MATERNAL MORTALITY MEASUREMENT

6-box method training material

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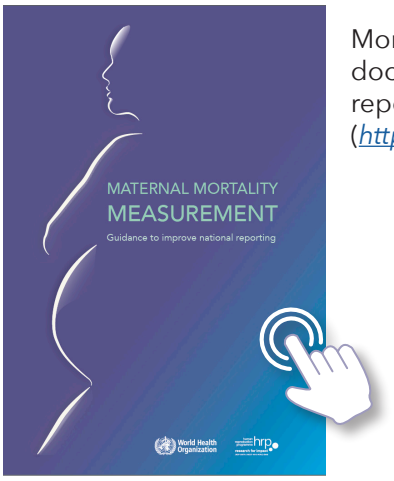
This training material is intended to support personnel working in ministries of health, national statistics offices and other national agencies responsible for maternal mortality data collection.



More details about maternal mortality measurement can be found in the document: Maternal mortality measurement: guidance to improve national reporting. Geneva: World Health Organization; 2022 (*https://apps.who.int/iris/handle/10665/360576*).

QUANTIFYING INCOMPLETE AND MISCLASSIFIED DATA: THE "SIX-BOX METHOD"

This training material 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.

INFO BOX

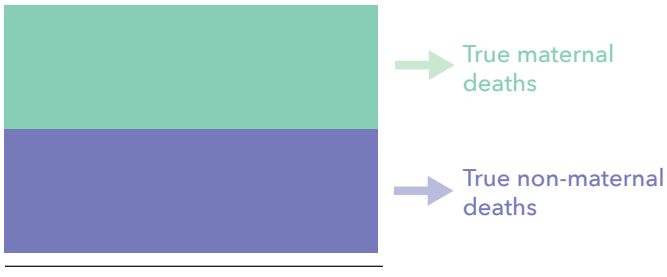
For more about designing a strategic plan to improve the quality of civil registration and vital statistics data, see *Improving the quality and use of birth, death and cause-of-death information: guidance for a standards-based review of country practices (WHO, 2010)*

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.[1] 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.

To enable more countries to use their own data to quantify incomplete and misclassified data, we can use a method for categorization of deaths in the official statistics 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:



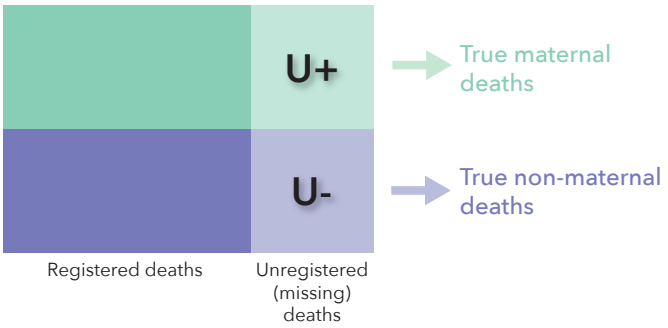
1 Peterson E, Chou D, Moller A-B, Gemmill A, Say L, Alkema L. Estimating misclassification errors in the reporting of maternal mortality in national civil registration vital statistics systems: a Bayesian hierarchical bivariate random walk model to estimate sensitivity and specificity for multiple countries and years with missing data. Stat Med. 2022;1–14. doi:10.1002/sim.9335.

Estimates for countries with limited or no such data are informed by data from other countries and periods.

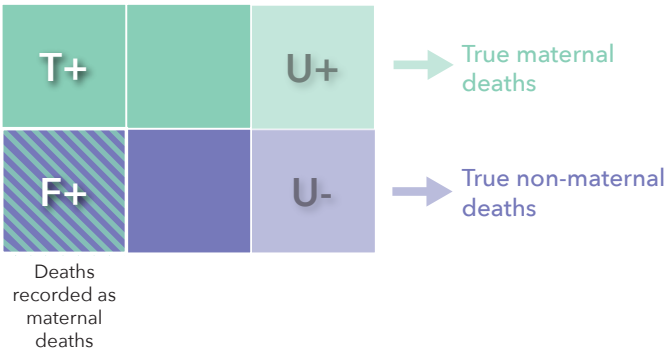
Some deaths will be captured/registered in the data-collection system (e.g. CRVS system) and some will not (i.e. they are missing). Some of these missing deaths will be unregistered true maternal deaths (denoted by U+) and some will be unregistered non-maternal deaths (denoted by U-). For a death to 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:

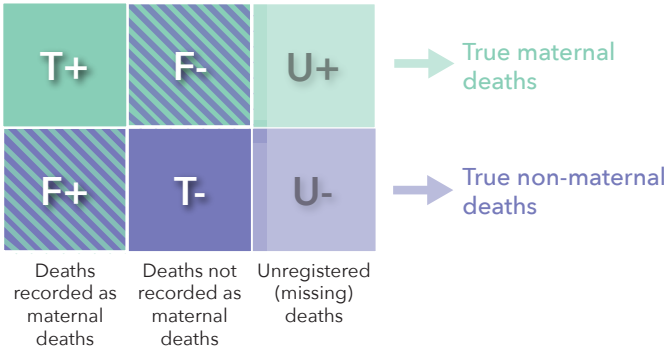


Of the deaths recorded in the data-collection system as maternal deaths, T+ denotes the true maternal deaths that are correctly recorded as maternal deaths while F+ denotes the true non-maternal deaths that are incorrectly recorded as maternal deaths:



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.



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 1).

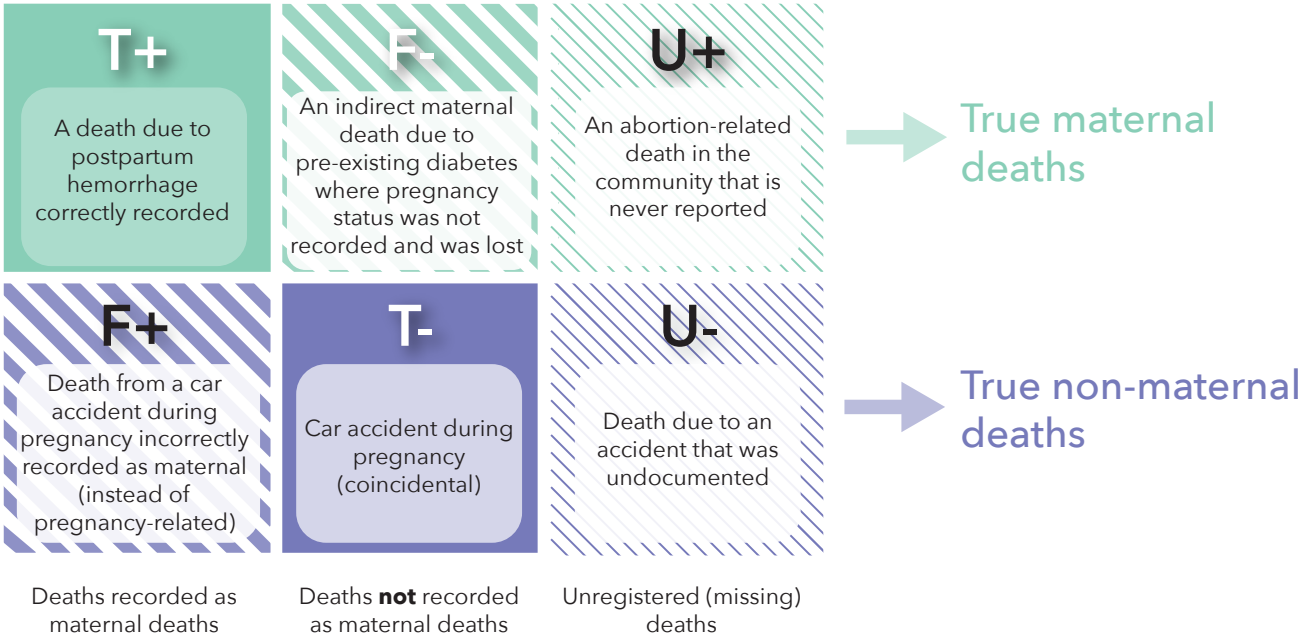
Finally, these numbers can be used to calculate sensitivity and specificity using two simple formulae:

$$Sensitivity = \frac{T^{+}}{T^{+} + F^{-}}$$

$$Specificity = \frac{T^{-}}{T^{-} + F^{+}}$$

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.

Figure 1. Examples of scenarios where a death may fall into each of the six boxes



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.

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.[2] 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. 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,[2] 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.

2 World Health Organization. The WHO application of ICD-10 to deaths during pregnancy, childbirth and the puerperium, ICD-MM. Geneva: 2012. (*https://apps.who.int/iris/bitstream/handle/10665/70929/9789241548458_eng.pdf*).

Figure 2. Representation of all deaths within a given year within a population of women of reproductive age (15–49 years) in country X

T+ N=21	F- N=6	U+ N=3	N=30 true maternal deaths
F+ N=3	T- N=192	U- N=25	N=220 true non-maternal deaths
N=24 maternal deaths captured in CRVS	N=198 non-maternal deaths captured in CRVS	N=28 deaths not captured in the CRVS	N=250 deaths to women of reproductive age

CRVS: civil registration and vital statistics

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.[3]
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.[4]

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.

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3 World Health Organization. Trends in maternal mortality 2000 to 2017: estimates by WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division. Geneva; 2019.

4 Musarandega, R., Ngwenya, S., Murewanhema, G. et al. Changes in causes of pregnancy-related and maternal mortality in Zimbabwe 2007-08 to 2018-19: findings from two reproductive age mortality surveys. BMC Public Health 2022:(22): 923. https://doi.org/10.1186/s12889-022-13.

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.