disease or condition directly leading to death on line a Report chain of events in due to order (if applicable) State the underlying cause on the lowest used line	a		
	b	Due to:	
	c	Due to:	
	d	Due to:	
2. Other significant conditions contributing to death (time intervals can be included in brackets after the condition)			

Source: WHO (2016). International statistical classification of diseases and related health problems, 10th revision, Volume 2 Instruction manual, fifth edition 2016. Geneva: World Health Organization (https://icd.who.int/browse10/Content/statichtml/ICD10Volume2_en_2016.pdf, accessed 25 November 2020).

Currently only about 70 WHO member countries produce good quality cause-of-death data from their civil registration and vital statistics systems.[2] Although a further 50 countries produce some cause-of-death data, the quality of the information is problematic because of poor certification and coding practices.

Even where medical certification of the cause of death is common practice, it does not guarantee that accurate cause-of-death diagnoses are recorded on the death certificate, or in the correct way. Doctors may lack diagnostic capabilities, be inexperienced in filling the death certificate, or simply lack of awareness or appreciation of the importance of cause-of-death data. All these human errors contribute to poor accuracy of information in the MCCD. In addition, there may be risk of negative financial or social consequences to the family if the doctor records causes of death that are potentially associated with stigma, such as HIV or suicide, thus further deterring accurate recording.

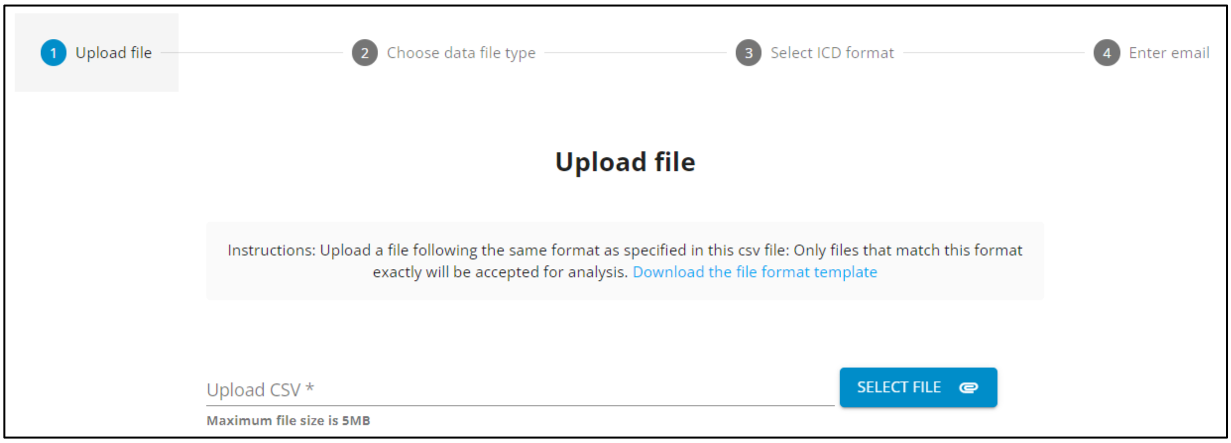
For all these reasons, cause-of-death data should be carefully reviewed and assessed to identify and correct quality problems. Unless this is done in a routine fashion, public health authorities risk inadvertently diverting resources away from those conditions whose suffering and death could be attenuated or even avoided.

[2] WHO (2020) WHO methods and data sources for country-level causes of death 2000-2019. Geneva, Switzerland.

Upload data files in ANACoD3

The user may choose to use one of the sample data sets in ANACoD3 or upload another data file. On the landing page, click on 'Upload data' then click on the grey cloud icon (fig. 2). Open the zipped file to see the detailed instructions and example template, then complete the blank template in the required format.

Figure 2. Upload a data file in ANACoD3



As a minimum, the data file should include, for each year:

- Total number of deaths by sex and age group
- Number of deaths by ICD code, by sex and age group

The sex categories include male=1, female=2, or unknown sex=9. Except where indicated, the ANACoD3 tool does not use unknown sex in the analyses; therefore, the user should consider imputing cases of unknown sex as male or female so all deaths are included in all analyses.

The age group categories refer to age at death in completed years[3], as follows:

- Age 0 (under 1 year, or within the first 365 days after birth)
- Age 0-4 years
- Age 5-9 years, 10-14 years, etc. by 5-year age groups, up to at least the 80-84-year age group
- Open age group, age 85 years and over, or other open year age group after the last 5-year age group, e.g., 90+ years, 95+ years
- Unknown age

In addition, the data file should include the mid- or end-year population for the same period as the mortality data, and by the same sex and age group categories. Population estimates are generally available from the decennial census and intercensal projections produced by the national statistics office. Population data and death data are used for the calculation of rates and other indicators in many ANACoD3 analysis steps.

[3] 'Completed years of age' is a demographic concept that defines the exact age at death. For example, a person who dies *after* their 34th birthday, but *before* their 35th birthday, will have completed 34 years, not 35 years of age. The age of death in completed years is thus 34.

Population and mortality data are tabulated in the data file in 5-year age groups except for ages under 5 years, which are subdivided into the first year of life (age 0) and ages 1 to 4 years. This is because childhood mortality tends to be highest in the first year, and the infant mortality rate requiring both population and mortality data at age 0 is a key development indicator. Precision is also important at older ages as chances of survival improve over time and life expectancy increases. Age at death should therefore be tabulated in 5-year age groups up to at least 80-85 years, after which the open age group 85+ is the terminal age group for statistical purposes. 85+ year should be the minimum terminal age group. ANACoD3 automatically aggregates 5-year age groups above 80-85 to 85+.

Valuable information is lost if deaths are tabulated to a low terminal age group, such as 55+ or 65+. Because individuals usually die well beyond 60, 70 and even 80 years, it is extremely important to monitor the effectiveness of preventive and curative health in older age groups. The use of standard five-year age groups for deaths is useful because the same age groups are commonly produced from census population data, facilitating their use as denominators for the calculation of rates and ratios.

Icons used throughout the tool

Clicking on the grey information icon, 'i', located next to each Step title, moves the user directly to the relevant section in the User Guidance document found in the Reference material menu item.

Clicking on the blue download icons the user download tables in CSV format and figures in PNG format

Step 1: check data

The purpose of these checks of the input data is to help the user quickly identify basic errors in the data set. The name of the data file, country, ICD format, and World Bank income grouping is displayed at the top of the page. The results are displayed separately for each year, starting with the most recent year in the dataset. In sections 1.1- 1.4, ANACoD3 produces tables and graphs showing population age structure and mortality patterns by age and sex.

In sections 1.5-1.7, ANACoD3 checks ICD codes in the dataset and matches them against the official codes (in the user-selected ICD format) and identifies specific ICD codes indicating invalid, inconsistent, and erroneous cause of death codes.

- Section 1.5 checks for invalid ICD codes. The tool enumerates invalid codes, that is, codes that were either mistyped or otherwise not able to be matched with the official list of ICD codes in the format selected by the user.
- Section 1.6 checks for inconsistent codes. The tool enumerates codes that are unlikely to cause death for a certain sex and/or in a certain age group, for example, male maternal deaths, suicides among young children, or prostate cancer deaths in females.
- Section 1.7 checks codes that should not be used for underlying causes of death, in line with ICD Volume 2 rules and guidelines.

The results of these checks alert users and authorities to potential problems in correctly completing the MCCD with a plausible sequence of morbid conditions, coding causes of death in death certificates, or selecting the proper underlying cause of death. At the bottom of the web page, the user can select another year in the data set and the results for that year are displayed in the same fashion.

Cases where sex is unknown (sex=9) are excluded from these basic checks. The user should revert to the input data file and impute sex proportionately as male or female where possible, and then re-upload the data file.

If errors in the data set are identified, users should correct the input data file as much as possible and re-upload it.

Smoothing fluctuations

In countries and subnational areas with small population numbers, the number of deaths in certain age groups may be very small. As a result, the results may appear erratic and be too unstable for analysis. In order to produce smoother results, the user may wish to create a data set with rolling average of both the number of deaths and the average populations for a 3- to 5-year period, and upload the data file to obtain smoother fluctuations. (ANACoD3 does not automatically generate rolling averages but it will analyse them). This is illustrated in Figure 3 for a small Pacific island which, on the left, shows the large fluctuations in annual age specific mortality rates (ASMR). The smoothed trend data are produced by using a 3-year moving average. Alternatively, the user may expand the age group or area to be studied, thus increasing the numbers of deaths and population in the calculation of ASMR and making it more stable. (ANACoD3 is not able to analyse these data in a non-standard age format.)

Figure 3: Annual age-specific mortality rates for selected age groups (males), and smoothed trends using a 3-year moving average

Summary of step 1

- Sections 1.1- 1.4 present tables and graphs showing population age structure and mortality data by age and sex

- Sections 1.5 – 1.7 checks for invalid, inconsistent, and erroneous underlying cause of death codes in the dataset
- If errors are identified, then the user should make corrections where possible and re-upload the data file to continue the analysis.

Step 2: Age distribution of deaths

Step 2 is a ‘Mortality levels’ analysis. On the left panel, the user may select the year of interest if a multi-year data file is uploaded. In the right-hand panel, ANACoD3 presents the number of deaths by sex and age group, in tabular and graphic formats. The objective of step 2 is to examine the age distribution of reported deaths. Section 2.1 displays a bar graph showing the percent distribution of deaths by age group. The pattern of age-distributed deaths differs by country due to many socioeconomic and environmental factors, but it is generally associated with the income level of the country. For example, a relatively larger share of deaths under 5 years is usually associated with low and lower-middle income countries. The user should compare the observed distribution of deaths with the expected distributions of death by income level in section 2.2 (and fig. 4). *Recall that the current World Bank income grouping for the uploaded data file is displayed at the top of step 1.*

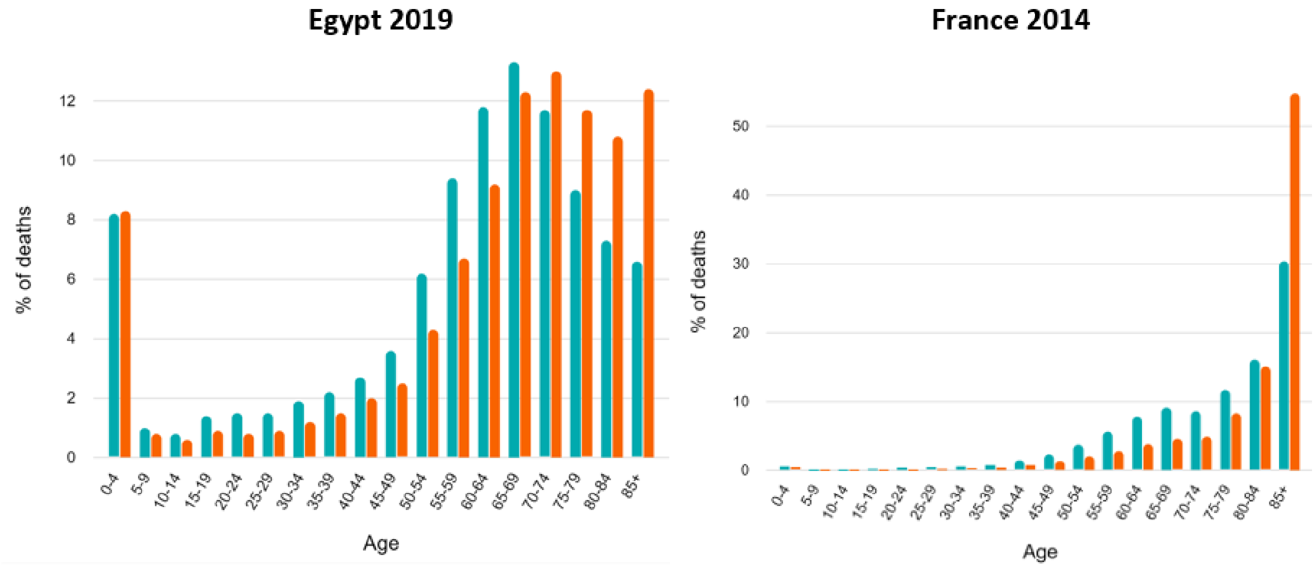
Figure 4: Percentage distribution of deaths by age, according to income grouping, 2019

Source: Global health estimates 2019, WHO (2020); World Bank classification of countries by income grouping (https://datahelpdesk.worldbank.org/knowledgebase/articles/906519)

Significant departures from the average distributions of deaths suggest underreporting or that the observed deaths by age group could be displaced. It is not uncommon for informants to report the age of death using a preferred digit, such as ending in '0', thus resulting in heaping deaths on certain age groups. Moreover, informants may displace the age of a deceased person into an older age group either through ignorance of the true age, or simply exaggerating the length of life. This is particularly true for elderly deceased persons. And, although not shown in this analysis step, misreporting age at death for early childhood deaths, for example, where an infant death (under one year) is reported as a death at 1-4 years instead of 0, or a death at age 4 is reported as age 5-9. These mistakes could significantly impact levels of infant and child mortality indicators (Step 5).

An example of the application of this check on data quality is shown in figure 5, which gives the reported age distributions of deaths calculated from civil registration data for Egypt 2019 and for France 2014. Egypt is a lower-middle-income country and France is a high-income country. Compared with Figure 4, the age distributions of deaths in Egypt and France are very similar to what is expected.

Figure 5: Percentage distribution of reported deaths in Egypt 2019 and France 2014



Summary of step 2

- Section 2.1 displays the percentage distribution of observed deaths by sex and age group.
- Section 2.2 provides comparison percentage distributions by major income grouping. Departures from these expected patterns are suggestive of underreporting of deaths at certain ages for males or females.

Step 3: Completeness and summary demographic indicators

Step 3 is a 'Mortality levels' analysis. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. In the right-hand panel, ANACoD3 presents the estimated completeness of death data (for national level data only) and compares the observed levels of summary demographic indicators with expected levels from UN databases.

The completeness of the data is the only analysis where ANACoD3 does not omit cases of death for which sex is unknown (sex=9). In section 3.1, the percentage completeness is calculated by dividing the total number of deaths by the most recently available UN-estimated number of expected deaths and multiplying by 100 to obtain a percentage. The result is rounded to a whole number. For an estimated completeness under 80%, the user should interpret subsequent results with caution as a selectivity bias may be introduced by common characteristics of missing records. ANACoD3 does not display a completeness value higher than 100%, therefore, a value of 100% may indicate true completeness, or it may indicate a number higher than 100% where the expected number of deaths is under-estimated. This is especially likely for countries with small populations where the estimated number of deaths are small, and statistics may be less reliable. A number higher than 100% could also reflect a problem with duplicate records.

In section 3.2, ANACoD3 presents two summary demographic indicators: crude death rate (CDR) and life expectancy. These are derived from the empirical life tables in section 3.3. The observed CDR is the simplest measure of mortality that can provide insights into the age structure and the health status of a population. Compared to the UN estimates also in section 3.2, an unexpectedly low observed CDR and/or an unexpectedly high observed life expectancy at birth may indicate underreporting of deaths.

The objectives of step 3 are to enable users to:

- Calculate the CDR and permit comparison with the UN-estimated CDR for the same year
- Use the CDR as an approximate indicator of completeness of death registration.
- Use the CDR as the first step to analyse the quality of mortality data

Definition and calculation of the crude death rate

The crude death rate (CDR) is a measure of the number of deaths in a population relative to the size of that population at a given point of time that represents a reference period. The CDR is typically expressed in units of deaths per 1000 population, usually at midyear; therefore, a crude death rate of 9.5/1000 in a population of 500,000 indicates there were 4,750 deaths at midyear in the total population (9.5/1000 X 500,000). The CDR is defined and calculated as follows:

$$\text{Crude death rate} = \frac{\text{Number of deaths in the usual resident population in a given year}}{\text{Number of the midyear usual resident population in that year}} \times 1000$$

Because mortality rates for males and females differ across age groups, it is useful to calculate the crude death rate separately for males and females, as well as both sexes combined.

It is important that both the numerator and denominator refer to the same population in terms of geographical area and time. It is standard practice to take the size of the population at midyear as the denominator because population size may vary during the year (due to migration, births and deaths) and the midyear population serves as an estimate of the average population exposed to the risk of dying over the course of the year.

Interpreting the crude death rate

The CDR is called a "crude" rate because it does not take into consideration the age and sex structure of the population. In practice, the risk of death in a given population group varies according to age and sex as well as patterns of socio-economic status, environmental and other factors. For example, populations with a large proportion of young children or a high proportion of elderly people will, all else being equal, have relatively higher crude death rates. This is because mortality risks are highest at very youngest and the oldest ages. In general, mortality rates are higher among males than females.

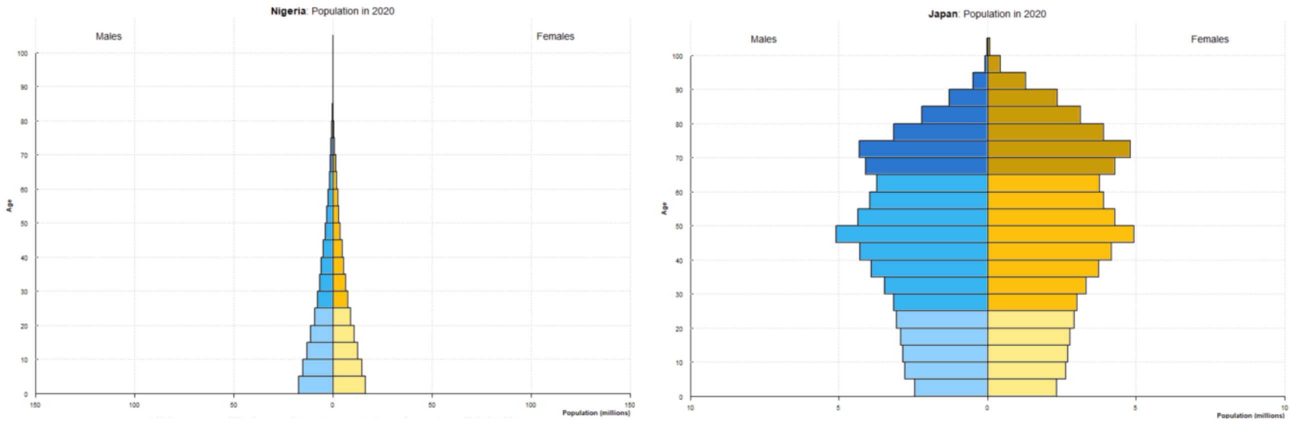
Crude death rate and population structures

In order to interpret the CDR, it is helpful to refer to the population age-sex pyramid, a graphical visualization of the distribution of the population by standard (usually 5-year) age groups (see step 1). The population pyramid typically consists of two back-to-back horizontal bar graphs, with age groups on the vertical axis and population size in each age group on the horizontal axis. Males are conventionally shown on the left and females on the right. The bars can represent either the absolute numbers (more common) or percentages of the male and female populations in each 5-year age group.

In countries with well-functioning civil registration vital statistics (CRVS) systems, the age-sex pyramid can be constructed based on the annual births added and deaths subtracted from the population of the previous year, with adjustments for migration. In countries where civil registration systems are weak, age-sex population pyramids can only be reliably estimated from the census or population estimates. Intercensal estimates of population size by age and sex are generally estimated from mortality rates derived from surveys or indirectly from model life tables, which are inherently uncertain. The United Nations Population Division (UNPD) generates regular updates on national population sex and age structures. The user should consult these comparison pyramids when there is doubt about the accuracy of a country's observed population data.[4]

The use of population pyramids in helping to interpret crude death rates is illustrated in Figure 6. The CDR for Nigeria (2020) is estimated to be 12 per 1000 population compared with 10.4 per 1000 population in Japan (2020). Neither of these is considered low CDR (under 10 per 1000), however, the reality behind this summary indicator is stark: Nigeria has a relatively high proportion of children under age five—approximately 20%-- and the mortality rates are very high in this young population. By contrast, Japan has a much smaller percentage of population in the youngest age group—approximately 3%-- but it has a large share of the population age 60+, when death rates are also increasingly high with age.

Figure 6: Population pyramids for Nigeria 2020 and Japan 2020



Source: https://population.un.org/wpp/Graphs/DemographicProfiles/Pyramid/900

Limits for the crude death rate

In 2015-2020, the highest CDRs were in Eastern Europe, averaging about 11 per 1000 (ranging from 10 to 15 per 1000). Based on many decades of experience in calculating crude death rates, demographers have demonstrated that the lowest crude death rates are around five per 1000. Several CDRs of 5 per 1000 or less are found in countries in Western Asia and many of these are in countries with sparse populations. In general, observed CDRs of 5 per 1000 or less should be examined closed to verify accuracy.

[4] https://population.un.org/wpp/Graphs/DemographicProfiles/Pyramid/900

A CDR below five per 1000 should be treated with caution since in some countries such a figure strongly suggests incomplete death registration.

The exceptional countries that may have very low CDRs are those with both high growth rates due to natural increase (i.e., a higher number of births than deaths), immigration, or both − and low age-specific mortality rates, including low childhood mortality, implying comparatively high life expectancy at birth. Several of the Gulf States, for example, have a CDR below 5 per 1000 because of this particular demographic configuration. In the vast majority of countries however, this does not apply and CDRs below 5/1000 are typically a sign of under-reporting of deaths.

Summary of step 3

- Section 3.1 computes the estimated completeness of cause-of-death reporting, based on the number of expected deaths for the same year. Estimates higher that 100% are presented as 100% (not higher).
- Section 3.2 computes the observed CDR and life expectancy at birth for males and females, separately.
- Section 3.2 also compares the calculated CDR and life expectancy at birth with the comparable indicators from the UN database.

Step 4: Age-specific death rates

Step 4 is a 'Mortality levels' analysis. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. In section 4.1, ANACoD3 presents the observed age-specific mortality rates per 100 000 population, and in section 4.2, the ratio of male and female mortality rates. Below these, section 4.3 plots the log of ASMRs, by sex, side-by-side with the average ASMRs for different income groupings. This facilitates easy benchmarking of observed results and may point to potential anomalies in the data. *Recall that the World Bank income grouping for the uploaded data file is displayed at the top of step 1.*

While the CDR is an important summary mortality measure, it is usually presented as a "crude" rate that does not take into account the age and sex structure of the population (*ref* step 3). The ASMRs, on the other hand, account for differences in population age and structure, and thus permit a direct comparison of mortality levels across countries, other geographic areas, and over time. It is important to examine ASMRs to identify possible age misreporting of deaths and other anomalies in or across age groups.

The objectives of step 4 are to enable users to:

- Observe ASMRs for 5-year age groups, by sex
- Compare the ratio of male:female mortality rates with the world average ratio
- Interpret the ASMRs on a log scale, and comparison with average ASMRs by income grouping

Definition and calculation of age-specific mortality rates

The age-specific mortality rate is calculated as the total number of deaths, occurring at a specific age or age group, in a defined geographic area (country, state, county, etc.), divided by the midyear population of the same age in the same geographic area. In contrast to the CDR, which is expressed per 1000 population, the ASMR is often expressed as a rate per 100,000 population. The standard demographic practice is to calculate the ASMR for 5-year age-groups, namely, 0-4, 5-9, 10-14, ..., 80-84, 85+. The ASMR is calculated as follows:

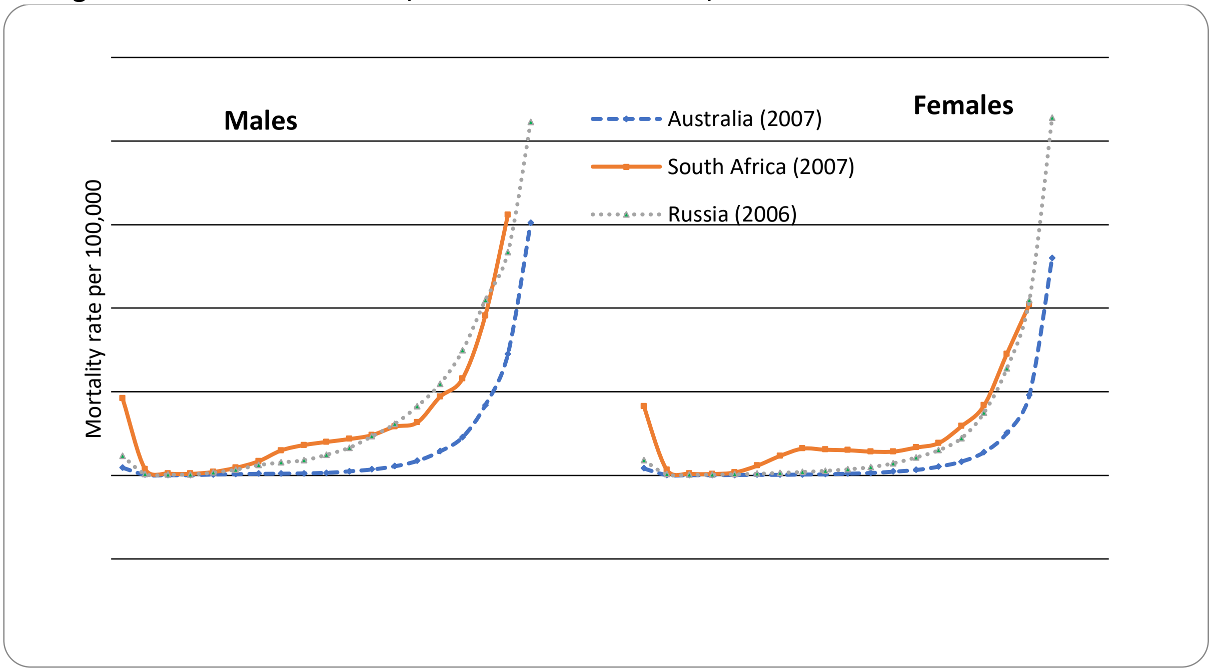
$$\text{ASMR} = \frac{\text{Deaths in a specific age group in a population over a specified time period}}{\text{Total mid-year population in the same age group and time period}} \times 100{,}000$$

Interpreting age and sex patterns of mortality

Once the ASMRs have been calculated for each age group, the next step is to examine the levels across age groups to assess plausibility. To do this, it is useful to have an independent source of comparative data on ASMRs, for example, a recent census or population-based survey. If there is not an independent source existing in a country, then compare the ASMRs with figures from neighbouring countries and countries having similar socioeconomic or other characteristics. The following examples can help in improving the understanding and interpretation of age and sex patterns of mortality in a given country. They also show how this analysis can assist in determining the quality and completeness of the mortality data in specific age groups.

As a general rule, regardless of the socioeconomic or other setting, mortality rates are higher during infancy and early childhood and fall to their lowest levels between the ages of 5 to 14 years. Subsequently, mortality rates start to rise with increasing age and increase exponentially beyond age 35 or so. Figure 7 shows patterns of mortality for Australia – where death registration is complete – compared with Russia and South Africa – where death registration is less complete and/or essential information about the decedent is missing, such as unknown age or sex. In Australia, mortality rates are very low up to about age 15, and although there is a small increase for males during the ages of 15-34 years due to accidents and other injuries, death rates only begin to rise sharply after about age 55 years. This pattern is typical of most high-income populations.

Figure 7: ASMRs for Australia, Russia and South Africa, males and females



In South Africa, mortality among infants is relatively high but declines during childhood. In South Africa, there is a "bump" in mortality during reproductive ages in both sexes, reflecting premature mortality due to

HIV/AIDS. A similar bump may occur in females of reproductive ages where the level of maternal mortality is high.

Reviewing your data in this way can provide a simple check on the quality of the mortality data and indicate possible under-registration of deaths in certain age groups. It is not the ***level*** of mortality that matters in this comparison but the ***relative age pattern*** of the ASMR between different age groups.

In section 4.3, the natural logarithm of ASDR on a log scale shows the relative variation of mortality rates across age groups and between subpopulations. The log scale clearly shows that, beyond about 35 years of age, death rates rise exponentially with age. Therefore, the *natural logarithm* of the age-specific death rate (m_x), written as $\ln(m_x)$ should be ***a straight line*** as age (x) increases.[5] Figure 8 shows examples of $\ln(m_x)$ for three countries – Australia, Colombia and Mauritius – with very different patterns of mortality and variable quality of mortality data.

The ASDR log scales sometimes reveal age heaping in the oldest age group by a slight bend in the right tip of curve. Figure 8 shows a hint of age heaping at 80+-- as we would expect in an open-ended age group—especially in Australia where there are more deaths to heap after age 80 due to the relatively longer life expectancy.

The primary purpose of preparing a graph of the log of the death rate at each age is to examine the data for irregular or implausible changes in $\ln(m_x)$ from age to age. In countries with high maternal or injury mortality in young adults (especially males), death rates will rise steeply (i.e. $\ln(m_x)$ will rise) around age 15 years, peak at age 25, and decline to a new low around age 35 years or so. Subsequently, the ASMRs will rise linearly with age. Any other departure from this linear pattern in adult death rates suggests that deaths are being selectively underreported in certain age groups, or that there is misreporting of the correct age of death. The latter is particularly common at older ages.

Figure 8: Male age-specific death rates (log scale): Australia, Mauritius and Colombia

[5] m_x, or $_nm_x$, is the standard demographic notation to indicate a mortality rate, "m", with the age group starting at age "x" and the interval "n". For example, $_5m_{35}$ is the age group 35-39.

With this in mind, we can make the following observations from Figure 8 showing age-specific death rates for males.

Australia: all deaths are registered and hence the ln(m_x) increases smoothly in a straight line with increasing age(x), as would be expected. Note the slight bump around ages 15-25, indicating an excess in injury-related deaths in this age group. The upward bend in the tail after age 80+ indicates a greater number of deaths in this wide, open-ended age group.

Mauritius: notice that in this case the ln(m_x) does NOT increase linearly with age after about age 65, suggesting underreporting of deaths, particularly at the oldest ages;

Colombia: note the large bump in mortality at ages 15-34 due to accidents and other violent deaths. One would expect to see a similar large bump in the ln(m_x) graph at these ages in countries with high HIV mortality or high maternal mortality among females.

Thus, plotting the ln(m_x) will help to identify if there are any age groups where deaths are being selectively underreported (e.g. ages 65+ in Mauritius). In addition, by comparing the graph of ln(m_x) for your population with a neighbouring country, assuming it has good quality mortality data, it will be possible to assess whether and to what extent, deaths are being systematically underreported at all ages. This will be the case if the graph for ln(m_x) for your population is systematically lower than the graph for a neighbouring population.

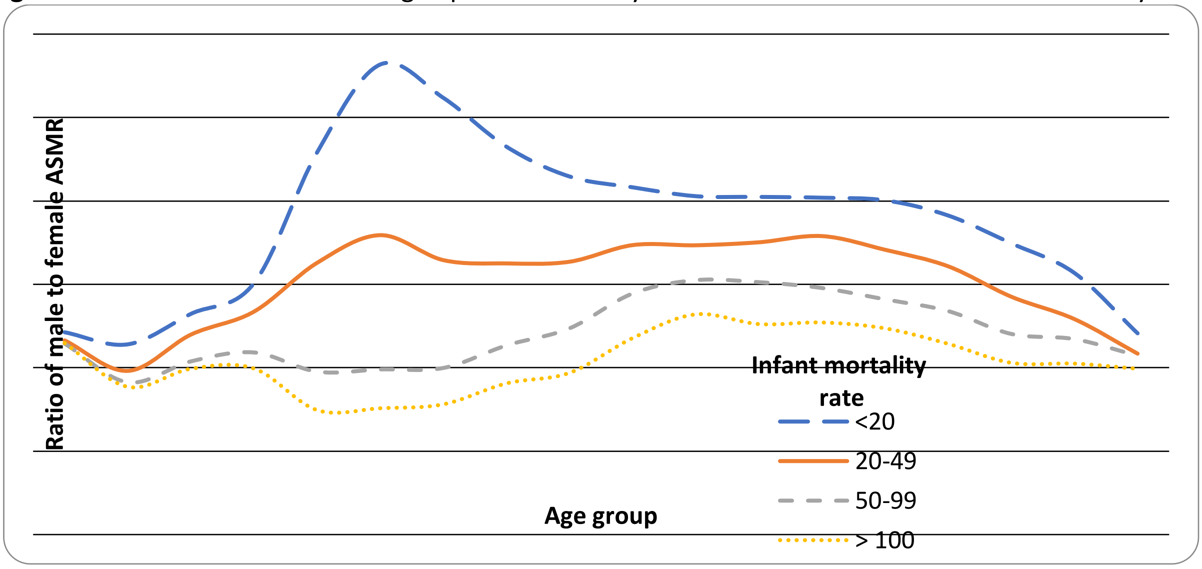
Ratio of male to female mortality rates

Overall, mortality rates tend to be higher at all ages for males than females. If the ASMR was the same for both sexes, the ratio would be 1 (i.e. a straight line) for all ages. In practice, the male to female ASMRs show considerable variation across age-groups and at different periods of time. Figure shows typical patterns of the male to female ratio in settings with different overall mortality levels, as reflected by levels of infant mortality.

Male death rates are higher than female death rates everywhere except in societies where females have a low social status. As the status of women in society improves, and discriminatory practices against females disappear, then female death rates should naturally be lower than male rates at all ages (except the oldest ages).[6] As Figure 9 shows, in settings with high levels of infant mortality (100 per 1,000 live births and higher), the male mortality excess is relatively small because of high female mortality in reproductive ages. As infant mortality declines, this pattern changes and male mortality is higher than female mortality across all age groups. As already noted, death rates among males aged 15-29 tend to be higher largely because of higher incidence of accidents and other external injuries among young men. A secondary swell in the male to female ratio of mortality rates typically occurs around age 55-64 years because males tend to die at higher rates from chronic disease than females, due primarily to greater exposure to risk factors such as tobacco, poor diet, and overweight/obesity.

[6] Waldron, D (1982) The sex differential in mortality rates: Demographic and behavioral factors. *American Journal of Epidemiology, 15(2)*

Figure 9: Ratio of male to female age-specific mortality rates at different levels of infant mortality



In section 4.2, ANACoD3 presents a similar figure showing the male to female ratio of age-specific death rates based on the observed data, using as a reference the average ratio of ASMRs for the world. The user can also compare the observed pattern with one of the curves shown in figure 9. If the observed pattern of male to female ratios of age-specific death rates is very different from what would be expected given your level of infant mortality, then there are good reasons for questioning the quality – that is, the completeness of death registration −of the reported data, particularly for females.

Note that in comparing the observed patterns of the ASMR ratios to one of those from Figure ***, it is important to use an independent value of the infant mortality rate derived from a recent census or population-based survey, or an estimate from the United Nations, WHO, or other source. Do not use the value from your vital registration data which may be underestimated.***

Summary of step 4

- Section 4.1 presents observed ASMRs by sex. It allows the user to examine ASMRs across all age groups for each sex separately. The user should observe a pattern of relatively high mortality in the 0-4 years age group, very low mortality in the age groups 5-14, and an exponentially increasing mortality rate after the age of 35+.
- Section 4.2 presents the ratios of male to female ASMRs across all age groups. In general, the user should expect male mortality rates to be higher than rates for females, especially in the age groups 15-35+ as young males are more likely to die as a result of violence, road traffic accidents, and other external causes of death. High mortality rates in young adults may also be due to HIV or maternal mortality. In some cases, female deaths are less likely to be recorded than male deaths, also leading to higher than expected ratios of male to female death rates.
- Section 4.3 plots the logarithm of the ASMRs so that relative changes in death rates are seen more readily. They should increase smoothly and linearly with age after about age 35.

Step 5: Early childhood mortality

Step 5 is a 'Mortality levels' analysis. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. In section 5.1, ANACoD3 presents a table with the early childhood mortality indicators, derived from the empirical life tables in section 3.3.

Mortality among children under five years old, more than any other age group, reflects a range of economic, social and health conditions that affect the health of populations. This indicator thus serves as a key indicator for public health monitoring. Mortality in children under age five can be divided into several components.

- Infant mortality – mortality among infants age less than one year old (who die before the first birthday)
- Child mortality – mortality among children aged one year to less than five years old
- Under-5 mortality – mortality among children age less than 5 years old.

The objectives of step 5 are to enable users to:

- Calculate the observed under-five, child, and infant mortality rates.
- Direct the user to an internationally produced chart containing estimates over the past 20 to 30 years of the probability of dying before age 5 (${}_5q_0$) from different sources, including civil registration, the census, household surveys and other studies, as shown in Figure 10.

Definition and calculation of early childhood mortality indicators

The infant mortality rate (IMR) is the probability (expressed as a rate per 1,000 live births) of a child born in a specific year, dying before reaching the age of one year. The child mortality rate is the probability of dying between age one and before the age of five years. Similarly, the under-five mortality rate (U5MR) is the probability (expressed as a rate per 1,000 live births) of a child born in a specific year dying before reaching the age of five. Thus, the IMR and U5MR are, strictly speaking, not rates (i.e. the number of deaths divided by the number of population at risk during a certain period of time) but a probability of death, expressed as a rate per 1,000 live births.

Below are the formulas for calculating the probability of a child dying between birth and age 1 (written as ${}_1q_0$), between age one and under 5 years (written as ${}_4q_1$), and between birth and under 5 years (written as ${}_5q_0$). These formula draw on ASMRs at age 0 (defined as deaths at age 0 divided by mid-year population at age 0, written ${}_1m_0$) and ASMR between age 1 and 4 years (defined as deaths between age 1-4 divided by mid-year population at age 1-4 years, written ${}_4m_1$). The formulas are:

${}_1q_0 = {}_1m_0 /[1+(1- a)\ {}_1m_0]$ where a = fraction of the year lived
= 0.1 for high income countries and a= 0.3 for other income group

${}_4q_1 = 1000 * [4* {}_4m_1 / (1 + 4 (1 - 0.4) * {}_4m_1)]$

${}_5q_0 = 1-(1-{}_1q_0)(1-{}_4q_1)$ where ${}_4q_1 = 4* {}_4m_1 /[1+ 4 (1- 0.4)\ {}_4m_1]$

An example of the calculation of the U5MR and IMR from observed data is given below:

Table 1: Child deaths by age and calculation of mortality indicators: Norway 2009

x	***n***	**Population**	**Deaths**	${}_nm_x$	${}_nq_x$

beginning of the age interval	number of years in the interval				
0	1	110892	278	0.00251	0.00250
1	4	431711	86	0.00020	0.00080

=> IMR = 1000* 0.00250 = 2.5
=> U5MR = 1000* 1-(1- 0.00250)(1-0.00080) = 3.3

These calculations are performed automatically in ANACoD3.

Sources of data on early childhood mortality

A well-functioning civil registration system generates vital statistics from which early childhood mortality measures can be derived at national and subnational levels, on a continuous basis. However, the coverage and quality of civil registration systems is often not sufficiently complete in lesser developed countries and the incomplete vital statistics may result in under-estimates.

There are particular reasons why deaths occurring in young children are less likely to be registered than adult deaths. In settings where civil registration is not universal, deaths are disproportionately registered when there are some benefits attached to doing so, for example to claim land ownership and inheritance or to claim compensation by the dependants. Registering the death of a child is not usually linked to such a benefit and as a result many such deaths remain unregistered. In such settings, data on infant and child mortality estimated from censuses and surveys tend to be more reliable.

In countries with incomplete civil registration systems the decennial census and surveys can be used to generate estimates of child mortality using direct or indirect techniques. [7] The direct method used in surveys involves questions to respondents about deaths in the household over a retrospective period of time. It involves the enumerator taking a detailed birth history for each birth that a woman has had during her lifetime. The births histories are then converted to rates of child mortality corresponding to a particular period in time.

The indirect method used with census or survey data is based on a short question set including questions to female respondents on children ever born and children that are still alive. Brass-type methods and model life tables are then used to obtain an estimate of under-five mortality. [8] However, the census is, by definition, an infrequent occurrence (usually every 10 years) so that it is not a good source of data for ongoing monitoring. It does, however, serve a very useful function of providing an alternate source that can be used to validate data from vital registration on the number of child deaths registered and hence the level of child mortality.

Interpreting different estimates of the under-five mortality rate

[7] United Nations Population Division (2001) Principles and recommendations for a vital statistics system, revision 2. Department of Economic and Social Affairs, Statistics Division, ST/ESA/STAT/SER.M/19/Rev2 http://unstats.un.org/unsd/publication/SeriesM/SeriesM_19rev2E.pdf

[8] United Nations Population Division. Manual X: indirect demographic estimation. New York: United Nations, 1983.

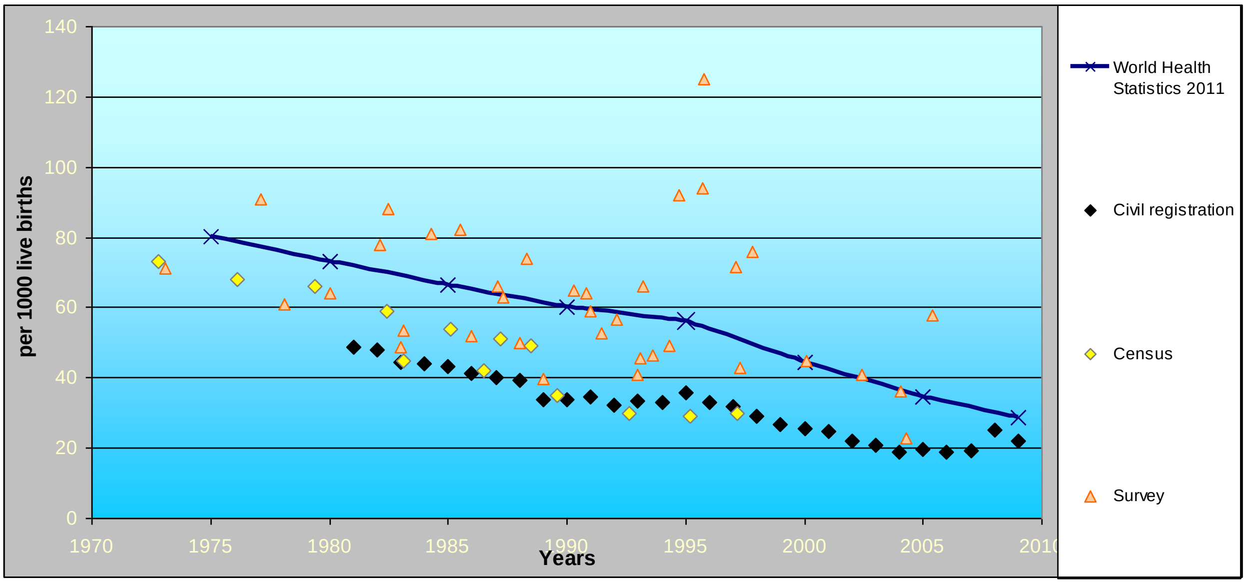
Most countries have data on child mortality from multiple sources, including vital statistics from the civil registration system, censuses, household surveys and the routine health information system. In this section, we show how information from censuses and surveys can be used to assess the completeness of child mortality reporting by the civil registration system.

Large differences between the levels of under-five mortality rates calculated from the reported data versus other sources, such as censuses, household surveys or estimates developed by UN international agencies, are likely to be due to underreporting of child deaths.

Figure shows data on under-five mortality for Kazakhstan. The estimates are derived from various data sources, including censuses, surveys and the civil registration system. This visual display of data from different sources clearly shows the extent to which the under-five mortality rates derived from civil registration are lower than those derived from the census or household surveys, especially during the earlier periods. This is indicative of substantial under-reporting of deaths among infants and children under five in the civil registration system. By comparing the line of best "fit" for the estimated under-five mortality rate derived from censuses and surveys with observed values calculated from the civil registration system for the same year(s) (shown as "diamonds" in Figure), it is possible to estimate the completeness of civil registration of child deaths by comparing the distance of the vital registration estimate ("diamonds") from the solid line, year by year.

From this analysis it can be concluded that under-five deaths in Kazakhstan and were grossly under-reported in the national civil registration system during the 1970s and 1980s. However, levels of reporting appear to have improved dramatically in the most recent decade (the trend in the "diamonds" for Kazakhstan is getting closer and closer to the solid line of best fit for the true level of the child mortality rate). Underreporting of under-five mortality in Kazakhstan appears to have diminished significantly in recent years.

Figure 10: Observed (from civil registration, census, surveys) and estimated levels of the under-five mortality rate, Kazakhstan 1970-2010



Users should produce similar figures for their country or populations with death registration, bringing together on one graph estimates of under-five mortality derived from difference sources including civil registration, to help interpret the multiple data points and diagnose possible incompleteness levels in death registration. To facilitate this, users can refer to the UNICEF/WHO Child Mortality Estimation database that brings together available data sets from different sources on a country-by-country basis and presents the information in tables and figures. [9]

Direct measures of incompleteness of death reporting

Special studies can also be carried out to determine the extent of under-reporting of deaths. The most widely used of these so called "direct" methods are "capture-recapture" studies[10] where deaths reported in the civil registration system for a sample of the population are compared (on a case-by-case basis) with deaths "captured" in an independent[11] survey of the same population.

While not all countries will have the technical and financial resources to carry out capture-recapture studies, we wanted here to highlight the fact that underreporting of deaths is likely to be much higher among children than adults, and hence special attention should be paid to evaluating probable levels of underreporting of child deaths using the methods proposed in this section.

Summary of step 5

- Section 5.1 defines the age ranges and inputs for the probabilities of early childhood mortality
- Section 5.2 points the user to the comparison estimates published by the Interagency Group for Child Mortality Estimation (IGME) and made available on the Child Mortality Estimation (CME) website

Step 6: Distribution of deaths by the global burden of disease (GBD) list[12]

Step 6 is a 'Causes of death - Basic analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. In the right-hand panel, section 6.1 distributes deaths, by sex and age group, per the global burden of disease cause list. Every ICD code in the uploaded data file is represented in this table. The categories in the table are hierarchical, whereby lower, more detailed categories of causes can be collapsed into higher, more broad categories of causes. The guidance below focuses on the three major groups of causes: Communicable, Noncommunicable, and Injuries. An additional category is ill-defined diseases. Finally, in order not to exclude a single death in the database, any cases in the uploaded database with an invalid, non-existent ICD code are enumerated under the GBD table.

A first step in any quality assessment of cause of death data is to calculate the percentage distribution of deaths by broad disease groups and compare the results with the expected distribution given the level of life expectancy for the population. These expected patterns have been documented by demographers and epidemiologists on the basis of many years of data and observations on patterns of causes of death in

[9] http://www.childmortality.org/cmeMain.html
[10] Sekara C, Deming W (1949) On a method of estimating birth and death rates and the extent of registration. *Journal of the American Statistical Association*, 44(245): 101-15.
[11] "Independence" as applied to capture-recapture studies means that the probability of a death not being reported under the civil registration system is not related to – is independent of – the probability that the same death will not be reported in another system or survey. In practice, this is very difficult to achieve.
[12] The Global Burden of Disease: 2004 Update, World Health Organization 2008.

different settings. Any significant deviation from the expected pattern that cannot be explained by contextual factors should be viewed as a potential problem with the quality of the cause of death data.

The ICD-10 contains over 10,000 codes, and ICD-11 contains about 14,000 codes.. All these causes can be categorized into three major groups of causes of death as per the Global Burden of Disease cause list. These groups are presented below, and the subgroups in each group, including corresponding ICD-10 codes, are available under the GBD Reference Material menu tab > GBD table > GBD Reference table for ICD-10 and GBD Reference table for ICD-11.

Group I:	Communicable diseases (e.g. TB, pneumonia, diarrhea, malaria, measles), maternal and perinatal causes (e.g. maternal hemorrhage, birth trauma) and nutritional conditions (e.g. protein-energy malnutrition)
Group II:	Non-communicable diseases (e.g. cancer, diabetes, heart disease, stroke)
Group III:	External causes of mortality (e.g. accidents, homicide, suicide)

The percentage distributions of causes of death into these three major groups varies across countries depending on where they stand in the "health transition", which refers to an interrelated set of changes in demographic structures, disease mix, and risk factors. Changing demographic structures include decreasing mortality rates among children, declining fertility rates, and increasing life expectancy-- all which result in an ageing population. Shifts in the major causes of disease and death are away from infectious diseases, such as diarrhoea and pneumonia (diseases traditionally associated with poorer countries), towards non-communicable diseases such as cardiovascular disease, stroke and cancers. Changes in risk factors include declines in infectious disease risk factors (undernutrition, unsafe water and poor sanitation, for example) and increases in chronic diseases risk factors (being overweight, using alcohol and tobacco, for example). Thus, a simple but effective way of checking the plausibility of mortality data is to compare the observed patterns of causes of death with those expected given the life expectancy in the country. As a general rule, countries with low life expectancy are characterised by high levels of mortality due to infectious and parasitic diseases especially in childhood, along with high maternal mortality (i.e. Group I causes). As life expectancy rises, the pattern of mortality changes, with more deaths occurring in older age groups due to non-communicable conditions such as cardiovascular diseases and cancers (i.e. Group II causes).

Table 2 shows how the percentage of deaths assigned to various causes in each of Groups I, II and III is expected to shift as life expectancy increases. Thus, a country with an average life expectancy of 55 years would have about 22 % of deaths due to group I causes of death, and 65 % due to group II causes. A country with a higher life expectancy of 65 years, would typically have a smaller percentage of deaths due to group I conditions (around 13%). While proportions of deaths in group I decrease with higher life expectancy, the proportion of deaths in group II increase with higher life expectancy. The proportion of deaths in group III show less variation than the other groups.

Table 2: Expected distribution of causes of death according to life expectancy by major groups

Life Expectancy	55 years	60 years	65 years	70 years
Group I causes of death	22%	16%	13%	11%
Group II causes of death	65%	70%	74%	78%
Group III causes of death	13%	14%	13%	11%

Note that these are model-based percentage distributions derived from the large database in the WHO Mortality Database on causes of death and mortality rates. It is unlikely that any country would fit exactly these proportions, but significant departures from them suggests either a bias introduced in incomplete registration or potential problems with the certification and/or coding of causes of deaths.

Users should review their most recent available data on causes of death data and the distributions by major groups of causes in step 6. They should also note the number of deaths coded as due to ill-defined causes in the ICD chapter on Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (ICD-10 chapter XVIII, excluding R95 Sudden infant death syndrome; ICD-11 chapter 21, MH11 Sudden infant death syndrome). When the proportion of ill-defined causes-- including also other vague or unspecific diagnoses that may be found throughout most of the other ICD chapters-- is substantially high (> 20% among all causes of death), then care should be taken in interpreting the data. The leading causes of death and their ranking, for example, may not be reliable.

Section 6.2 redistributes ill-defined causes proportionately to groups I and II; it does not distribute them to group III because a death due to an external injury is usually evident (even if the intention is not, in which case they will be in 'Injuries of undetermined intent', in group III). The user may review the results in tables 6a, 6b and 6c.

The user can compare the findings with the expected distributions above in Table 2, according to the life expectancy in the country. However, in doing this comparison it is important to use an independent source of life expectancy data (e.g. WHO, or the United Nations, or from your census), not the life expectancy calculated from the uploaded data file as it may be unreliable if the cause of death data are incomplete.

Summary of step 6

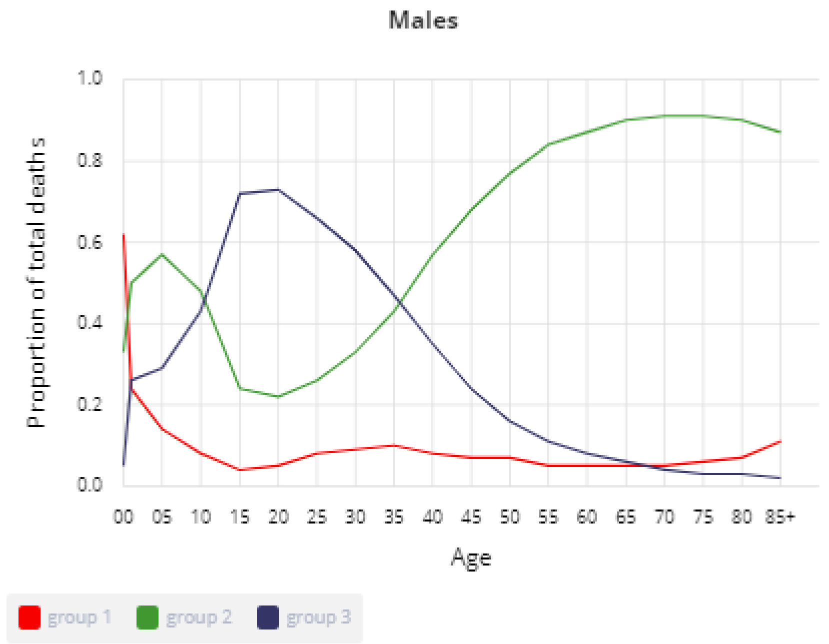
- Section 6.1 tabulates data on cause of death according to the GBD list of causes, by sex and age group
- Section 6.2 summarizes the causes into three major cause-of-death groups (groups I, II and III), and ill-defined and invalid codes (table 6a). The number of deaths of unknown age are distributed proportionately across age-groups in the respective causal group (groups I, II or III). Table 6b redistributes the ill-defined causes proportionately age and sex groups in groups I and II. Table 6c shows the proportion of the ill-defined causes of death by major cause group. It excludes the invalid codes.

Step 7: Distribution of major causes of death

Step 7 is a 'Causes of death - Basic analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. In the right-hand panel, section 7.1 produces line graphs of the major causes of death by age group, for males and females, separately. Since deaths due to these major causes follow a predictable age pattern documented from decades of epidemiological research, the user may compare the observed patterns with those of income groupings. Section 7.2 shows comparison groups by income grouping. *Recall that the World Bank income grouping for the uploaded data file is displayed at the top of step 1.*

Figure 11 shows the proportions of deaths across groups I, II & III, by age group, for males in Mexico in 2017.[13] At each age, the graph shows the observed proportion (fraction) of deaths at that age that occurred in each group. The three fractions, at any age, sum to 100%. Although Mexico is an upper-middle income country in 2017, the patterns compare most closely with the pattern of high-income countries. Since the income group patterns represent the *average* proportions across countries in the income group, it is not uncommon that a country in a certain income group may compare better with patterns in an adjacent income group.

Figure 11: Distribution of major cause of death group (group I, II and III) by age, Mexico 2017



Below is a summary of the age group pattern for each major cause group:

The proportion of deaths due to **group I** causes (communicable diseases, maternal, perinatal and nutritional conditions) is high among children but declines thereafter to very low levels although it may rise again at older ages (above 80 years or thereabouts) due to pneumonia.

The proportion of deaths due to **group II** causes is relatively high in children (for example, congenital anomalies), declines in adulthood, but rises significantly at older ages due to the increasing incidence of cancers, cardiovascular diseases and stroke, and other chronic diseases.

The proportion of deaths due to **group III** causes, i.e. external causes of death including accidents and violence, is generally highest in young adulthood. This pattern is especially marked among males.

[13] World Health Organization mortality database, https://www.who.int/data/data-collection-tools/who-mortality-database

This is a typical cause of death pattern by age and would not be replicated exactly in every country. However, significant departures from this pattern should be closely investigated as they are suggestive of problems such as poor medical certification of the cause of death and coding practices and age-misreporting of deaths.

In general, the patterns for males and females should be similar although there is often higher mortality due to external causes among young males (group III), while young women may have higher mortality due to maternal causes (group I).

The principal reason for carrying out this analysis is to identify any serious biases in the data. Depending on the country's system to compile cause-of-death data, or the socio-cultural context, there may occasions for bias to be introduced. For example, where unnatural deaths in group III are likely to require a lengthy medico-legal investigation, the final cause of death may not be incorporated into the death record at the time of death registration. There may also be strong pressure on certifiers to not certify cause of death due to certain causes due to stigma, e.g., HIV, suicide. This analysis will help to identify the extent of potential bias in your data.

Summary of step 7

- Section 7.1 plots the major cause of death patterns by sex and age group from the uploaded datafile.
- Section 7.2 facilitates comparison of the observed pattern with the average pattern according to income grouping.

Step 8: Leading causes of death

Step 8 is a 'Causes of death - Basic analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. In the right-hand panel, section 8.1 produces the observed 20 leading causes of death for all ages, for both sexes, and then for males and females, separately. It also produces the 20 leading causes of death for children under age 5, both sexes combined. Below the country results, section 7.2, the user may compare observed results with the 20 highest ranked causes, for all ages and both sexes, according to income level grouping. *Recall that the World Bank income grouping for the uploaded data file is displayed at the top of step 1.*

These rankings by income group assist users to ascertain divergences in their observed leading causes of death compared to leading causes of death estimated by WHO by country income grouping. These estimates refer to the average experience of all countries in each of the country groups and hence it is unlikely that the percentage distribution of deaths in any one country would exactly match them. However, significant departures from these average rankings of leading causes of death are suggestive of problems with the quality of cause of death data.

An analysis of the leading causes of death can also indicate certain biases in the certification and coding of causes of death thus indicating the degree of reliability of the cause of death data from the civil registration system. .

Summary of step 8

- Section 8.1 calculates the 20 leading causes of death from uploaded data

- Section 8.2 facilitates comparison of the observed leading causes with the leading causes for all ages, both sexes, according to income grouping.

Step 9: Ratio of non-communicable to communicable causes of death

Step 9 is a 'Causes of death - Basic analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. In the right-hand panel, section 9.1 produces the country specific ratio of deaths from non-communicable diseases (group II) to communicable diseases (group 1), and compares them side-by-side with the average ratios according to income grouping (both sexes combined).

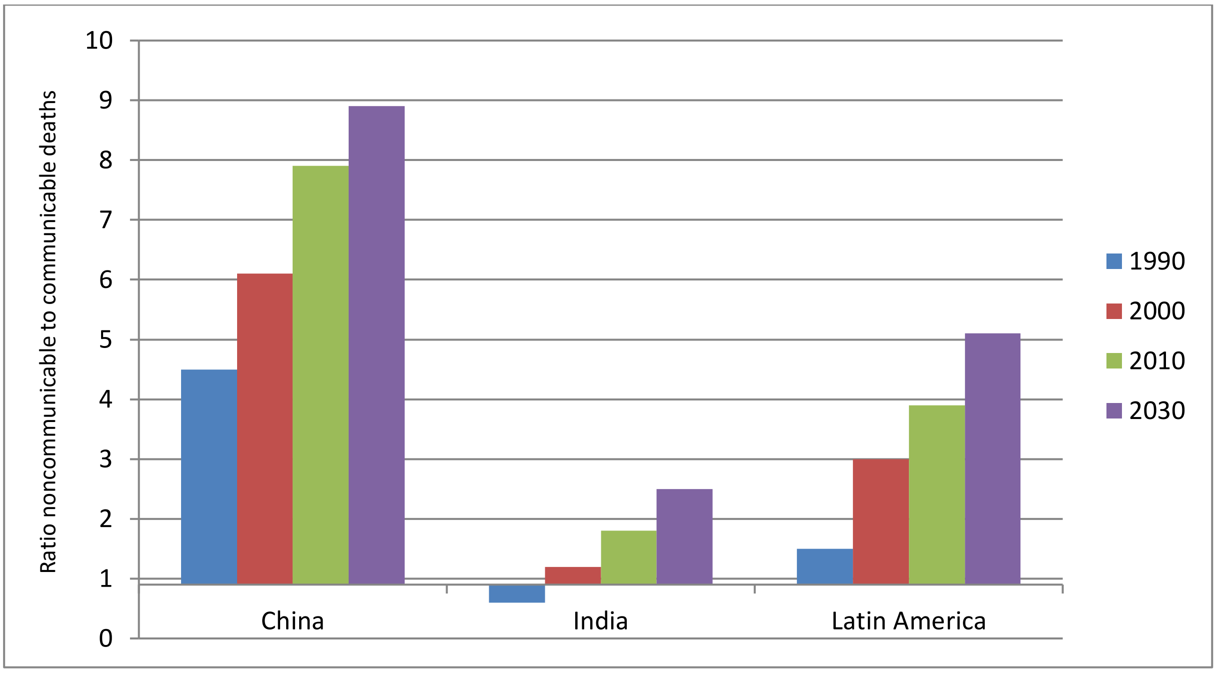
If there were the same number of deaths in group II and group I then ratio would be 1. Globally, there are about four times as many deaths due to group II causes as group I causes. In high-income countries, non-communicable diseases account for 13 times as many deaths as communicable diseases. By contrast, in low-income countries, there are more deaths due to communicable diseases (the ratio is less than 1). In the upper middle-income countries, there are about ten times as many deaths due to non-communicable diseases compared with communicable diseases. This reflects the fact that in high-income and upper middle-income countries, most deaths occur late in life, due to chronic conditions such as cancers and cardiovascular diseases. In low-income countries by contrast, most deaths occur in early childhood, due to infectious diseases conditions-- pneumonia, diarrhoea, and vaccine preventable conditions-- and perinatal causes.

Recall that the World Bank income grouping for the uploaded data file is displayed at the top of step 1.

As countries develop their health systems, communicable diseases such as diarrhoea and pneumonia, as well as maternal, perinatal and nutritional risks, will be increasingly brought under control. As a result, more and more people will survive to adulthood where chronic diseases such as ischaemic heart disease, stroke, cancer and chronic obstructive pulmonary diseases claim more and more lives. Hence, the simple ratio of group II deaths to group I deaths should progressively increase as a country moves through the epidemiological transition and life expectancy increases.

Over time, as child mortality decreases and life expectancy increases, the pattern in low-income countries will start to look more like that observed in middle-income and high-income countries. This is illustrated in the Figure which shows estimated trends in the ratio of non-communicable to communicable conditions in China, India and Latin America. In India in 1990, there were more deaths due to communicable diseases than to non-communicable diseases, hence the ratio is less than 1. Since 2000, however, deaths due to non-communicable diseases have exceeded those due to communicable diseases.

Figure 12: Estimated trends in ratio of non-communicable to communicable deaths, selected regions, 1990-2030



Departures from this overall picture are suggestive of errors in cause of death data.

Summary of step 9:

- Section 9.1 presents the ratio of deaths from non-communicable diseases to communicable diseases (group II to group I deaths) and allows the user to compare the findings with averages of other income groupings.

Step 10: Ill-defined causes of death

Step 10 is a 'Causes of death - Basic analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. In the right-hand panel, section 10.1 computes the usability index, which is a function of completeness (from step 3) and the proportion ill-defined (from the last row of the table in section 10.2). The higher the usability index, the better quality the data and the more accurate the indicators. However, the usability index will realistically never be 100% because it is next to impossible to have perfect cause-of-death data. That is, in the real world, there will always be some deaths coded to the chapter on signs and symptoms and other vague or unspecified causes of death. The use may find further information as well as recent usability indexes for countries in WHO (2020).[14]

[14] WHO methods and data sources for country-level causes of death 2000-2019 (2020) https://cdn.who.int/media/docs/default-source/gho-documents/global-health-estimates/ghe2019_cod_methods.pdf?sfvrsn=37bcfacc_5

Section 10.2 presents the number and percentage of deaths attributed to ill-defined or vague and unspecified causes of death according to ICD chapter, by sex and age group. Note that the number of ill-defined deaths in the row labelled, 'Symptoms, signs and…' is the same number in the bottom row of the GBD table in step 6.

When a death occurs and is medically certified, coders make every effort to correctly ascertain the underlying cause of death. The underlying cause of death is the most informative condition in developing public health interventions that target treatment and prevention measures on the root conditions which will most effectively prevent or postpone death. Coding deaths to ill-defined or vague and unspecified conditions does not generate information of public health value. Where a high proportion of all deaths are coded as ill-defined causes, then the cause-of-death distribution will likely be biased and unreliable. ANACoD3 highlights the percentage in blue if it exceeds 10%.

When certifying and coding causes of death, the ill-defined causes should be avoided or not used as the underlying cause of death if possible. Below are the two types of ill-defined codes:

i. Deaths classified as Symptoms, signs or clinical findings, not elsewhere classified (ICD-10 chapter XVIII excluding R95 Sudden infant death syndrome, ICD-11 chapter 21, excluding MH11 Sudden infant death syndrome)
ii. Vague or unspecified causes of death in other ICD-10 chapters include those in the list below. These codes can be mapped to the corresponding ICD-11 codes using the ICD mapping tool[15]. In addition, since specific ICD-10 and ICD-11 codes may change over time, the user should also consult the GBD reference tables for ICD-10 and ICD-11 inside of the tool, located among the Reference material items. At the row towards the bottom of these tables, labeled 'Ill-defined disease' are the corresponding ICD codes for ill-defined causes.
    - A40-A41 Streptococcal and other septicaemia
    - C76, C80, C97 Ill-defined cancer sites
    - D65 Disseminated intravascular coagulation [defibrination syndrome]
    - E86 Volume depletion
    - I10 Essential (primary) hypertension
    - I269 Pulmonary embolism without mention of acute cor pulmonale
    - I46 Cardiac arrest
    - I472 Ventricular tachycardia
    - I490 Ventricular fibrillation and flutter
    - I50 Heart failure
    - I514 Myocarditis, unspecified
    - I515 Myocardial degeneration
    - I516 Cardiovascular disease, unspecified
    - I519 Heart disease, unspecified
    - I709 Generalized and unspecified atherosclerosis
    - I99 Other and unspecified disorders of circulatory system
    - J81 Pulmonary oedema
    - J96 Respiratory failure, not elsewhere classified

[15] ICD-11 mapping tools, https://icd.who.int/browse11/l-m/en

- K72 Hepatic failure, not elsewhere classified
- N17 Acute renal failure
- N18 Chronic renal failure
- N19 Unspecified renal failure
- P285 Respiratory failure of newborn
- Y10-Y34, Y872 External cause of death not specified as accidentally or purposely inflicted

Deaths classified to either of these two categories of *ill-defined diagnoses* are insufficiently detailed to be of value for public health purposes, although in the majority of cases they help to describe overall mortality due to major disease group (e.g. CVD, respiratory disease) or injury group. Identifying their frequency in cause-of-death tabulations is essential for deciding upon remedial action to reduce their usage. This could involve interventions to improve certification practices, coding practices, or both.

While there will always be individual cases where it is not possible to classify the cause to a specific ICD category due to lack of appropriate information, such cases should be relatively infrequent. As a general principle, the proportion of ill-defined deaths coded to either category i) or category ii) above should collectively not exceed 10% for deaths at ages 65 years and over, and should be less than 5% for deaths in age groups below 65 years.

When reviewing a time series of cause of death information, it is important to study how the proportion of ill-defined causes of death has changed over time. Large fluctuations may be indicative of changes in certification and coding practices rather than real changes in patterns of mortality.

The proportion of deaths assigned to ill-defined causes tends to be higher for deaths occurring at older ages. There are many possible explanations, including the fact that many such deaths occur outside health care facilities and also because of the higher frequency of comorbidities which renders such deaths harder to correctly diagnose. Nonetheless, with good certification and coding practices, it should be possible to reduce this proportion to less than 10% of deaths among the elderly.

Summary of step 10

- Section 10.1 computes the usability index, a function of completeness (from step 3) and the proportion ill-defined (from the last row of the table in section 10.2)
- Section 10.2 presents a table with overall percentages, by sex and age-group, for both types of ill-defined causes: i) symptoms, signs or clinical findings, not elsewhere classified, and ii) vague and unspecified conditions in other ICD chapters. Percentages exceeding 10% are highlighted in blue, to call the user's attention. The overall percentage of defined and ill-defined causes are visualized in a vertical stacked bar chart, and a breakdown of ill-defined causes by ICD chapter in a second vertical bar chart.
- Section 10.3 enumerates the specific ill-defined codes, ranks them by number and percentage, and distributes them according to broad age groups. The feedback is aimed at improving certification and coding practices.

Step 11: Age-specific causes of death

Step 11 is a 'Causes of death - Basic analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. Also, in the left panel, the user may type in or click on any of the cause-of-death categories from the GBD list. This list matches the list in step 6.

For any cause of death group selected, section 11.1 presents in the right-hand panel the number of deaths and the death rate per 100 000 population, by sex and age group, that corresponds with the selected causal group. The user can hover over the lines in the charts to see specific values. The number of deaths, the population, and the death rates are also produced in the table below the charts.

This is a useful analysis for the user to see results, or identify potential anomalies, for specific causes, at a glance.

Summary of step 11

- Section 11.1 presents the numbers of deaths and death rates, by sex and age group, for specific cause of death groups from the GBD list of causes
- It presents the same results below in a table format.

Step 12: Trends in causes of death

Step 12 is a 'Causes of death - Basic analysis'. In the left panel, the user may type in or click on any of the cause-of-death categories from the GBD list. This list matches the list in step 6. (The option to select a year is not relevant because, by default, ANACoD3 presents trend information for all years in the data file.)

For any cause of death group selected, section 12.1 presents in the right-hand panel the trend in the number of deaths, and the death rate per 100 000 population. The number of deaths, the population, and the death rates are also produced in the table below the charts, by year.

Section 12.2 shows the cause-specific trends for each year in the data set by age group, including number of deaths and deaths for both sexes combined per 100 000 population in each age group.

Summary of step 12

- Section 12.1 presents trends in the numbers of deaths, by sex, for each year uploaded in the data file, for specific cause of death groups from the GBD list of causes
- Section 12.2 shows these trends by cause according to age group, for both sexes combined.

Special analyses: External causes of death

The following steps 'Ext 1-11', for external causes of death, represent a deeper analysis of deaths due to injuries. The WHO definition of an 'injury' is: 'Injuries are caused by acute exposure to physical agents such as mechanical energy, heat, electricity, chemicals, and ionizing radiation interacting with the body in amounts or at rates that exceed the threshold of human tolerance. In some cases, (for example, drowning and frostbite), injuries result from the sudden lack of essential agents such as oxygen or heat' (WHO, ICD-11, version 09/2020).

Deaths from injuries are one of the three major causes of death, categorized in group III (recall, group I is communicable, maternal, perinatal and nutritional conditions; and group II is noncommunicable diseases). An injury may be due either to an accident or due to violence in the form of self-harm or interpersonal. In its hierarchical structure, the GBD table (step 6), categorizes deaths from injuries according to intent: Unintentional injury (road traffic accidents, poisonings, falls, fires, and drownings); Intentional injury (self-inflicted injury/suicide, homicide, and war and conflict); and Ill-defined injuries/accidents (Undetermined intent).

Another important dimension in analysing external causes is the mechanism by which the death due to injury occurred. For example, drowning may be the mechanism by which a homicide or a suicide occurred, it also may be the result of a transport accident (boat). Similarly, a firearm, poisoning, fall, or fire may be the mechanism by which an accident (unintentional) or violence (intentional) occurred. The CDC developed an 'External Cause of Injury Mortality Matrix for ICD-10 (2002-03)' used to analyse deaths by injury in the United States[16]. ANACoD3 also provides the user with CDC's 'External Cause of Injury Matrix' in the Reference material menu.

ANACoD3 provides the special analysis of external causes for data files containing ICD-10 codes. The special analysis will be available for data files containing ICD-11 codes in the future.

Ext 1: Most assigned ICD-10 codes to deaths due to external causes

Ext 1 is a 'Causes of death – Special analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. In the right-hand panel, ANACoD3 ranks the top 15 external causes of death codes.

The objective of this analysis is to give more detail on the most assigned codes for external causes of injury. It alerts the user to habitually used codes, especially if they are of an unspecified nature. Pay special attention to non-specific codes including X59 Exposure to unspecified factors, and Y10-Y34 Event of undetermined intent (and particularly Y34 Unspecified event, undetermined intent). There may be room to improve the specificity of medical certification and/or coding if ANACoD3 shows that certain codes are excessively used, or if many of deaths are assigned codes of an unspecified nature.

Ext 2: Ill-defined external causes of death

Ext 2 is a 'Causes of death – Special analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. In the right-hand panel, ANACoD3 presents the percentage of deaths due to injuries. (This percentage is the same as the proportion of deaths in group III, table 6c, in step 6). Among the deaths due to external causes, it shows the percentage which are due to ill-defined injuries i.e., injuries of undetermined intent, Y10-Y34.

[16] https://www.cdc.gov/nchs/injury/ice/matrix10.htm

In the panel below, Ext table 2.2, ANACoD3 presents two specific codes which are ill-defined external causes, X59 and Y34, and the number of cases to which these codes are attributed. Y34, referring to *an injury of an unspecified event, undetermined intent*, contributes to the percentage of deaths due to injuries of undetermined intent, in the table above. X59 is additional, unspecific external code, referring to an *injury due to exposure to unspecified factor*. Countries should strive to eliminate or at least reduce the use of both of these codes by improving the specificity of certification and coding of external causes of injury.

Ext 3: Distribution of external causes of death by GBD cause of death list

Ext 3 is a 'Causes of death – Special analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. In the right-hand panel, ANACoD3 presents the number of external deaths by sex, according to GBD external cause categories (group III causes). This table is extracted from the Injury categories in the GBD table, step 6. The table also provides external death rates for each causal category, per 10 000 population, and age-specific death rates for broad age groups: 0, 1-4, 5-14, 15-59, and 60+. The ratio of male to female deaths gives a quick indication of the relative risk of each causal group. A ratio of '1.0' indicates the same number of deaths for each sex; the ratio is usually higher than 1.0, indicating males have a higher incidence of death due to external injuries.

In the bottom panel, the first figure, 'Distribution of deaths by external cause of injury' shows at-a-glance the age groups where deaths due to external causes most frequently occur. The stacked bar for each age group shows the share of each causal group among all external causes. The second figure, 'Ratio of male to female mortality rates- all ages combined', reproduces the ratio values in the table, facilitating a visual analysis of the differential occurrence between sexes for each cause.

Ext 4: Distribution of deaths by cause of death groups, and selected external causes by age group and mechanism

Ext 4 is a 'Causes of death – Special analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. In the right-hand panel, ANACoD3 produces line graphs of the major causes of death by age group, for male and female separately. (Note, these are the same graphs as in step 7 and the user may revert to that step for more detailed guidance in interpretation).

In the bottom panel, the first figure, 'Percentage of deaths by age group, for selected external causes of death' shows at-a-glance the age groups in which homicides, suicides, road traffic, and all other deaths due to external causes occur most frequently. The second figure shows the percentage share of the mechanism which resulted in the homicide and suicide deaths, and all other deaths due to external causes combined.

Ext 5: Deaths from transport accidents, share of external causes and by mechanism

Ext 5 is a 'Causes of death – Special analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. In the right-hand panel, ANACoD3 produces results of transport accidents including the total number of deaths from transport accidents (the sum of 'Motor vehicle traffic accidents [a]' and 'Other transport accidents [b]' enumerated in the detailed table in the panel below, and shown in the pie chart.

[a]A motor vehicle traffic accident is any accident involving a motorized vehicle that occurs on a public highway.

[b]Other transport accidents involve vehicle accidents, motorized or non-motorized, that occur in any place other than a public highway, by land, water, air or space.

ANACoD3 presents the percentage of transport accidents among all deaths from external causes; the denominator is the number presented in the GBD category of 'Injuries' (step 6). ANACoD3 also presents the transports death rate per 10 000 population; the denominator is the total population (step 1).

The categories of 'Motor vehicle traffic accidents' are analyzed according to the CDC External Cause of Injury Matrix. The Matrix provides the specific ICD-10 codes in each category. This table is available to the user in the ANACoD3 Reference material menu, 'External Cause of Injury Matrix'.

Ext 6: Deaths from suicide, share of external causes and by mechanism

Ext 6 is a 'Causes of death – Special analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. In the right-hand panel, ANACoD3 produces the total number of suicide deaths, which are also referred to as 'self-inflicted' deaths in the GBD table (step 6). ANACoD3 presents the percentage of suicides among all deaths from external causes; the denominator is the number presented in the GBD category of 'Injuries' (step 6). It also presents the suicides death rate per 10 000 population; the denominator is the total population (step 1).

The second table presents the mechanism used to commit suicide. This is a percent distribution for which the sum is 100%. The same information is presented in the stacked bar, separately for males and females.

The specific ICD-10 codes, including 3-character and 4-character codes, that are used to analyze self-inflicted injuries (suicides) are in the GBD Reference Table. This table is available to the user in the ANACoD3 Reference material menu, 'GBD table'.

Ext 7: Deaths from homicide, share of external causes and by mechanism

Ext 7 is a 'Causes of death – Special analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. In the right-hand panel, ANACoD3 produces the total number of homicide deaths, which are also presented in the GBD table under the same category, 'homicides' (step 6). ANACoD3 presents the percentage of homicides among all deaths from external causes; the denominator is the number presented in the GBD category of 'Injuries' (step 6). It also presents the homicides death rate per 10 000 population; the denominator is the total population (step 1).

The second table presents the mechanism used to commit homicide. This is a percent distribution for which the sum is 100%. The same information on total numbers is presented in the horizonal bar, for males and females.

The specific ICD-10 codes, including 3-character and 4-character codes, that are used to analyze homicides are in the GBD Reference Table. This table is available to the user in the ANACoD3 Reference material menu, 'GBD table'.

Ext 8: Deaths from firearms (mechanism), share of external causes and by intent

Ext 8 is a 'Causes of death – Special analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. Unlike suicide and homicide, which are *causes of death* categorized as intentional deaths in the GBD table (step 6), a firearm represents a *mechanism* of death. (Other mechanisms, for example, are fire, drowning, poisoning, etc.) Deaths by a firearm mechanism are cross-cutting across causes, meaning they may be implicated in homicide or suicide, or unintentional deaths, or deaths of undetermined intent. Firearms may also be a mechanism for a death due to a legal mechanism or war.

In the right-hand panel, ANACoD3 produces the total number of deaths resulting from firearms. These deaths are dispersed across several of the GBD causal categories mentioned above and are not in a single category in the GBD table. ANACoD3 presents the percentage of deaths resulting from firearm injury, among all deaths from external causes. It also presents the firearms death rate per 10 000 population; the denominator is the total population (step 1).

The second table presents the use of firearms by the intent associated with the cause of death, including homicide, suicide, unintentional, undetermined, and legal intervention or war. This is a percent distribution for which the sum is 100%. The stacked bar graph shows the share of each mechanism that resulted in the external deaths, by the same intent categories above, associated with the cause of death. The stacked bars present the results separately for male and female.

The last visualization, a vertical bar chart, shows the number of deaths caused by a firearm by broad age group, regardless of intent.

Ext 9: Deaths from burns (mechanism), share of external causes and by intent

Ext 9 is a 'Causes of death – Special analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. Unlike suicide and homicide, which are *causes of death* categorized as intentional deaths in the GBD table (step 6), a burn-- due to a fire or other hot object or substance-- represents a *mechanism* of death. (Other mechanisms, for example, are firearm, drowning, poisoning, etc.) Deaths by a burning mechanism are cross-cutting across causes, meaning they may be implicated in homicide or suicide, or unintentional deaths, or deaths of undetermined intent. A death by burning may also be a mechanism for a death due to a legal mechanism or war.

In the right-hand panel, ANACoD3 produces the total number of deaths resulting from burns due to fire, a hot object or substance. These deaths are dispersed across several of the GBD causal categories mentioned above and are not in a single category in the GBD table. ANACoD3 presents the percentage of deaths resulting from a burn injury, among all deaths from external causes. It also presents the death rate due to burns per 10 000 population; the denominator is the total population (step 1).

The second table shows the type of mechanism that caused the burn—a fire or flame, or a hot object or substance. The type of mechanism that caused the burn is presented for each of the intent categories associated with the cause of death: homicide, suicide, unintentional, undetermined, and legal intervention or war. All of this information in this table is presented for males, female, and both sexes, separately.

In the first chart, the first stacked bar uses the total number of deaths due to hot object or substance as denominator, and presents the percentage of each intent category. The second stacked bar uses the total number of deaths due to fire or flame as the denominator, and shows the percentage of each intent category.

The second chart presents the broad age group in which each burn death occurred, by type of mechanism – a burn due to fire or flame, or a burn due to a hot object or substance.

Ext 10: Deaths from drowning, share of external causes and by intent, and additional deaths due to drowning in a water transport accident

Ext 10 is a 'Causes of death – Special analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. ANACoD3 presents the percentage of drownings among all deaths from external causes; the denominator is the number of unintentional drownings presented in the GBD category of 'Injuries' (step 6), plus drownings due to other intent categories, plus drownings due to boat (transport) accidents. It also presents the death rate for these drownings per 10 000 population; the denominator is the total population (step 1).

The second table presents the percent distribution of intent associated with the drowning, including homicide, suicide, unintentional, undetermined, and additional deaths from drowning due to boating (transport) accidents. This is a percent distribution for which the sum is 100% of drownings. The vertical bar chart shows the same numbers as in the table of drowning deaths according to intent categories, by sex.

The second vertical bar distributes all the deaths by drowning into broad age groups.

Ext 11: Age-standardized death rates for external causes, overall and for selected causes, with income level group comparisons

Ext 11 is a 'Causes of death – Special analysis'. In the left panel, the user may select the year of interest if a multi-year data file is uploaded. ANACoD3 presents age-specific death rates (ASDR), per 100 000. The ASDRs are standardised using the WHO standard population[17] so the country results are directly comparable with the world and with the average ADSRs for income groups, regardless of the population structures. (A standardised ASDR can be understood as a weighted average of ASDRs using the standard population as a weight. Using the weights from the standard population and applying them to the observed rates ensures comparability over time and across countries.)

The comparison data for the income groups come from the WHO disease and injury estimates for 2008; more recent estimates will be provided in an updated version of ANACoD3.

[17] WHO (2001). Age Standardization of Rates: A new WHO standard. GPE Discussion Paper Series: No.31. https://www.who.int/healthinfo/paper31.pdf?ua=1