CRVS technical guide
Summary: Guidance for interpreting verbal autopsy results

This guidance document provides summary information on the process of interpreting verbal autopsy results for use in public health decision-making. The full version of this document, *Guidance for interpreting verbal autopsy results*, can be found on the CRVS Knowledge Gateway at https://crvsgateway.info/file/18768/3231

Reliable and representative mortality and cause of death (COD) statistics are essential to inform public health policy, respond to emerging health needs, and document progress towards nationally and internationally endorsed goals and targets, such as the Sustainable Development Goals (SDGs). Yet, an estimated 62 per cent of all deaths are never officially registered and, therefore, remain invisible to health policy-makers.[1] The majority of these unregistered deaths occur in low- to- middle-income countries (LMICs), where a large proportion of deaths occur at home without the presence of a person (such as a physician) trained to determine the medical COD accord to the World Health Organization's (WHO) international standards.

Verbal Autopsy (VA) is a process for determining the probable cause of death (COD) based on responses collected, usually by a frontline health or community-based worker, from families and/or caregivers of the deceased.[2] Currently, VA is the only practical alternative to medical certification of cause of death (MCCOD) by a trained physician, and the subsequent coding of that death certificate by a trained coder. While MCCOD represents the very best practice for countries to follow, in many countries, the information from VA can be of enormous value for informing public health policy by generating relevant and timely COD information for populations where no such information exists.

These summary guidelines outline the five steps for users of VA to follow to help interpret and present VA data, thus improving the utility of VA for public health decision-making. For more detailed interpretation guidelines, see the full version of this document available at: https://crvsgateway.info/file/18768/3231

Questionnaires and diagnostic algorithms for verbal autopsy

VA comprises three main elements:

1. A structured questionnaire to elicit information from the respondents on signs and symptoms experienced by the decedent before death, known as the verbal autopsy instrument (VAI).
2. A method to diagnose the most probable COD based on the responses recorded in the VAI. Previously done by physicians and referred to as physician-certified verbal autopsy (PCVA), automated algorithms are available to generate the probable COD.
3. A target COD list, which includes all causes that can realistically be diagnosed from a brief VA interview with reasonable accuracy and that can be mapped to the International Classification of Diseases (currently in its 10th revision [ICD-10]), allowing for the VA-determined cause to be classified according to ICD.

There are two VA questionnaire options currently in widespread use:

- Population Health Metrics Research Consortium (PHMRC) shortened questionnaire or SmartVA questionnaire: www.healthdata.org/verbal-autopsy/tools
- WHO 2016 VA questionnaire: www.who.int/healthinfo/statistics/verbalautopsystandards/en/

Both questionnaires map to cause lists that are compatible with ICD-10 and to that used in the Global Burden of Disease (GBD) Study.[3] The target cause lists differ in details, but both focus on major CODs of public health relevance, and both are likely to account for 80 to 90 per cent of CODs that typically occur in LMICs.[4]

1 GBD 2017 Mortality Collaborators. Global, regional, and national age-sex specific mortality and life expectancy, 1950–2017: A systematic analysis for the Global Burden of Disease Study 2017. The Lancet. 2018; 392(10159):1684–1735.

2 World Health Organization. Verbal autopsy standards: Ascertaining and attributing cause of death. Geneva: WHO; 2007.

3 GBD 2017 Causes of Death Collaborators. Global, regional, and national age-sex specific mortality for 282 causes of death, in 195 countries and territories, 1980–2017: A systematic analysis for the Global Burden of Disease Study 2017. The Lancet. 2018; 392(10159):1736–1788.

4 Ibid.

Currently, three automated diagnostic methods are available to diagnose the probable COD from a VA interview: Tariff, InterVA and InSilicoVA. For those using the WHO 2016 VAI, it is probable that using the three different diagnostic algorithms will often produce two or even three discrepant results and it will be necessary to assess and select the algorithm producing the most plausible COD estimates.[5] This is not relevant for SmartVA, which applies a single diagnostic algorithm (Tariff) to assign the most probable COD.

Uncertainty around VA data

VA can yield extremely useful information on the probable pattern of CODs in populations where access to health facilities is low or non-existent. However, the method is essentially a proxy for proper clinical diagnosis, and hence likely to be characterised by considerable uncertainty, especially when used to predict an individual's COD. VA data are designed to represent patterns of mortality at the population level, where the aggregation of individual causes will inevitably result in compensating errors. This is because the number of cases is fixed. Hence, each cause will benefit or suffer from diagnostic inflows and outflows that, in aggregate, tend to balance each other out and have far less impact on diagnostic accuracy than individual COD predictions from VA.

Comparison data for the interpretation

To help assess plausibility, comparator datasets are used alongside the VA data. The appropriate comparator dataset will depend on the application of VA or the stage of implementation. For VA implementation using a method that produces a representative sample for the whole country, a national-level comparator dataset is appropriate. Where VA implementation is confined to specific locations, or for specific populations, other datasets (if available) may be more appropriate. The important thing to note when comparing data is how alike the populations are from the different datasets. This will reflect how alike the cause distribution from the various datasets would be expected to be.

Available comparison data may include:

- Population statistics from the CRVS system
- COD information from MCCOD or health management information systems
- COD distributions from ongoing health and demographic surveillance system (HDSS) sites
- Morbidity data from hospitals that provide information on the diseases presenting at hospitals
- Specific mortality surveillance and program data such as from maternal/perinatal death notifications, and registries for cancers, malaria, HIV/AIDS and tuberculosis
- Periodic household surveys such as Demographic and Health Surveys (DHSs) or maternal mortality surveys.

Step 1: Understand the verbal autopsy population

In most countries, VAs will be collected from a subset of the national population in certain geographic areas, such as subdistricts. The characteristics of the chosen VA population are important to understand because they influence COD patterns in that population. Characteristics of the VA population as reflected in **Table 1** (and how similar they are to the general population) will affect how well the VA data represent this wider population. More generally, knowing the VA population characteristics will help to interpret VA results.

Representativeness is important for two reasons. Firstly, it allows us to determine how applicable the cause-specific mortality fractions (CSMFs) from VAs are to the whole population – that is, it helps us understand the generalisability of the data. Secondly, it helps us to assess the plausibility of the CSMFs from VAs against comparator data, which may represent a different population. If the VA data under analysis have been selected using an appropriate sampling method as outlined in CRVS-VA Sample Size Calculator Guidance,[6] the need to assess the relative epidemiological and demographic characteristics of the VA area is less critical, since the sample is designed to represent the whole country.

The characteristics defined in **Table 1** help to understand the key aspects of the VA population relevant for interpreting VA results, and can also help to explain the plausibility of VA results when compared with a comparator dataset. Although these characteristics will affect COD patterns, this effect will be greater for some causes than others. As an example, certain infectious diseases, such as malaria and measles, can have a marked geographic variation within a country.

5 Nichols EK et al. (2018) The WHO 2016 verbal autopsy instrument: An international standard suitable for automated analysis by InterVA, InSilicoVA, and Tariff 2.0. PLOS Medicine. 2018; 15(1):e1002486.

6 University of Melbourne. Sampling strategies for representative national CRVS verbal autopsy planning: A guidance document and sample size calculator tool. Melbourne, Australia: University of Melbourne, Civil Registration and Vital Statistics Improvement, and Bloomberg Philanthropies Data for Health Initiative; 2018. Found at: https://crvsgateway.info/file/10249/2085

Table 1: Parameters important for assessing representativeness of verbal autopsy population

Parameter	Importance of parameter for interpretation	Potential data sources
Geographic coverage	The geographic areas where VAs are collected, whether a statistically representative sample of the national or sub-national populations, or selected by convenience	Population censuses, national statistical office annual population estimates
Population age distribution	The population age distribution, which influences overall COD patterns (because the CSMFs of most diseases vary with age)	Population censuses, national statistical office annual population estimates, socioeconomic or Demographic and Health Surveys, the UN World Population Prospects,[7] GBD Studies[8]
Socioeconomic characteristics of the population	A population's economic resources, knowledge to prevent and treat diseases, and access to health facilities will all influence COD patterns	Population censuses, socioeconomic or Demographic and Health Surveys, national statistical data, surveillance reports
Epidemiological profile	Geographic areas will vary in the levels and patterns of mortality due to the prevalence of different types of diseases, which will affect the COD distribution	Demographic and Health Surveys, surveillance reports
Hospital deaths	The proportion of hospital deaths, where CODs will vary significantly from those that occur outside a facility	Annual health data, annual statistics reports

COD = cause of death; CSMF = cause-specific mortality fraction; GBD = Global Burden of Disease; VA = verbal autopsy

Additionally, it is important to be explicit about which type of deaths VAs will be conducted on (for instance, will VAs be conducted for deaths where the deceased was discharged from hospital shortly before death, for dead on arrival cases, or for police cases), as this may vary from country to country.

Geographic coverage of verbal autopsy

Where the goal of VA is to produce nationally representative COD distribution data, the VA population should be chosen to represent the national (or sub-national) population of interest using a sampling frame and statistical approach. The CRVS-VA Sample Size Calculator Tool assists users to define and select population clusters that provide CSMFs with a predetermined level of uncertainty for a given number of clusters and VAs.[9] The sampling design would be used by countries that have conducted appropriate piloting of VA and are rolling out to national CRVS VA implementation.

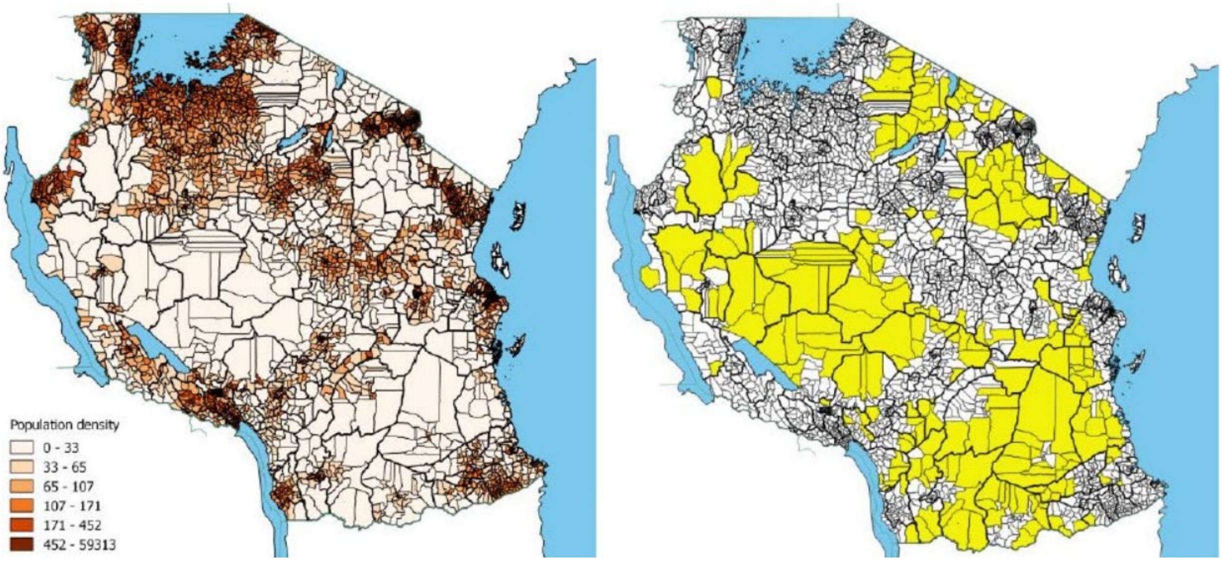
Geographic information systems software can be used to explore several geographical characteristics of interest for the VA population. For example, maps can be used to identify urban–rural populations, populations outside hospital catchment areas, remote or difficult to reach areas and disaster-prone areas. It can also be used to exclude areas where it would be logistically difficult to implement VA, such as remote and sparsely populated areas. **Figure 1** shows areas excluded (highlighted) from the sample in Tanzania because of a population density of less than 15 people/km^2.

7 UN World Population Prospects: The 2019 revision (population.un.org/wpp/).

8 Global Burden of Disease Study 2017 results (ghdx.healthdata.org/gbd-results-tool).

9 University of Melbourne. Sampling strategies for representative national CRVS verbal autopsy planning: A guidance document and sample size calculator tool. Melbourne, Australia: University of Melbourne, Civil Registration and Vital Statistics Improvement, and Bloomberg Philanthropies Data for Health Initiative; 2018. Found at: https://crvsgateway.info/file/10249/2085

Figure 1: Map showing sampling frame of VA implementation sites in Tanzania[10]



Age-sex distribution of the verbal autopsy population

Age-sex distribution (the percent of the population at each age and sex) is important to understand because it will influence the COD distribution (see Step 3). This is because the risk of dying is strongly associate with age. The age-sex distribution of deaths will then influence the leading CODs within a population because the likelihood of dying from a specific COD varies by the age and sex of the decedent (e.g. a higher proportion of deaths at older age would imply more deaths from non-communicable diseases [NCDs] than in a population with a younger age distribution of deaths).

The **percentage of the population aged 65 years and over** is a summary measure of the population age distribution and is useful to quantify the relative age distribution of each population. Population data for five-year age groups and each sex should be available for a VA population from a national statistics office.

Socioeconomic status of the VA population

Differences in socioeconomic status (SES) are related to the health of populations. Socioeconomic characteristics of a population reflect the population's economic resources and knowledge to prevent and treat diseases, as well as their access to health facilities. Populations with higher SES also tend to have an older age distribution caused by lower fertility and mortality due to factors such as improved child survival, urbanisation and increased female education. If the VA population has different socioeconomic characteristics to other parts of the country, the patterns of disease would therefore be expected to be different. For instance populations with higher SES are likely to have a higher proportion of deaths due to NCDs.

Measures of SES need to be readily available at lower administrative levels and also be easy to compare across different populations. **Table 2** is an example of demographic and socioeconomic indicators in a VA population and at the national level. Although the VA population has an older population age structure than the national level, it has a less urbanised and less educated population. The VA population can be described as having a somewhat lower socioeconomic status than the national level.

10 Ibid.

Table 2: Example demographic and socioeconomic indicators for verbal autopsy and national populations

Indicator	Verbal autopsy population	National level
Population in urban areas	12.0%	30.0%
Population aged 25-29 that have finished secondary education	28.0%	38.0%
Population aged 65+	7.6%	5.8%

Epidemiological profile of the verbal autopsy population

The use of COD results in a VA population needs to be undertaken with an understanding of its epidemiological profile. The level of mortality, the prevalence of different diseases and risk factors associated with certain diseases will affect COD patterns in a population.

The following information can be used to understand a VA population's epidemiological profile and to compare it with the national level of other comparator populations:

- Under-five mortality, or 5q0 (probability of dying from live birth to five years of age)
- Evidence on disease prevalence
- Evidence on risk factor prevalence

Hospital deaths within the verbal autopsy population

While VA is mostly conducted for deaths that occur outside of hospitals, it is nonetheless important to understand the number and characteristics of hospital deaths with the VA population. The number of deaths that occur in hospitals is important to know, because it helps measure the completeness of VA deaths as a percentage of non-hospital deaths[11] (see Step 2). Additionally, knowledge of the COD profile of hospital deaths allows hospital and VA CODs to be integrated, which can inform CODs at the population level (see Step 5).

Step 2: Estimate the completeness of VA death reporting

In addition to understanding the characteristics of the VA population and how well it represents mortality conditions in the country, the actual number of VAs that have been recorded will affect how the results should be interpreted. It is important to estimate the completeness of VA death reporting to improve confidence in the usefulness of the data for planning. The less complete death reporting for VA is, the less likely the VA data will accurately represent the CODs among the VA target population. Completeness of VA death reporting below about 60 to 70 per cent should be interpreted with caution.

Completeness of VA death reporting can be measured as the percentage of:

- Total deaths in a population that are captured by VA
- Non-hospital deaths in a population that are captured by VA (this indicator will be more relevant and useful if VAs are only collected for non-hospital deaths).

Methods to estimate completeness

A relatively simple method to estimate the completeness of death reporting as a percentage of all deaths in a population has been developed.[12] This method, developed using empirical data from 110 countries in the GBD Study, enables estimation of completeness of death reporting using only the following data:

- Number of VAs. For the completeness calculation, if VA are not from a 12-month period, they will need to be annualised. For example, if 1000 VAs were collected over three months (i.e. three out of twelve months or one out of four months), the number of VAs will need to be multiplied by the inverse of the fraction (i.e. 4) to get the annualised number of VAs (4000)

11 This may not be complete if data are only available for public facilities

12 Adair T, Lopez AD. Estimating the completeness of death registration: An empirical method. PLoS ONE. 2018; 13(5):e0197047

- Total population in the VA population, which should be the mid-year population
- Percentage of the population aged 65 years and above
- An estimate of the under-five mortality rate for the VA population (number of deaths under five years of age per 1000 live births). National-level estimates can be obtained from the UN Inter-agency Group for Mortality Estimation (IGME)[13] or GBD[14]. Sub-national-level mortality rates can be obtained from DHS data or censuses; this should be scaled to the IGME or GBD estimate.[15] Some VA populations won't have an under-five mortality estimate. In this case, an estimate from the next administrative level should be used (e.g. the state-level estimate used for the district).

Knowledge about the completeness of death reporting is used to estimate the total number of **all deaths** in the VA population (the number of VAs divided by VA completeness, as a fraction).

To estimate the completeness of VAs as a percentage of non-hospital deaths, a few additional calculations are needed (see below). This relies on the availability of the number of hospital deaths of residents of the VA population (see Step 1).

$$\frac{\text{VA deaths}}{\text{completeness (all deaths)}} = \text{estimated total deaths (1)}$$

$$\text{estimated total deaths} - \text{hospital deaths} = \text{non} - \text{hospital deaths (2)}$$

$$\frac{\text{VA deaths}}{\text{non}-\text{hospital deaths}} = \text{completeness (non} - \text{hospital) (3)}$$

This completeness method has some limitations. Firstly, the degree to which hospital deaths are incomplete will affect the validity of this measure of non-hospital completeness of VA. Secondly, the method does not perform well in populations with high mortality at adult ages relative to the level of child mortality, such as countries with high HIV/AIDS deaths. Finally, this method will not work well where the calculated crude death rate for VA is <1 per 1000.

Step 3: Assess the plausibility of the age–sex distribution of deaths from VA

This step involves assessing the plausibility and generalisability of the age-sex distribution of deaths from VA data. This involves (a) assessing the age-sex distribution of VA deaths, (b) comparing the age-sex distribution of VA deaths with a (usually national) comparator, and (c) comparing the age-sex distribution of VA deaths with hospital deaths. Here, plausibility refers to whether VA deaths follow a pattern that would be expected based on what is known about the socioeconomic and epidemiological situation of a country and typical mortality patterns from data worldwide. Generalisability refers to the extent to which VA findings can be used as evidence to inform national level COD patterns.

Assess the age-sex distribution of VA deaths

A histogram can be used to represent the age–sex distribution of deaths. It is expected that, for each sex, the percentage of deaths will increase with age, except for a likely higher percentage of death among infants than other young child ages (see **Figure 2** for an example).

Epidemiological evidence from around the world consistently shows that men have higher death rates than women at almost all ages. The only exceptions are populations with high prevalence of HIV infection or high maternal mortality, and populations where the low status of women and girls in society negatively affects their chances of survival. Typically, the higher rates of male deaths will peak somewhere in the 15- to 34-year age groups, because higher male than female mortality is associated with accidents, suicides and violence. The other (although lower) peak in male deaths is often seen around 55 to 64 years as more males than females tend to die from chronic diseases at those age (particularly in societies where males consume significantly more tobacco and alcohol than females). Deviations from the typical age pattern of excess male mortality are possible, but should be investigated for plausibility. In particular, a higher than expected male to female mortality ratio at any age is likely indicative of differential underreporting of female deaths.

13 United Nations Inter-Agency for Group for Child Mortality Estimates (UNIGME). Child mortality estimates 2018. Retrieved from, http://www.childmortality.org

14 Global Burden of Disease Study 2017 (GBD 2017) Results [Internet]. 2018. Available from: http://ghdx.healthdata.org/gbd-results-tool.

15 The ratio of the sub-national to national under-five mortality rate would be multiplied by the IGME or GBD under-five mortality rate.

Figure 2: Typical age-sex distribution of verbal autopsy deaths (example)

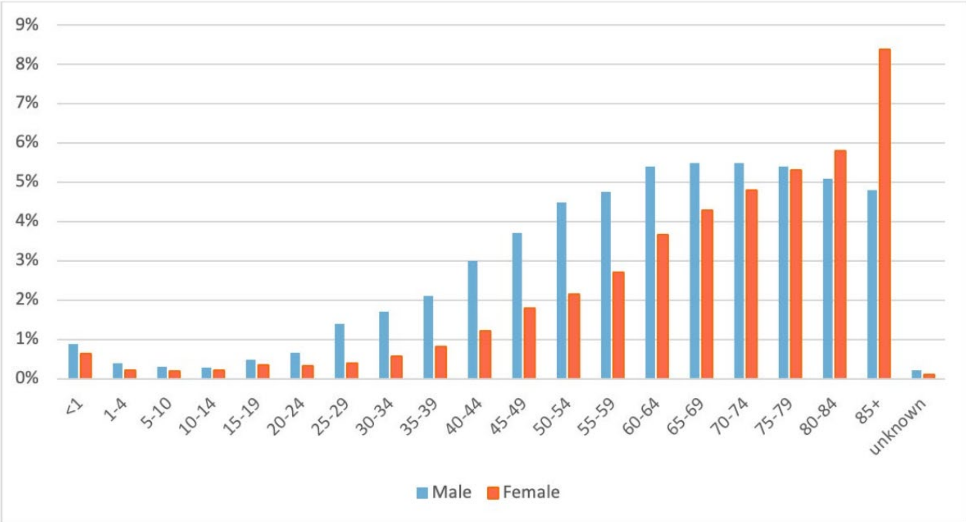
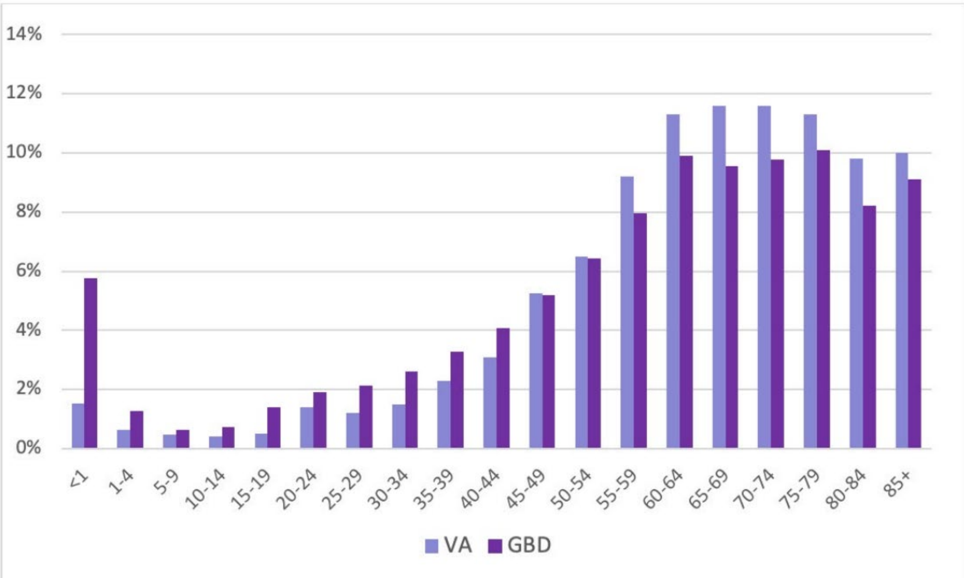


Figure 3: Typical age distribution of deaths, verbal autopsy deaths versus Global Burden of Disease (example)



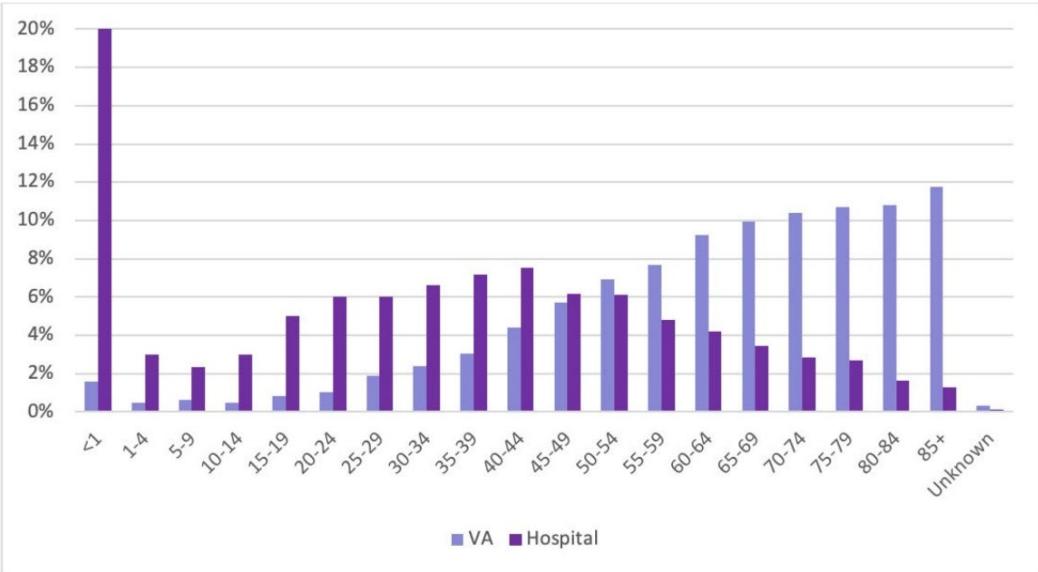
Compare the age-sex distribution of VA deaths with comparator data

Figure 3 shows an example of a comparison between a typical age-sex distribution of VA (males and females combined) and GBD estimates (representing all deaths, including hospital deaths) for a country. As acute cases of infection and injury (incurred by younger more than older people) tend to dominate hospital deaths, community deaths would be expected to have an older age distribution than hospital deaths. This distribution is seen in the example, with deaths at younger ages under-represented in the VA data, and deaths and older ages over-represented compared with GBD estimates. Such information should be considered whenever CODs from different datasets are compared, since older people die from different causes than younger people. It is also important to keep in mind that GBD data are estimates, and should therefore only be used as a guide for national-level patterns. If other good-quality, national-level data on age at death are available, they should be used as the comparator, provided their quality (completeness, diagnostic accuracy) is known.

Compare the age-sex distribution of VA deaths with hospital deaths

The example shown in **Figure 4** compares the age distribution of VA to hospital deaths. Here, the differences in age distribution between hospital and community deaths are more pronounced, with a much younger distribution in hospital than in the VA results. As mentioned in Step 1, there are likely to be fewer neonatal deaths in the community. This is due, in part, to the high proportion of facility-based delivery in many countries (and thereby neonates are more likely to die in hospital) and because community neonatal deaths are often not reported.

Figure 4: Typical age distribution of deaths, verbal autopsy versus hospital deaths (example)



Step 4: Conduct a plausibility analysis on the cause-specific mortality fractions from VA

The fundamental aim of VA is to generate population-level cause-specific mortality data on the leading CODs in populations where physicians are not readily available to certify CODs. This step involves interpreting the COD analysis from VAs and is, therefore, critical for countries to follow if VA data are to be used confidently. This step can be broken into three parts:

1. Assessing the COD distribution generated from VA by analysing the plausibility of the cause-specific mortality fractions (CSMFs) using the information from Steps 1-3 and comparator data.
2. Assessing the plausibility of the CSMFs from VA by exploring the relationship between CODs and risk factors, or co-variates.
3. Calculating the extent and pattern of undetermined and residual CODs.

Step 4.1: Assessing the plausibility of cause-specific mortality fractions from verbal autopsy

The plausibility of CSMFs relates to whether the results conform to what would be expected for a given population. Epidemiological research has established predictable changes in the leading CODs at different stages of life. Communicable diseases such as diarrhoea, meningitis and pneumonia are most common among infants and young children; accidents, injuries, tuberculosis and HIV are major CODs among young adults. In older adults, major NCDs such as heart disease and stroke, cancer, chronic respiratory diseases and diabetes are the most likely CODs. The age pattern of CSMFs, or the distribution of leading CODs at each age, should reflect this epidemiological reality.

The plausibility of the VA COD data can also be assessed by comparing them with other country-level data (e.g. hospital data, health and demographic surveillance system data, GBD data), considering the known biases in all datasets that are being compared. It is critically important for sound interpretation of VA data that there is an appropriate mapping between VA causes and the causes from the comparator data, to ensure that cause categories being compared are the same.

A plausibility analysis of VA CSMF should first examine broad patterns of disease, and then progress to a more detailed analysis within age groups or by location. The extent of analyses that are possible depends on the number of VAs available. It is therefore good practice to always indicate the number of VAs analysed when reporting CSMF results.

Number of verbal autopsies needed to provide reliable cause-specific mortality fractions

VA results can be subject to considerable uncertainty when based on small numbers of deaths, potentially resulting in inaccurate CSMFs and cause rankings. Small numbers of deaths are, however, common for pilot and early phases of VA or where analysis of VA sub-populations (location or age groups) is required, making it important to understand how to carefully interpret CSMFs calculated from these data.

To know how many VAs are required to be sure that results are accurate within a specified range depends on how much certainty policy-makers need. Policy-makers are typically interested in knowing how much confidence they can have in the ranking of causes or how certain they can be about the size of each CSMF. It is important to first understand which of these two policy frameworks are of more importance to users before deciding on the number of VAs required for analysis. Refer to section 4.1 in *Guidelines for interpreting verbal autopsy data* for detailed instructions on selecting verbal autopsy numbers: https://crvsgateway.info/file/18768/3231

Broad categories of causes of death

One way to assess the plausibility of the broad categories, relative to the country's epidemiological transition (changing patterns of population age distributions, mortality, fertility, life expectancy, and causes of death), is to compare them with expected COD distributions based on life expectancy (**Table 3**). Generally, 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 (Group I causes). As life expectancy rises, the pattern of mortality changes, with more deaths occurring in older age groups due to NCDs such as cardiovascular diseases and cancers (Group II causes). The proportion of deaths due to injuries (Group III causes) typically remains constant as life expectancy increases.

Table 3: Expected distribution of cause of death according to life expectance, by broad disease groups[16]

Disease category	Life expectancy (years)				
	55	60	65	70	75
Group I (%) *Infectious and parasitic diseases (e.g. tuberculosis, pneumonia, diarrhoea, malaria, measles); maternal and neonatal causes (e.g. maternal haemorrhage, birth trauma); malnutrition*	22%	16%	13%	11%	8%
Group II (%) *Non-communicable diseases (e.g. cancer, diabetes, heart disease, stroke); mental health conditions (e.g. schizophrenia)*	66%	70%	74%	78%	83%
Group III (%) *Injuries (e.g. accidents, homicide, suicide)*	13%	14%	13%	11%	9%

16 AbouZahr C et al. Mortality statistics: A tool to improve understanding and quality. Working Paper no. 13. Brisbane: University of Queensland School of Population Health, Health Information Systems Knowledge Hub; 2010.

Any large deviations from these patterns might warrant further investigation into whether the different results could be due to the characteristics of the VA population or the fact that VA is performed only on community deaths.

Age pattern of broad causes

Another way to look at broad CODs is according to age. The risk of dying from the different diseases and injuries covered in each group varies with age. For example, a higher proportion of deaths in young children are from diarrhoea and malaria (Group I) than in older ages. Although Group II causes also contribute to some mortality in children, particularly due to congenital malformations, a higher proportion of deaths at older ages, typically 50 years and above, can be expected to occur from these diseases. For Group III, the proportion of deaths is generally highest in young adulthood, particularly for male deaths due to traffic accidents and violence (see **Figure 5**).

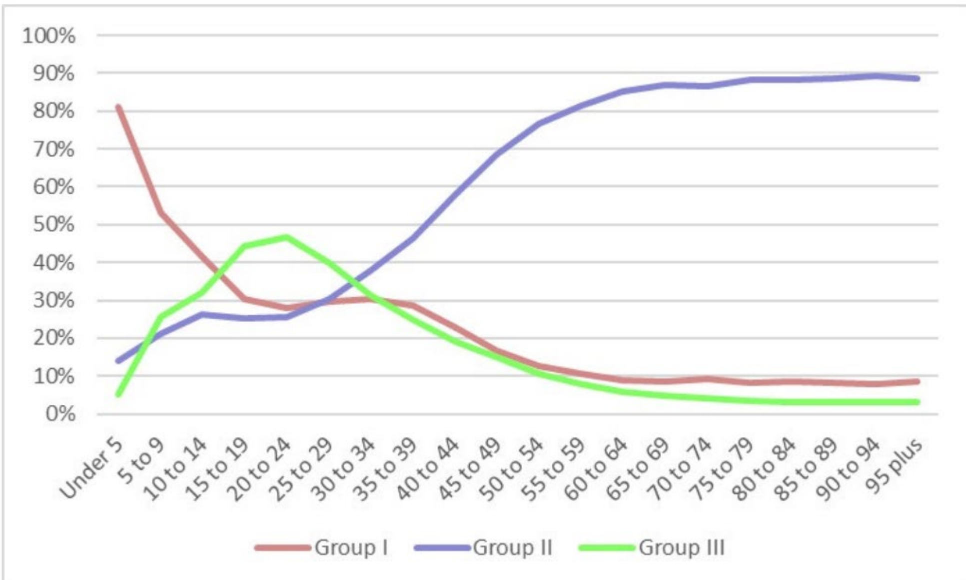
Leading causes of death

Another step in the plausibility analysis for VA CSMFs is to look at the leading CODs. At a minimum, analyse by broad age category following the VA modules (neonatal, child, and adult and adolescent). Since men and women tend to have different CODs, analyse the data by sex, particularly for adults. At the population level, CSMFs are usually distributed so that:

- The first two ranked causes account for 10 to 25 per cent of all deaths each
- The next four causes have CSMFs of three to 12 per cent
- The next five include causes with CSMFs of approximately two to three per cent.

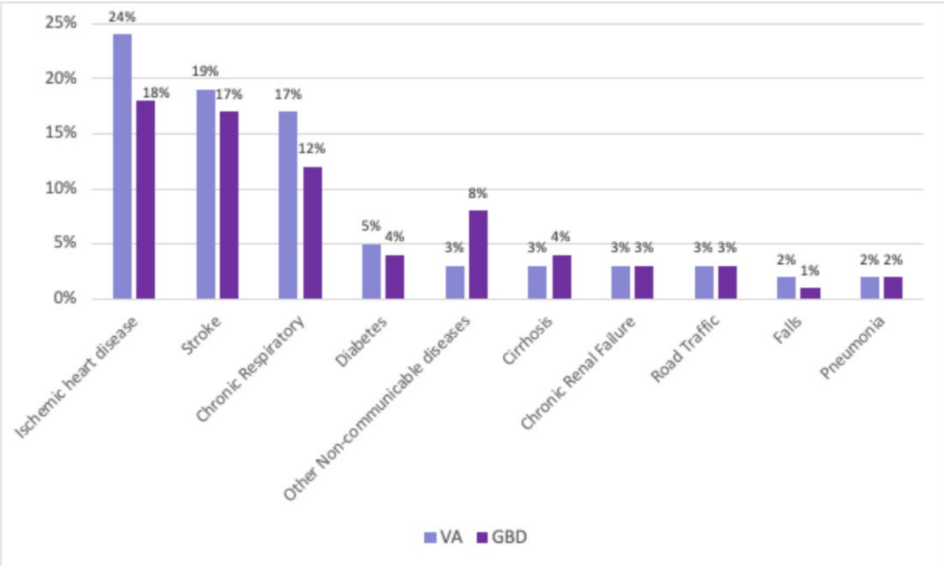
With around 1500 deaths, the top 10 CODs can be identified, although there will be moderate uncertainty for deaths ranked six and below. Comparing this with other data sources (such as GBD data) can help identify potential problems with the VA COD data (see **Figure 6**). However, as previously mentioned, it is not necessarily expected that the COD distribution from VA will be the same as the comparison dataset, depending on the characteristics of the populations that they come from (Steps 1-3).

Figure 5: Typical age distribution of broad causes of death



Source: Global Burden of Disease Study 2017 results website (ghdx.healthdata.org/gbd-results-tool)

Figure 6: Example cause-specific mortality fractions for adults, from verbal autopsy (VA) and Global Burden of Disease (GBD) data



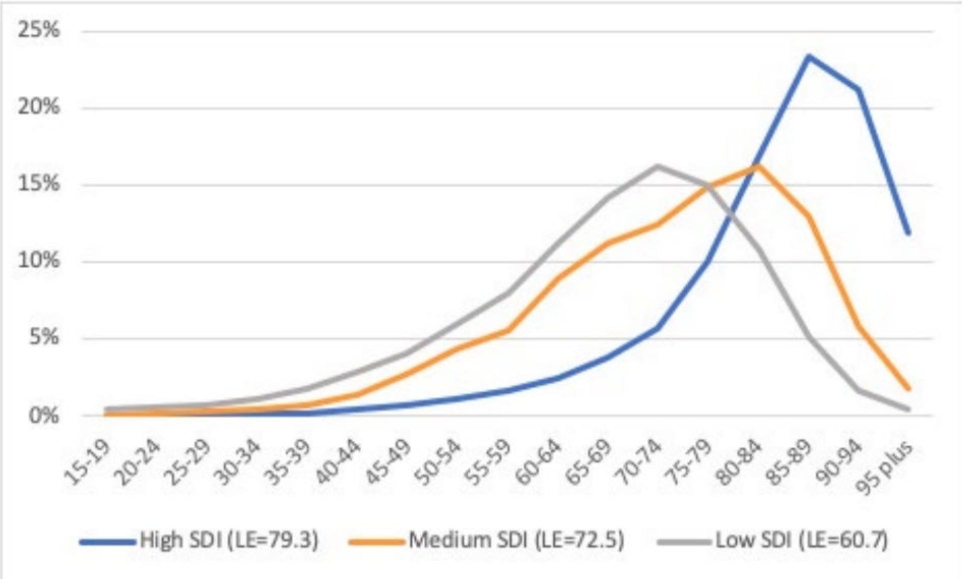
Investigating the CSMF of leading causes by age and sex can also help to understand whether patterns are plausible (see **Table 4**) by highlighting where there is an unexpectedly high or low proportion of deaths due to a disease in a particular age group. Even if these percentages are higher in younger age groups, the actual number of deaths due to these causes is likely to be higher in the older ages, when most deaths occur. For example, in **Table 4,** a larger proportion of women die from diabetes in the 50- to 59-year age group (seven per cent) than the 70- to 79-year age group (six per cent). However, due to the higher number of total deaths in the 70- to 79-year age group, there are more deaths due to diabetes in that age group (178) than the 50- to 59-year age group (94).

Table 4: Cause-specific mortality fractions of selected causes of death by age group

Cause	12-39 years		40-49 years		50-59 years		60-69 years		70-79 years		80+ years	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
AIDS	2%	2%	8%	6%	2%	1%	1%	0%	0%	0%	0%	0%
Chronic kidney disease	2%	1%	7%	3%	5%	2%	4%	1%	1%	1%	1%	1%
Chronic respiratory	3%	1%	4%	2%	8%	5%	8%	9%	13%	11%	12%	12%
Cirrhosis	3%	1%	9%	3%	8%	4%	5%	1%	2%	1%	1%	0%
Diabetes	2%	3%	3%	5%	3%	7%	4%	6%	3%	6%	3%	3%
Drowning	16%	10%	6%	1%	1%	0%	0%	0%	0%	0%	0%	0%
Ischaemic heart disease	2%	3%	9%	7%	15%	13%	17%	19%	18%	20%	20%	22%
Lung cancer	1%	0%	3%	1%	6%	2%	7%	4%	4%	2%	2%	0%
Pneumonia	2%	2%	2%	3%	4%	3%	5%	3%	6%	4%	7%	5%
Road traffic accident	22%	10%	12%	6%	3%	1%	0%	0%	0%	0%	0%	0%
Stroke	4%	3%	9%	7%	12%	15%	17%	19%	21%	23%	18%	20%
Suicide	4%	1%	3%	2%	1%	0%	0%	1%	0%	0%	0%	0%
Tb	4%	2%	5%	2%	7%	3%	4%	2%	2%	1%	1%	1%
Other causes	32%	61%	20%	52%	26%	44%	28%	35%	30%	31%	35%	36%
Total deaths in age-group	**660**	**390**	**2175**	**1243**	**3453**	**1343**	**3467**	**2517**	**2958**	**2966**	**1680**	**2550**

Deaths due to particular diseases tend to follow a predictable age distribution pattern. For instance, **Figure 7** shows the age distribution of stroke by low, middle and high Socio-Demographic Index (SDI) for adult females. Refer to Appendix 10 in *Guidelines for interpreting verbal autopsy data* for more similar figures for other leading causes: https://crvsgateway.info/file/18768/3231. Some diseases, such as ischemic heart disease and other NCDs, show a COD age distribution that is skewed to older ages. For some causes, such as road traffic accidents, the age distribution is skewed to younger ages. Other diseases, such as cirrhosis and diabetes, may peak in the middle age groups. If your VA reveals age distribution of deaths for leading causes that vary significantly from the patterns relevant to your country's SDI, it might be important to investigate to determine whether these are due to real differences in your VA area or country, or whether they are implausible results.

Figure 7: Age distribution of stroke deaths in adult females



Step 4.2: Assessing the plausibility of verbal autopsy outputs in the context of risk factors and health determinants

CODs may be understood in terms of the underlying disease or injury that initiated the train of morbid events leading to death (as defined and classified in ICD), or in terms of the individual exposure or population-level characteristics that an individual experiences and that have been shown to increase the risk of death. These exposures or population characteristics are generally known as risk factors, and may be related to a disease or injury. Understanding the risk factors associated with, or present in, a population will help to assess the plausibility of the CSMFs.

Example questions to be asked when interpreting CSMFs from VA include:

- Is HIV prevalence known to be high?
- Does the population live in a malaria-endemic zone?
- Is much of the population exposed to rivers, lakes or other large water bodies where drowning is more likely?

In other words, understanding the likely extent of exposure of the population to large, predictable causes of disease and injuries will help assess the plausibility of the disease and injury patterns that the VA data are suggesting for that population. For example, if smoking is prevalent in a population (and has been for the past 20 to 30 years), the CSMFs should be relatively high for causes for which smoking is a major risk factor, such as lung cancer, heart disease and chronic obstructive pulmonary disease. If more men in the population smoke and drink alcohol than women, then diseases precipitated by these risk factors should comprise a higher proportion of deaths for men than for women.

Step 4.3: Calculating the extent and pattern of undetermined and residual causes of death

Undetermined causes of death

Since VA is a relatively blunt diagnostic procedure, it is reasonable to expect that the probable CODs will be difficult to determine if the reported pattern of symptoms experienced by the deceased is complex, confusing or poorly recalled by the family member responding to the VA interviewer.

When interpreting VA data, it is important to analyse the number and characteristics of the undetermined CODs to see how they vary according to age or location. For instance, while high fractions of undetermined CODs (typically more than 20 per cent) can significantly affect the interpretation of COD patterns, a threshold of 10 to 20 per cent of undetermined CODs might be a reasonable expectation for established VA areas where VA interviewers have had enough time to develop their interview skills and where the population is accustomed to the VA methods. Higher levels of undetermined causes should signal potential problems with the interviewer methods or skills, and indicate the need for reappraisal and, potentially, refresher training.

Countries should investigate the following from the VA dataset:

- **Do the numbers of undetermined CODs increase with age?**
  It is expected that most of these deaths will be in older ages where symptoms may be vague with greater likelihood of comorbidities before death. If a significant fraction (>30 per cent) of all undetermined CODs occur in the younger age groups (<70-75 for females or <60-65 for males), data collection procedures should be reviewed.
- **Is the number of undetermined CODs reasonably standard across different sites?**
  If undetermined levels are unacceptably high across all sites, this could indicate a systemic problem (e.g. translation, training or choice of health worker to conduct VA). These are higher order issues that need to be addressed.
- **Are there differences between regions implementing VA?**
  This may point to a problem with the quality of some VA interviewers, or the training and supervision offered *in those places* which needs to be addressed.

The proportion of undetermined CODs should always be considered when interpreting CSMFs. Ignoring undetermined CODs can lead to biased CSMFs because certain causes and ages are more likely to be assigned to undetermined.

Residual categories

Sometimes the information gathered from a VA interview is not sufficient to assign a specific COD, but is sufficient to assign a broad COD, such as cancer. For these broad COD groups, VA uses a residual cause category called ‘other’.

Public health action is typically focused on controlling specific diseases or injuries (e.g. lung cancer, breast cancer, road traffic injuries). For COD data to be useful for monitoring and evaluating policy responses to these diseases or injuries, they need to be able to be separately identified in the COD data system of a country. Leading COD lists where ‘other’ or residual categories of diseases – such as ‘other cancers’, ‘other CVDs’ (cardiovascular diseases), ‘other injuries’ – are the common outputs from a VA are likely to be less useful for informing public health action. The presence of such residual categories among VA output can increase uncertainty about the relative importance of specific conditions and, hence, significantly affect the value of the data for public health policy.

Although VA cannot disaggregate these causes further, it is possible to estimate the probable composition of these residual categories using information from external sources such as hospital data or the GBD cause-specific estimates. It is recommended, however, that countries not over-disaggregate the residual categories. Since the purpose of this post-hoc VA analysis is to try and identify what are likely to be the main diseases or injuries in each, users should only attempt to identify causes among the residuals that account for about one per cent of deaths overall, since CSMFs lower than this threshold are likely to be uncertain and uninformative for deciding policy priorities.

Step 5: Present the main findings of your VA data for policy action

VA results need to be presented in a simple, concise and meaningful way for policy-makers to quickly grasp the messages and implement actions.

This step deals with three key aspects of interpreting data for policy-making:

1. Information from VAs needed by policy-makers
2. Best types of visualisations to use to communicate the data
3. Principles for integrating VA and MCCOD data.

Information needed by policy-makers

If senior-level policy-makers have directed resources to implementing VA to scale in their countries, it is because they want to know about CODs in their populations but do not have enough information to inform public health planning. They will not need to know a lot about the VA method itself, which will be a matter for the technical experts and implementers. Rather, they will be looking for summaries of the VA findings in terms of their implications for policy. Generally, policy-makers require information that is clear, succinct, simple and – above all – actionable.

Materials should be written in non-technical language and be action-oriented. The most efficient vehicle for this purpose is a policy brief or report, which should comprise:

- A short presentation of the findings from VA directed to a non-specialised audience
- A succinct exploration of the challenges and lessons learned from the VA implementation
- An overview of policy options and advice

Indirect approaches can also be an effective means of targeting secondary audiences that influence policy-makers. Secondary targets include academics and researchers, the media, health professional entities, non-government organisations and civil society.

Visualising data for communication

Whether you are preparing visualisations for a policy brief or for another audience, there are some key considerations required to ensure that the visualisations you include have the effect you want. For instance, what is appropriate to include in a policy brief is different from what you would want to have in a professional journal or PowerPoint presentation.

Basic guidelines for visualising statistics, including examples of good and bad charts and tables, can be found in the Learning Centre on the CRVS Knowledge Gateway: https://crvsgateway.info/Introduction~382

Integrating verbal autopsy and medical certification of cause of death data

For countries to understand their overall national mortality statistics and to be able to track national and international targets, different sources of mortality data will need to be integrated. The quality, completeness and accuracy of the different datasets (e.g. VA and MCCOD) need to be carefully examined and adjusted based on known biases. If the integrated data sources include deaths from different populations (e.g. community deaths versus hospital deaths), the data will need to be weighted according to the fraction of all deaths happening in these discrete populations.

The data post-aggregation will also need to be examined to ensure overall mortality statistics are plausible, based on principles outlined in the ANACONDA guidance and software.[17] This is an iterative process that aims to produce national mortality statistics, and helps users to better understand the quality of different data sources and to put in place actions to improve them.

Integration of VA and MCCOD data is a five-step process involving:

1. Separately assessing characteristics, strengths and weaknesses of CSMFs for MCCOD and VA data
2. Estimating the number of deaths that occur in the community and in hospitals
3. Mapping MCCOD causes to VA causes
4. Estimating the number of deaths (by age and sex) for each cause
5. Calculating the CSMF for all deaths (community and hospital deaths combined).

Integration assumes a large number of VAs from community deaths are available. Such integration is not recommended if VA is at early stages of implementation.

For detailed guidance on integrating VA and MCCOD data, see *Integration of data from medical certification of cause of death and verbal autopsy* available on the CRVS Knowledge Gateway at: https://crvsgateway.info/file/19400/4534

Conclusion

VA is an important source of information on CODs, especially in populations where a large proportion of deaths occur outside hospitals and do not have a physician to complete a medical certificate of COD. As a relatively new source of routinely collected information, it is particularly important that the VA data are analysed to assess plausibility of cause-specific mortality fractions, given other known factors in the country and in the VA population. During the earlier stages of VA implementation, the data should be analysed often. During later stages, the data should be analysed ideally as part of routine monitoring (two or four times each year), and COD statistics compiled and assessed once a year.

17 ANACONDA mortality data quality assessment tool (https://crvsgateway.info/ANACONDA-Mortality-Data-Quality-Assessment-Tool~686)

The program partners on this initiative include: The University of Melbourne, Australia; CDC Foundation, USA; Vital Strategies, USA; Johns Hopkins Bloomberg School of Public Health, USA; World Health Organization, Switzerland.

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