MATERNAL MORTALITY MEASUREMENT

Guidance to improve national reporting
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For any further information relating to this guidance, you may contact Dr Jenny Cresswell (email: cresswellj@who.int) and Dr Lale Say (email: sayl@who.int) of the WHO Department of Sexual and Reproductive Health and Research and HRP.
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Executive summary

Background

Reducing maternal mortality is a prominent part of the Sustainable Development Agenda. Specifically, it is the first target of the Sustainable Development Goal on health and well-being (SDG3, target 3.1). The target is to reduce the global average maternal mortality ratio (MMR) to below 70 per 100,000 live births by 2030, and it has two associated indicators: MMR and the proportion of births attended by skilled health personnel. The United Nations Maternal Mortality Estimation Inter-Agency Group (MMEIG) synthesizes the available data on maternal mortality from a wide range of national sources, involving a multistage consultative process, and publishes data on the estimated numbers of maternal deaths and the estimated MMR at country, regional and global levels, adjusted to be internationally comparable. These data are used to monitor progress towards the SDG target.

In 2017, the global MMR was estimated at 211 maternal deaths per 100,000 live births, with wide disparities indicated by the MMR of 462 in low-income countries versus 11 in high-income countries. In 2021, the steering committee on ending preventable maternal mortality (EPMM – co-chaired by the World Health Organization [WHO] and the United Nations Population Fund [UNFPA]) launched interim milestone targets to support countries’ progress each year up to 2025, and then onwards to 2030. The MMEIG supports country-led efforts to improve maternal mortality measurement, through regular dialogue and consultations.

As we approach 2023 – the mid-point for the SDGs – and continue to monitor progress towards achieving the targets, improving measurement of maternal mortality is more pertinent than ever. It is crucial, not just for monitoring progress against the target globally and in countries, but to inform the development and monitoring of the policies, programmes and interventions that improve maternal health and help to end preventable maternal deaths. Challenges and biases in maternal mortality measurement not only affect populations in vulnerable, marginalized, humanitarian and fragile settings, they exist in all settings, including countries with high, medium and low burdens of maternal mortality.

To improve the accuracy of maternal mortality measurement and track the progress towards targets, two types of reporting error – incomplete reporting and the misclassification of causes of death – need to be quantified so that appropriate and evidence-based adjustments can be made. Incomplete reporting is also known as missingness or underreporting, and results from deaths not being registered into a designated data-collection system. Misclassification happens when the cause of death is not accurately documented, which affects whether the death is considered to be a “maternal death” or not. The most common reasons for incompleteness and misclassification, and potential solutions to reduce these errors, are a key focus of this guidance.
Rationale, audience and aims of the guidance

While working as part of the MMEIG to enhance data validity, WHO has noted the emergence of common themes about the challenges of measuring maternal mortality at the national level, and it has become evident that countries could benefit from relevant guidance. Strengthening national-level maternal mortality data will ultimately improve the robustness of the inputs used to develop the MMEIG maternal mortality estimates. This guidance is intended to support personnel working in ministries of health, national statistics offices and other national agencies responsible for maternal mortality data collection.

The aim of this operational guidance is to outline the best practices and recommendations for (i) the robust collection of valid, reliable and standardized data on maternal mortality; (ii) improved quality and completeness of various data sources and systems, and linkages between them; and (iii) the appropriate integration, interpretation and use of data, and consistent and standardized reporting of maternal mortality data at the country level.

This guidance is intended for widespread use and is not limited to low- and middle-income countries, given that challenges with measurement are known to persist in high-, middle- and low-burden countries and in the varying systems for surveillance and data collection. Four case studies were developed and are presented in the sections of this document where they are most relevant, representing a diverse group of countries and settings (Sri Lanka, Georgia, Zimbabwe and Cox's Bazar, Bangladesh) where steps have been taken to improve the accuracy of their maternal mortality data – these are intended to illustrate a range of experiences and effective practices across diverse settings.

Practical guidance to improve measurement and reporting of maternal mortality

The main section of this document (Chapter 2) presents the key guidance for accurately reporting and measuring maternal mortality, linking data to produce reliable statistics at all levels up to national reporting, and identifying missing information. The main data-collection systems to identify maternal deaths are introduced, along with ways of improving their completeness: civil registration and vital statistics (CRVS), confidential enquiries into maternal deaths (CEMD), facility-based identification of deaths (e.g. maternal death surveillance and response [MDSR]) and community-based identification. An overview is provided of the framework used by WHO to define and classify deaths as maternal, which is based on the International Statistical Classification of Diseases and Related Health Problems (ICD). The framework covers details of establishing the underlying cause of death, certifying and coding the cause of death, and information about indirect obstetric deaths, late maternal deaths, maternal suicide and contributory conditions unlikely to cause death. Chapter 2 also describes the importance of linking and triangulating data from different data-collection systems, agencies and sources. Finally, the chapter presents a method of quantifying the extent and type of any incomplete and misclassified maternal mortality data found in a system that has been linked and triangulated. Known as “the six-box method”, this is a simple way to calculate the sensitivity and specificity of the country’s maternal mortality data, provided that good-quality data and systems are in place along with strong inter-agency collaboration. The six-box method is described in detail – step by step, with examples – with the intention of enabling more countries to use their own data to quantify incomplete and misclassified data.

Special considerations

This guidance document also addresses fragile states and humanitarian and emergency contexts, including pandemics (Chapter 3), providing information about special considerations for the monitoring and measurement of maternal deaths, specific to the dynamics, priorities and likely resources in these types of settings and circumstances. Finally, Chapter 4 recommends the metadata to use in describing the features of data that should be reported nationally to WHO alongside the numbers and causes of deaths. These types of information include a description of the population, the processes used to identify maternal deaths and to classify cause of death, the timeliness of reporting, true-zero reporting and the characteristics of the deaths (e.g. maternal age, trimester of pregnancy and timing of maternal death).
Application and impact

This guidance, applicable across a range of settings, aims to facilitate the improvements that may be needed to more accurately capture the burden of maternal mortality, within the health system and community, as well as at the national level. While the guidance introduces approaches to improving the validity and reliability of these mortality data, the document has also remained cognizant of the widely recognized challenges to data collection in a variety of contexts and for a number of reasons. To ensure that a country’s maternal mortality data can nonetheless be interpreted accurately, it is important for policymakers, health services and statistical offices to acknowledge the existence of such limitations and to document their context-specific methods and data challenges transparently. This guidance and the related resources it cites offer some stepwise assistance, and examples to follow, as part of crucial endeavours to improve measurement and transparency.

In addition to taking action directly to strengthen data systems – including CRVS and MDSR – it will also be important for countries to consider ways in which strategies and programmes on maternal mortality can be aligned and bolstered through the creation of enabling policy environments. The successful implementation of enhanced data systems to improve maternal mortality measurement will also be facilitated by adopting policies such as the mandatory notification of maternal deaths, with clear protocols for the actions that need to be taken to respond to occurrences of maternal mortality at the local, subnational and national levels.

With supportive leadership, key lessons shared through case studies in this guidance, and using some of the tools and best practices presented, maternal mortality measurement may be improved, which in turn will lead to improved monitoring, measurement and impact of the efforts to reduce maternal mortality, contributing to improved health as envisioned in the 2030 Sustainable Development Agenda.
Introduction
1.1 Towards the Sustainable Development Goals

Reducing maternal mortality is a prominent part of the Sustainable Development Agenda. Significant progress has been made to reduce maternal mortality worldwide in recent decades, evidenced by a 38% decrease in the global maternal mortality ratio (MMR) between 2000 and 2017, from 342 down to 211 maternal deaths per 100,000 live births (WHO, 2019a). However, there is still much progress to be made. Sustainable Development Goal (SDG) target 3.1 aims to reduce the global average MMR to less than 70 per 100,000 live births by 2030, and it has two associated indicators: MMR (SDG indicator 3.1.1) and the proportion of births attended by skilled health personnel (SDG indicator 3.1.2). A significant disparity remains between low- and high-income countries. In low-income countries in 2017, the MMR was 462 versus just 11 maternal deaths per 100,000 live births in high-income countries. A woman’s lifetime risk of maternal death1 in high-income countries is 1 in 5400, but 1 in 45 in low-income countries (WHO, 2019a). To achieve SDG target 3.1, considerable programmatic, political and strategic efforts are needed to address the complications of pregnancy and childbirth, the levels of which remain high in low- and middle-income countries. Accurate data are needed on the number and causes of maternal deaths at the national and subnational levels in order to effectively inform such programmes, policies and strategies to end preventable maternal mortality.

In 2015, the World Health Organization (WHO) released Strategies towards ending preventable maternal mortality (EPMM), a report that underscores the need to improve the systems of measurement and the quality of data feeding into them, to ensure all maternal deaths are accurately counted (WHO, 2015). It also highlights the need for countries to develop national civil registration and vital statistics (CRVS) systems and to implement standardized death certificates, in line with the 2011 recommendations of the Commission on Information and Accountability for Women’s and Children’s Health (UN ColA, 2011) and the available WHO guidance on strengthening CRVS systems (WHO, 2012a). Countries are also encouraged to use standardized definitions for the coding of deaths, as found in the International Statistical Classification of Diseases and Related Health Problems (ICD) (see Box 1). The EPMM steering committee has proposed coverage targets for 2025 to support tracking progress to 2030 (WHO, 2021a).

1.2 Tracking global progress in reducing maternal mortality

Maternal mortality data come from many sources globally, including CRVS systems, population-based household surveys, reproductive age mortality surveys (RAMOS), confidential enquiries into maternal deaths (CEMD), verbal autopsies, censuses and other specialized maternal mortality studies. The United Nations Maternal Mortality Estimation Inter-Agency Group (MMEIG)2 synthesizes this information and publishes data on the estimated numbers of maternal deaths and the estimated MMR at country, regional and global levels, adjusted to be internationally comparable (WHO, 2019a).

Since its inception, the MMEIG has worked towards gaining a better understanding of the causes of maternal mortality, and of the accurate documentation of maternal deaths, to support the design of well-targeted programmes, policies and strategies to reduce the burden of maternal mortality. WHO also publishes estimates of the causes of maternal deaths (Say et al., 2014). The MMEIG supports country-led efforts to improve maternal mortality measurement, through regular dialogue and consultations when particular issues arise.

Challenges in maternal mortality measurement not only affect populations in vulnerable, marginalized, humanitarian and fragile settings, they exist in all settings, including countries with high, medium and low burdens of maternal mortality. Measurement biases across all settings present a risk to the prioritization of interventions to improve the public health response to reduce maternal mortality.

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1 Adult lifetime risk of maternal death: The probability that a 15-year-old girl will eventually die from a maternal cause (WHO, 2019a).

2 The constituent agencies of the MMEIG are WHO, UNICEF, UNFPA, the World Bank Group and the UNPD.
While the extent and type of measurement difficulties vary, some of the challenges are common, including in well-resourced settings. An exclusive reliance on data from death certificates can result in significantly incomplete reporting of maternal deaths (defined below), even in high- and middle-income countries (Abalos et al., 2019; Garces et al., 2012; Horon, 2005; Lomia et al., 2018). A study that examined maternal deaths in the United States (Massachusetts and North Carolina) and Europe (Finland and France) described significant levels of incomplete reporting, from 22% in France to 93% in Massachusetts (Deneux-Tharaux et al., 2005). In Austria, the rate was 38% incomplete reporting, from a study of direct and indirect obstetric deaths (Karimian-Teherani et al., 2002). The main contributing factors to inadequate maternal mortality measurement need to be understood to improve the validity and reliability of the data and ultimately their comparability.

1.3 Incomplete reporting and misclassification of maternal deaths

To improve the accuracy of maternal mortality measurement and track the progress towards targets, two types of reporting error – incomplete reporting and the misclassification of causes of death – need to be quantified so that appropriate and evidence-based adjustments can be made to minimize them.

1.3.1 Incomplete reporting

Incomplete reporting is also known as missingness or underreporting, and results from deaths not being registered into a designated data-collection system. Incompleteness is often the big

Box 1. Definitions of maternal death in the International Statistical Classification of Diseases and Related Health Problems, 11th revision (ICD-11)

The following definitions of a maternal death are the most current as per ICD-11.

**Maternal death**
A maternal death is defined as the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes.

**Late maternal death**
A late maternal death is defined as the death of a woman from direct or indirect obstetric causes, more than 42 days but less than one year after termination of pregnancy.

**Comprehensive maternal death**
A grouping that combines maternal death and late maternal death.

**Direct and indirect obstetric deaths**
Maternal deaths, late maternal deaths, and comprehensive maternal deaths are subdivided into two groups:

- **Direct obstetric deaths**: those resulting from obstetric complications of the pregnant state (pregnancy, labour and puerperium), and from interventions, omissions, incorrect treatment, or from a chain of events resulting from any of the above.
- **Indirect obstetric deaths**: those resulting from previously existing disease or disease that developed during pregnancy, and that were not due to direct obstetric causes but were aggravated by the physiologic effects of pregnancy.

**Death occurring during pregnancy, childbirth and puerperium (also known as a “pregnancy-related death”)**
A death occurring during pregnancy, childbirth and puerperium is defined as: the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the cause of death (direct and indirect obstetric and non-obstetric death).

challenge where there is no formal registration system, such as a CRVS system, for all deaths, or where there are limitations in the CRVS system’s coverage. In settings where a large number of deaths occur outside of health-care facilities, notification systems to report these community deaths are often weak and slow, contributing to further incompleteness. Even where the majority of deaths happen within health-care facilities, this mortality may be missed without a formal, robust system to aggregate the data nationally (Owolabi et al., 2014). Many settings now have facility-based audits and maternal death surveillance and response (MDSR) in place (Kinney et al., 2021; Okonofua et al., 2017; Vora et al., 2018; Umbeli et al., 2018). The data are not always consistently aggregated from the MDSR panel, however, to the district, regional and/or national levels, where the information could be used to guide higher-level decisions about programming and to monitor national progress towards mortality targets.

Incomplete reporting occurs for maternal deaths in general, but the potential for differential levels of incomplete reporting by specific cause grouping should also be noted. This is of concern as it not only affects the accuracy of estimates used for overall monitoring but may bias decisions about how resources should be prioritized to address different causes of death. Deaths resulting from indirect obstetric causes may be at particular risk of incomplete reporting, for example, as research has shown that these deaths often occur at home and are therefore less likely to be observed (Abouchadi et al., 2018). In some cases, social, cultural and legal considerations have affected misclassification, as has been seen with abortion-related deaths (Walker et al., 2004; Gissler et al., 1997). Even in settings where induced abortion has not been legally restricted, incomplete reporting has been well documented (Wilcox and Horney, 1984; Fu et al., 1998; Gerdzts et al., 2013).

1.3.2 Misclassification

Misclassification happens when the cause of death is not accurately documented, which affects whether the death is considered maternal or non-maternal. Even a civil registration system with good coverage (i.e. low levels of incomplete reporting) may have weak or inconsistent mechanisms to identify maternal deaths. Misclassification can occur for multiple reasons. One important reason is an absence of information in the reporting system to relate a death to pregnancy. This may happen when a death occurs early in pregnancy but the person reporting the death is unaware that the deceased was pregnant. Local customs relating to when it is normal to openly acknowledge and discuss a pregnancy may therefore affect classification.

Furthermore, the methods used to collect data and the site of data collection are also important factors behind the problem of misclassification. Verbal autopsy, for example, may be more prone to over-representing the visible causes of maternal death, such as obstetric haemorrhage. In settings where facility-based delivery rates are low, underlying causes that rapidly become life-threatening around the time of delivery may be over-represented if only facility-based data are relied on (e.g. there may be a higher proportion of deaths due to haemorrhage being observed compared with deaths due to sepsis, as the latter are more likely to occur sometime after the woman has returned home with her newborn).

Conversely, late maternal deaths (more than 42 days but less than one year after the end of pregnancy) may be misclassified if the person reporting the death was unaware of the woman’s pregnancy, especially if it did not end with a live birth. Indirect obstetric deaths are vulnerable to misclassification as these may be coded to the disease or condition outside the obstetric chapter of the ICD, and the link to pregnancy status not made explicit. To address these issues, the inclusion of a pregnancy checkbox on death certificates was approved by the World Health Assembly in 1990. One study found that including this in Taiwan, China, in 2014 increased the reporting of maternal deaths and led to changes in the classification of their causes (Lin et al., 2019).

The most common reasons for incompleteness and misclassification, and potential solutions to reduce these errors, are a key focus of this guidance.

Box 2 provides definitions for some key terms relating to the quality of maternal mortality data and their measurement.

1.4 Using this guidance

1.4.1 Rationale for the guidance

For the MMEIG, arriving at comparable estimates of maternal mortality involves a multistage consultative process. Some of the insights from these consultations have revealed the need for the present guidance.
The estimation and consultation process begins with the retrieval of data. These are publicly available or requested via established channels from Member States and come from a variety of primary sources within a country, such as the CRVS system, the census, nationally representative household surveys and health-care facility records. The data are compiled and validated, and then included in statistical models to derive comparable estimates.

Once the statistics have been calculated, consultations with Member States help to ensure that the estimates include the most recent and relevant information. During this process of communications between official nominated national-level focal points (i.e. individuals in the ministries of health and/or national statistics offices, and at the WHO country offices), Member States are invited to comment on the methods and data sources, and may provide additional primary data before the official reporting and dissemination. This also gives the focal points the opportunity to review the health data and discuss any discrepancies between the MMEIG estimates and other sources.

Over the last several years, WHO has carried out a number of these country consultations and undertaken joint assessments of the data to enhance validity. Common themes have emerged about some of the challenges to measuring maternal mortality at the national level, and it has become increasingly evident that countries could benefit from some guidance derived from these lessons.

1.4.2 Aim, target audience and objectives

The overall aim of this data-driven operational guidance document is to outline the best practices and recommendations for the robust collection of maternal mortality data, including making appropriate linkages between various data-collection systems using a standardized reporting framework.

Under this overall aim, there are three objectives:

1. To improve the validity and reliability of the data collected on maternal mortality;
2. To improve the quality and completeness of various data sources and to improve linkages between these sources;
3. To support efforts for estimating maternal mortality and its causes through the integration and use of diverse data sources, and efforts for improving reporting consistency across countries.

This guidance is intended to support personnel working in ministries of health, national statistics offices and other national agencies responsible for maternal mortality data collection to enhance the quality and completeness of the data and the systems used to capture it, and to improve the consistency and standardization of maternal mortality reporting across countries. The recommendations provided here will support the
appropriate use and interpretation of the data, which in turn will lead to improved monitoring and measurement of the efforts to reduce maternal mortality.

Strengthening national-level maternal mortality data by meeting the aims and objectives of this guidance, will ultimately improve the robustness of the inputs used to develop the MMEIG maternal mortality estimates. Some case studies from a diverse group of countries are included to demonstrate various contexts and challenges and how these have been successfully managed.

This guidance is intended for widespread use and is not limited to low- and middle-income countries, given that challenges with measurement are known to persist in a wide range of systems and settings, including in countries with well-established CRVS and surveillance systems.

The focus of this guidance is distinct from that of the WHO guidance on MDSR, which was targeted to health-care facility managers and district health officials who are directly involved in undertaking reviews of maternal deaths at the local and subnational levels (WHO, 2021b).

1.4.3 Development of the guidance and case studies

This guidance provides practical suggestions and recommendations based on the successful implementation experiences of countries that have taken steps to improve the accuracy of their maternal mortality data. Case studies were purposively selected to illustrate a range of experiences and effective practices across diverse settings. The different locations and programmes described represent various levels of resourcing, different data-collection systems and a diversity of challenges in data coverage and completeness (see Table 1). For Georgia and Sri Lanka, this information was obtained via the consultative process outlined earlier (section 1.4.1). The case study from Bangladesh is based on work by the United States Centers for Disease Control and Prevention (CDC), the United Nations Population Fund (UNFPA) and the Center for Injury Prevention and Research Bangladesh (CIPRB) (Parmar et al., 2019), while the example from Zimbabwe comes from a separate review of existing data made in collaboration with the WHO Department of Sexual and Reproductive Health and Research (SRH).

The general approach taken in formulating the case studies and agreeing the lessons learnt to highlight had four steps: (i) email correspondence, meeting notes and minutes, reports from country engagements and other internal documentation were reviewed by the SRH Department’s team to create an initial summary and outline; (ii) a draft case study was produced against this outline in consultation with the relevant personnel in the country, (iii) one or more online meetings were held to discuss the draft and agree additions and amendments, and (iv) the final versions were reviewed iteratively until all parties were satisfied with the content.

A final phase of feedback from countries was facilitated by an inter-regional consultation meeting held online over two days in December 2020, with over 50 participants from 13 countries, to review the guidance. Substantive feedback was also collected at the meeting to improve the applicability of the guidance across a range of settings, and considerations for future implementation were discussed.
Table 1. List of case studies with the key features that were the basis for selection

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<th>Key feature</th>
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<td>Setting up a maternal death surveillance system in a refugee camp setting</td>
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<td>Upper-middle income</td>
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<td>Sri Lanka</td>
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<td>Lower-middle income</td>
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<td>Zimbabwe</td>
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<td>Quantifying underreporting of maternal deaths; an example of the application of the “six-box method”</td>
<td>See section 2.6 (p. 27)</td>
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</table>

Having outlined in this chapter the background on maternal mortality measurement and the approach taken to develop this guidance, the following provides an overview of the remaining chapters:

- Chapter 2 delivers the key guidance for accurately reporting and measuring maternal mortality, linking data to produce reliable statistics at all the levels up to national reporting, and identifying missing information. It includes sections that:
  - introduce the main data-collection systems to identify maternal deaths (CRVS, CEMD, facility-based identification of deaths – such as via an MDSR – and community-based identification) and an overview of the framework, based on the ICD, used by WHO to define and classify deaths as maternal (sections 2.1–2.3);
  - describe the importance of linking and triangulating data from different data-collection systems (sections 2.4–2.5);
  - offer a method of quantifying the extent and type of any incomplete and misclassified maternal mortality data found in a system that has been linked and triangulated; known as “the six-box method”, this is a simple way to calculate the sensitivity and specificity of the country’s maternal mortality data, provided that good-quality data and systems are in place along with strong inter-agency collaboration (section 2.6).

- Chapter 3 has a specific focus on fragile states and humanitarian and emergency contexts and discusses special considerations for the monitoring of maternal deaths specific to the dynamics, priorities and likely resources in these types of settings.

- Chapter 4 recommends the metadata to use in describing the features of data that should be reported nationally to WHO alongside the numbers and causes of deaths.
Measuring maternal mortality, linking the data and identifying gaps
2.1 Identifying and classifying maternal deaths

The specific procedures and checks for the identification of deaths will differ by setting depending on the data-collection system used and the proportion of deliveries that take place outside of health-care facilities. This chapter outlines the main types of systems used.

2.1.1 Civil registration and vital statistics

In a well-functioning civil registration and vital statistics (CRVS) system, there is complete registration of births and deaths, including medical certification of the cause of death. Vital statistics are generated from this registration and used for analysis. Maternal mortality reporting for the CRVS system will differ by country, but ideally covers the priority characteristics, including the date and location of both the death and its registration, whether the occurrence is urban or rural, the cause of death, the certifier and the type of certification.

A CRVS system needs to be supported by legislation that makes it mandatory to report all deaths occurring in the population. The system should be clear about the population it covers – whether, for example, it includes citizens of foreign states who are residents of the country, citizens living abroad, or nomadic, asylum-seeking or displaced populations.

The required timing of reporting should also be specified clearly, including a clear schedule for the aggregation of data from district offices up to the regional and national levels.

The case study of the system in Sri Lanka (see pp. 13–14) shows an example of a system that includes mandatory reporting and a clear system of notification and review, and that addresses the issue of timeliness.

Clear standards for data management also need to be in place, as with any other data system, to ensure that information is not lost or misreported during transfer between paper and electronic formats. Certain types of maternal death are particularly vulnerable to misclassification in CRVS systems. Indirect obstetric deaths should be identified by ICD-10 codes O98 or O99 (or JB63 or JB64, if ICD-11 is being used) combined with a code denoting the specific disease or condition that was exacerbated by pregnancy. Pregnancy status is often mistakenly omitted, however, or the coding physician is unaware of the need to assign two codes, and so these deaths may not be identifiable from a national CRVS database.

Similar issues may affect late maternal deaths, which are becoming more important as a proportion of total maternal deaths. In the United Kingdom of Great Britain and Northern Ireland between 2009 and 2013, for example, the number of women who died between 42 days and one year after the end of pregnancy was nearly double the number of maternal deaths during pregnancy and up to 42 days postpartum (Nair et al., 2017). Most of these late maternal deaths were found to be linked to pre-existing conditions (e.g. cardiovascular diseases and mental health disorders).

INFO BOX

For further details on civil registration and vital statistics, see Improving the quality and use of birth, death and cause-of-death information: guidance for a standards-based review of country practices (WHO, 2010).
2.1.2 Confidential enquiries

Well-functioning CRVS systems are generally considered the best source of vital statistics data because they generate data continuously and for the entire country. Yet, even in countries where there is routine registration of deaths, maternal deaths may be underreported due to misclassification of the causes, and special investigations may then be needed to properly identify the causes of death and uncover the true extent of maternal mortality. One such investigation – confidential enquiries into mortality in the United Kingdom and Ireland, 2009-2012 - identified 79% more maternal deaths than had been reported in the routine CRVS systems (Knight et al., 2014).

In the United Kingdom, the programme of surveillance and confidential enquiries into maternal deaths (CEMD) is the world’s longest running (Kurinczuk et al., 2014), and the existence of such systems dedicated to reviewing maternal deaths in itself increases their reporting. In the example of the United Kingdom, a maternal death is reported to the CEMD team by a health worker directly involved in the late woman’s care, or comes to their attention through sources such as the coroner, family members or media reports, with supplemental information available from the death certificate. As maternal deaths are notifiable events, the health workers are required to report all deaths to the CEMD team. Complete medical records are obtained for the deceased, and the data are anonymized prior to conducting the review.

Confidential enquiries gather valuable information on the timing of death in relation to the end of the pregnancy (during pregnancy, intrapartum or postpartum timing). With a few exceptions, these details are generally not available from CRVS data, yet they are important for planning and prioritizing health services.

2.1.3 Facility-based identification

WHO’s technical guidance on maternal death surveillance and response (MDSR) recommends daily checking of death logs by a designated individual at the health-care facility to avoid missing any suspected maternal deaths (WHO, 2021b). It is essential that this inspection is not limited to the obstetric ward and includes death logs in any areas that may serve as a point of entry to the facility or where women of reproductive age seek care. These include facility records and logs in adult or women’s wards, emergency departments, operating theatres and the mortuary. Any deaths of women of reproductive age that are identified will require a review of the woman’s medical record for possible documentation of pregnancy or end of pregnancy within the last 42 days. If such evidence of pregnancy or recent pregnancy is available, the notification of the suspected maternal death must be made to the appropriate authorities in the health system (in many countries, this is at the district level). A more in-depth review of the patient’s records is then needed to determine if the suspected maternal death was due to, or aggravated by, the pregnancy or its management. If this finds that the death was a probable maternal death (as opposed to an accident or incidental cause), a more extensive review is necessary. An inquest and/or postmortem can be used to determine the cause of death.

See Beyond the numbers: reviewing maternal deaths and complications to make pregnancy safer (WHO, 2004) for more detail about facility-based identification of maternal deaths; Also see the Maternal and perinatal death surveillance and response: materials to support implementation (WHO, 2021b)
2.1.4 Community-based identification

Deaths occurring in the community are typically notified by community health workers (CHWs), traditional birth attendants or other key informants at the community level. After determining whether the woman of reproductive age died while pregnant or within 42 days of the end of a pregnancy, the community-based worker notifies the relevant authorities in the health system. Under circumstances where dates and timing cannot be easily established, for the purposes of review and identification, the timing of 42 days can be extended to two to three months to avoid potentially missing maternal deaths. Upon notification, the health authorities should then initiate a review to determine the medical cause of death and capture information on any non-medical factors potentially contributing to the death.

2.2 Increasing the completeness of recording

2.2.1 Addressing the “blame and shame” culture and reducing the fear of litigation

Investigations into maternal deaths should take place within a framework and culture that avoids blaming or shaming individual health personnel, to encourage open and transparent reporting. Where health-care providers fear litigation, it is challenging to achieve full and accurate reporting of the circumstances surrounding deaths. The example of Sri Lanka’s system of reporting and review given in the case study on the next pages includes the assurance of confidential investigations that name no names.

2.2.2 Capturing all deaths of women of reproductive age and systematically assessing pregnancy status

Where data capture is electronic, an automated check or alert can be implemented for all women of reproductive age. This can be a useful prompt to enhance the completeness of the data, and can be set to ensure a response about whether or not the woman was pregnant at the time of her death is completed before the form can be submitted. All pregnancy-related deaths should be reviewed by expert-level committees to reduce the likelihood of missing indirect obstetric deaths or other causes vulnerable to misclassification (see Box 1). If the initial selection is restricted to deaths that have been classified as maternal deaths, then the likelihood of events being missed increases. In settings where substantial numbers of deliveries take place outside of health-care facilities, making use of any existing CHW networks and fostering strong local engagement are recommended to help with this process of identifying all deaths that occur during pregnancy, childbirth and the postpartum period.

2.2.3 Using clear operating protocols and data-management practices

A lack of written guidelines and clear leadership from senior members of staff have been identified as barriers to the accurate recording of causes of maternal death (Owolabi et al., 2014).

In common with data collection on any topic, clear standard operating procedures and data-management protocols should be followed consistently – and led, supervised and quality-checked by a designated person acting as a focal point – to ensure that the data reach their full potential in terms of completeness and accuracy.

These practices are particularly important in systems where reporting involves a mix of paper-based and electronic records.

Notifications should continue even when no suspected maternal deaths have occurred. The active recording of a zero – “true-zero reporting” – makes it clear that the true number of deaths was zero, rather than denoting a possible absence of reporting.
SRI LANKA CASE STUDY
Structured processes built upon the original MDSR system (WHO South-East Asia Region)

Sri Lanka is a lower middle-income country with low maternal mortality; the MMR was estimated at 36 maternal deaths per 100,000 live births (80% UI: 31–41) in 2017 (WHO, 2019a). Sri Lanka is considered a success story in terms of both reducing maternal mortality and improving its measurement.

Sri Lanka has an established history of maternal death monitoring. The maternal death surveillance and response (MDSR) system was started in 1981, with the notification of probable maternal deaths being made mandatory in 1985. A decade later, a structured review of probable maternal deaths was initiated, and a national database has been in place since 2000. Post-mortems must be sought for all probable maternal deaths to confirm pregnancy or recent delivery or pregnancy loss/termination among women of reproductive age, contributing to delineating pathology and more accurately determining the cause of death. In addition, Sri Lanka also uses community health workers (field public health midwives; PHMs) to notify potential maternal deaths that took place both inside and outside of health-care facilities, minimizing the potential for underreporting.

Figure 1 summarizes the process for MDSR and related reporting in Sri Lanka. As shown, when a death takes place in a hospital, the head of the institution is responsible for notifying and leading an investigation. Their investigation team includes senior clinicians (consultants or relevant specialists in the obstetrics unit or other relevant department), all care providers involved in the case at any stage, plus any who were involved in the provision of first-contact care (prior to a transfer), and field health medical officers and the PHM from the deceased’s area of residence. This review, using standardized forms and procedures, must be initiated within 14 days of the death. When a death is reported, even in the community, a similar time frame applies – an investigation should start as early as possible but ideally within 14 days. The field health-care team (led by a divisional health-care manager and other categories of field health workers, including an area PHM) also uses standardized forms, and conducts a verbal autopsy. Death review panels take place at the district level, and then annually at the national level. Active involvement of professional groups – from obstetric, public health, anaesthesiology, forensic pathology, administrative and other related clinical specialities – facilitates an objective case review.

Mandatory death notification in Sri Lanka is a key strength of the system in ensuring high levels of completeness. All health workers – both those working in government or private sector health-care facilities and those working in the community – are legally bound to notify eligible death events to the Family Health Bureau (FHB) – the maternal and child health arm of the Ministry of Health. The criteria for notification are broad: irrespective of cause, all deaths among women aged 15–49 years occurring during pregnancy or up to one year after the end of pregnancy must be reported. All relevant field and hospital clinical records of the index case are collected by the FHB to compile a comprehensive case scenario. This ensures that all the events of possible relevance are available for review by senior coding and reporting experts at the national level, and reduces the risk that deaths prone to misclassification are not being counted.

The surveillance process in Sri Lanka has a clear and established “no name, no blame” policy at all stages. This assurance of confidentiality helps to give confidence in accurate reporting without the fear of repercussions or reprisals, ensuring that appropriate, evidence-based actions can then be taken to make improvements.

One challenge for the system has been a time lag between the notification of the death and the availability of review outcomes, which are needed for decision-making. Typically, several months pass before experts at the national level in Sri Lanka are able to discuss the case of a maternal death, and not until the following year in some cases. To help to address this issue, the Ministry of Health has introduced an immediate-response system, whereby the Director General of Health Services (the highest-level administrator) convenes a fact-finding discussion with all caregivers in cases where service gaps have been identified, with the aim of implementing improvements at the community, hospital and national levels.
Further details relating to MDSR in Sri Lanka can be reviewed at the FHB/MOH website and in the article on this subject by Wijesinghe et al. (2019).

Figure 1. The process of maternal death reporting in Sri Lanka

AMOH: additional medical officer of health; FHB: Family Health Bureau; JMO: judicial medical officer; MOH: medical officer of health (divisional health manager) (MOOH is the plural form); MOMCH: medical officer – maternal and child health (district-level MCH coordinator); MO-PH: medical officer – public health; NMMR: national maternal mortality review (a district-level meeting including national-level experts and officials); PDHS: provincial director of health services; PHM: public health midwife (includes field PHMs and area PHMs, i.e. the field PHM assigned to the area of the mother’s residence); PHNS: public health nursing sister; RDHS: regional director of health services; RSPHNO: regional supervising public health nursing officer; SLCOG: Sri Lanka College of Obstetricians and Gynaecologists; VOG: visiting obstetrician and gynaecologist (VOGG is the plural form).

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2.3 Classifying the cause of death

The ability to capture accurate maternal mortality data depends on the use of standard cause-of-death classifications according to ICD guidelines. The WHO application of ICD-10 to deaths during pregnancy, childbirth and the puerperium: ICD-MM was released in 2012 to support consistency in the collection of maternal mortality data, to clarify the coding of conditions and to standardize cause-of-death attribution (WHO, 2012b).

The application of ICD-MM has been linked directly to reduced coding errors and misclassification, and improved cause-of-death attribution (Agampodi et al., 2014). A systematic review found significant improvement in the performance of health workers when they were trained/educated to correctly record the cause of death in death certificates (Aung, Rao and Walker, 2010). However, coding of deaths according to differing definitions in various revisions of the ICD may contribute to misclassification of deaths. Use of the definitions in the 9th revision (ICD-9) compared with the 10th revision (ICD-10) has been linked to higher levels of incomplete reporting, as the designation for late maternal deaths is not included in earlier ICD versions (Turner et al., 2002). Implementing death coding using ICD-MM was found to increase the accuracy of maternal death recording in the United Republic of Tanzania (Said et al., 2020).

WHO recommends that all countries adopt the classification system outlined in ICD-MM, reflecting a common framework, so that reliable comparisons can be made within and between countries and regions.

IMPORTANT NOTE:
The 11th revision of the ICD (ICD-11) began implementation in January 2022. Implementation plans for ICD-11 will be rolled out by countries; the timing of implementation will vary. It is therefore very important to be clear when reporting mortality statistics which iteration of ICD was used (ICD-10, ICD-11, or rarely, ICD-9).

2.3.1 Establishing the underlying cause of death

A key area of confusion often encountered by medical staff completing death certificates is how to apply the ICD principles when assigning the underlying cause of death. The underlying cause is defined as “(a) the disease or condition which initiated the train of morbid events leading directly to death or (b) the circumstances of the accident or violence which produced the fatal injury” (WHO, 1979). Only one underlying cause can be recorded. The chain of events leading to death are filled out in reverse chronological order in Part 1 of WHO's International Form of Medical Certificate of Cause of Death (WHO, 1979). The first event listed in Part 1 is the most recent, and the bottom row (i.e. the initial event in the chain) is always the underlying cause. Correctly identifying the order of events is thus essential to determining the underlying cause.

Contributory conditions – that is, those that may have contributed to a death or predisposed the individual to it, but that are not the condition that initiated the chain of events – should be given in Part 2 of the death certificate, which allows multiple contributory conditions to be assigned.

Box 3 shows an example of Parts 1 and 2 of the death certificate being used appropriately to record the cause of a maternal death, including identification of direct, underlying and contributory causes, and completion of the final question regarding pregnancy.

2.3.2 Certifying versus coding maternal mortality

There is an important distinction between the certification and the coding of cause of death. Certification is made by the attending physician involved in the woman's care before the death. In some countries, the coding is also done by this same physician. However, it is more common – and best practice – for the coding to be done by a specific cadre of specialized coders and statisticians who have specific training in the ICD rules and procedures. All coders should receive formal training, which should be updated regularly with refresher courses, and/or when new versions of the ICD are released. Medical education should also include training in how to complete the medical certificate of cause of death and on the importance of reliable, consistent and accurate information. Table 2 shows groupings for the causes of maternal death, as recommended by ICD-MM (WHO, 2012b).
### Medical certificate of cause of death

<table>
<thead>
<tr>
<th>Cause of death (the disease or condition thought to be underlying cause should appear in the lowest completed line of Part 1)</th>
<th>Approximate interval between onset and death</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Disease or condition leading directly to death</td>
<td>(a) hypovolaemic shock</td>
</tr>
<tr>
<td>Antecedent causes: Due to or as a consequence of</td>
<td>(b) postpartum haemorrhage</td>
</tr>
<tr>
<td>Due to or as a consequence of</td>
<td>(c) uterine atony</td>
</tr>
<tr>
<td>Due to or as a consequence of</td>
<td>(d)</td>
</tr>
<tr>
<td>2. Other significant conditions Contributing to death but not related to the disease or condition causing it</td>
<td>Anaemia</td>
</tr>
</tbody>
</table>

The woman was:
- ☒ pregnant at the time of death
- ☐ not pregnant at the time of death (but pregnant within 42 days)
- ☐ pregnant within the past year

### Table 2. Main classification groups of causes of maternal death recommended for statistical reporting and analysis

<table>
<thead>
<tr>
<th>Type</th>
<th>Group name</th>
<th>Examples of potential causes of death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal death: direct</td>
<td>Group 1: Pregnancies with abortive outcome</td>
<td>Abortion, miscarriage, ectopic pregnancy and other conditions leading to maternal death and a pregnancy with abortive outcome</td>
</tr>
<tr>
<td>Maternal death: direct</td>
<td>Group 2: Hypertensive disorders in pregnancy, childbirth and the puerperium</td>
<td>Oedema, proteinuria and hypertensive disorders in pregnancy, childbirth and the puerperium</td>
</tr>
<tr>
<td>Maternal death: direct</td>
<td>Group 3: Obstetric haemorrhage</td>
<td>Obstetric diseases or conditions directly associated with haemorrhage</td>
</tr>
<tr>
<td>Maternal death: direct</td>
<td>Group 4: Pregnancy-related infection</td>
<td>Pregnancy-related, infection-based diseases or conditions</td>
</tr>
<tr>
<td>Maternal death: direct</td>
<td>Group 5: Other obstetric complications</td>
<td>All other direct obstetric conditions not included in groups 1–4</td>
</tr>
<tr>
<td>Maternal death: direct</td>
<td>Group 6: Unanticipated complications of management</td>
<td>Severe adverse effects and other unanticipated complications of medical and surgical care during pregnancy, childbirth or the puerperium</td>
</tr>
<tr>
<td>Maternal death: indirect</td>
<td>Group 7: Non-obstetric complications</td>
<td>Non-obstetric conditions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cardiac disease (including pre-existing hypertension)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Endocrine conditions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Gastrointestinal tract conditions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Central nervous system conditions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Respiratory conditions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Genitourinary conditions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Autoimmune disorders</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Skeletal diseases</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Psychiatric disorders</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Neoplasms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Infections that are not a direct result of pregnancy</td>
</tr>
<tr>
<td>Death during pregnancy, childbirth and the puerperium</td>
<td>Group 8: Unknown/ undetermined</td>
<td>Death during pregnancy, childbirth and the puerperium where the underlying cause is unknown or was not determine</td>
</tr>
<tr>
<td>Death during pregnancy, childbirth and the puerperium</td>
<td>Group 9: Coincidental causes</td>
<td>Death during pregnancy, childbirth and the puerperium due to external causes</td>
</tr>
</tbody>
</table>

2.3.3 Clarity with indirect obstetric deaths

For indirect obstetric deaths, Part 1 of the certificate should always include clear information about whether mutual aggravation between a disease and pregnancy led to the death. For cases of indirect obstetric deaths, it is this interaction between the disease or health condition and the pregnancy that is the underlying cause of death. The certifying physician assesses any mutual aggravation, and this is critical since only proper reporting in Part 1 of the certificate will guide the coders.

2.3.4 Including late maternal deaths

Maternal deaths are those taking place during pregnancy or up to 42 days postpartum; late maternal deaths take place more than 42 days but less than one year after the end of the pregnancy. Countries are encouraged to report both maternal deaths and late maternal deaths, by cause of death. The data should be tabulated and presented in a way that allows these respective time frames to be distinguished, to facilitate standardized aggregation and reporting for purposes of international comparisons.

2.3.5 Including maternal suicide

Maternal suicide is considered a direct cause of maternal death by WHO. Thus, to eliminate underreporting of suicide in pregnancy, information about the pregnancy needs to be clearly indicated on the death certificate, either in Part 1, Part 2 or via the pregnancy checkbox.

Some countries code suicides differentially as direct or indirect obstetric deaths depending on whether or not a link has been established to puerperal psychosis or depression. Clear tabulation and presentation of these deaths in the reporting allows them to be aggregated consistently for international comparisons and reporting.

2.3.6 Contributory conditions unlikely to cause death

ICD-MM presents a list of conditions and their codes that are unlikely to cause death (in Annex B2 of ICD-MM; WHO, 2012b). These codes may instead be used in Part 2 of the medical certificate of cause of death (thus as contributory conditions) and may be useful in multiple coding analyses. It is very rare that any of these conditions could be appropriately assigned as the underlying cause of death. The inappropriate use of these codes in Part 1 must be avoided because they do not capture the most useful data needed to inform interventions to prevent further deaths. Coders should ensure they are familiar with this list.

2.4 Strengthening links between agencies and systems working with maternal death data

Good engagement and dialogue within countries between the authorities responsible for the CRVS system and the expert review committee investigating the causes of maternal death is important for the initiation and continuation of robust measurement of maternal mortality. Many countries have multiple stages of review, ranging from weekly or monthly meetings and procedures at the level of the health-care facility – to identify any immediate lessons for care provision – to periodic reviews at the regional or national level, depending on the overall burden – to verify the cause of death classification. Clear mechanisms of communication are needed to ensure that the data obtained through different systems align. Such measures to ensure robust data linkage between agencies, especially where this is strengthened by multiple people working at different levels to report and review data through a central body of expertise, is explored further in the Georgia case study (see pp. 21–22).

2.5 Linking sources of maternal mortality data

This section focuses on linking data systems and sources - an important activity in its own right due to the benefits in terms of identifying additional deaths, and so reducing incompleteness. Moreover, transparent documentation of the number and type of these additional deaths can be used to inform the adjustment of similar types of data.
2.5.1 Triangulating data from multiple sources

Given the number of potential sources capturing data on maternal deaths in a particular setting, it is essential to compare and triangulate these data - to identify deaths that might have been missed - and to come to an agreement on which sources should be considered the most reliable for the official version of the country's statistics.

It is important for data sources to be triangulated at the subnational level to avoid potential errors from the double-counting of maternal deaths (e.g. the same death is duplicated in the data because of both a facility report and a community report for it).

Where multiple systems exist, procedures should be established between the different agencies and departments responsible for managing the databases, to convene and triangulate the various sources. These teams may include, among others, those responsible for overseeing the health management information system (HMIS), MDSR and CRVS systems.

2.5.2 Some considerations before data from different systems can be linked

The following are helpful to consider, depending on the setting, when planning to establish systems and processes that enable data from different sources and alternative statistical systems to be linked. One country may already have some or all of the enablers in place when planning to link sources of maternal mortality data, while another will need to consider establishing some of these items before it is possible to do this data linkage work and report the results towards more reliable national statistics.

**Unique-ID systems to reveal duplicates and avoid double-counting**

When two systems are compared, and both purport to measure mortality within the same population, a large proportion of the deaths - 100% in an ideal world - should be duplicated; one record of the same person’s death in each system. Whatever the actual level of matching cases, personal identifiers are needed to identify these duplicate death records and assess whether they relate to the same person/event. Such an assessment requires robust processes of confidentiality and data management to be in place alongside strong data security - to ensure the identification of duplicates can be done while protecting privacy.

**Engagement and buy-in from all relevant agencies and stakeholders**

Before proceeding with data linkage, it is helpful to ensure that all parties agree on the benefits and advantages; this makes it more likely the linkage will be successful and sustainable over time. This buy-in is more likely to be achieved if thorough groundwork has been done and there is active engagement and dialogue with all the relevant entities involved in the existing systems.

Effective data linkage also needs the respective roles and responsibilities of each relevant agency or authority to be clearly determined, including the sequencing and workflow of their respective tasks. Clarity is also needed on what evaluation and feedback mechanisms will be in place, and who will take the lead in resolving any identified issues.

**Conducting a baseline assessment and designing a strategic plan**

While planning how to link the data, a baseline assessment is essential, to map all the existing sources of data relevant to maternal mortality and the existing systems for collection and reporting these data. A strategic plan then needs to be developed to set out how the goal of data linkage will be achieved. Particular care should be taken to ensure that any function found in the assessment to be specific to only one part of the existing systems is not excluded from the strategy, so that the function is not lost in the harmonization process.

**Optimizing the use of electronic records and automated checks**

Use of computerized forms with in-built automated checks is recommended, to link them into web-based HMISs, such as the widely used District Health Information Software 2 (DHIS2). A recent systematic review assessing the challenges associated with data from paper-based routine health information systems (RHIRS) noted substantial limitations with such forms. Critical patient information and standard definitions were often missed, contributing to substandard data quality and an inability to estimate maternal mortality correctly (Hoxha et al., 2020).
2.5.3 Country examples of linkage studies using existing data systems

In the United States of America, record linkage has been implemented at the subnational level across a variety of settings. One example, the California Pregnancy-Associated Mortality Review (CA-PAMR), is based on linked data from birth, fetal and maternal death certificates to identify pregnancy-related deaths. This linked information is then combined with hospital discharge data, medical examiner findings, autopsy results and toxicology reports (Mitchell et al., 2014).

In Norway, the linking of birth registers with cause-of-death registers revealed sizeable underreporting of maternal deaths between 2005 and 2009 (Vangen et al., 2014). During this linkage procedure, all deaths of women aged 15–49 years were transmitted from the cause-of-death registry to the birth registry and these records were merged using personal identification numbers. Detailed patient data were also collected from hospitals and all data sources were collated by Statistics Norway, the national statistics bureau. Analysis of the linked datasets resulted in maternal mortality estimates that were nearly double what was officially reported in the country. Results from this research support the effective use of data linkage between birth and death registers, in combination with direct hospital data, to provide more valid estimates of maternal mortality.

In Sweden, three registers—the cause-of-death, medical birth and national patient registers—are linked and so may be triangulated for complete maternal mortality data.

- The cause-of-death register contains the ICD codes for the causes of death, based on death certificates issued by attending physicians and/or via autopsies. This register is the source used to report mortality data by cause to WHO.

- The medical birth register contains information on women who gave birth to infants, whether live or stillborn, with a gestational age of at least 28 weeks or a birth weight of at least 500 g.

- The national patient register has information on discharges from public hospitals and outpatient care.

The linkage of the cause-of-death register to the medical birth register enables the identification of women who might have died within a year of the end of a pregnancy, but whose pregnancy or postpartum status had not been recorded on the death certificate. This is a particularly useful method for identifying deaths due to indirect obstetric causes, and this was the route via which most of the additional maternal deaths not originally appearing in Sweden’s cause-of-death register were identified in a study by Esscher et al. (2012).

Additionally, the cause-of-death register in Sweden is linked to the national patient register, allowing the identification of women who have an entry on the latter because of a diagnosis related to a pregnancy, but without any entry on the medical birth register, and without their entry on the cause-of-death register being coded as a maternal death.

Even with such a comprehensive set of data, facilitating triangulation among these three sources, and despite linkages being in place between data systems, it is still possible for certain types of maternal death to be more vulnerable to being missed. Examples of these include deaths taking place early in a pregnancy or after a spontaneous or induced abortion. These cases of maternal death will be missed if the cause-of-death register did not capture the complete set of data.

In Taiwan, China, there have been efforts to improve maternal mortality estimation by researchers linking similar national datasets. Wu et al. (2015) were able to examine the trends in maternal mortality and the causes of death between 2004 and 2011 by merging data from birth registration, birth notifications, national health insurance inpatient claims, and cause-of-death information. The unique identification numbers that are assigned to all residents of Taiwan, China, were the key to linking these data. The results of the research indicated significant underreporting of maternal deaths in official national maternal mortality estimates, finding that 57% had not been included for the period studied up to 2011.

Similar research in Italy has demonstrated the importance of countries enhancing data linkage for maternal mortality measurement. A 2018 study by Donati et al., across 10 regions in Italy, confirmed that underreporting can be addressed – and the identification of late maternal deaths enabled – by ensuring that robust procedures of record linkage are in place between routine statistics. It found that death certificate data alone would not have included 60% of the maternal deaths across the regions studied. The study used data from regional and national death registers.
and matched these records to hospital discharge databases. At the regional level, nominal data were used to link the woman’s records, and at the national level, tax identification numbers were used for the linking.

The case study describing the systems and processes established in Georgia (see below) includes a description of such data-linkage studies being applied routinely at the national level and of the robust practices and processes in place to enable them.

**GEORGIA CASE STUDY**

**Linking and harmonizing different data systems (WHO European Region)**

Georgia is an upper middle-income country where maternal mortality is low; the MMR was estimated at 25 maternal deaths per 100 000 live births (80% UI: 21–29) in 2017 (WHO, 2019a). Every member of the population of Georgia has a personal identification number – a unique identifier required to access government services (such as insurance, pensions and schooling). The population also has universal health coverage for hospital-based services, and services for pregnant women and children are free (women receive vouchers for eight antenatal care visits). Much of the population also pays for separate private insurance schemes to cover preventive services. Hospitals in the country are primarily private facilities, with the exception of some government facilities that have been maintained in remote areas.

### Overview of data sources and systems in place for maternal mortality surveillance

Three competing data sources have been used historically for maternal death reporting in Georgia. Mortality data have been collected: (i) through the CRVS system; (ii) from health-care facilities reporting all potential maternal deaths (including late maternal deaths) directly to the Ministry of Health; and (iii) by the National Center for Disease Control and Public Health (NCDC). The NCDC collects information about the deaths of women of reproductive age using the electronic information disease surveillance system (EIDSS), supplemented with CRVS data, to create a comprehensive list. The NCDC list includes all deaths within one year of a pregnancy and all the cases are subsequently investigated by medical record review and verbal autopsy. A special commission under the Ministry of Health reviews the results of these investigations and makes a decision for each case, determining whether the death was maternal.

Since 2016, Georgia has maintained a new countrywide information system, called the Georgian Birth Registry (GBR), which is also the responsibility of the NCDC. The system provides continuous monitoring of all antenatal care visits and deliveries, including description of childbirth. Health-care staff open a record for the GBR at the time of a confirmed pregnancy and close this record at the end of the pregnancy. If a pregnancy ends at 22 weeks of gestation or earlier, it is recorded as an abortion or loss. If a pregnancy ends after 22 weeks, it is recorded in the CRVS system as a live birth or stillbirth. The GBR records are also linked to the Department of Justice so that a birth certificate may be issued for a live birth and a death certificate in case of an early or late neonatal death. The survival outcomes for the mother are documented in the GBR.

The NCDC has mechanisms in place to review deaths from all causes among women and girls aged 15-49 years. In some areas, the NCDC contracts local public health centres for the case-finding of all deaths of women of reproductive age - work that involves reviewing media reports, consulting community leaders and using other local information, and conducting a verbal autopsy with the family members or relatives of the deceased woman. Around 80% of deaths occur in facilities, and the remainder (most of which occur at home) are subject to pathology/autopsy and/or verbal autopsy to determine the cause of death. Hospitals are required to report every facility-based maternal death to the NCDC within one hour, to provide a completed form within one day, and to provide a copy of the medical records within five days. Triangulation of data is conducted, checking the hospital discharge records against the registry data.
Cause of death assignment

The reviews undertaken by the NCDC are used to verify Part 1 of the death certificate, which is based on WHO's International Form of Medical Certificate of Cause of Death (WHO, 1979). The underlying cause of death is given a final determination by the National Statistics Office of Georgia (GEOSTAT), which also submits CRVS data to the WHO mortality database.

The NCDC estimates that there is close to 100% completeness of registration of births and deaths in Georgia. At present, the various data systems are cross-checked regularly. The NCDC collects, records and runs all validations, which are built into the software packages recommended by WHO, such as AIRIS, ANACONDA and ANACODE. All deaths of women of reproductive age are checked. If the NCDC finds that a cause of death is invalid or a non-maternal cause has been assigned for a woman who was pregnant (a check enabled by a registry of pregnancies), its Department of Medical Statistics clarifies the cause of death by reviewing all the available medical records in the health institution that registered the death. If such records are unavailable or inconclusive, a verbal autopsy is conducted. All records of deaths to women of reproductive age are revised by the Division of Maternal, Child and Reproductive Health within the Department of Noncommunicable Diseases at the NCDC if the assigned cause of death was deemed inaccurate upon review. As a result, underlying causes are correctly assigned and provided to GEOSTAT.

GEOSTAT additionally triangulates various data sources before final assignment of the underlying cause of death.

The Georgian team has cited a clear benefit of having a centralized, sophisticated system for cause of death assignment: it says that following the process outlined in this case study, it reclassified as many as 80% of the 803 deaths among women of reproductive age in 2017 after giving specific attention to reclassifying deaths with ill-defined causes. Twenty-one pregnancy-related deaths were identified, 11 of which were ultimately determined to be maternal deaths. Seven of these occurred within 42 days of the end of pregnancy and the remaining four were late maternal deaths.

Having multiple data-reporting systems as in Georgia can create uncertainties as to which of them represents the most accurate data. Nevertheless, over time, Georgia has been able to move to a harmonized system by linking all three systems in a process of data triangulation to confirm complete and accurate documentation of deaths and their causes. It currently has a very high level of completeness and provides valuable recording of instances of data incompleteness and misclassification.
2.6 Quantifying incomplete and misclassified data: the “six-box method”

This section describes a method that can be used to quantify incomplete and misclassified data. It is based on comparing two different data sources to identify deaths that appear in one source but not the other, and then recording and presenting this information, in addition to presenting the final revised version of the data.

All data-collection systems are vulnerable to incomplete and misclassified data. While the aim is always to reduce these issues so that the data are as complete and valid as possible, identifying and quantifying incomplete and misclassified data in a clear and systematic way allows for appropriate interpretation of the data in light of its limitations.

2.6.1 The six-box method

In the MMR estimates of the United Nations Maternal Mortality Estimation Inter-Agency Group (MMEIG), an adjustment factor is applied to CRVS data to account for misclassification due to error in the medical certification of cause of death, and/or error in applying the correct code (Peterson et al., 2022). For countries with specialized studies providing empirical data on the extent of misclassification, this context-specific information can be used to directly estimate sensitivity and specificity for that country period. Estimates for countries with limited or no such data are informed by data from other countries and periods. To enable more countries to use their own data to quantify incomplete and misclassified data, we can use a method for categorization of deaths by correctness of reporting status and assigned maternal cause, known as the “six-box method”. Completing these six boxes with empirical data allows measures of sensitivity and specificity to be calculated. Even partial completion of the boxes yields useful information.

The following description is intended as a step-by-step explanation of the concept of the six-box method. First, in a defined population (e.g. a country), 100% of the deaths that occur are represented by a rectangle. Some of these deaths will be true maternal deaths, but most of them will be non-maternal deaths (i.e. deaths from other causes). Note that the scale of the diagram is simply to illustrate the concept; it is very unlikely that true maternal deaths and true non-maternal deaths would be equally distributed within a population:

For more about designing a strategic plan to improve the quality of civil registration and vital statistics data, see Improving the quality and use of birth, death and cause-of-death information: guidance for a standards-based review of country practices (WHO, 2010).

INFO BOX

Some deaths will be captured/registered in the data-collection system (e.g. CRVS system) and some will not (i.e. they are missing). Some of these missing deaths will be unregistered true maternal deaths (denoted by U+) and some will be unregistered non-maternal deaths (denoted by U-). For a death to be considered missing, it is not necessary for no one to be aware of the death, just that the event has not been recorded in such a way that it could be aggregated upwards and included in official statistics (i.e. it is unregistered). For example, sometimes deaths take place within a health-care facility and are reviewed by a maternal death surveillance and response (MDSR) committee but not included in the CRVS because of gaps and poor integration between different reporting systems.

Because these deaths are missing in the CRVS, they are not visible (observed) among the official statistics. Only deaths depicted in a solid colour are visible in the CRVS:
Of the deaths recorded in the data-collection system as maternal deaths, \( T^+ \) denotes the true maternal deaths that are correctly recorded as maternal deaths while \( F^+ \) denotes the true non-maternal deaths that are incorrectly recorded as maternal deaths:

\[
\begin{array}{c|c|c}
\hline
T^+ & U^+ & \text{True maternal deaths} \\
F^+ & U^- & \text{True non-maternal deaths} \\
\hline
\end{array}
\]

Deaths recorded as maternal deaths

An example of a \( T^+ \) death could be one due to postpartum haemorrhage being correctly coded as such in the data. An example of an \( F^+ \) death is one that happened during a car accident to a woman who was pregnant but that was incorrectly reported as a “maternal death” rather than a pregnancy-related death.

Of the deaths recorded in the data-collection system as non-maternal deaths, \( T^- \) denotes those deaths that are correctly recorded as non-maternal, e.g. a woman who dies in a car accident during pregnancy where the death is correctly recorded as accidental. \( F^- \) denotes those deaths that were true maternal deaths but incorrectly recorded as non-maternal. An example of an \( F^- \) death is an indirect obstetric death due to pre-existing diabetes where the pregnancy status was not recorded on the death certificate.

\[
\begin{array}{c|c|c|c}
\hline
T^- & F^- & U^+ & \text{True maternal deaths} \\
F^- & T^- & U^- & \text{True non-maternal deaths} \\
\hline
\end{array}
\]

Deaths recorded as maternal deaths
Deaths not recorded as maternal deaths
Unregistered (missing) deaths

Examples of the types of scenarios where a death may fall into one of the six boxes are provided below. There are an almost infinite number of possible examples; this should be considered illustrative only.

**Figure 2. Examples of scenarios where a death may fall into each of the six boxes**

- **\( T^+ \)**: A death due to postpartum hemorrhage correctly recorded.
- **\( F^- \)**: An indirect maternal death due to pre-existing diabetes where pregnancy status was not recorded and was lost.
- **\( U^+ \)**: An abortion-related death in the community that is never reported.
- **\( F^- \)**: Death from a car accident during pregnancy incorrectly recorded as maternal (instead of pregnancy-related).
- **\( T^- \)**: Car accident during pregnancy (coincidental).
- **\( U^- \)**: Death due to an accident that was undocumented.
Finally, these numbers can be used to calculate sensitivity and specificity using two simple formulae:

\[
\text{Sensitivity} = \frac{T^+}{T^+ + F^-}
\]

\[
\text{Specificity} = \frac{T^-}{T^- + F^+}
\]

The sensitivity result is the proportion of correctly classified maternal deaths out of all true maternal registered deaths. The specificity is the proportion of correctly classified non-maternal deaths out of all true non-maternal registered deaths.

### 2.6.2 Applying the six-box method

The following overarching steps need to be followed while setting up a specialized study to investigate missing mortality data using the six-box method.

**Be clear about the population and comparisons**

Describe in detail the available registration systems or data sources that will be used to triangulate the data, including details such as target population, coverage, procedures to assign the underlying cause of death, data quality controls, and the timeliness of reporting within each system. This step is essential to allow the results of the validation study to be adequately interpreted, as the results are dependent on what is selected as the “best”, or reference standard.

**Include linkages to birth registration**

Ideally link to a birth registration system as well as to systems collecting mortality data. This will enable those deaths to be identified for which the pregnancy status was not indicated on the death certificate.

**Obtain relevant information from as many different sources as possible**

The types of data that can be used in the six-box method to find true maternal deaths include – among other examples of any relevant documentation – death certificates, coroner and inquest reports, autopsy reports and medical records.

**Include experts with different areas of relevant expertise in the review panel**

The panel reviewing maternal deaths should be multidisciplinary and include senior obstetrician-gynaecologists and midwives, but also clinical specialists in other relevant areas, depending on the cases to be reviewed – that is, they should be relevant to the specific conditions concerning the indirect obstetric deaths under review (e.g. psychiatry in the case of a suicide). The panel should also include expertise in ICD coding rules and procedures. Document all discussions and decision-making carefully.

**If six boxes are not available, use the method with four boxes**

Countries will not always have the ability to quantify all six boxes. However, do not “allow the perfect to be the enemy of the good”. Resources and opportunity will often mean that it is feasible to consider investigating only four boxes, e.g. to verify the correct assignment of cause of death for those deaths that have previously been identified as maternal. This is a useful exercise that can still provide a lot of valuable information.
2.6.3 Illustrative example of six-box verification

Let us consider researchers in hypothetical country X conducting a study to assess the completeness of data and misclassification of maternal mortality in the CRVS.

The researchers identified records relating to the deaths of women of reproductive age from multiple sources, including the CRVS, records and files submitted to both the institutional and national-level MDSR committees, medical case notes from the facilities where the deaths had occurred, police and forensic pathology reports, and an independent maternal surveillance system. In addition, birth registrations were linked with the mortality records to identify those cases of death that were temporally related to pregnancy but for which this pregnancy or postpartum status was not recorded on the death certificate.

All possible pregnancy-related deaths were audited by a national review committee of senior experts and classified according to the ICD-MM (WHO, 2012b). Two separate teams initially conducted the classification, and their decisions were compared and any differences reconciled through further discussion. The underlying causes of death were grouped into the main cause groupings outlined by the ICD-MM for this purpose (see Table 2, p. 17). The example here describes the six-box allocation applied to all maternal deaths, but the process could equally be repeated to assess potential differential misclassification for a single cause grouping (e.g. pregnancy-related infections or indirect obstetric deaths).

The researchers identified 250 deaths occurring among women of reproductive age (15–49 years) during the year of the study. Of these, 222 had been recorded in the CRVS system, with 24 originally being recorded in it as maternal deaths and 18 as non-maternal pregnancy-related deaths (due to accidental or incidental causes). The linkage of the birth registration and mortality data identified five additional deaths that had occurred around the time of pregnancy but for which the pregnancy checkbox had not been marked and so these were not recognized as pregnancy-related. These 47 deaths were reviewed by the national expert review panel.

The national expert review panel determined that, of the 24 maternal deaths originally recorded in the CRVS as maternal, 21 were true maternal deaths. Of the cases that had been incorrectly classified, the women had died from another health condition that was a contributory but not an underlying cause of death, and the ICD coding rules had been incorrectly applied in the original assessment.

Of the 18 non-maternal pregnancy-related deaths originally captured in the CRVS, the national expert review panel determined that six were true maternal deaths. In most of these cases, the cause of death was suicide, which is considered a direct maternal death by ICD-MM (WHO, 2012b), or an indirect obstetric cause of death. The latter cases were where the pregnancy had exacerbated a pre-existing condition but the pregnancy checkbox had not been ticked, and the ICD coding rules had been incorrectly applied.

Of the 28 deaths to women of reproductive age that had not been captured at all in the CRVS, the expert review panel determined that three were true maternal deaths and the remaining 25 were non-maternal.

**Figure 3.** Representation of all deaths within a given year within a population of women of reproductive age (15–49 years) in country X

<table>
<thead>
<tr>
<th></th>
<th>T+</th>
<th>F-</th>
<th>U+</th>
<th>N=30 true maternal deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=21</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F+</td>
<td></td>
<td></td>
<td></td>
<td>N=220 true non-maternal deaths</td>
</tr>
<tr>
<td>N=3</td>
<td>T-</td>
<td></td>
<td></td>
<td>N=28 deaths not captured in CRVS</td>
</tr>
<tr>
<td></td>
<td>N=192</td>
<td></td>
<td></td>
<td>N=25 deaths to women of reproductive age</td>
</tr>
<tr>
<td>N=24 maternal deaths captured in CRVS</td>
<td>N=198 non-maternal deaths captured in CRVS</td>
<td>CRVS: civil registration and vital statistics</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ZIMBABWE CASE STUDY
Quantifying underreporting of maternal deaths – an example of the application of the “six-box method” (WHO African Region)

Zimbabwe is currently a lower middle-income country where maternal mortality is high; the MMR was estimated at 458 maternal deaths per 100,000 live births (80% UI: 360–577) in 2017 (WHO, 2019a). In common with many other settings in sub-Saharan Africa, deaths often take place outside of a health-care facility.

The primary source for maternal mortality data has been periodic population-based surveys that use the “sisterhood method”, such as the Demographic and Health Surveys (DHS). This method is an indirect survey technique in which women are asked about the survival and pregnancy-related mortality of female siblings to aid the calculation of the MMR. Zimbabwe also collects CRVS data in line with its Births and Deaths Registration Act of 1986, which requires mortality to be reported to the Registrar-General, by registering deaths to the district offices and compiling mortality data up to the central/national level. In practice, however, the CRVS has incomplete registration of deaths and has never been used by the United Nations Maternal Mortality Estimation Inter-Agency Group (MMEIG) to produce national MMR estimates. Research was therefore conducted in Zimbabwe in 2019–2020 to quantify the missing and misclassified maternal deaths, by revisiting the findings and methods of a reproductive age mortality survey (RAMOS) conducted earlier, in 2007–2008.

RAMOS study 2007–2008

During the 2007–2008 RAMOS study, standardized questionnaires were completed for every delivery identified within the 11 districts of the study (N=45,240), regardless of whether they took place in health-care facilities or the community. The researchers interviewed mothers to complete questionnaires, and extracted data from antenatal, maternity and postnatal records. For deaths that occurred in the community, verbal autopsies were conducted with close relatives of the deceased (husband, mother, sister or anyone who cared for the deceased). For women who had died in health-care facilities, the questionnaires were completed using data from the medical records. The RAMOS study identified 234 pregnancy-related deaths. At the time of that study, Zimbabwe did not use the ICD coding rules to assign cause of maternal death. Further methodological details and substantive findings relating to this study have been published by Musarandega et al. (2022).

2019–2020 review of maternal deaths for the 2007–2008 RAMOS study

The 2019–2020 study took place in the 11 districts of the original RAMOS study, and the data from 2007–2008 were rechecked, cleaned and verified using the previous questionnaires and notes. The Registrar-General’s offices (where CRVS records are collected and stored) were visited in each of the 11 districts, and records for all deaths of women of reproductive age taking place during the original RAMOS period were identified and reviewed. All hospitals in the 11 districts were also visited and case notes relating to relevant deaths identified. Various registers were reviewed at the hospitals, including those in the maternity and delivery wards, medical wards and the mortuary records. Reports of maternal death surveillance and response (MDSR) panels were identified from the district and provincial health offices. The DHIS2-based health management information system (HMIS), which reports all deaths by month and institution, was also checked. All data collection was done by two trained research midwives.

A panel of obstetrician-gynaecologists reviewed all the documentation for all of the pregnancy-related deaths identified – including documents originally obtained in 2007–2008 and supplementary cases and information obtained in the 2019–2020 survey. Training and guidance on the use of ICD-10 was provided.
by the WHO Department of Sexual and Reproductive Health and Research, because a secondary objective of the sub-study was to build capacity in Zimbabwe for the ICD-10 classification to be implemented. Where complicated cases arose, the expert review panel discussed these with the Department’s team.

In 2007–2008, a total of 45 240 deliveries and 234 pregnancy-related deaths were reported. After the review in 2019–2020, 45 579 deliveries, 325 pregnancy-related deaths (including 296 maternal deaths) were identified in the same locations for the same period as the original study - a substantial increase in numbers.

Analysis of missing and misclassified deaths in the RAMOS study

Eleven of the 234 deaths in 2007–2008 were found to be duplicate records that had been entered by mistake, leaving 223 unique pregnancy-related deaths captured in the original study. The 2019–2020 review identified 8 pregnancy-related deaths that had been identified in 2007–2008 but with the questionnaires incorrectly completed, 18 pregnancy-related deaths for which a paper questionnaire existed from the 2007–2008 study but the data had not been entered into the study database, and 80 pregnancy-related deaths that had apparently not been identified at all in the 2007–2008 study. Of the 325 pregnancy-related deaths identified as the verified total, there were four duplicated deaths created by twin deliveries, so that 296 were maternal deaths and 29 were pregnancy-related deaths due to accidental or incidental causes (non-maternal deaths).

The panel of obstetrician-gynaecologists reviewed the cause of death assigned for all the pregnancy-related deaths. Of the 325 pregnancy-related deaths verified by the 2019–2020 study, 86% were determined to have had the cause correctly assigned by the trained research midwives. In the remaining cases, the expert review panel felt that the ICD-10 coding principles for assigning the underlying cause of death had not been correctly followed by the research midwives. The main reasons for the incorrect classification were inappropriate knowledge and/or lack of expertise of the original assessor (i.e. the trained research midwives). These findings underline the importance of having a review panel.
Data-collection challenges in fragile, humanitarian and emergency contexts
3.1 Measuring maternal mortality in fragile and humanitarian settings

The United Nations Population Fund (UNFPA) estimates that 48 million women and girls are living in emergency settings worldwide, including 4 million pregnant women (UNFPA, 2020). Furthermore, the majority of countries with the highest burden of maternal mortality (above 300 per 100,000 live births) are among those considered fragile states by the Organisation for Economic Cooperation and Development (OECD, 2015). Emergency settings pose significant challenges for women and girls seeking sexual and reproductive health (SRH) services due to a combination of factors, including a high prevalence of pre-existing nutritional deficiencies and increased infectious disease susceptibility. Other vulnerabilities in humanitarian settings include poor access to essential services such as family planning services and contraceptives, comprehensive abortion care, protection from gender-based violence, and clinical management of rape. In addition, limited access to antenatal care, skilled birth attendance and emergency obstetric care remain substantial barriers to maternal health and contribute to an increased risk of pregnancy-related death in humanitarian and emergency contexts (Zeid et al., 2015).

Establishing systems for measuring and monitoring maternal mortality in humanitarian and fragile settings is crucial and needs to take into account system constraints and particular challenges faced in these contexts.

3.1.1 Implementing MDSR in humanitarian and fragile settings

Acute phase in humanitarian settings

MDSR should not be implemented during the acute phase in any humanitarian settings (the first six months post-disruption). Only maternal death surveillance is appropriate at this stage. Tracking deaths is crucial, and the focus should be on rapid surveillance, counting deaths and establishing critical health services. A landscape analysis should be done to determine what health systems and infrastructure remain in place to count the deaths.

Protracted phase in humanitarian settings (after the first six months)

Implementing an MDSR system should be considered during the protracted phase in humanitarian settings (after the first six months) if health services are in place – with the focus at first on strengthening health systems and quality of care. When establishing an MDSR system, focus should first be on health-care facilities, with later expansion to surveillance and response for community-based deaths. Once the MDSR system is established, it is essential to institute both death surveillance and high-quality death reviews.

3.2 Challenges in emergency contexts such as pandemics

The challenges to collecting data on maternal mortality during a pandemic have also affected the monitoring of COVID-19 itself in terms of the excess deaths caused, some of which are maternal deaths where COVID-19 was aggravated by the pregnancy. Yet the COVID-19 crisis has provided an opportunity to reflect on the existing as well as the new challenges to routine data collection, including for the monitoring of maternal mortality during crisis and emergency situations.
There has been widespread disruption during the pandemic to daily life across the world as countries have implemented lockdown measures and introduced restrictions. The ability to conduct face-to-face data-collection activities such as surveys and censuses has also been impacted by COVID-19 (Bidarbakhtnia, 2020), leading to an increased risk of administrative data being incompletely reported or misclassified. Yet the crisis has also accelerated the emergence of potentially promising new approaches, including surveillance using mobile phone surveys (Adjiwanou et al., 2020). Although such methods have yet to be tested in practice, they are worthy of further exploration.

The WHO technical note issued in 2020 to support the correct identification and coding of COVID-19 deaths and help with crude mortality measurement may be relevant to the users of the present guidance (WHO, 2020). Support is also available for surveillance and epidemic response in a technical package focused on rapid mortality surveillance (Vital Strategies and WHO, 2020).

COX’S BAZAR, BANGLADESH CASE STUDY
Setting up a maternal death surveillance system in a refugee camp setting (WHO South-East Asia Region)

The refugee camp in the town of Cox’s Bazar is currently host to the world’s largest refugee settlement. In response to the massive influx of refugees into Bangladesh in the last few years, efforts to manage this large-scale humanitarian emergency have been established, despite very limited infrastructure and a challenging environment. These efforts have included the development of a maternal mortality surveillance system. Measuring mortality in humanitarian crises and among other populations in vulnerable and marginalized situations poses a substantial challenge. The United Nations Maternal Mortality Estimation Inter-Agency Group (MMEIG) does not estimate the MMR for subnational populations, and countries differ in whether or not they include refugees and other non-national populations in their own national statistics. Measurement difficulties naturally result from the constrained resources and challenging environments inherent to temporary and/or fragile contexts, and the need to prioritize services in emergencies may call for alternative solutions to measurement and estimation.

In the refugee camp in Cox’s Bazar, a combined facility-based and community mortality surveillance system was established. A partnership between the United States Centers for Disease Control and Prevention (CDC), the United Nations Population Fund (UNFPA) and the Centre for Injury Prevention and Research Bangladesh (CIPRB) was formed in September 2018 to guide the development of the surveillance system for this population of refugees, who have moved mainly from Rakhine State in Myanmar. Since then, the partnership has worked alongside a network of community health workers (CHWs) from the Rohingya refugee population and local Bangladeshi implementing partners to gather community-level data on maternal deaths in the Rohingya refugee camps.

The measurement of maternal mortality among the Rohingya refugee population began with a retrospective reproductive age mortality study (RAMOS) that was implemented between August 2017 and August 2018 and has progressed over time. The results from the study informed the creation, in October 2018, of a verbal autopsy questionnaire for women of reproductive age - a tool used to capture details on death retrospectively in communities. Training on the tool was then conducted in November 2018 and has since been integrated into the system. The Early Warning, Alert and Response System (EWARS), developed by WHO for use in all humanitarian settings, aims to capture disease, including deaths (WHO, 2019b). However, this system does not capture data on deaths that occur outside of health-care facilities. The EWARS implementation in Bangladesh in April 2019 integrated components of the existing mortality system (including maternal mortality) to support the timely notification of deaths of women of reproductive age and their investigation using verbal autopsies. A timeline of these key activities in the development of the maternal mortality surveillance system is shown in Figure 4. Prospective data collection for maternal mortality began in November 2018 and is ongoing.
Process evaluation of the maternal mortality surveillance system

An evaluation of the surveillance system was conducted in late autumn of 2019 with two local partners, Research, Training and Management (RTM) International and Partners in Health and Development (PHD). This evaluation aimed to document the efficiency of the system, identify strengths and limitations and provide recommendations for future actions. The evaluation used a mixed-methods approach, including key informant interviews, direct observation and quantitative analysis.

Key informant interviews were carried out with CHWs and their supervisors, health information officers, medical doctors based in health-care facilities, the lead for the maternal mortality surveillance, the lead for the EWARS system, and managers from partner organizations. Direct observations were also undertaken to capture information on daily surveillance activities at the community and facility levels. These observations involved joining CHWs during their routine activities as well as observations at health-care facilities of data-recording procedures, data management and medical professionals’ interactions with the system. In addition to the qualitative methods used, the evaluation applied quantitative analysis to three sources of data: (i) EWARS (electronic database), (ii) CHW mobile data collection into an electronic database of aggregate numbers of deaths (using KoBoToolbox software) and (iii) CHW mortality documentation (paper-based forms).

Desk review and triangulation of data sources

Each CHW paper form was assigned a unique identifier during a desk review of reporting documents, including CHW general mortality reports, EWARS data entry results, verbal autopsies and death reviews. Data collected and kept by nongovernmental organizations (NGOs) were entered into KoBoToolbox, while data collected by health-care facilities and CHWs were entered into EWARS. To compare these, a list was made for each form, including the following items: deceased age, deceased gender, camp location, date of death, time of death, CHW, cause of death, place of death, presence of health-care facility medical signature, date of EWARS submission, and if the form used was the most up-to-date version. For triangulation, the paper forms completed by CHWs but sent to NGOs were compared with the corresponding electronic line list from the EWARS in a two-step process. This was achieved by first filtering the EWARS for women of reproductive age and then ordering by date of death and CHW organizational affiliation. Date of death and age of the deceased were used to match the paper forms to the EWARS.
records. If no match was identified, the second step involved filtering the EWARS line list by gender and a code associated with a health-care facility location.

To compare aggregate numbers across EWARS data, KoBoToolbox data from the CHW working groups (WGs), and the CHW paper-based forms, a final assessment was carried out between the systems. EWARS aggregate data were determined by filtering the line list by gender and then ordering by age of deceased. The CHW WG KoBoToolbox data were provided by the United Nations High Commissioner for Refugees (UNHCR) team and the aggregate numbers from the paper-based forms were calculated by hand. To facilitate comparisons across different systems, five-year age groups were used to aggregate the data rather than the total population of women of reproductive age.

Table 3. Types of data and collection processes presently used in the Cox’s Bazar refugee camp

<table>
<thead>
<tr>
<th>Type of record</th>
<th>Types of information collected</th>
<th>Data-collection methods</th>
<th>Level and frequency of data collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community health worker (CHW) mortality reports, verbal autopsies, and death reviews</td>
<td>Deceased age Gender Camp location Date and time of death Pregnancy status at death Name of the partner/affiliated CHW organization Estimated cause of death</td>
<td>Interviews of deceased’s family members by sexual and reproductive health (SRH) CHWs Record reviews from affiliated nongovernmental organization (NGO) partners</td>
<td>Individual level data collection beginning at time of death notification (within 24 hours)</td>
</tr>
<tr>
<td>Early Warning, Alert and Response System (EWARS) data entry results</td>
<td>Health-care facility associated with location Deceased age Gender Date of death</td>
<td>Data extracted from CHW mortality reports, entered online into WHO platform by health-care facilities</td>
<td>Individual level data entered within 24-48 hours of death notification</td>
</tr>
<tr>
<td>CHW working group (WG) KoBoToolbox</td>
<td>Deceased age Gender Date of death</td>
<td>Data extracted from CHW mortality reports, entered into CHW WG platform by NGO partners</td>
<td>Aggregate data collected monthly</td>
</tr>
</tbody>
</table>

Lessons learnt

Timeliness of reporting

Qualitative data from the key informants highlighted challenges related to the timeliness of reporting within the system, noting that it took one to two weeks to input into the EWARS a death identified in the community. These delays resulted from the intensive hierarchical system of mortality reporting, which involved signatures from the CHW, the CHW supervisor and a medical practitioner before the report could be referred up to a health information officer to be entered into EWARS. If the death was maternal or perinatal, mortality report details would also be verified with the family by the CHW supervisor prior to EWARS data entry. Health information officers were often overburdened, and organizations may have been understaffed. Depending on the type of death, the mortality reporting details were also manually entered into two or three different data-entry systems. This complex system of verification, the varied levels of signature acquisition and the duplicative recording requirements for health information officers all created delays in reporting.
Data quality and completeness

A newer component added to the latest version of the mortality report was a signature by a medical officer to confirm the death. However, assessment of the CHW mortality reports from the study time period revealed that the majority of forms completed for women of reproductive age did not use the most recent version, which resulted in fewer signed reports. Direct observations also confirmed this limitation regarding out-of-date forms.

The paper forms were reviewed for completeness, and this indicated challenges related to documenting all the required information. While name, age, gender and date of death were included on all forms, cause-of-death data were missing from 50% of the forms. Informal conversations with medical officers revealed that they did not feel comfortable signing for a cause of death on a case where they had never seen the patient.

An assessment of agreement between the paper forms and the EWARS data demonstrated low levels of matching between the two systems. For one CHW partner organization, none of the forms matched submissions found in the EWARS. For the other partner, only two out of nine forms matched what was included in the EWARS. An assessment of the agreement between the paper forms and the CHW WG’s KoBoToolbox data could not be done, as line list information had not been gathered in the KoBoToolbox system.

Future maternal mortality surveillance system improvements in the humanitarian setting of the refugee camp

The assessment of the surveillance system in the refugee camp highlighted common challenges related to aspects of data quality, including the timeliness of reporting, consistency between reports, and completeness – challenges that can have solutions here in Cox’s Bazar and in similar settings in other parts of the world. A set of five actionable recommendations for improving the surveillance system in the setting have been suggested through the partnership between the CDC, UNFPA and CIPRB, including:

1. Consider community-level notification of deaths of women of reproductive age, rather than waiting until this information flows from the community to the health-care facility and then to EWARS. This will prompt earlier investigation via verbal autopsy. The proposed data flow diagram is given in Figure 5.

2. Undertake quarterly training on the CHW mortality forms to engage CHWs, CHW supervisors, health information officers, physicians and CHW WG members to improve data quality. CHWs, being Rohingya themselves, cannot leave the refugee camps and so need consistent, targeted refresher training that reflects feedback received by their supervisors on aspects of data quality. CHW supervisors, health information officers and physicians should also have training, quarterly - this would help to address the effect of a high turnover of staff in these positions.

3. Many issues with duplicative reporting have already been overcome due to the reorganization of SRH CHWs into assigned catchment areas. Each catchment-area CHW is also associated with a specific organization that coordinates reporting. However, at the camp organizational level, a single coordinating SRH body under UNFPA should be used to clarify reporting streams. Distinctions between community and health-care facility reporting streams should also be defined to avoid missed notifications.

4. Currently, a monitoring and evaluation framework has been designed to evaluate the maternal mortality surveillance system and coordinate with the SRH sub-sector and the CHW WG. This framework should be implemented to assess data quality, coverage and use of the system for the specific populations.

5. Death review committees, composed of trained physicians, should be used to assess initial surveillance system data obtained from death notifications and verbal autopsies. This assessment should generate actionable recommendations as part of routine death-mapping activities and to improve the health system. These review committees should also be integrated into the SRH sub-sector and the CHW WG to facilitate the coordination and implementation of recommendations.

6. The requirement for a medical officer’s signature on the mortality report should be removed, and printed copies of the most up-to-date CHW mortality forms should be distributed. Additionally, further medical information for women of reproductive age would be captured during verbal autopsy.
The data flow diagram (Figure 5) shows the ideal flow of information. CHWs visit each household twice a month. During the visit, they inquire if any deaths have occurred. If the answer is yes, this begins the data-acquisition flow (indicated by green arrows). The time indicated is the cumulative time from when the CHW first hears of a death from the household.

**Figure 5. Community surveillance of maternal mortality in the refugee camp in Cox’s Bazar, Bangladesh - proposed revision of data flow system (October 2019)**


The CHW fills out the mortality form at the same time they are visiting the house and hear of the death. They then have 24 hours to notify their CHW supervisor and give them the form. The CHW supervisor then calls the UNFPA maternal mortality lead if the deceased was a female aged 12–49 years (purple arrow). The UNFPA lead maintains a line list of women of reproductive age needing verbal autopsy and reminds the appropriate partner to complete the verbal autopsy within 10–14 days. The results of the verbal autopsy are then inputted into the verbal autopsy KoBoToolbox once they have been completed (within 24–48 hours of completion). The information will then be reviewed by a formal death review committee (established by the SRH coordination mechanism) and used to identify preventable causes of death and develop actionable implementation strategies to prevent future mortalities.

After the CHW supervisor notifies the UNFPA lead, the supervisor takes the form to the assigned health-care facility as indicated by the CHW WG. Lastly, the form is given to the appropriate data information specialist for electronic submission into EWARS and the CHW WG’s KoBoToolbox software. Any further details or mistakes in the mortality report that are uncovered during the verbal autopsy can also be used to correct data in EWARS/KoBoToolbox.
Providing metadata in national mortality reporting
In addition to information on the number and causes of maternal deaths, and the sensitivity and specificity of identification of maternal deaths using the six-box method, clear and standardized reporting of metadata - describing where the data came from, including their strengths and weaknesses - is of the utmost importance to facilitate appropriate interpretation and application of the data.

This section provides a description of the types of information that are important to document alongside reported maternal death data.

### 4.1 Description of the population

It is important to distinguish if the target population includes everyone in a country, and to explicitly describe the treatment of data from visitors, refugees or resident non-citizens, or if certain regions or areas are excluded due to political instability or for other reasons.

While the maternal mortality ratio (MMR) estimates of the United Nations Maternal Mortality Estimation Inter-Agency Group (MMEIG) are calculated using national-level data, subnational data are sometimes used to estimate the cause-of-death distribution. If the data being reported are subnational, then information relating to the catchment population should be defined clearly. In addition, it is very useful to provide information about how this area compares with the national population (e.g. in terms of urban/rural density, relative wealth/poverty, the particular mix of ethnic or religious groups, and the access to and usage/uptake of health services).

### 4.2 Processes for identifying maternal deaths

The methods used to identify deaths (including those set out in Chapter 2) should be clearly stated, including whether multiple data sources were linked, whether deaths outside of health-care facilities have been captured, and quantification of the completeness of the data.

### 4.3 Processes for coding the cause of death

The process of how the causes of death were assigned and who assigned them should be documented. A process sheet on the coding process can be helpful for this purpose to indicate the person who assigned the codes, how the codes were assigned, if standard classifications were used (and, if these followed the ICD, which version). Information on the training and guidance of the coders in terms of ICD rules is also valuable to include.

### 4.4 Timeliness of reporting

How quickly a death is expected to be reported after its occurrence, and the optimal timing of any review by an expert panel should be described clearly and reported.

### 4.5 True-zero reporting

Maternal death is a rare event. Particularly in smaller countries, and/or countries with a low absolute burden of maternal mortality, it often happens that there were no deaths for a given maternal cause for the time period for which the data are being presented. It is important that there is a clear system in place for distinguishing between true zeros - where it is known for certain that no deaths occurred - and situations where no deaths have been recorded but it is unclear whether this was because a response to the question was omitted. Using a documentation convention that stipulates not leaving any field blank can help to avoid such situations.
4.6 Characteristics of the deaths

As well as giving the number and causes of the deaths, every effort should be made to include information on maternal age, to allow age-specific breakdowns to be calculated. The risk of maternal mortality and the distribution of causes differ according to age, and this may have important programming implications.

Information on the trimester of pregnancy and the timing of the maternal death is necessary for the accurate measurement of maternal mortality. For deaths that occur after termination of the pregnancy, documentation on timing should cover these five categories: days 1–6, days 7–13, days 14–27, days 28–42, and days 43–365.

<table>
<thead>
<tr>
<th>Question</th>
<th>Notes</th>
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<tbody>
<tr>
<td><strong>Section I: Civil registration and vital statistics (CRVS) data</strong></td>
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</tr>
<tr>
<td>1  Through which authorities are deaths reported in your country? Please indicate all that apply.</td>
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<tr>
<td>Civil registry □</td>
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<td>Local health authorities □</td>
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<tr>
<td>Local police authority □</td>
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<tr>
<td>Ministry of health □</td>
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<tr>
<td>Other (specify) □</td>
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<tr>
<td>Don’t know □</td>
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<tr>
<td>2  Is death registration compulsory?</td>
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<tr>
<td>Yes □</td>
<td></td>
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<tr>
<td>No □ (skip to Question 5)</td>
<td></td>
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<tr>
<td>Don’t know □</td>
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<tr>
<td>3  Does the death registration aim to capture all deaths nationally?</td>
<td></td>
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<tr>
<td>Yes □</td>
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<tr>
<td>No □</td>
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<tr>
<td>Don’t know □</td>
<td></td>
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<tr>
<td>4  Is reporting of the cause of death compulsory?</td>
<td></td>
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<tr>
<td>Yes □</td>
<td></td>
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<tr>
<td>No □</td>
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<tr>
<td>Don’t know □</td>
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<tr>
<td>Question</td>
<td>Notes</td>
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</table>
| **5** What is the national estimated completeness of overall registered deaths?  
Level of completeness (specify %) ____________  
Unknown □ (skip to Question 8) | Specify if any particular area, region or population group is not included in the mortality data provided to WHO or is significantly underreported in comparison with other areas, regions or population groups |
| **6** Specify the year to which estimated completeness refers  
Year__________  
Unknown □ | |
| **7** What is the source of completeness estimate?  
___________________________________________  
___________________________________________  
___________________________________________  
___________________________________________  
If there is no source for completeness estimate, please describe how completeness was estimated  
___________________________________________  
___________________________________________  
___________________________________________  
___________________________________________ | Please indicate the name of relevant authority/agency, confidential enquiry committee, report name, etc. |
| **8** Are maternal deaths within overseas territorial units included in the figures provided to WHO?  
Yes □  
No □  
Don’t know □ (skip to Question 10)  
Not applicable □ (skip to Question 10) | |
| **9** Which overseas territories are excluded in the figures provided to WHO? | |
| **10** Do you use the current International Form of Medical Certificate of Cause of Death as recommended by WHO in ICD?  
Yes □  
No □  
Don’t know □ | If no, please upload a copy of death certificate used |
<table>
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<tr>
<th>Question</th>
<th>Notes</th>
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<tbody>
<tr>
<td><strong>Section II: Surveillance data (maternal death surveillance and response [MDSR] system)</strong></td>
<td></td>
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</table>
| 11 Does the ministry of health (or other authority) publish guidance on the identification and reporting of maternal deaths within health-care facilities? | Yes ☑  
No ☐ (skip to Question 13)  
Don’t know ☐ |
| 12 Do these guidelines define reporting procedures at all levels?        | Reporting procedures include guidelines for cause of death assignment |
|                                                                        | Yes ☑  
No ☐  
Don’t know ☐ |
| 13 Is maternal death a notifiable event?                                | Maternal death notification should be within 24 hours - check existence of national policy for maternal death notification |
|                                                                        | Yes ☑  
No ☐ (skip to Question 17)  
Don’t know ☐ |
| 14 What percentage of facility-based maternal deaths are notified?      |                                                                      |
|                                                                        | ________________ |
| 15 What percentage of community-based maternal deaths are notified?     |                                                                      |
|                                                                        | ________________ |
| 16 Are maternal deaths notified via an electronic and/or a paper-based system? | To determine if electronic devices used for notification in communities |
|                                                                        | Electronic ☑  
Paper ☐ |
| 17 Is there a national maternal death review committee in your country? |                                                                      |
|                                                                        | Yes ☑  
No ☐ (skip to Question 21)  
Don’t know ☐ |
| 18 What is the composition of the national maternal death review committee? |                                                                      |
|                                                                        | ________________  
______________________________________________________________________
<table>
<thead>
<tr>
<th>Question</th>
<th>Notes</th>
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<tbody>
<tr>
<td><strong>19</strong> How often does the committee meet?</td>
<td></td>
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<tr>
<td>Monthly □</td>
<td></td>
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<tr>
<td>Quarterly □</td>
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<tr>
<td>Annually □</td>
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<tr>
<td>Don’t know □</td>
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<tr>
<td>Other □ (please specify)</td>
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<tr>
<td><strong>20</strong> What proportion of maternal deaths notified through MDSR are reviewed at national committee meetings?</td>
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<td>______________________________________________________________________</td>
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<tr>
<td><strong>21</strong> Are there any subnational maternal death review committees in the country?</td>
<td></td>
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<tr>
<td>Yes □</td>
<td></td>
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<tr>
<td>No □ (skip to Question 23)</td>
<td></td>
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<tr>
<td>Don’t know □ (skip to Question 23)</td>
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<tr>
<td><strong>22</strong> How many subnational maternal death review committees are there?</td>
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<td>______________________________________________________________________</td>
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<td>______________________________________________________________________</td>
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<tr>
<td><strong>23</strong> What is the estimated level of completeness of the surveillance system?</td>
<td></td>
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<td>______________________________________________________________________</td>
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<td>______________________________________________________________________</td>
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<tr>
<td>To determine the catchment/target population of the deaths</td>
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<tr>
<td><strong>24</strong> Are causes of maternal deaths based on application of ICD?</td>
<td></td>
</tr>
<tr>
<td>Yes □</td>
<td></td>
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<tr>
<td>No □ (please describe how cause of death is assigned)</td>
<td></td>
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<tr>
<td>Don’t know □</td>
<td></td>
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<tr>
<td><strong>25</strong> Who assigns cause of death codes?</td>
<td></td>
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<td>______________________________________________________________________</td>
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<tr>
<td><strong>26</strong> Who reviews cause of death coding?</td>
<td></td>
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<tr>
<td>______________________________________________________________________</td>
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<tr>
<td><strong>27</strong> Do members of the MDSR committee receive specific training on assignment of underlying cause of death according to ICD principles?</td>
<td></td>
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<tr>
<td>Yes □</td>
<td></td>
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<tr>
<td>No □</td>
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<tr>
<td>Don’t know □</td>
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<td>Question</td>
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<tr>
<td>28  Please provide any information on the non-reported subpopulation</td>
<td>Detailing the non-reported subpopulation: provide information on demographics (literacy, marital status, socioeconomic status, etc.) of study cases, facility characteristics, referral patterns, care uptake, barriers, cultural and behavioural factors (results from data triangulation)</td>
</tr>
<tr>
<td>29  Have you conducted a validation study to estimate misclassification?</td>
<td>Yes ☐  &lt;br&gt; No ☐  (skip to Question 31)  &lt;br&gt; Don’t know ☐</td>
</tr>
<tr>
<td>30  Describe the details and main findings of any recent validation studies</td>
<td></td>
</tr>
<tr>
<td>31  Are maternal death certificates linked to birth certificates, fetal death records and/or termination of pregnancy registries?</td>
<td>Note that linkage refers to whether the registries themselves are individually linked (for most countries this is “no”)</td>
</tr>
<tr>
<td>32  Please describe which sets of records are linked in this setting</td>
<td></td>
</tr>
<tr>
<td>33  What proportion of maternal deaths identified in MDSR are included in the CRVS?</td>
<td></td>
</tr>
<tr>
<td>34  What proportion of maternal deaths identified in MDSR are reported in the health management information system (HMIS)?</td>
<td></td>
</tr>
</tbody>
</table>
References


