Maternal Mortality Estimation: Separating Pregnancy-related and Non-pregnancy-related Risks

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The increased availability of survey data and improved estimation techniques have furthered our understanding of maternal mortality in developing countries. Both the indirect and direct sisterhood methods of estimation depend on time-of-death information from surveys. This report proposes a method for calculating two rates, one during the pregnancy period and one outside of it. Analysis of both rates provides more information about mortality associated with pregnancy than do methods that only produce one rate. The pregnancy-related mortality rate can be estimated by assuming that non-pregnancy-related risks are constant, irrespective of whether women are pregnant or not. An estimated 69 percent of deaths in Bolivia during pregnancy may be pregnancy related; this result is significantly lower than that obtained using the traditional sisterhood method. In certain cases, this result may be viewed as a plausible lower bound. A variety of estimates should probably be used for policy purposes. (STUDIES IN FAMILY PLANNING 1995; 26,1: 33–38)

The World Health Organization (WHO) definition of maternal mortality includes all deaths among pregnant and recently pregnant women except for deaths from "accidental or incidental causes" (Graham et al., 1989). Typically, two survey methods are used to estimate maternal mortality in developing countries: the sisterhood method (Graham et al., 1989), and a direct variant of the sisterhood method (Rutenberg et al., 1990). These methods assume that all deaths among women who are pregnant or within eight to twelve weeks following pregnancy should be included in the measurement of maternal mortality. This may be inappropriate in many developing-country settings, however. Pregnancy-related risks may be better understood by studying the relationship between the mortality of pregnant women relative to the "normal" mortality of nonpregnant women.

Two principal justifications exist for including in the measurement of maternal mortality all deaths among women during or shortly following a pregnancy. First, the unreliability of the data has discouraged refinement. Second, since the maternal mortality rate is often underestimated because of reporting omissions, including all deaths during pregnancy can help partially to compensate for the errors. (See Graham et al., 1989, for an excellent discussion of problems with sisterhood data.) These assumptions may be reasonable in settings where the mortality of pregnant women is overwhelmingly pregnancy related. Separating pregnancy-related from non-pregnancy-related mortality, however, will not only provide a measure of maternal mortality that is more consistent with the WHO definition, but may also lead to new insights concerning the types of risks being measured.

This report explains how to calculate separate mortality rates for women during and outside of pregnancy. This calculation can be made using the data currently collected in the Demographic and Health Survey (DHS) module on maternal mortality.[1] In certain situations, removing the estimated non-pregnancy-related mortality from current estimates of maternal mortality may yield more accurate data. If maternal mortality calculations are to assist in the evaluation of health interventions in developing countries, the risks to both pregnant and nonpregnant women should be considered, particularly in places such as sub-Saharan Africa, where non-pregnancy-related risks such as AIDS are increasingly important. While the research incorporating these refinements may produce somewhat lower estimates of maternal mortality, its goal is not to belittle the potential gains to be made from health interventions. On the con-

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trary, the development of more reliable measures of maternal mortality levels should make assessing the effect of any intervention or comparing levels of mortality over time or across countries easier.

The data used for this analysis are from the 1989 Bolivia DHS, in which some 7,923 women provided information on their 11,934 ever-married sisters. (Refer to Sommerfelt et al., 1991, for further details on the data.)

Estimating Maternal Mortality from Survey Data

Although an estimated 500,000 women around the world die annually from pregnancy-related causes (Boerma, 1987), the majority of these deaths are easily preventable through the introduction of health measures aimed at identifying women at high risk and insuring that they receive special care. An increase in the availability of contraceptives and legalization of abortion services can also reduce maternal mortality by reducing the number of unwanted pregnancies and abortion-related maternal deaths (Darney, 1988).

Two important and innovative methods are currently used for calculating maternal mortality from survey data. The sisterhood method (Graham et al., 1989) is an indirect method that relies on model fertility and mortality schedules in order to calculate maternal mortality rates. The second method, developed by Rutenberg and Sullivan (unpublished), is a direct method of estimation that does not require model schedules. The direct method of estimating maternal mortality is referred to here as the direct sisterhood method. Although the sisterhood method requires fewer data and is easier to calculate than the direct sisterhood method, the advantage of the latter is that it can provide more current estimates and allow more thorough evaluation of the results. Because mortality is approximated over the lifetimes of the respondents' sisters, the resulting estimates of maternal mortality rates are not estimates applicable to the immediate past. Thus, these estimates will be more useful when mortality conditions have not changed greatly during the interval included in the calculation (Rutenberg et al., 1990).

When a respondent is questioned in a maternal mortality survey about the death of a sister, the cause of death is not elicited. Estimates of maternal mortality are based solely on the timing of the death in relationship with pregnancy. All deaths occurring during pregnancy, childbirth, and within six to eight weeks following the pregnancy are included as maternal mortality. This 11-month interval is referred to here as the pregnancy period. The implication is that deaths occurring during the pregnancy period but not related to pregnancy are negligible. In-depth studies by cause of death in Bangladesh[2] and Egypt show that a great majority of deaths (90 percent and 87 percent, respectively) during the pregnancy period were directly or indirectly related to the pregnancy, and should, therefore, have been included as maternal mortality (WHO, 1985).

Although the results above appear to be generally accepted, the evidence from other data offers a more complicated picture. Mortality risks for nonpregnant women are considerable, even relative to the mortality risks during pregnancy. For example, research from The Gambia shows that about one-third of sisters reported dead by respondents younger than 50 died during the pregnancy period (Graham et al., 1989). If we assume that women in The Gambia are pregnant for roughly one-sixth of their childbearing years (the United Nations, 1993, estimates the 1985 Gambian TFR to have been 6.5 lifetime births per woman), and that mortality risks during the pregnancy period are the same as those outside the pregnancy period, we would expect one-sixth of the sisters who died to have died during the pregnancy period. The Gambian numbers clearly imply that the risks during the pregnancy period and outside the pregnancy period are unequal, because twice the expected number of sisters who died did so during the pregnancy period.

How much greater is the mortality during the pregnancy period than the mortality outside the pregnancy period? In this simple example, the mortality rate during the pregnancy period is 2.5 times greater.[3] While this first step provides some idea of the relative magnitude of the risks, the following section describes how to estimate the percentage of deaths during the pregnancy period that is attributable to pregnancy-related causes.

Pregnancy-related and Non-pregnancy-related Mortality

According to the current WHO definition of maternal mortality, the ideal measure should include all deaths where the cause is either directly or indirectly pregnancy related.[4] Information on cause of death cannot be collected using survey methods, however, and both the indirect and direct sisterhood methods measure maternal mortality from information provided by respondents on their sisters' times of death. The same survey data allow calculation of the mortality rate for women outside of the pregnancy period (the nonpregnancy-period mortality rate). The first stage in analyzing mortality conditions for women of reproductive age should include an examination of both the pregnancy- and nonpregnancy-period risks.

The second step involves estimating the increased risks associated with pregnancy. We can assume a constant baseline risk for all women during their reproductive years irrespective of their pregnancy status. Although it is unlikely that, on a cause-specific basis, pregnancy has no effect on non-pregnancy-related risks, in aggregate, no obvious direction exists to the bias that is introduced. Women appear to be more at risk from certain causes during the pregnancy period, but they may be less at risk from others.[5]

Studies appear inconclusive on how pregnancy and the chances of dying from non-pregnancy-related causes interact, particularly in developing countries, where primary risks differ substantially from those in developed countries. According to Peckham and Marshall (1983), "although it is sometimes suggested that infections in the pregnant woman are more severe than in the non-pregnant woman, in the vast majority of infections there is little evidence to support this view." One important disease that appears to be more severe in pregnant women is malaria. Klufio (1992) notes that immunity to malaria is reduced during pregnancy and that malaria is one of the leading causes of indirect obstetric deaths in parts of the developing world.

Other diseases may have different success patterns among pregnant women, however. Perhaps the most important interaction concerns AIDS, which is rapidly becoming the primary cause of death among women of reproductive age in many sub-Saharan African countries. Johnstone et al. (1992) found that survival times for AIDS patients were not reduced by pregnancy. Further research is necessary on the manner in which non-pregnancy-related risks interact with pregnancy-related risks during pregnancy. In effect, previous methods have assumed that non-pregnancy-related mortality equals zero during the pregnancy period. Here, non-pregnancy-related mortality during the pregnancy period is assumed to equal non-pregnancy-related mortality during the nonpregnancy period. The assumption that the baseline (non-pregnancy-related) risks are constant regardless of whether a woman is in the pregnancy period appears to be a useful starting point.

Results

In this section, the method of disaggregated risks is applied to Bolivian DHS data covering exposure from 1975–88. Table 1 (columns A, B, and C) presents the numbers of deaths, the person-years of exposure, and the mortality rate during the pregnancy period. The middle section of the table (columns D, E, and F) shows the deaths, exposure, and mortality rate outside of the pregnancy period. (Recall that the pregnancy period includes the nine-month pregnancy interval and the two months immediately thereafter.) In order to calculate the two rates, we need to measure exposure separately (columns B and E).

Estimating the pregnancy-period exposure and nonpregnancy-period exposure is the most complicated part of this procedure, because the information is not directly available from the DHS, but must be imputed. We can estimate total pregnancy-period exposure based on parity. Respondents were asked about the parity of the sisters that died, so an estimate of person-years of exposure during the pregnancy period can be calculated. Although no parity was reported for sisters who were still alive, this information can be inferred from the standard fertility component of the DHS by imputing the average fertility schedule for the respondent population to the "live" sister population. If women spend 11 months (or 0.916 person-years) in the pregnancy period for each

Table 1 Number of deaths, number of person-years of exposure to mortality risk in pregnancy and nonpregnancy periods, and summary risk measures, all by age group, Bolivia, 1975–88

	Pregnancy period			Nonpregnancy period			Summary risk measures		
	(A)	(B)	(C)[a]	(D)	(E)	(F)[b]	(G)[c]	(H)[d]	(I)[e]
Age group	Deaths	Exposure	Mortality rate	Deaths	Exposure	Mortality rate	Pregnancy to nonpregnancy mortality ratio	Pregnancy-related mortality ratio	Pregnancy-related pregnancy-period mortality (%)
15–19	9	4,744	1.90	5	23,714	0.22	1.00	1.68	88.3
20–24	10	5,305	1.89	9	21,753	0.48	3.94	1.41	74.8
25–29	15	4,832	3.10	28	18,967	1.53	2.03	1.58	50.8
30–34	16	2,952	5.42	17	14,739	1.13	4.80	4.29	79.2
35–39	9	1,970	4.57	15	10,449	1.50	3.05	3.07	67.3
40–44	7	1,025	6.83	19	5,264	3.45	1.99	3.38	49.4
45–49	7	418	16.75	10	2,420	3.11	5.39	13.63	81.4
All	73	21,246	3.44	103	97,306	1.06	3.25	2.38	69.2

[a]A/B x 1,000. [b]D/E x 1,000. [c]C/F. [d]C–F. [e]H/C x 100.

child ever born, then the sum of all women's pregnancy-period exposure is the total pregnancy-period exposure. The total exposure minus the pregnancy-period exposure is the nonpregnancy-period exposure.

Comparing the results produced here to the results of the direct sisterhood method is difficult, because the measurement of exposure used in this research is the number of pregnancy-period person-years lived. The direct sisterhood method produces rates from the count of pregnancy-period deaths divided by total exposure, both during and outside pregnancy. Still, the general shape of the age-specific pregnancy-period mortality rate is similar to that found using the direct sisterhood method (Rutenberg et al., 1990). Our method is arguably more appropriate since the denominator—person-years of pregnancy-period exposure—is a function of the fertility level in the population (similar to the maternal mortality ratio, which is a function of the number of live births in a population), and a decline in fertility will not necessarily produce a corresponding decline in the rate.

In the table, columns G, H, and I provide summary measures using the estimated pregnancy-period and nonpregnancy-period mortality rates (columns C and F). Column G shows the ratio of the estimated rate during pregnancy to the estimated mortality rate outside of pregnancy. For all age groups combined, the data suggest that mortality levels during the pregnancy period are about 3.25 times greater than are mortality levels during the nonpregnancy period. This large factor points to the high risks faced by women during pregnancy relative to the nonpregnancy period.

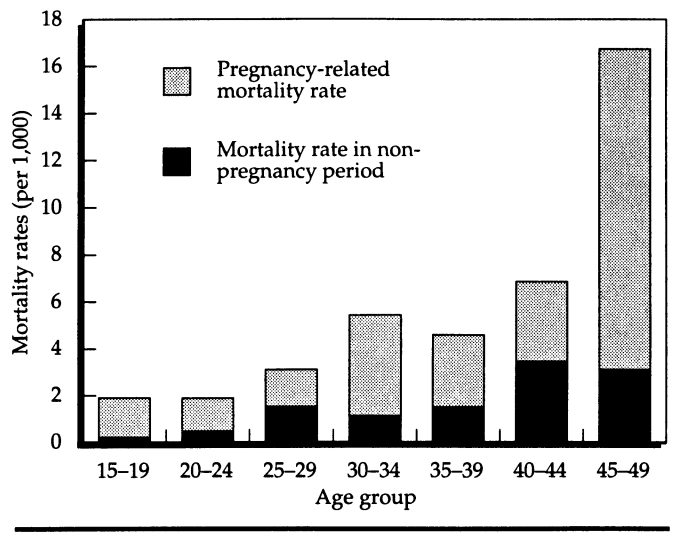
Now, we can proceed by assuming that non-pregnancy-related risks are constant, irrespective of pregnancy status. The pregnancy-related mortality ratio (column H) is the difference between the pregnancy-period mortality rate (column C) and the nonpregnancy-period mortality rate (column F). The data indicate that women in the youngest and oldest age groups face the greatest proportionate risks from pregnancy-related mortality (see column I), with more than 80 percent of pregnancy-period mortality being actually pregnancy related. For all age groups combined, 69 percent (column I) of the deaths during the pregnancy period can be attributed to increased risks associated with pregnancy, significantly fewer than the almost 90 percent reported earlier from Egypt and Bangladesh (WHO, 1985).

Three separate measures of pregnancy mortality are shown in Figure 1. The total height of each bar represents the measure of maternal mortality similar to that derived using the direct sisterhood method. The proposed method suggests that the total height of each bar (pregnancy-period mortality rate) can be separated into the baseline mortality (the bottom portion of each bar) and the pregnancy-related mortality (the top portion of each bar). The pregnancy-related mortality rate appears to have the same overall age pattern as the pregnancy-period rate (where all deaths are included). The similarity to the pregnancy-period rate, which parallels that derived from the direct sisterhood method, is reassuring. Several new features from the two separate rates may be important, however. The pregnancy-related rate still begins at a relatively low level, although a slight decline is discernible after the youngest age group. Estimates of nonpregnancy-period mortality (baseline mortality) also seem reasonable, slowly increasing with age. (The hump in overall mortality observed among 30–34-year-olds may be an artifact of the small sample size.) For the oldest women, both the DHS findings (Rutenberg et al., 1990) and the pregnancy-related method show a rapid rise in the risk associated with pregnancy. Although distinguishing different age patterns of pregnancy-related and non-pregnancy-related risks with the new method is difficult because of the small number of deaths in each age category, this approach does appear to offer a story consistent with that derived using the sisterhood method. The pregnancy-related rate, however, shows that some of that rise is due to increasing non-pregnancy-related mortality, which also climbs with age.

Misreported Deaths and Other Possible Biases

The mortality rates shown in Table 1 (columns C and F) must be interpreted with caution. The most obvious and possibly most important source of error concerns the underreporting and misreporting of sisters' deaths. If

Figure 1 Pregnancy-related and non-pregnancy-related mortality rates, by age group, Bolivia, 1975–88



pregnancy-period deaths are more likely to be omitted, the pregnancy-period mortality rate will be underestimated as a result. A more likely problem is misreported abortions, especially among unmarried women (Darney, 1988). Particularly in countries such as Bolivia, where abortions are illegal, women who die from abortions may be reported by their sisters, intentionally or unintentionally, to have died outside the pregnancy period. The result will be to lower the pregnancy-period mortality rate and raise the nonpregnancy-period mortality rate. The small number of deaths shown in Table 1 implies that a slight shift in the classification of deaths between columns A and D would result in large changes in the mortality rates.[6] Clearly, misreporting is a problem that needs to be recognized, and future surveys might be designed to address this issue when possible.

The method proposed in this report also relies on separate estimates of exposure for the pregnancy and nonpregnancy periods. Presumably, a significant number of pregnancy-period person-years are missed because miscarriages and other pregnancies that do not end in live births are not included as pregnancy-period exposure. This omission could lead to an overestimation of the pregnancy-period mortality rate and an underestimation of the nonpregnancy-period mortality rate.

The possible bias of misreported abortion deaths should be taken seriously, especially for the summary risk measures in Table 1 (columns G, H, and I). Where such misreporting is significant, the method will compound the errors involved. While this problem may lead to underestimates of maternal mortality, the error may be minor relative to the error introduced by including all deaths occurring during pregnancy as maternal mortality. Where abortion is not as likely to be misreported, this method will offer a more accurate estimate of pregnancy-related risks than other methods do. Finally, this technique potentially may be used for measuring abortion deaths in places that lack better information.

Conclusion

New data sources, such as the DHS, and improved maternal mortality estimation techniques, allow more accurate measurement of pregnancy risks in developing countries. Eventually, vital registration and accurate censuses will greatly facilitate the analysis of health conditions. In the meantime, health planners and researchers should have the means to evaluate interventions aimed at reducing pregnancy-related mortality.

The method that is proposed here and applied to the Bolivia DHS data suggests that 69 percent of deaths during the pregnancy period may be attributed to pregnancy—that is, 31 percent of deaths during the pregnancy period are caused by factors unrelated to pregnancy. The method's basic assumption is that risks unrelated to pregnancy remain constant, whether women are pregnant or not. This assumption may be invalid, but a review of the literature shows no clear consensus. As noted above, one possible bias that this method may exacerbate is the underestimation of pregnancy-related mortality where abortion deaths are misreported. Such a limitation will be particularly acute in places where abortion is illegal. Nevertheless, calculating separate rates for the pregnancy and nonpregnancy periods can still be helpful in this context.

If pregnant women are, in fact, at greater risk of dying from malaria and other non-pregnancy-related factors than are nonpregnant women, then this method may offer a plausible lower bound on estimates of maternal mortality, given the quality of the data used for the analysis. A measurement based on the inclusion of all deaths during the pregnancy period might then be considered an upper bound. Although pregnancy-related mortality levels may still be higher than those estimated using the traditional method, empirical analysis should use the available data as efficiently as possible. When the data quality is poor, offering a range of maternal mortality estimates will be preferable to offering a single index.

Several future lines of research may be suggested: First, studies should be designed to better determine how respondents report their sisters' abortion-related deaths. Second, the sensitivity of the different estimation methods to changes in mortality (such as increasing AIDS death rates) should be examined, perhaps through simulation. Finally, in cases where abortion is believed responsible for a large proportion of female mortality during the reproductive years, the method proposed here may provide a tool for estimating abortion deaths.

The type of analytic decomposition of risks presented here can help shed light on the relative risks facing women, without requiring additional data collection. Bolivia may be an example of a place where a great majority of pregnancy-period deaths are pregnancy related, or one where misreported abortion deaths result in the underestimation of pregnancy-related mortality rates. However, in other settings (for example, countries with high levels of AIDS mortality), the inclusion of all deaths among women during the pregnancy period will result in poor estimates of the actual risks. In certain sub-Saharan African countries such as Malawi, where AIDS mortality is very high and increasing, the direct sisterhood method may be inappropriate. Especially since young women of reproductive age suffer the highest

AIDS death rates, the inclusion of all deaths during the pregnancy period could seriously exaggerate maternal mortality. While women may be dying during the pregnancy period, the cause could be unrelated to pregnancy. In developing countries, where female fertility and mortality levels in the reproductive ages are high and where non-pregnancy-related risks are on the rise, the proposed method may provide a more accurate measure of the true risks of pregnancy.

Notes

1 DHS maternal mortality modules are available for other countries, including Egypt, Madagascar, Malawi, Morocco, Namibia, Niger, Senegal, and Sudan.

2 Note that the data from Bangladesh are based on a detailed examination of 41 deaths that occurred to women during pregnancy or within 12 weeks following pregnancy (Chen et al., 1974).

3 The ratio of the deaths (1/2) divided by the ratio of the exposures (1/5) equals 5/2, or 2.5.

4 In this report, pregnancy-related mortality refers to deaths for which pregnancy was either directly or indirectly the cause.

5 Within the pregnancy period, mortality from pregnancy-related causes and from non-pregnancy-related causes are treated as independent competing risks.

6 For example, of the 103 deaths reported during nonpregnancy periods, if 10 actually were misreported abortion deaths, then the overall pregnancy-period mortality rate would rise by nearly 14 percent and the nonpregnancy-period mortality rate would fall by almost 10 percent.

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