UNITED NATIONS EXPERT GROUP MEETING ON THE METHODOLOGY AND LESSONS LEARNED TO EVALUATE THE COMPLETENESS AND QUALITY OF VITAL STATISTICS DATA FROM CIVIL REGISTRATION

Lessons learned from recent experiences with the evaluation of the quality of vital statistics from civil registration in different settings

Tim Adair, School of Population and Global Health, University of Melbourne, Australia

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Background

Civil Registration and Vital Statistics (CRVS) systems should play an important role in providing governments with timely and reliable data on fertility and mortality as evidence for program and policy development. However a significant proportion of the global population reside in countries where CRVS systems are incomplete.[1] In such countries there needs to be regular and routine assessment of the completeness of birth and death registration, to assist in monitoring CRVS system performance and to, if necessary, adjust registration data to produce fertility and mortality statistics.

This paper describes recent experiences and with the assessment of the completeness of death registration in the Data for Health Initiative (D4H). The D4H project is strengthening CRVS systems in 18 low-to-middle income countries and cities that have systems of varying levels of maturity and completeness. It focuses on the availability of vital registration and other data to estimate completeness in D4H countries, the most appropriate methods for countries to apply to estimate completeness given available data, current methods employed by countries, existing in-country capacity and D4H activities to build capacity in the countries. The paper considers some of the lessons learned from these activities, and provides some guidance to assist countries to appropriately make routine assessments of the completeness of registration.

Data for Health Initiative (D4H)

The D4H Initiative, which commenced in 2015, is a project jointly funded by Bloomberg Philanthropies and the Australian Department of Foreign Affairs and Trade. The CRVS component of the project aims to strengthen birth and death registration systems in 18 countries/cities.

[1] AbouZahr, C., de Savigny, D., Mikkelsen, L. et al., (2015), Civil registration and vital statistics: progress in the data revolution for counting and accountability, *Lancet*, 386: 1373-85, p1374.

The 18 countries and cities in the D4H project are shown in Table 1:

Table 1: D4H project countries/cities

Africa	**Asia-Pacific**
Ghana	Bangladesh
Malawi	Mumbai (India)
Rabat (Morocco)	Indonesia
Rwanda	Myanmar
Tanzania	Papua New Guinea
Zambia	Philippines
Latin America	Shanghai (China)
Brazil	Sri Lanka
Ecuador	Solomon Islands
Peru	

The partner organisations of the CRVS component of D4H are University of Melbourne, Vital Strategies (formerly Union North America) and the Centers for Disease Control. D4H-CRVS project interventions include technical assistance to improve practices to register of births and deaths, improve the quality of cause of death information at hospitals, apply verbal autopsy to better understand probable causes of death in communities, assessment of the completeness and quality of registration data and building data analysis skills for policy and program analysis.

The D4H activity to assess the completeness of birth and death registration comprises three stages:

1. Assessment of country's own estimate of completeness of birth and death registration.
2. Independent baseline estimate of completeness of death and birth registration using publically available data by the Institute of Health Metrics and Evaluation, University of Washington and University of Melbourne.
3. Training of country specialists to understand and apply methods to measure registration completeness. This training may also involve access to additional data sources to estimate completeness (e.g. additional vital registration data, other census or survey data), which may adjust the independent baseline assessment.

This activity is important to improve the ability of national statistical organisations or other relevant institutions to apply appropriate methods to assess completeness of registration.

Methods to estimate completeness of death registration

This section provides a brief review of methods to estimate the completeness of death registration. These methods can be grouped as:

- Indirect or death distribution methods.
- Direct or capture-recapture methods.
- Estimating total deaths from multiple data sources, which forms the denominator in the calculation of completeness of registration.

Indirect or death distribution methods are a group of measures that estimate the completeness of death registration from data of the age distribution of the population and the age distribution of deaths. Death distribution methods measure the proportion of all deaths that are registered at ages 5 years and above. Detailed description of the methods is made elsewhere[2] [3], however they can be classified into two groups: growth balance methods and synthetic extinct generations methods (see Table 2). Within each of these two groups, there is a method that relies on population data at one point in time and uses the assumption of a stable population (i.e. Brass Growth Balance [4] and Preston-Coale methods[5]) and another that utilises population data by age group at two points in time (i.e. two censuses) and assumes a closed population (i.e. Generalised Growth Balance [6] and Bennett-Horiuchi or Synthetic Extinct Generations methods [7]). Given that the assumption of a stable population is restrictive and unlikely to be realistic in most populations, the D4H assessment of completeness and this paper only focus on the two methods that utilise population from two points in time.

Table 2: Summary of indirect methods

Method	**Assumption**	**Population data required**
Growth balance methods		
Brass Growth Balance	Stable population	Population by age group
Generalised Growth Balance	Closed population*	Population by age group from two censuses (or at two points in time from another source)
Synthetic extinct generations methods		
Preston-Coale	Stable population	Population by age group, population growth rate
Bennett-Horiuchi (also known as Synthetic Extinct Generations)	Closed population*	Population by age group from two censuses (or at two points in time from another source)

Note: each method requires the age distribution of deaths from the CRVS system as inputs.

[2] Dorrington, R., (2013) The generalized growth balance method, in Moultrie, T. et al. *Tools for Demographic Estimation*, Paris: IUSSP, pp. 258-274.
[3] Murray C.J.L., et al. (2010) What can we conclude from death registration? Improved methods for evaluating completeness, *PLoS Med* 7(4): e1000262.
[4] Brass W. (1975) *Methods for Estimating Fertility and Mortality from Limited and Defective Data*, Chapel Hill NC: Carolina Population Centre.
[5] Preston S.H. et al., (1980) Estimating the completeness of reporting of adult deaths in populations that are approximately stable, *Population Index*, 46: 179–202.
[6] Hill, K. (1987). Estimating census and death registration completeness, *Asian and Pacific Census Forum*, 1(3):8–13, 23–24.
[7] Bennett, N.G. & Horiuchi, S., (1981) Estimating the completeness of death registration in a closed population, *Population Index*, 47(2): 207–221.

The advantages of indirect methods is that they rely on commonly available data - intercensal death registration data by age and sex, population data from two censuses by age and sex and possibly migration data – to estimate the completeness of intercensal registered deaths. They are not necessarily time and resource intensive and can be applied in many settings.

A drawback of indirect methods is that the assumption of a closed population may not be relevant to most populations, especially subnational areas where there is high internal migration. However this assumption can be overcome by incorporating age-sex-specific net migration data into calculations, however such data are not available for many populations. Age trimming (i.e. applying the methods to a limited age range, e.g. 40-70 years), can reduce bias from high levels of migration in young adulthood; Murray and Hill have suggested using age trims for this purpose.[8] [9] The indirect methods also assume constant completeness at all ages above five years, cannot be used for ages less than 5 years and rely on accurate age reporting. The timeliness of estimates is also problematic – they assess the completeness of intercensal deaths, which might be a period of 5-15 years ago, or even earlier. They also require a country having more than one census in recent years to provide timely estimates of completeness; timeliness is a problem if there has only been one census in the past 20 years. Another problem is there is significant uncertainty of the completeness estimates of approximately plus or minus one-quarter of the estimate.[10] A common approach for using indirect methods is to apply a hybrid method; using the Generalised Growth Balance method's measurement of the relative completeness of the two censuses and the Bennett-Horiuchi method's measurement of completeness of death registration.

Direct or capture-recapture methods directly match an individual death record from registration data to another independent source[11]. This independent source could be existing data from a HDSS site, or household death reporting in a survey or census (where a respondent is asked to report details of household members who had died within a defined period of time). Conducting a separate survey to collect data on household deaths is not time or resource efficient, given the large number of households that need to be visited to collect a sufficient numbers of deaths to provide reliable estimates. Direct methods rely on high quality data that can be linked, so it can be difficult and time-consuming to match deaths from two sources, due to missing data, errors in spelling of name and errors in reporting of dates. Finding a data sources that is truly independent from registration data can also be problematic. The two data sources should also relate to the same population (i.e. same geographic boundaries and definition of residency, minimal migration). Direct methods have an advantage that they are more readily interpretable by policy makers than indirect methods, 95% confidence intervals can be readily computed and, when there are enough deaths, can enable completeness estimates to be made at the sub-national level or by demographic group (e.g. age). Direct methods cannot be applied in all settings given their data requirements.

Another approach is to calculate completeness as the number of registered deaths divided by an estimate of the actual number of deaths in the population. The actual number of deaths can be

[8] Murray C.J.L., et al. (2010)
[9] Hill, K., You, D. & Choi, Y. (2009) Death distribution methods for estimating adult mortality: Sensitivity analysis with simulated data error, *Demographic Research*, 21(Article 9): 235–254.
[10] Murray C.J.L., et al. (2010)
[11] Chandrasekar, C., Deming, W. (1949) On a method of estimating birth and death rates and the extent of registration, *Journal of American Statistics Association*, 44: 101.

estimated by modelling mortality rates generated from a range of data and methods. Estimates are be made of adult mortality rates (${}_{45}q_{15}$) and under-five mortality rates (${}_{5}q_{0}$) over time (e.g. a period of 20-30 years) using a range of methods (e.g. summary and complete birth histories, sibling survival data, reported household deaths, death registration adjusted for completeness measured by indirect methods). Trends in both adult mortality rates and under-five mortality rates are modelled based on this time series of estimates of mortality rates from different sources and methods. Mortality rates beyond the most recent year of data can be projected, along with uncertainty intervals, using estimated trends. These mortality rates are used as inputs into a model life table to produce a complete life table for that population. The Global Burden of Disease (GBD) and United Nations World Population Prospects use a similar approach to estimate total deaths in a population. [12] [13] [14] These methods are particularly valuable where indirect and direct methods cannot be applied due to availability of data.

Experiences with the assessment of completeness of death registration in D4H countries and cities

This section describes some preliminary findings from assessment of completeness of death registration in the 18 D4H countries and cities. The following topics are covered:

- Availability and quality of CRVS data.
- Non-CRVS data sources to estimate completeness.
- Methods to estimate completeness.
- In-country capacity and D4H capacity building activities.

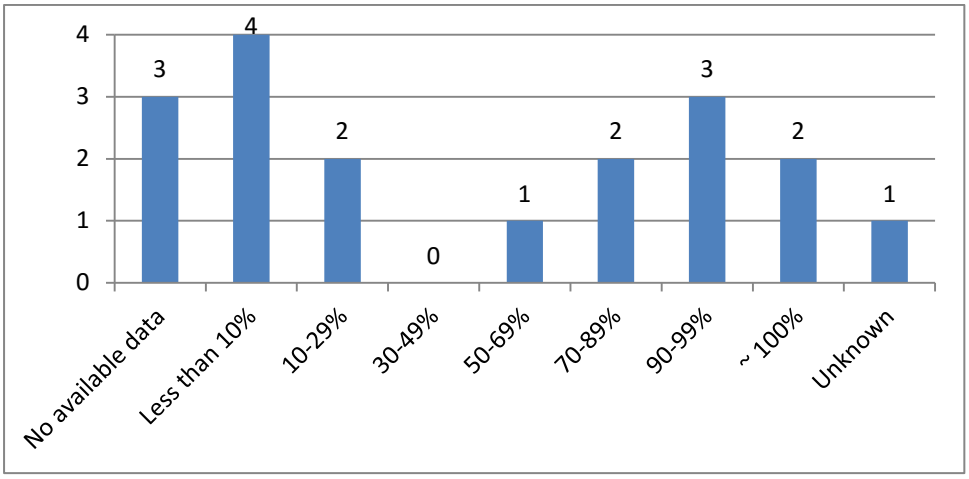
The range of levels of death registration completeness in the 18 D4H countries and cities according to the independent baseline estimate of completeness is shown in Figure 1.

[12] United Nations, Department of Economic and Social Affairs, (2015) *World Population Prospects: The 2015 Revision*, http://esa.un.org/wpp/

[13] GBD 2015 Mortality and Causes of Death Collaborators, (2016), Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 388: 1459–544.

[14] Wang, H.A. et al. (2012) Age-specific and sex-specific mortality in 187 countries, 1970–2010: a systematic analysis for the Global Burden of Disease Study 2010, *Lancet*, 380: 2071–94.

Figure 1: Level of completeness of death registration in D4H countries/cities



No available data: no aggregated data available to analyse. Completeness likely close to 0%.
Unknown: Government have not made number of registered deaths available.

Availability and quality of CRVS data

As shown above, three D4H countries/cities do not have any death registration data available for analysis – in these places a CRVS system does exist, however data have not been aggregated for analysis. Of the remaining 15 countries and cities:

- 7 have less than 10 years of data available, and
- 8 have at least 10 years of data available.

The low number of years of data has implications for being able to death distribution methods to estimate completeness of intercensal death registration.

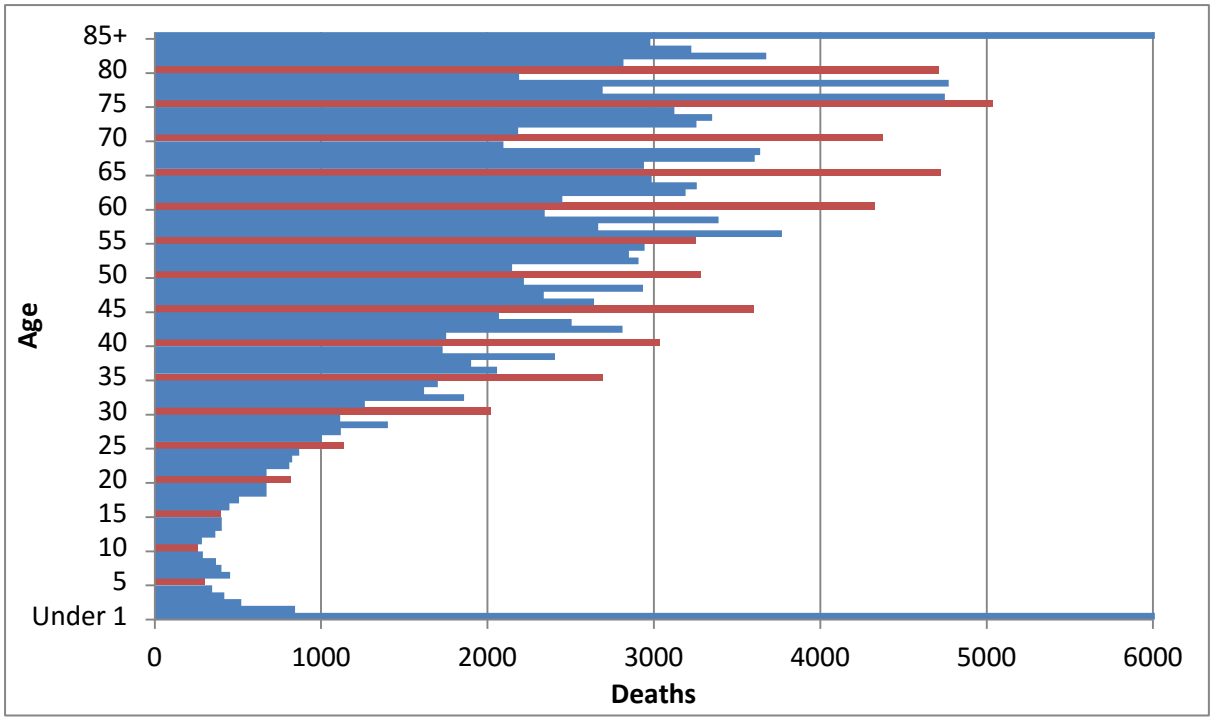
Another issue with vital registration data in D4H sites is the inconsistency of definition used to classify vital events by year. Where possible, the year of death should be classified as year of occurrence, with information included on delayed and late registration.[15] However, some countries classify deaths using a definition of year of registration (e.g. Peru's national vital statistics publication[16]). Three countries/cities use a definition of 'deaths that occurred and were registered in the same calendar year'.

In addition to completeness, the quality of age reporting in CRVS data is also an issue in some countries/cities. In some countries/cities that make data available by single year of age, heaping of deaths at ages ending in 0 and 5 is a significant problem (see Figure 2 for a country example). In another site, the Whipple's Index for ages ending in 0 or 5 is in excess of 200 (i.e. twice as many deaths reported at ages ending in 0 and 5 compared with what there would be with a no age heaping). In most settings with age heaping of deaths, the problem emanates from there being no

[15] UN Statistics Division, (2014), *Principles and Recommendations for a Vital Statistics System, Revision 3,* Department of Economic and Social Affairs, UN Statistics Division, New York, http://unstats.un.org/unsd/demographic/standmeth/principles/M19Rev3en.pdf,
[16] Instituto Nacional de Estadística e Informática (2015), *Perú: Natalidad, Mortalidad y Nupcialidad*, 2014, Instituto Nacional de Estadística e Informática, Lima.

date of birth of the deceased on the registration form, and only an item for reporting age at death. Poor age reporting has implications for the application of indirect methods of completeness estimation, which rely on accurate age reporting.[17]

Figure 2: Number of registered deaths by single year of age



Note: Red bars show deaths for each age that ends in digits 0 or 5.

In D4H cities, there is also are most likely problems with the reporting of usual place of residence of the deceased. In two of the cities, there is a completeness of death registration in excess of 100%. This may be due to over-reporting of deaths of residents in the city (i.e. due to deaths of non-residents being recorded as deaths of residents), uncertainty about the estimate of total deaths or low level of completeness of population data. Is likely that poor quality of residence data contributes to completeness of greater than 100%, given that it is possible that a family member of the deceased may confuse place of usual residence and where they may have lived in the period prior to death.

Non-CRVS data sources to estimate completeness

The availability of non-CRVS data sources is important to assist in the estimation of death registration completeness. Indirect methods that measure intercensal deaths require population data from two censuses. Of D4H countries, Myanmar has only conducted one census in the previous 30 years (2014); the greatly restricts the methods that could be applied in this setting.

[17] This can be mitigated somewhat by age smoothing,

While all countries/cities have ${}_5q_0$ data, some countries have no ${}_{45}q_{15}$ data. For example, in Myanmar there are no publically available data on ${}_{45}q_{15}$, even though reported household deaths were collected in the 2014 census. That census was conducted by the Ministry of Labour, Immigration and Population, which is different from Central Statistical Office who has responsibility for publishing CRVS data.

Many D4H countries/cities also have household deaths in their most recent census, however the feasibility of linking such data to the CRVS has yet to be ascertained. Some D4H countries/cities have data from HDSS sites to link to CRVS data, however these will be of limited use to provide estimates of completeness at the national level.

Methods to estimate completeness

As a result of the availability of both CRVS and non-CRVS data sources, indirect methods using two censuses can only be applied in 7 out of the 18 D4H countries/cities. These countries have population data from two censuses and death registration for the entire intercensal period. In remaining countries, there is a reliance on estimating deaths from multiple data sources. In these countries, where there are no or limited ${}_{45}q_{15}$ data, there are implications for the extent of uncertainty. For example, in Myanmar estimated deaths are 410,958 but with 95% uncertainty intervals of 275,812 to 560,627.[18] This issue is particularly relevant for subnational areas.

There are a range of methods are employed by D4H countries/cities to estimate the completeness of their death registration. These methods are primarily utilised by either the national statistical organisation or the ministry of health (whoever has responsibility for producing vital statistics). The methods employed in many cases lack rigour. Some examples of methods applied are:

- Use of the Preston-Coale method, even when intercensal indirect methods could be applied to intercensal registered deaths. The estimate of completeness is significantly different from the independent assessment by the D4H project.
- Estimating total deaths simply by summing the highest number of deaths reported by each of three sources in each township. The three sources of data are the statistics office, ministry of health and ministry of population.
- A capture-recapture study from 7 years ago.
- Assuming a crude death rate of 10 deaths per 1,000 and multiplying this by the estimate of population.
- Assuming 100% completeness.
- No assessment conducted.

In-country capacity and D4H capacity building activities

The range of methods employed that are described above suggests a lack of capacity to reliably estimate completeness in some D4H countries/cities. While capacity has not been fully assessed in

[18] GBD 2015 Mortality and Causes of Death Collaborators, (2016), op. cit.

all countries/cities at this stage, in some countries capacity is limited to fairly basic demographic skills (e.g. life tables), with no knowledge of any completeness estimation techniques. This is appears to be a result of the low priority placed on estimating completeness and the lack of previous training opportunities to conduct such an assessment.

There does appear to be enough existing capacity in many of the countries to be taught indirect and direct estimation techniques, however these can only be applied in less than half of D4H countries. Teaching more complex statistical modelling such as that used in the GBD and UN World Population Prospects is more challenging given available capacity, especially in those countries with a lack of data to apply indirect estimation methods and therefore needing to apply these methods. In such countries there is a significant gap between skills to apply the most appropriate methods and existing capacity.

The D4H project is conducting a 3-4 day training course in project countries/cities on the topic of estimating the completeness of registration. Such a course is important to ensure that countries are appropriately employing appropriate methods to estimate completeness. The structure and content of the curriculum varies depending on the existing capacity and available data sources in each country.

The target audience for the training is practitioners (e.g. demographers, statisticians, epidemiologists) who have routine responsibility for generating fertility and mortality estimates from the CRVS system. Such practitioners may be located in the National Statistics Office, Ministry of Health, or the institution responsible for CRVS (e.g. Ministry of Internal Affairs).

The objectives of the training are that participants will be able to:

- Understand how to utilise a range of methods to estimate the completeness of birth and death registration, including how to critically evaluate the strengths and limitations of each method.
- Select the most appropriate method(s) to utilise to estimate the completeness of birth and death registration for given their country's demographic characteristics and available data.
- Use the completeness estimate to adjust death and birth registration data and generate summary mortality and fertility measures, while appreciating the assumptions and limitations of the method(s) employed.

Topics covered by the training include:

- Purposes of estimating completeness
- Data sources
- Summary measures of mortality and fertility
- Direct or capture-recapture methods
- Indirect methods
- Estimating mortality and fertility rates from a range of data sources

The training includes significant course time for participants to apply methods to own country's data. Post-training follow-up and supervision is provided to assist skills learnt to be incorporated into countries' routine CRVS functions.

Lessons learned from completeness assessment and guidance for improving country application of appropriate methods to routinely estimate completeness

While it is difficult to make generalisations about a groups of countries with diverse quality of CRVS systems, some specific lessons are apparent:

- 10 of the 18 countries/cities have less than 10 years of computerised death registration data countries available for basic aggregation. This has implications for the application of death distribution methods.
- Where data are available, the quality of age reporting is quite poor in some cases.
- Measurement of completeness of registration can have significant uncertainty where this is a lack of other data sources available - a prime example is Myanmar where there are no ${}_{45}q_{15}$ estimates available. This is particularly apparent at the subnational level. At least some assessment of other sources of ${}_{45}q_{15}$ should be made, especially household reporting of deaths in a census which can potentially be linked with CRVS data.
- There is an apparent lack of capacity within many countries to appropriately apply methods to estimate completeness. Where methods are applied, there is insufficient appreciation of method assumptions. This stems from a lack of training in appropriate methods to estimate completeness, as well a relatively low priority given to CRVS data as a potential source of mortality statistics by some statistical offices.
- This lack of capacity is exacerbated by the relative complexity of methods that need to be applied in countries where there is a lack of data (e.g. GBD methods where no ${}_{45}q_{15}$ data exists Myanmar). Such methods are significantly beyond the capacity of the vast majority of analysts in national statistical offices.

Below is some guidance for countries based on the lessons learned from D4H completeness assessment activities.

- Improve the availability of death registration data as back as practical for analysis by providing readily analysable unit record files of deaths with a complete list of variables available on the death reporting/registration form.
- Improve the quality of death registration data by taking steps such as adding date of birth of the deceased to the death registration form and having a clear definition of place of residence. The UN Principles and Recommendations for a Vital Statistics System provide recommendations on these.[19] This should be complemented by having sufficient data quality control mechanisms at various stages within the system.
- Make estimation of death registration completeness a higher priority within the national statistical office and a routine activity of the CRVS system. Adequately resourced and train

[19] UN Statistics Division, (2014), op. cit.

staff with the responsibility to estimate completeness, and provide access to all available data useful for its estimation.

- Report the level of completeness of death registration in national vital statistics publications.
- Report deaths by year of occurrence, with separate reporting of late registrations, in national vital statistics publications.
- Investigate linkage of vital registration data with household deaths in the 2010 census round.
- Investigate linkage of vital registration data with HDSS or other data sources.
- Retain inclusion of household deaths in 2020 census round – but greater focus on quality of data (especially date of birth of the deceased).

Below is some guidance for the international experts based on the lessons learned from D4H completeness assessment activities.

- Promote estimation of completeness as a core routine activity of a CRVS system.
- Develop and conduct training activities to strengthen the ability of country statistical offices to estimate completeness of death registration using a range of methods.
- Investigate ways to bridge the gap between appropriate methods and available capacity in settings where a lack of available data sources requires use of advanced modelling techniques.

Feedback from meeting participants about the issues raised in this paper is most welcome.