ABSTRACT

Context: Accurate measurement of maternal mortality is an imperative for policy and planning on maternal health care. 

Objective: The objective of this review is to focus attention on the various methods of measuring maternal mortality, advantages, and drawbacks. Source of materials for this article are from learned journals and reports on the subject. 

Conclusion: The measurement of maternal mortality poses unique challenges in resource-poor settings in developing countries. In these settings, though various methods may be employed, a census, cumbersome as it may be, offers the best possible source of data. 

Key words: Direct counting; maternal mortality; special surveys.

Measuring maternal mortality is difficult and complex and reliable estimates of the dimensions of the problem are not generally available. The 1990 World Summit for Children set the goal of halving the 1990 levels of maternal mortality by the year 2000, but assessing progress toward the goal was difficult. However, in more recent years, new ways of measuring maternal mortality have been developed with the needs and constraints of developing countries in particular in mind. As a result, there is considerably more information available today than was the case even a few years earlier. Nonetheless, the methods available differ considerably, making it hard to compare the data obtained from different sources. Moreover, problems of under-reporting and misclassification of maternal deaths are endemic to all methods. 

An ideal methodology for estimating maternal mortality should be capable of producing acceptably precise estimates at the national level as well as producing differentials in maternal mortality by region, urban/rural residence, age, and other characteristics of interest. The method should be capable of producing multiple indicators of maternal mortality, i.e., in addition to the maternal mortality ratio, the method should also generate the maternal mortality rate, the proportion of maternal causes of adult female deaths and lifetime risk of maternal death. The interplay between changing rates of maternal mortality and fertility often produces unexpected results. Therefore, sole reliance on one indicator such as the maternal mortality ratio is insufficient and may produce misleading information for program and policy process. 

Maternal mortality data should in the ideal be collected by an institution other than those responsible for implementation of maternal health programs. The burden of data collection on small, community-based programs seriously detracts from their primary mandate of providing health services. The best approach relies on methods capable of generating indicators annually in order to provide information on long-term trends. This may be possible where the prevalence of maternal deaths

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is high but in communities where it is rare, even complete vital statistics may not provide useful annual estimates.

Annual data on maternal mortality from industrialized countries over the last century are almost always presented as 5-year rolling averages to avoid the erratic nature of the maternal mortality ratio. Arguably, annual data on maternal mortality levels may not be useful for program planning and policy. Furthermore, dramatic decline in maternal mortality over a short period of time in developing countries is not expected given the understanding of the critical role of skilled health personnel, health infrastructure, and access to emergency obstetric care in reducing maternal mortality. Thus, from a practical perspective, maternal mortality measurement needs to only generate data once every 10 years. This may be particularly useful in developing countries where annual births and death measurements are non-existent or grossly inaccurate. It may also be challenging to keep data safe and untampered with for this duration.

In general, two forms of measurement are used: direct counting and special surveys. The former includes vital registration system, use of hospital records, and census. Special survey techniques include reproductive age mortality studies, direct household survey methods, and the sisterhood methods (direct and indirect).

**Direct Counting**

In the industrialized world, civil registration systems generate the needed data on maternal mortality, albeit with substantial and often acknowledged underreporting. However, in the majority of developing countries, civil registration data are simply too incomplete to be useful or may be absent. The reasons for underestimates of maternal mortality and vital registration vary according to the degree of sophistication of the registration system.

Although the definition of maternal death appears in the international classification of diseases (ICD 9 and 10) is scientifically incontrovertible, in practice maternal deaths often escape being so classified because the precise cause of death cannot be given even though the fact of the woman being pregnant is known. To facilitate the identification of maternal deaths, the ICD 10 has introduced a new category that of pregnancy-related death, which is intended for use in countries that wish to count maternal deaths but where the cause of death cannot be identified precisely. This requires that all death certificates include a question on pregnancy status of the deceased woman. Only a few countries do so at present and in only a minority of the world’s population, the cause of death is routinely reported.

Where good vital registration does exist, biases are usually due to incorrect classification of the cause of death. There may be many social, religious, emotional, or practical reasons for not classifying a maternal death as such, especially if it relates to abortion. In most developed countries and hospital settings, there is usually an inquiry following a maternal death. This may constitute an incentive to attribute a maternal death to a less blameworthy cause. Such misrepresentation may not be very common in countries with a tradition of “no name no blame” confidential inquiries, though quite common elsewhere.

Where maternal mortality is low, few maternal deaths actually take place in obstetric departments of large hospitals because when life-threatening conditions arise the patient is transferred to another specialist department. An obstetrician will not certify the death and the cause of death appearing on the certificate may well not mention the obstetric condition which triggered the fatal sequence of events. An inquiry in France brought to light that as much as a third of 41 cases of maternal death reported as being related to maternal conditions by the certifying doctor were subsequently miscoded by the coding clerks. For example, cerebral hemorrhage was classified in “Diseases of the circulatory system” instead of “Complication of pregnancy, childbirth, and the puerperium.”

In countries where all or most deaths are medically certified, maternity-related deaths can still be grossly underestimated. Record linking and other studies have shown misreporting of between 25% and 70% of maternal deaths in USA. The situation is even worse where the registration of the fact of death is complete for deaths but poor for the cause of deaths. Maternal mortality measures based on such data are extremely misleading. Thus, even in the most favorable conditions, special efforts have to be made to get good data on maternal deaths.

**Hospital Data**

In the absence of civil registration, many researchers use hospital data to estimate maternal mortality. There are limitations to this approach and estimates calculated on hospital data alone tend to be under-representative. First, a large proportion of the women who die in hospitals are emergency admissions, women who had intended to give birth at home but who were transported to hospital when they developed a life-threatening condition. Safe deliveries at home do not, of course, appear in the denominator. This phenomenon emerges very clearly when hospital data are divided into booked and unbooked patients. At the Black Lion Hospital in Addis Ababa, Ethiopia, for example, the maternal mortality rate in 1980–1981 was 210 for booked compared with 1050 for unbooked patients.
Another possible cause of bias is a functioning referral system. Working efficiently, most high-risk women are referred to the hospital for delivery. This means that among the women giving birth at the hospital, there is a disproportionate number with obstetric complications and hence of women who die there. The women who have been referred to the hospital for delivery will appear in the statistics as booked patients. Therefore, it is not possible to estimate the degree of bias introduced into the maternal mortality rate as a result. A third source of bias is that of socioeconomic selection. If a hospital is fee-paying or caters for patients with a certain type of insurance, e.g., private clinics, it will attract economically advantaged women. Such hospitals are likely to have a lower maternal mortality rate than that prevailing in the community.

In general, the fewer births that take place in hospital, the greater the discrepancy between the true and the usually unknown population rate and the hospital rate. Valuable information can still be obtained from hospital studies, which can shed light on avoidable factors, especially those in hospitals and suggest specific interventions. Several studies have used hospital deaths as a starting point in tracing back the path followed by the dead woman, her prenatal care, who attended the birth, problems encountered in transport, financial and social barriers to the use of services, as well as shortcomings in the health care systems.

Hospital data must be used cautiously for cause of death information. In general, emergency complications from which women die quickly, e.g., hemorrhage, will be underrepresented because many women will not reach the hospital in time. A study in Bangladesh showed that only 1 of the 58 deaths identified took place in hospital and this was from eclampsia, whereas the majority of deaths at home were from hemorrhage. Deaths occurring early in pregnancy, e.g., abortions and ectopic pregnancies, may not be included because they occur in a different part of the hospital.

**Census**

Census measurement of maternal mortality would meet all the criteria of an ideal measurement technique. A high-quality census that includes question on deaths in the household in the last 1 to 2 years, followed by question which would permit identification of maternal deaths, would produce current national and sub-national estimates as well as various differentials. This type of census could produce all four of the commonly used maternal mortality indicators and would allow for trend analysis if undertaken more than once. The issue of sampling or other random error would be eliminated or greatly reduced, as a census is not sample based. However, it is possible to restrict the maternal mortality questions to a sufficiently large sub-sample of the census. In addition, an institution removed from health service provision would undertake data collection. The periodicity would be adequate as most developing countries undertake a census about every 10 years.

The discussion of maternal mortality in a census implies the measurement of a particular subset of all causes of deaths of adult females, i.e., deaths due to maternal causes. However, the literature on direct estimation of overall adult mortality via a census in the developing world suggests that questions about recent deaths in the household in a census have rarely provided useful information. A typical example is the cases of African censuses where 40–50% of deaths are estimated to have been omitted. This may be related to the break-up of the household after the death of a mother.

So far five countries are identified which collected maternal mortality data in their most recent censuses (Benin, Islamic Republic of Iran, Lao Peoples Democratic Republic, Madagascar, and Zimbabwe). The data collection methods and questions varied between countries. For each country, standard evaluation procedures were used to assess the completeness of reporting of all female deaths and births. Based on historical records of estimates of mortality and fertility in developing countries, the results were adjusted upward. The results of the census data were comparable to outcome of Demographic and Health Survey in two countries.  

**Vital Registration Plus record Linkages**

One method of obtaining more complete information on maternal mortality relies on vital registration to identify deaths and supplements the cause of death information with further enquiry. This method works especially well where registration at least for adult death is fairly complete but specific information on cause is lacking from the death certificate. Three approaches are commonly used.

1. Birth record linkage
2. Family interview
3. Hospital linkage.

Birth-record linkage involves linking live birth and (if available) stillbirth registration records to adult female death records within a given time frame. This approach automatically excludes women who die undelivered or where the infant dies and the birth goes unregistered. By linking death certificates of all women of childbearing age with corresponding birth certificates, a time of death approach in relation to pregnancy can be ascertained; the studies also confirmed that the deaths were maternal by checking a variety of health-service records and speaking to community health workers. A computerized...
vital registration system is vital to facilitate linkage. This technique has been tried with some success, in the United States and Bangladesh.\[10\]

An alternative approach is to identify all female deaths of reproductive age through vital registration and to conduct family interviews with relatives of the deceased so as to identify maternal deaths. This approach, which is sometimes called the RAMOS approach, has been used successfully in Egypt.\[11\] Another traces health-service records of all female deaths of reproductive age initially identified through vital registration and ascertains cause of death. This method has been used in North America with success. However, it should be noted that in this setting, most of the deaths occurred in the presence of medical personnel. In settings where this is not the case, verbal autopsies involving interviews with relatives of the deceased would have to be used in conjunction with hospital records.

These methods described above still assume extensive completeness of the vital registration system, a feature not common in developing countries. Multiple additional sources of information on death are often used to supplement hospital and vital registration sources. These include various records such as burial certificates, church records, newspapers, police and coroners’ reports, and key informants such as government officials, community health workers, and teachers. Others include community members, village headmen, traditional birth attendants, school children, and funeral cooperatives.

**Surveys**

In developing countries, household surveys are required to obtain a representative sample of deaths. Family members are unlikely to forget adult deaths and may well know if the deaths were maternal or occurred around the time of a pregnancy. However, family members may be unwilling to report deaths they are ashamed about either for reasons of social stigma, legal sanction in the case of abortion-related deaths, or culpability. In some cultures, it may simply be bad luck or bring accusations of witchcraft to talk about death.\[12\] Death of unattached women (such as students or domestic workers), who might be at risk of death because of their social status, are also likely to be missed.\[6\]

Survey approaches can be categorized as one of three types: single round, multi-round, and continuous surveillance or prospective. Censuses, which provide 100 percent coverage of the population, are treated as special cases of large single-round household surveys.

One strategy for ascertaining deaths using household surveys is the direct approach of enquiring retrospectively about deaths in the household within a specified period. Demographic experiences with such direct approaches for measuring maternal mortality, especially for child mortality, are not universally successful in developing country settings.\[13\] Furthermore, large samples are required to obtain sufficient numbers of maternal deaths directly, especially if the recall time span under consideration is short. A maternal mortality study in Ethiopia visited 35,700 households using a 24-month recall period and only identified 45 maternal deaths.

Measurement problems of this direct strategy include

1. Difficulties in identifying deaths to domestic workers who may not be considered part of the household or to single unattached women living on their own
2. Omission of deaths for other social or cultural reasons
3. Misreporting of the time of death, erroneously placing the death within the or outside the specified reference period
4. Misreporting of the cause of death, incorrectly including or excluding it as a maternal cause
5. Dissolution of the household where the death occurred, leading to omission of reports of deaths
6. Inappropriate choice of respondents, leading to suboptimal information.

Various methodological alternatives to the direct survey approach have been proposed: one using an indirect approach and two using direct approaches.

The sisterhood method is an indirect approach which incorporates a number of mechanisms for minimizing the sample size requirements and for overcoming the response-related difficulties of the direct strategy. This method, which ideally is added on to large surveys, asks both men and women about their adult sisters who died and then ascertains whether they died during pregnancy, delivery, or the puerperium. Asking both men and women increases the number of respondents per household and provides identifiable and potentially reliable informants. The method also increases the number of women about whom information is gathered (since on average respondents have more than one sister) and provides both numerators and denominators for the various measures it gives. Finally, the omission of a specified time frame means the experience of deaths are accumulated over a number of years. The method may be affected by multiple reporting of sisters. However, there are conflicting reports that the method may over or underestimate maternal mortality.

Various adaptation of this method has been suggested. In Malawi, the method was used to detect deaths in the recent past for in-depth follow-up.\[14\] The method may also be used
to determine the place of death, for example, whether the death occurred at home, in a medical facility, or on the way to a medical center. The chief weakness of this method is that it gives a retrospective, not a current estimate. Other limitations of the original sisterhood method include lack of cause-specific and other details about the deceased and the fact that sisters may not have died in the region for which the estimate is obtained, in other words interpretation of the estimates are complicated where there is extensive migration.

Some of the attributes of the indirect sisterhood method approach have been adopted to obtain a more efficient estimate than the conventional direct approach. The Demographic and Health Systems (DHS) surveys have asked adult respondents to report on deaths of sisters in the pregnancy or 42 days postpartum. However, rather than model the time location as is done with the indirect sisterhood approach, the year of death is ascertained, enabling a more recent estimate to be derived. The advantage of this over conventional direct approaches is that there can be more than one adult respondent per household and more than one sister per respondent. The estimate is also more recent than the indirect sisterhood approach. Nevertheless, the requirement for a restricted time period means that the method is less efficient and requires a larger sample size than the indirect sisterhood approach.

Another direct method for identifying maternal deaths uses a networking or snowball mechanism whereby respondents in a survey are asked to identify any maternal deaths of which they are aware. Though this has a potential of identifying many more deaths than conventional methods, the overall usefulness of the technique has not been validated. The method was tried during a survey of childhood mortality in Kenya. Sixty-nine percent of respondents denied knowledge of any maternal deaths although the investigators believe that significant numbers of these women refused to talk about deaths of non-kin for fear of being accused of witchcraft. Among willing informants, it is likely that awareness of the cause of deaths among non-kin is lower than among family members, particularly in cases of early pregnancy or abortion related deaths.

**Addendum**

An index of measurement of maternal mortality may also include the maternal mortality index which is equal to the number of maternal deaths/number of maternal deaths and number of severe acute maternal morbidity cases expressed as a percentage. The mortality to morbidity ratio may also be useful. The ratio compares the number of maternal deaths compared with the number of severe acute maternal morbidity cases. These measurements are described to address the relationship between maternal mortality and severe acute maternal morbidity (previously referred to as near-miss cases). They both reflect the impact of a condition on severe morbidity and mortality and identify those conditions that are more or less amenable to intervention. However, the challenge is classifying patients as severe acute maternal morbidity as there is no set uniform criteria for identifying such patients.

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**Conflicts of interest**

There are no conflicts of interest.

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