Measuring maternal mortality with dual method: A new method for maternal mortality estimation in developing countries

Saifuddin Ahmed
Johns Hopkins University Bloomberg School of Public Health

Correspondence

Saifuddin Ahmed, MBBS, PhD
Department of Population, Family and Reproductive Health
Bloomberg School of Public Health
Johns Hopkins University
615 North Wolfe Street #E4642
Baltimore, MD 21205
Tel:(410) 614-4952
e-mail: sahmed@jhsph.edu

Abstract

Background: The estimation of maternal mortality ratio (MMR) is notoriously difficult and extremely expensive for a country without a functional and complete vital registration system. Estimates from surveys often reflect retrospective deaths over 10 years, and are useless for monitoring trends and progress in mortality reduction. Measures of MMR based on medical records and death audits are known to be seriously biased and grossly underestimated.

Method: Using a statistical procedure earlier developed for correcting under-registration of births and deaths, we present a method of unbiased maternal mortality estimation by combining data from two independent sources, medical records and community deaths audits, with correction for under-reporting. We also provide a method for constructing a confidence interval for maternal mortality estimates.

Findings: We estimate maternal mortality in Bangladesh for a single year 1996-97 using the proposed "dual method" and compare to the results from a large nationally representative Bangladesh Maternal Health Services and Maternal Mortality Survey (BMMS 2001) of more than 100,000 households. The estimated maternal mortality ratio (MMR) by the dual method was 375 (95% CI: 369-380) per 100 000 live births, and the pregnancy related mortality ratio (PRMR) was 419 (413-425). The survey based direct estimation of MMR from BMMS was 322 (253-391), and PRMR was 382(305-460) for the period 1998-2000. Maternal mortality estimate as PRMR was 449 (400-498) from direct sisterhood method for the period 1996-2000.

Conclusion: The proposed method is feasible, less costly, and likely to provide an unbiased maternal mortality estimates in developing countries where complete vital registration is not available. It is also possible to implement this method through a sampling procedure and estimate national level estimates with weighted totals of deaths. The maternal mortality estimates from this method reflect the deaths in current period, and hence the method is suitable for monitoring progress in achieving the fifth Millennium Development Goal (MDG-5) and safe motherhood initiative.

Introduction

The evaluation of safe motherhood programs and monitoring the progress in achieving the Millennium Development Goal-5 (MDG-5) of reducing maternal mortality ratio by three-quarters between 1990 and 2015 remains a major challenge because of the difficulties in measuring maternal mortality in the context of weak information systems. The global estimate of maternal mortality ratio(MMR) by WHO, UNICEF and UNFPA for the year 2000 was 400 per 100,000 live births.[1] Only 60 countries, out of 173 included in the analysis, had data from a reliable vital registration system, and 62 countries (36%) had no national data at all on maternal mortality. The accurate estimation of maternal mortality is notoriously difficult in developing countries primarily because of the lack of a complete vital registration system. Globally, only 13% of births are covered by vital registration systems. Even where a good vital registration system is available, such as in most developed countries, misclassification and underestimation of maternal mortality is not uncommon.[2-8] For example, in the US 39%, in the UK 56% and in France 50% maternal deaths are misclassified in vital records.[9]

In the absence of complete vital registration with good attribution of causes of deaths, the most commonly employed methods for maternal mortality estimates are household surveys with direct death inquiry, indirect and direct sisterhood methods, and reproductive age mortality surveys (RAMOS). For the countries where no data are available on maternal mortality, regression based methods are used to estimate maternal mortality. Of the 198 countries and territories included in the WHO's study for estimating maternal mortality in 1990, 114 countries (57.6%) had no data available on maternal

mortality or could be calculated be with the regression method.[10] There are several reasons for such failures to provide a national level maternal mortality statistics. Maternal mortality is a rare event in a statistical sense, and requires a very large sample size for conducting a household survey for a reliable estimate with a reasonable margin of confidence. As an example, Bangladesh Maternal Health Services and Maternal Mortality Survey (BMMS, 2001) estimated a targeted sample of 104,323 households for measuring national level maternal mortality and costs about $US 1 million.[11] Even from such a large survey, the estimated MMR has large margin-of-error and reflects average deaths over last 3-5 years, rather than a more recent period. As a result, surveys are not cost effective and not suitable for monitoring progress in MDG-5 or evaluating safe motherhood programs. Panel 1 shows the major reasons for difficulty in measuring maternal mortality. The currently employed maternal mortality estimation methods are inefficient to address the problems. As an example, one of the most commonly methods the direct sisterhood method can not exclude the accidental or incidental causes of maternal deaths, and the estimated MMR is really not maternal mortality estimate, but pregnancy-related mortality, a new classification under ICD-10.

Medical records alone are not suitable for maternal mortality estimates where delivery at health facilities is not universal. The maternal mortality estimates from medical records or facility deaths audits are severely biased and grossly underestimated, and almost never used for national level estimates in a developing country. In recent years facility based maternal death reviews were undertaken in several countries primarily to ascertain the

causes of preventable deaths and improve quality of services.[12,13] Similarly, at the community level attempts have been made to identify maternal deaths through deaths audits and death reporting systems to assess the clinical and underlying causes of maternal deaths, and quality of services available in the area.[13-16] Community based maternal deaths audits, however, do not engage in house-to-house interview and coverage is known to be incomplete, and as a result not suitable for national level maternal mortality estimates.

It remains an extremely difficult challenge to estimate maternal mortality for evaluating safe mother initiatives and monitoring progress in MDG-5. Several authors suggest use of process indicators, such as the percentage of births attended by skilled providers, as proxy for maternal mortality.[17,18] However, process indicators are problematic as proxy for maternal mortality estimates. In Asia, 34% of deliveries are attended by a skilled birth attendants (SBA) and the maternal mortality ratio is estimated to be 540. In contrast, in Sub-Saharan Africa, about 35% of the deliveries are attended by a SBA, but the MMR is almost twice than that of Asia (920 per 100 000 live births).

We present a new method of unbiased maternal mortality estimation by combining two data sources: medical records and community deaths audits, both which are known to be independently insufficient to provide a national level maternal mortality estimate.

Method

Maternal deaths can occur in only two places: at health facilities (e.g., hospital, maternity clinic, private clinic) or outside of health facilities (e.g., at home, on the way to a health facility). It is possible to enumerate the deaths at health facilities from medical records and clinical death audits, but in countries where deliveries at health facilities are not universal, deaths outside the health facilities are likely to be missed. The extent of underestimation bias for a maternal mortality estimate from the facility death records depends on the extent of omission, i.e., the (unrecorded) deaths that occurred outside of health facilities.

On the other hand, with community level maternal death audits, it is possible to identify significant number of maternal deaths in the area that occurred both at health facilities and at home. However, it is not possible to enumerate and cover all deaths in the area without a house-to-house census. As a result, in the absence of a census, a significant number of deaths are likely to be missed. We illustrate the extent of death coverage by a 2X2 cross-tabulation in Table 1. It shows that by combining the enumeration of maternal deaths from health facilities and community deaths audits, we can capture deaths for three groups: (1) died at health facilities and also reported by community death audits (x_{11}); (2) died at home and other places outside of health facilities and reported by community death audits(x_{10}); and, (3) died at health facilities and missed by community death audits (x_{01}). The extent of maternal deaths which occurred at home and could not be found by community death audits remains unknown (x_{00}).

Theoretically, it is possible to estimate the total number of maternal deaths if we can estimate the non-enumerated (missing) deaths which occurred at home and was missed by community death audits(x_{00}). We know from basic epidemiological method of estimating association in a 2X2 crosstab that odds-ratio (OR) equals to:

$$OR = \frac{x_{11}x_{00}}{x_{10}x_{01}}$$

$$So,\ x_{00} = \frac{x_{10}x_{01}}{x_{11}}OR$$

If the odds of identifying the facility based deaths in the community equals to the odds of identifying home based deaths by community death audits, which is not an unrealistic assumption, then odds-ratio($OR)=1$. In which case, $x_{00}=(x_{10}x_{01})/x_{11}$. Alternatively, if we suspect that *OR* is not equal to *1* (say, from a previous study or theoretical reasoning), we may use a specified *OR* value as a "bias correction factor" for maternal mortality estimation.

Using this relationship, it is possible to unbiasedly estimate the total number of maternal deaths, $N=x_{11}+x_{10}+x_{01}+[(x_{10}x_{01})/x_{11}]OR= x_{11}+x_{10}+x_{01}+(x_{10}x_{01})/x_{11},$ with the assumption that OR=1. We can directly estimate $N=(N_1N_2)/x_{11}$, under the assumption of independence.

In summary, the estimation process involves four steps:

1. *Health facility deaths audits (N_1)*: Listing maternal deaths at health facilities (during a year) from medical records.
2. **Community deaths audits (N_2)*: Listing maternal deaths at community by case-finding/deaths audits (e.g., from health professionals, auxiliary health workers, outreach workers, traditional birth attendants, other informants).
3. *Identify the matched records(x_{00})*: Matching of the records of deaths from facility and community deaths audits (by name, address and if needed on other auxiliary variables for confirmation: e.g., husband's name, age, parity)
4. *Underestimation correction:* Estimate the expected number of maternal deaths by the proposed method: $N=(N_1N_2)/x_{00}$. The underlying assumption taken for simplicity is that the odds of identifying the clinic based deaths in the community equals to the odds of identifying home based deaths by community death audits, i.e, odds-ratio(OR)=1.

This work was influenced by Chandra Sekar and W. Edward Deming's[19] method developed for improving the registration of births and deaths coverage in mid 1950s which gained significant interest in checking birth registration completeness. Several variants of the method subsequently emerged as capture-recapture[20] method to estimate closed animal population. Sekar and Deming proposed to estimate the variance of estimated *N* based on probability distribution of the cells, and other methods proposed in capture-recapture literature are complex for general user. We propose to estimate the confidence level of a maternal mortality estimate using Poisson distribution which we consider appropriate and simple, and can be used by in-country investigators.

Estimates of Confidence Interval:

Maternal mortality is a rare event, and the counts of maternal deaths can be assumed to have a Poisson distribution. Under Poisson distribution, the variance of count is equal to the mean of count, and standard error is the square root of the count. The confidence interval for the maternal deaths at a specified error level (α) based on approximate normal method is then, $CI = Death\ Counts \pm Z_{1-\alpha/2}\sqrt{Death\ Counts}$.

We can directly estimate confidence interval by the exact Poisson method where lower limit, $LL = \chi^2(2*count, \alpha/2)/2$, and upper limit, $UL = \chi^2(2*[count+1],[1-\alpha/2])/2$, where $\chi^2(\nu,\alpha)$ is the chi-square quintile for upper tail probability α with ν degrees of freedom (df).

For the estimation of confidence intervals of rates and ratios, the deaths counts need to be divided by the population size and the number of live births.

We present the application of this new method of maternal mortality estimation using empirical data from Bangladesh.

Data:

Bangladesh Institute of Research for Promotion of Essential and Reproductive Health and Technologies (BIRPERHT) undertook a national study in 1996-97 to enumerate maternal deaths during a year before the survey through a case finding approach. The detail of the study design was described elsewhere.[14,21] Briefly, the study team reviewed medical records and interviewed service providers at 4751 health facilities providing obstetric, maternal and child health services, including family planning. The hospital facilities included all public sector medical college hospitals (13), district maternity and child welfare centers (96), district hospitals (58 of 64), infectious disease hospitals (5), and *thana* (subdistrict) health complexes (453 of 469). At the community level, interviews were conducted at family welfare centers (3113 of 3175), union council clinics (909), and at non-public facilities: non-government organization (NGO) run clinics and private clinics (96). Four out of 64 districts, primarily located in Chittagong Hill Tracts, were excluded because of an ongoing natural calamity at the time of study implementation. At each facility, physicians, nurses, medical assistants, and village level workers (family welfare visitors, family welfare assistants, and traditional birth attendants) were interviewed and asked, "How many women 10-50 years of age do you know who died in the past 12 months?" The cause of deaths, pregnancy status, place of death, and surrounding circumstances were ascertained for each reported death. Recent medical graduates reviewed the medical records and abstracted information on the causes of deaths. Community level outreach health workers, family welfare assistants (FWA) and family welfare visitors (FWV), primarily served as the informants for the village and union level death reporting. After compiling the deaths from medical records and interviews, all deaths were cross-checked manually by the study team from all reported

sources for duplication based on name, address of residence and certain sociodemographic characteristics (e.g., age, parity). We utilize the strength of these aspects of the data set - independent retrieval of data on maternal death from medical records, case finding through deaths audits at community level, and matching of records - to apply the proposed method to estimate potentially unbiased maternal mortality in Bangladesh for 1996-97 period with the necessary correction for underreporting.

We estimate maternal mortality rate (per 100,000 women) by dividing the enumerated deaths with the estimated female population of reproductive age in Bangladesh for the year 1996 (excluding the population of four districts in which interviews were not done), and maternal mortality ratio (per 100,000 live births) by dividing the enumerated deaths with the expected number of live births from the general fertility rate (GFR: 129 per 1000 women (BDHS, 1996-97)) and female population size during the reference period.

Results

The BIRPERHT study obtained case reports of 28 998 deaths of women aged 10-50, of which 7770 deaths were pregnancy related (reported deaths from any causes during pregnancy, delivery and within 42 days after delivery), and 7086 were maternal mortality (accidental or incidental deaths excluded).

Table 2 shows the reported deaths from medical records and deaths audits by case-findings approach, and maternal mortality estimates by dual method. The medical records identified 1863 maternal deaths and 1889 pregnancy related deaths (from any causes, including accidental and incidental causes) from health facilities. The interview of informants identified 5880 maternal deaths and 6544 pregnancy related deaths. In total, the health facility and community-based deaths audits identified 7086 maternal deaths and 7770 pregnancy related deaths. Approximately 35% of maternal deaths in medical records were (657 of 1863) also reported by the informants.

Using the proposed method, we estimated $N_1XN_2)/x_{11}$= (1863X5880)/657 = 16674 (95% confidence interval: 16422-16929) maternal deaths and 18645(18378-18915) pregnancy related deaths (Table 2). These estimates suggest that the maternal death audits by case finding method underestimated the total number of maternal deaths by almost (1-7086/16674 =0.575) 57.5%, and pregnancy related deaths by (1-7770/18645=.583) 58.3%. Our analysis further suggests that about 11.2% (1863/16674) deaths occurred at health facilities. This is not surprising, given that only 4.1% births took place at health facilities according to Bangladesh Demographic and Health Survey, 1996-97, and emergency care seeking for life threatening obstetrical complications remained low.[22]

The estimated maternal mortality ratio (MMR) was 375 (369-380) per 100,000 live births and pregnancy related mortality ratio (PRMR) was 419 (413-425) for 1996-97 period in Bangladesh. Rahman and other co- authors[14] who first reported the obstetrical deaths findings from the data recognized the problems of severe underestimation, and did not

attempt to estimate maternal mortality ratio. We show that it is possible to estimate maternal mortality from dual sources of deaths reporting using a simple statistical method of correcting underestimation.

Discussion

We present a simple method to estimate maternal mortality by combining data from two sources: medical records and community level deaths audits. As an independent source of data, both medical records and community deaths audits, is insufficient and likely to underestimate maternal mortality grossly. We provide a statistical solution to correct under-registration of deaths by combining these two data sources.

Our application of the method on data from Bangladesh suggests that maternal mortality estimates are comparable to the results of a large national survey, based on the interview of about 100,000 households, in Bangladesh (BMMS 2001).[11,22] The estimated maternal mortality ratio(MMR) by the new method was 375 (369-380) per 100 000 live births, and the pregnancy related mortality ratio (PRMR) was 419 (413-425). The survey based direct estimation of MMR from BMMS was 322 (253-391), and PRMR was 382(305-460) for the period 1998-2000. Maternal mortality estimate as PRMR was 449 (400-498) from direct sisterhood method for the period 1996-2000. The estimated confidence intervals were much smaller with the new method. There is no sampling error in census (variance of an estimate from a census is always zero), and as the coverage of population

in this method is almost like a census (all areas covered with a small level of uncertainty), the estimated sampling error is also expected to be low, and hence the extent of uncertainty (confidence interval) smaller.

The proposed maternal mortality estimation method involves four steps: (1) conduct health facility audit using medical records, (2) conduct community level deaths audit from informants (e.g., trained and untrained health professionals), (3) match death records from facility and community audits, and (4) correct underestimation. The implementation of steps 1 and 2 is not difficult. WHO has recently recommended to undertake clinical and community level deaths audits, primarily to investigate the causes of deaths and quality of care to answer the question why deaths occurred and how can be averted.[12] In many settings, the clinical deaths audits have become an ongoing process for quality improvement process.[15,23] Medical records have been extensively used in clinic based mortality studies and listing of deaths from medical records is not very expensive. WHO has operationalized the community-based maternal death review process "As method of finding out the medical causes of death and ascertaining the personal, family or community factors that may have contributed to averting the deaths in women who died outside of a medical facility."[12] We recommend including all deaths, irrespective of the place of deaths, in the community based deaths audits so that the data can be directly used for maternal mortality estimation using the proposed method. The experience of Bangladesh maternal mortality case finding study[14] has shown that it is possible to enumerate maternal deaths at community levels from the outreach health workers, recognizing that the listing is not complete.

The major challenge of the method is to match the records between medical records (N_1) and community deaths reports (N_2). Often medical records are incomplete and addresses may not be listed correctly. With due demand in improving address recording at a health facility, this may change. As an example, the Maternal Death Review Form used by the Ministry of Health in Malawi as a part of facility audit has a highlighted box to record patient's address. Matching of the records may further improve if the list of deaths from the facility is provided to the teams of community deaths audit beforehand so that the team may take resolution steps for confirmation at the field level.

This method is significantly different from RAMOS. In RAMOS, the listing of deaths for reproductive aged women must be exhaustive. In this method, no attempt is made to list all deaths and no exhaustive search for deaths is required. No household interview is required. Our method was significantly influenced by the "dual records systems" used in vital registration field for under-registration correction. A dual records system is the simultaneous collection of vital events, mainly births and deaths, by two independent data collecting methods: a continuous vital recording system and a periodic household sample survey conducted in the same geographical area. Subsequently, by matching the events reported by the two procedures provides an opportunity to improve the estimate of the total number of vital events. We refrain from calling our method "two records system" considering significant differences in the two procedures, and to avoid subsequent misinterpretation that the method is based on vital registration system. Instead, the method may be referred simply as "dual methods" for maternal mortality estimation (1

record from health facility and 1 report from community informants). Similar procedures evolved as "capture-recapture" methods to estimate closed animal population. Capture-recapture methods have been also used in epidemiology for estimating rare diseases and hidden population. Literature on capture-recapture methodology suggests that three or more independent sources of data provide better estimation procedures for adjusting non-independence than the two sources of data. Considering simplicity and that the methods can be used at country levels by the health planner and health professionals, we presented our method with two sources of data, with an extra "bias correction factor" for adjustments of non-independence if required. Moreover, it is possible to improve the estimation through stratification if case finding probabilities of the two reporting systems are found to vary by geographical regions or other attributes (by conducting separate analysis for each geographical region, urban-rural area, socio-economic status, etc, and then combining the results).

Maternal mortality is always likely to be underestimated, even in the most developed countries like the US, UK and France. Deaths during early pregnancy and abortion related deaths are likely to be underreported in any settings. This method is also not a magic bullet. We consider that the method is simple, and has the potential to provide unbiased estimates of maternal mortality with a narrow range of uncertainty (confidence interval) in developing country settings where undertaking large scale population surveys and RAMOS is not feasible and where complete vital registration is not available. Facility surveys and community level deaths audit are also likely to be much less costly than conducting a population-level survey for maternal mortality estimation as the former

do not need extensive geographic coverage for house-to-house visits and large number of interviewers.

The method is quite flexible. This method can be also implemented at sub-national level and for local level estimates of maternal mortality. It is also possible to implement this method through a sampling procedure and estimate national level estimates with weighted totals of deaths. The only modification will be needed is the revised variance estimation procedure for a confidence interval estimate (in summary, if weight=w_i=inverse selection probability of the sampling area *i*, the variance is $\sum w_i^2 * deaths\ count_i$.).]

We expect that the method will be soon field tested for feasibility and validation in different contexts. Until all countries have the opportunity to ultimately implement a complete vital registration system, this simple method may provide a feasible, low cost method to estimate maternal mortality in developing countries.

References

1. World Health Organization(WHO), ed. Maternal mortality in 2000 : estimates developed by WHO, UNICEF and UNFPA. Geneva: WHO, 2004.
2. Deneux-Tharaux C, Berg C, Bouvier-Colle MH, et al. Underreporting of pregnancy-related mortality in the United States and Europe. *Obstet Gynecol* 2005;**106**(4)**:**684-92.
3. Berg CJ, Atrash HK, Koonin LM, Tucker M. Pregnancy-related mortality in the United States, 1987-1990. *Obstet Gynecol* 1996;**88**(2)**:**161-7.
4. Karimian-Teherani D, Haidinger G, Waldhoer T, Beck A, Vutuc C. Under-reporting of direct and indirect obstetrical deaths in Austria, 1980-98. *Acta Obstet Gynecol Scand* 2002;**81**(4)**:**323-7.
5. Turner LA, Cyr M, Kinch RA, et al. Under-reporting of maternal mortality in Canada: a question of definition. *Chronic Dis Can* 2002;**23**(1)**:**22-30.
6. Schuitemaker N, Van Roosmalen J, Dekker G, Van Dongen P, Van Geijn H, Gravenhorst JB. Underreporting of maternal mortality in The Netherlands. *Obstet Gynecol* 1997;**90**(1)**:**78-82.
7. Bouvier-Colle MH, Varnoux N, Costes P, Hatton F. Reasons for the underreporting of maternal mortality in France, as indicated by a survey of all deaths among women of childbearing age. *Int J Epidemiol* 1991;**20**(3)**:**717-21.
8. Kao S, Chen LM, Shi L, Weinrich MC. Underreporting and misclassification of maternal mortality in Taiwan. *Acta Obstet Gynecol Scand* 1997;**76**(7)**:**629-36.
9. Campbell O. Measuring progress in Safe Motherhood: uses and limitations of health outcome indicators. *Reproductive Health Matters* 1999(Supplement on Safe Motherhood Initiatives: Critical Issues)**:**31-42.
10. WHO/UNICEF. Revised 1990 estimates of maternal mortality: a new approach by WHO and UNICEF. Geneva: World Health Organization, 1996.
11. Hill K, El Arifeen S, Koenig M, Al-Sabir A, Jamil K, Raggers H. How should we measure maternal mortality in the developing world? A comparison of household deaths and sibling history approaches. *Bull World Health Organ* 2006;**84**(3)**:**173-80.
12. World Health Organization W. Beyond the numbers : reviewing maternal deaths and complications to make pregnancy safer. Geneva: World Health Organization, 2004.
13. Cochet L, Pattinson RC, Macdonald AP. Severe acute maternal morbidity and maternal death audit--a rapid diagnostic tool for evaluating maternal care. *S Afr Med J* 2003;**93**(9)**:**700-2.
14. Rahman MH, Akhter HH, Khan Chowdhury ME, Yusuf HR, Rochat RW. Obstetric deaths in Bangladesh, 1996-1997. *Int J Gynaecol Obstet* 2002;**77**(2)**:**161-9.
15. van Dillen J, Stekelenburg J, Schutte J, Walraven G, van Roosmalen J. The use of audit to identify maternal mortality in different settings: is it just a difference between the rich and the poor? *Healthc Q* 2007;**10**(2)**:**131-7.

16. Santos C, Diante D, Jr., Baptista A, Matediane E, Bique C, Bailey P. Improving emergency obstetric care in Mozambique: the story of Sofala. *Int J Gynaecol Obstet* 2006;**94**(2)**:**190-201.
17. Wardlaw T, Maine D. Process indicators for maternal mortality programs. In: Berer M, Ravindran T, eds. Safe motherhood initiatives: Critical Issues. Oxford, England: Blackwell Science, 1999: 24-30.
18. Campbell O. Measuring progress in safe motherhood programmes: uses and limitations of health outcome indicators. In: Berer M, Ravindran T, eds. Safe Motherhood Initiatives: Critical Issues. Oxford, England: Blackwell Science, 1999: 31-42.
19. Chandra-Sekar C, Deming WE. On a Method of Estimating Birth and Death Rates and the Extent of Registration. *Journal of the American Statistical Association* 1949;**44:**101-15.
20. Amstrup SC, McDonald TL, Manly BFJ. Handbook of Capture-Recapture Analysis: Princeton University Press, 2005.
21. Yusuf HR, Akhter HH, Rahman MH, Chowdhury ME, Rochat RW. Injury-related deaths among women aged 10-50 years in Bangladesh, 1996-97. *Lancet* 2000;**355**(9211)**:**1220-4.
22. National Institute of Population Research and Training (NIPORT), ORC Macro. Bangladesh Maternal Health Services and Maternal Mortality Survey (BMMS), 2001. Final Report. Dhaka/Calverton, Maryland, 2003.
23. Supratikto G, Wirth ME, Achadi E, Cohen S, Ronsmans C. A district-based audit of the causes and circumstances of maternal deaths in South Kalimantan, Indonesia. *Bull World Health Organ* 2002;**80**(3)**:**228-34.

Panel 1: Challenges of maternal mortality estimation

- **Problems of meeting definition criterion of maternal mortality**
  - Deaths from accidental and incidental causes should be excluded. Causes of deaths are difficult to ascertain and most often not known. When these causes are not excluded, instead of measuring maternal mortality, the measures estimate *pregnancy related deaths,* a new definition used by ICD-10. Inclusion of *accidental and incidental deaths* overestimates maternal mortality.
  - Maternal deaths within 42 days post-partum period are only included. Women may die from pregnancy related complications after 42 days, and exclusion of such cases may underestimate maternal mortality. Misclassification of deaths is more likely in countries with low literacy, and without vital registration and death certificates.
  - Requires deaths from irrespective of the duration and site of the pregnancy that may miss maternal mortality during early pregnancy period. Because most deaths from abortions are in early pregnancy period, abortion related deaths are most affected and grossly underestimated.

- **Problems in ascertaining causes of maternal death**
  - Misclassification of the causes of deaths affects both incidence and cause-specific mortality estimation. Causes of deaths reported by relatives cannot be validated.

- **Problems in death reporting and recording**
  - Medical records/death certificates are often incomplete and the causes of deaths reporting are flatly wrong. When deaths are reported by sisters and other relatives, the causes of deaths are often unknown, and deaths from abortions are misclassified. Sometime a husband is reluctant to speak about his previous wife when remarried.

- **Problems in survey sampling and estimation methods**
  - Extremely large sample size is needed for a dedicated survey for direct maternal mortality estimation. In current practice, the maternal mortality estimates have low precision and wide variability in reliability. The examination of the trends and determinants/risk factors for maternal deaths is almost impossible with a statistical method from studies even with a moderate sample size. To be practically feasible maternal mortality estimates are averaged over a prolonged period, say over 10 years, to increase the sample size. This may bias maternal mortality *ratio* estimation in a country with rapid fertility decline.

- **Problems in political commitment and financial resources allocation**
  - Often it is considered that maternal mortality estimation is very expensive and a daunting task, and the available financial funds should be utilized for direct maternity care when resources are limited.

Three major consequences on maternal mortality estimation:

- **Underestimation [or even non-availability a maternal mortality estimate in a country]**
- **Low precision**
- **Lack of current estimation (provides past period estimation [average ~10 years])**

Table 1: Crosstabs between the place of deaths and potentials for finding the cases with community death audits

a)

Deaths identified by community deaths audit	Deaths occurred at health facilities: Yes	Deaths occurred at health facilities: No
Yes		
No		**?**

b)

	Deaths occurred at health facilities: Yes	Deaths occurred at health facilities: No	
Yes	x_{11}	x_{10}	N_2
No	x_{01}	x_{00}	
	N_1		N

Table 2: Maternal mortality estimates of Bangladesh, 1996, by dual methods

	Reported				Estimates from dual methods		
	Deaths in medical records (N1)	Deaths from community case-findings (N2)	Deaths in both medical records and community reports (x11)	Total deaths	Estimated number of deaths N (95% CI)	Mortality Rate/ 100,000 WRA (95% CI)	Mortality Ratio/ 100,000 Live Births (95% CI)
Maternal mortality estimates	1863	5880	657	7086	16674 (16422-16929)	48.33 (47.60-49.07)	375 (369-380)
Pregnancy mortality estimates	1889	6544	663	7770	18645 (18378-18915)	54.04 (53.26-54.82)	419 (413-425)