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This study presents an assessment of the quality of data relating to maternal mortality collected in 14 Demographic and Health Surveys (DHS) for 13 countries that included a complete sibling history. Four aspects of data quality are considered: completeness of the data for reported events, evidence of omission in the reporting of events, plausibility of the pattern of sibling deaths, and sampling errors of the maternal mortality estimates. Although the data relating to reported events are complete for most variables, comparisons of sibling-history-based estimates of adult mortality for both males and females with other independent estimates suggest that sibling estimates are more likely to be underestimates than overestimates. The downward bias is probably greater for female mortality than for male mortality. The sampling errors associated with maternal mortality ratios are substantially larger than those associated with other frequently used DHS indicators. This lack of precision precludes the use of these data for trend analysis and has led to the recommendation that this DHS module not be used more than once every ten years in the same country. (Studies in Family Planning 2000; 31[2]: 111–123)

Since the launching of the Safe Motherhood Initiative in 1987, attention directed toward the issues surrounding maternal health has increased greatly. A primary goal of this initiative is the reduction of maternal mortality. Findings from the hospital and small community-based studies that first shed light on the severity of the problem have not been adequate to inform national-level policymaking and program management, however. An increased awareness of the problem has augmented the demand for measuring and monitoring maternal mortality at a national and subnational level.

Developing-country governments and international donor agencies have long relied on Demographic and Health Survey (DHS) data to monitor a variety of family planning and child survival program indicators. In response to the increased interest in maternal mortality, DHS began collecting data on maternal deaths in an optional module added to the core DHS questionnaire in 1988. Since that time, the maternal mortality module has been included in the questionnaires for more than 30 countries. This article examines maternal mortality data from the 13 countries for which data sets were available at the time it was being prepared. Table 1 summarizes key aspects of the surveys included. The purposes of this study are to document the DHS approach to data collection and analysis used in these countries, to assess the quality of the data collected in the maternal mortality module, and to discuss the appropriate use and interpretation of these data.

Four indicators of maternal mortality are presented here: the maternal mortality ratio (MMRatio), defined as the number of maternal deaths within a specified time period divided by the number of live births in the same time period and expressed per 100,000 live births; the maternal mortality rate (MMRate), defined as the number of maternal deaths within a specified time period divided by the number of women of reproductive age and expressed per 1,000 women; the proportion of adult female deaths due to maternal causes; and the lifetime risk (LTR) of maternal death, defined as the risk of a woman's dying of maternal causes at some point in her reproductive life span, given current rates of fertility and maternal mortality.

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Table 1 Sample size and characteristics of Demographic and Health Surveys for 13 countries studied, by country, 1989–95

Region/country	Year of survey	Sample size	Respondents
Africa			
Central African Republic	1994–95	5,884	All women 15–49
Madagascar	1992	6,260	All women 15–49
Malawi	1992	4,850	All women 15–49
Morocco	1992	9,256	All women 15–49
Namibia	1992	5,421	All women 15–49
Niger	1992	6,503	All women 15–49
Senegal	1992–93	6,310	All women 15–49
North Sudan	1989–90	5,860	Ever-married women 15–49
Zimbabwe	1994	6,128	All women 15–49
Asia			
Indonesia	1994	28,168	Ever-married women 15–49
Philippines	1993	15,029	All women 15–49
Latin America			
Bolivia (1)	1989	7,923	All women 15–49
Bolivia (2)	1993–94	8,603	All women 15–49
Peru	1991–92	15,882	All women 15–49

Methods

The Sisterhood Method (Indirect Approach)

In 1989, Graham et al. described an indirect technique for estimating maternal mortality based on the survival of sisters for use in settings with inadequate data from other sources. This indirect estimation technique is referred to as "the sisterhood method" and is based on the principles and assumptions of the indirect sibling survivorship method for estimating adult mortality (Graham et al. 1989). The sisterhood method involves asking a representative sample of adults about the survival of their sisters (born to the respondent's mother) who reached adulthood and, for sisters who died, about the time of death relative to pregnancy and childbirth. By inquiring about female siblings in a high-fertility setting, sample size is expanded with little additional cost. By focusing only on adults, reporting problems such as ignorance of siblings' deaths prior to the respondent's birth are avoided.

Two indicators of maternal mortality are generated by the indirect method: These are the lifetime risk of maternal death and the proportion of adult female deaths due to maternal causes. An approximation of the maternal mortality ratio (MMRatio) is easily calculated by using the lifetime risk and the total fertility rate. The maternal mortality indicators obtained from the indirect method are derived from data covering a period of up to 40 years before the survey. The estimate centers on 12 years before the survey; that is, the estimates obtained should, under conditions of little change in fertility and fairly steady change over time in maternal mortality risk, reflect the period value in effect 12 years before the survey.

An important advantage of this method is its minimal data requirements. Four questions are posed to obtain: (1) the total number of sisters who have reached adulthood (or marriage) who were born to the respondent's mother; (2) the number of those sisters who are currently living; (3) the number of those sisters who are deceased; and of the deceased, (4) the number who died during pregnancy, childbirth, or the postpartum period. Thus, by classifying any death that occurs during pregnancy, childbirth, or the postpartum period as maternal, the indirect sisterhood approach identifies pregnancy-related deaths as defined in the tenth revision of the International Classification of Diseases (ICD), as opposed to true maternal deaths (WHO 1993). By using a time-of-death definition, some deaths due to incidental or nonobstetric causes will be classified as maternal. The effect of this definition on the estimation of maternal mortality is debatable and is discussed elsewhere (Stecklov 1995; Stanton et al. 1997).

Sibling-history Method (Direct Approach)

In the late 1980s, the DHS project began experimenting with the collection of maternal mortality data. The 1988 Egypt DHS was the first survey to include a maternal mortality module. In Egypt, the four questions listed above for the original indirect technique were expanded into seven questions and integrated into the household schedule. The formulation of the original questions was altered so that the fourth question on timing of death in relation to pregnancy, childbirth, and the postpartum period was broken into three separate questions.

Soon thereafter, other DHS surveys began to include questions for the estimation of maternal mortality in the individual woman's questionnaire. In these questionnaires, data were collected to allow for direct estimation of maternal mortality.[1] Direct estimation relies on the same underlying principle of proxy reporting as the indirect method, that is, sibling data are collected both as a means of expanding the sample size and of gathering information about deceased siblings who cannot be interviewed themselves.

The data requirements for the direct method are considerably more demanding than for the indirect approach. In the direct approach, a respondent is asked to provide the birth history of her mother, including the current age of all living siblings and the age at death and years since death for all deceased siblings. These data allow births, exposure time, and deaths to be placed in calendar time (after imputation for missing data) and, therefore, permit the calculation of sex- and age-specific death rates for reference periods defined by the analyst. The three timing-of-death questions are used to distinguish maternal from nonmaternal deaths. The questions required for the direct approach to maternal mortality estimation are as follows: How many children did your mother give birth to? How many of these children did your mother have before you were born? What was the name given to your oldest (next oldest) brother or sister? For each sibling, the following questions are asked: Is (NAME) male or female? Is (NAME) still alive? How old is (NAME)? In what year did (NAME) die? or How many years ago did (NAME) die? How old was (NAME) when she died? The questions about dead sisters only are: Was (NAME) pregnant when she died? Did (NAME) die during childbirth? Did (NAME) die within two months after the end of her pregnancy or childbirth?

As with the indirect method, the direct method defines a maternal death based on the time of death relative to pregnancy, childbirth, and the postpartum period. The indirect method defines the postpartum period as six weeks following childbirth, reflecting the 42-day period recommended in the ICD definition. To simplify reporting for the respondent, in most surveys, the direct method defines the postpartum period as the two months following childbirth. This discrepancy between the direct and indirect methods is assumed to have little effect; studies have shown that a large majority of maternal deaths occur in the peripartum period (Fauveau et al. 1988; Kane et al. 1992; Ministry of Health–Egypt Child Survival Project 1994).

The direct method requires fewer assumptions than does the indirect method. Both methods assume that no relationship exists between the number of siblings and their survival probabilities and that no correlation of mortality risks exists between siblings. The only other assumption required for the direct method concerns data quality: that respondents are able to report accurately the current age of their living siblings; the age at death and years since death for all dead siblings; and for dead sisters, the timing of death relative to pregnancy. This assumption is clearly far-reaching, given the context in which these surveys are conducted. Nevertheless, reliance on the data provided by respondents avoids having to turn to the modeled distributions used in the indirect technique and provides estimates with a defined time reference.

The statistic generated by the direct approach is the maternal mortality rate (MMRate). The MMRatio is obtained by dividing the MMRate by the general fertility rate (GFR). The MMRatio from the DHS, therefore, relies on data from two sections of the questionnaire. The MMRate is calculated from the sibling history and the GFR is calculated using data from respondents' birth histories. The GFR is likely more accurate than the MMRate, because the GFR is based on women's reports concerning their own children, as opposed to women's reports of events concerning their sisters.

After the experiences of using the indirect estimation technique in Egypt (1988) and the direct approach in Sudan (1989) and Bolivia (1989) were reviewed, the decision was made at DHS to proceed with the direct approach for future surveys. This decision was based on the advantages found to be associated with the direct approach (Rutenberg and Sullivan 1991): It requires that fewer assumptions be made than does the indirect approach; it allows for the calculation of rates and ratios for the reference period of interest; it allows the monitoring of trends; it permits maternal mortality to be analyzed by parity (or other characteristics added to the questionnaire); and it permits a substantial number of data-quality checks for completeness and plausibility that are not possible with the indirect approach. The disadvantages of the direct approach are: It requires an additional eight to ten minutes, on average, per interview; it requires additional training and supervision in the field; and it adds considerable complexity to data processing.

Results

Table 2 presents four maternal mortality indicators (MMRatio, MMRate, the LTR, and the proportion of all adult female deaths due to maternal causes), two indicators of adult mortality, and the general fertility rate for the period zero to six years before each survey. Compilation of all these indicators for a specific country offers several perspectives on the level of maternal mortality and provides a more readily understandable picture of the situation. For example, in Malawi, more than 750 maternal deaths occur per 100,000 births. One woman in 18 in Malawi will die from maternal causes at some point in her reproductive life. At a national level, fewer than two maternal deaths per 1,000 women occur annually. Maternal deaths are clearly the leading cause of death among Malawian women of reproductive age, however, constituting one-fourth (24 percent) of all deaths to women aged 15–49.

The Sibling History

In general, the sibling-history data pertaining to basic demographic indicators such as reported vital status, sex, age for living siblings, and age at death for dead siblings are complete in most surveys. For example, in all countries, vital status was recorded for at least 99 percent of siblings. In 11 of the 13 countries, a small number of siblings was reported with unknown sex, and in

Table 2 Maternal mortality ratio, maternal mortality rate, lifetime risk of maternal death, proportion of all adult female deaths due to maternal causes, adult mortality, and general fertility rate for the period zero to six years before the survey, 13 countries, Demographic and Health Surveys, 1989–95

Region/country	Year of survey	Maternal mortality ratio[a]	Maternal mortality rate[b]	Lifetime risk of maternal death	Proportion maternal[c]	Adult mortality between ages 15 and 50[d] Female	Male	General fertility rate per 1,000
Africa								
Central African Republic	1994	1,451	2.7	0.090	34.0	0.291	0.294	184.8
Madagascar	1992	663	1.3	0.045	23.4	0.211	0.250	201.6
Malawi	1992	752	1.6	0.058	24.4	0.223	0.223	211.2
Morocco	1992	380	0.5	0.019	32.6	0.063	0.067	129.9
Namibia	1992	395	0.6	0.027	19.3	0.125	0.219	160.7
Niger	1992	672	1.7	0.054	37.0	0.177	0.143	249.3
Senegal	1992	566	1.1	0.039	35.6	0.111	0.127	199.7
Sudan	1990	569	0.9	0.033	34.2	0.103	0.107	161.7
Zimbabwe	1994	393	0.6	0.020	16.6	0.142	0.202	151.8
Asia								
Indonesia	1994	454	0.4	0.015	21.8	0.090	0.102	96.3
Philippines	1993	208	0.3	0.010	16.4	0.067	0.132	130.5
Latin America								
Bolivia 1	1989	580	0.9	0.037	33.3	0.112	0.108	161.5
Bolivia 2	1994	396	0.6	0.024	23.9	0.110	0.134	160.0
Peru	1991	218	0.3	0.008	15.4	0.073	0.099	121.2

[a]Expressed per 100,000 live births. [b]Expressed per 1,000 women. [c]Proportion of all adult female deaths due to maternal causes. [d]Probability of dying between ages 15 and 50.

most cases, between one-fourth to one-half of these siblings were also lacking information on vital status. Overall, with the exception of Madagascar, age was recorded for more than 95 percent of living siblings. This information is similar to that from previous DHS surveys on respondents' ability to report their own ages (IRD/Macro Systems 1990). In Madagascar, the reports for 9 percent of all living siblings were missing a current age. Regardless of the amount of missing age data, differences by sex of the sibling are not apparent (Stanton et al. 1997).

Not surprisingly, more data are missing for dead siblings than for live ones. Placement of a death in time appears to be more difficult for the respondent than declaring the sibling's age at death. In every country, reports for less than 3 percent of dead sisters are missing an age at death, whereas a number of countries show 10 percent to 24 percent of dead sisters with missing years since death. A nearly identical pattern exists for male siblings. A description of the procedures used by DHS to impute missing data for these two variables is presented elsewhere (Stanton et al. 1997).

Time of Death Relative to Pregnancy

Table 3 presents the proportion of adult female deaths recorded with missing data on time of death relative to pregnancy for the periods zero to six and seven to 13 years before the survey. With the exception of Madagascar and Morocco, for which the surveys show 1 percent or less with missing information, most countries show between 5 percent and 15 percent of reports of adult female deaths missing enough data from the three time-of-death questions to prevent the death from being identified as maternal or nonmaternal. The surveys of Malawi and Namibia show the most missing data—17 percent and 26 percent, respectively. It is curious that Madagascar has such complete reporting in this section of the module, given that the reports for nearly one-fourth of the female deaths in this survey were missing information for years since death. Little difference is found in the proportion of adult female deaths recorded with data missing between the recent and distant periods

Table 3 Percentage of adult female deaths recorded with missing data on time of death relative to pregnancy, childbirth, and the postpartum period, by country, according to period before survey, 13 countries, Demographic and Health Surveys, 1989–95

Region/country	0–6 years before survey: Missing time-of-death data	Adult female deaths (N)	7–13 years before survey: Missing time-of-death data	Adult female deaths (N)
Africa				
Central African Republic	4.8	(493)	3.3	(211)
Madagascar	1.0	(495)	0.5	(236)
Malawi	17.3	(335)	11.9	(104)
Morocco	0.6	(176)	0.0	(166)
Namibia	25.7	(211)	21.0	(112)
Niger	8.8	(306)	4.4	(231)
Senegal	11.1	(199)	6.8	(133)
Sudan	5.4	(327)	5.4	(202)
Zimbabwe	8.7	(333)	6.5	(119)
Asia				
Indonesia	8.9	(824)	11.8	(533)
Philippines	13.8	(375)	13.6	(211)
Latin America				
Bolivia 1	12.0	(187)	11.7	(141)
Bolivia 2	8.7	(230)	12.4	(157)
Peru	10.2	(340)	6.3	(257)

before the survey. Missing data are more common, however, for the more recent deaths in all cases but two, a surprising finding given that recent data may be expected to be more accurate than data from the distant past.

Thus, the three variables determining time of death relative to pregnancy, childbirth, and the postpartum period show higher percentages of missing data than do other variables in the sibling history. The number of maternal deaths was adjusted here to account for these types of missing data. In each country, the proportion of adult female deaths due to maternal causes among those with complete reporting was applied to the number of observations with missing time-of-death data to generate an adjusted total for maternal deaths in the calculation of the maternal mortality indicators.

Evidence of Omission

A concern about the use of sibling data for estimating maternal mortality is that reporting on events in the distant past may be faulty as a result of inaccurate recall, especially among older respondents. The same problem could also result when younger respondents fail to report events in their siblings' lives that occurred when the respondents were young children or before they were born. The effect on the resulting estimate of maternal mortality varies depending on the estimation technique used. For example, recall problems in data used for direct estimation will most likely appear as an increasing trend in maternal mortality. By contrast, recall problems in data used for indirect estimation will be less apparent and will underestimate lifetime risk of maternal death 12 years before the survey.

With the possible exception of countries in the infertility belt (a crescent of countries extending from Cameroon through the Central African Republic and the Congos to Gabon) in sub-Saharan Africa, fertility in most developing countries has either remained high and stable or decreased over the past 35 years. Examining the parity of mothers of increasingly older respondents is one means of shedding light on the fertility component of the sibling history, since the average number of siblings reflects the respondents' mothers' lifetime fertility. Table 4 addresses this issue by showing the average parity of respondents' mothers by respondent's age. In 11 of the 13 countries, fertility apparently increased over time, according to reports in the sibling history. In some countries, for example, the Central African Republic, Madagascar, Morocco, and Senegal, average parity increased more than 20 percent from reports of respondents aged 45 to 49 compared with those of respondents aged 15 to 19. Moreover, some of the mothers of the younger respondents could continue to have children.

These data are difficult to interpret. That fertility has increased or remained stable over the 35-year period before the survey in all of these countries is implausible. The more likely explanation for the increasing pattern of fertility is that older respondents have omitted reporting all of their mothers' births. The births of siblings, particularly siblings who died many years before the survey, may well have been forgotten and these births may represent a substantial proportion of the omitted events. If the omitted births resulted in childhood deaths, the omissions would not affect the estimation of adult or maternal mortality. Likewise, if the omissions represent adult deaths that occurred more than 14 years before the survey, neither the direct estimates of adult mortality nor those of maternal mortality would be affected, because the DHS used sibling-history data only for the 13 years before the survey. Any omitted maternal death would, however, affect the indirect estimate of maternal mortality. Differences between the two Bolivia surveys from 1989 and 1994 strongly suggest relative underreporting at all ages during the earlier survey.

External Validation of the Adult Mortality Data

The sibling histories collected by the DHS direct method provide estimates of age-specific mortality rates for both males and females as well as estimates of maternal mortality rates and ratios. The mortality rates can be used to compute summary measures of adult mortality such as the probability of dying between the ages of 15 and 50, expressed as ${}_{35}q_{15}$. Ideally, the accuracy of the sibling-based mortality estimates could then be assessed by comparing them with summary indicators from other, valid sources. Unfortunately, in most countries where sibling histories have been collected, no alternative valid sources of adult mortality data exist against which to compare the sibling estimates. Three types of comparison are presented here: with estimates of life expectancy prepared by the United Nations in its population projections for similar time periods, given expected relationships in model life tables; with DHS estimates of the probability of dying by age five, again given expected relationships in model life tables; and for four countries with independent estimates of ${}_{35}q_{15}$ believed to be of good quality.

Comparisons with United Nations General Mortality Indicators

The United Nations 1994 Revision of World Population Prospects (UN 1995) provides estimates of life expectancy at birth, by sex, for five-year periods. For each country with sibling data, linear interpolation was applied to these estimates to obtain an estimate of life expectancy for the midpoint of the seven-year reference period for sibling mortality. For this exercise, the UN esti-

Table 4 Average parity of respondents' mothers, by country, according to respondent's age, 13 countries, Demographic and Health Surveys, 1989–95

Region/country	Respondent's age 45–49	40–44	35–39	30–34	25–29	20–24	15–19	Respondents (N)	Percentage decrease from age group 15–19 to 49
Africa									
Central African Republic	4.9	5.3	5.8	6.1	6.4	6.6	6.6	(5,884)	26
Madagascar	6.1	7.0	7.2	7.6	7.8	7.8	7.6	(6,260)	20
Malawi	6.4	6.7	7.2	7.1	7.4	7.5	7.5	(4,849)	15
Morocco	6.1	6.8	7.4	7.8	7.9	7.8	7.7	(9,256)	21
Namibia	6.3	6.4	6.7	6.8	7.0	7.0	6.7	(5,421)	6
Niger	6.4	6.4	6.6	6.4	6.8	6.9	7.1	(6,503)	10
Senegal	5.5	5.9	6.2	6.5	6.8	7.1	7.0	(6,310)	21
Sudan	6.4	6.6	6.9	7.3	7.7	7.8	7.7	(9,732)	17
Zimbabwe	7.2	7.6	7.7	7.6	7.5	7.3	6.7	(6,128)	–7
Asia									
Indonesia	5.3	5.7	5.8	5.9	5.9	5.8	5.3	(38,334)	0
Philippines	7.1	7.3	7.3	7.3	7.0	6.5	6.1	(15,029)	–16
Latin America									
Bolivia 1	4.8	5.0	5.2	5.1	5.1	5.1	4.9	(7,923)	2
Bolivia 2	5.2	5.7	5.9	6.3	6.2	6.1	6.1	(8,603)	15
Peru	6.0	6.3	6.4	6.5	6.5	6.2	6.0	(15,882)	0

mates were assumed to apply to the midpoint of their five-year periods. Thus, for example, the Zimbabwe DHS was conducted between July and November 1994, with an average date at around September 1994. The seven-year reference period of the sibling estimates, therefore, runs from about September 1987 to September 1994, with a midpoint at around March 1991. The United Nations estimate of life expectancy at birth for March 1991 was obtained by linear interpolation between the estimate for 1985–90 (the midpoint being the beginning of 1988) and 1990–95 (with the midpoint at the beginning of 1993).

The sibling-based estimate of $_{35}q_{15}$ is then plotted against the comparable United Nations estimate of life expectancy at birth on a graph that shows the relationships between $_{35}q_{15}$ and life expectancy in each regional family[2] of the Coale-Demeny (1983) model life tables. If the Coale-Demeny models capture the whole potential range of human mortality patterns, and the sibling and UN estimates are consistent, all observations should fall within the "cigar" of points traced by the Coale-Demeny families. The resulting graphs are shown in Figure 1 for males and Figure 2 for females. An observation above or to the right of the Coale-Demeny patterns indicates higher $_{35}q_{15}$ from sibling data than would be expected on the basis of the United Nations estimate of life expectancy at birth, whereas an observation below or to the left indicates a lower $_{35}q_{15}$ sibling value than would be expected.

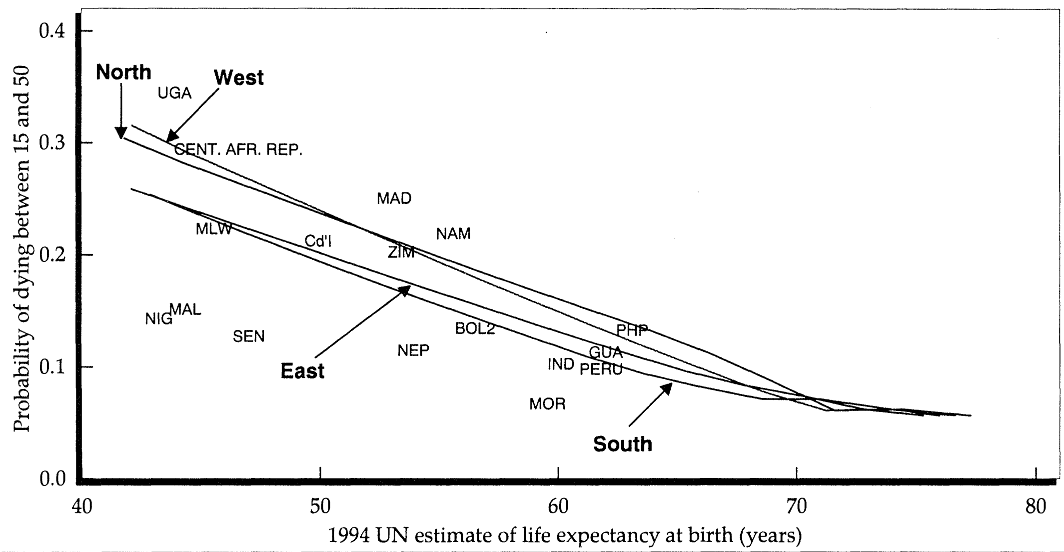
In both Figures 1 and 2 substantial scatter is seen around the model relationships, with observations both above and below the Coale-Demeny patterns. For both males and females, Central African Republic, Madagascar, and Uganda show higher sibling estimates than United Nations estimates, whereas for Mali, Morocco, Nepal, Niger, and Senegal, the sibling estimates are lower than the United Nations estimates. For the remaining countries, the sibling estimates are close to the United Nations estimates, although for female mortality (see Figure 2) the observations all fall around the Coale-Demeny relationships indicating the lowest probability of dying between age 15 and 50 for a given life expectancy, those from the "South" and "East" families. These comparisons indicate no clear systematic pattern of deviation from the United Nations mortality estimates, although they suggest that the sibling estimates are generally lower for females than would be expected in light of the United Nations mortality estimates.

Comparisons with DHS Child Mortality Indicators

The DHS birth histories provide estimates of child mortality by sex and time period prior to the survey. For this exercise, estimates of the probability of dying by age five have been computed for the same reference period, zero to six years before each survey, as for the sibling estimates of the probability of dying between the ages of 15 and 50. The two estimates have then been plotted against each other, in Figure 3 for males and in Figure 4 for females. In each figure, the relationships between the two indicators implied by the four families of the Coale-Demeny model life tables are also shown. Observations above or to the left of the Coale-Demeny patterns indicate higher than expected sibling estimates of $_{35}q_{15}$, given the birth-history estimate of dying by age five, whereas observations below or to the right indicate lower than expected sibling estimates of $_{35}q_{15}$.

The results show reasonable consistency between the child and adult mortality estimates. For both males and

Figure 1 Sibling estimates of male adult mortality compared with United Nations life-expectancy data, 17 DHS countries



Notes: Sudan is not included because the DHS sample was limited to Northern Sudan. UN estimate for Bolivia 1 is not available.

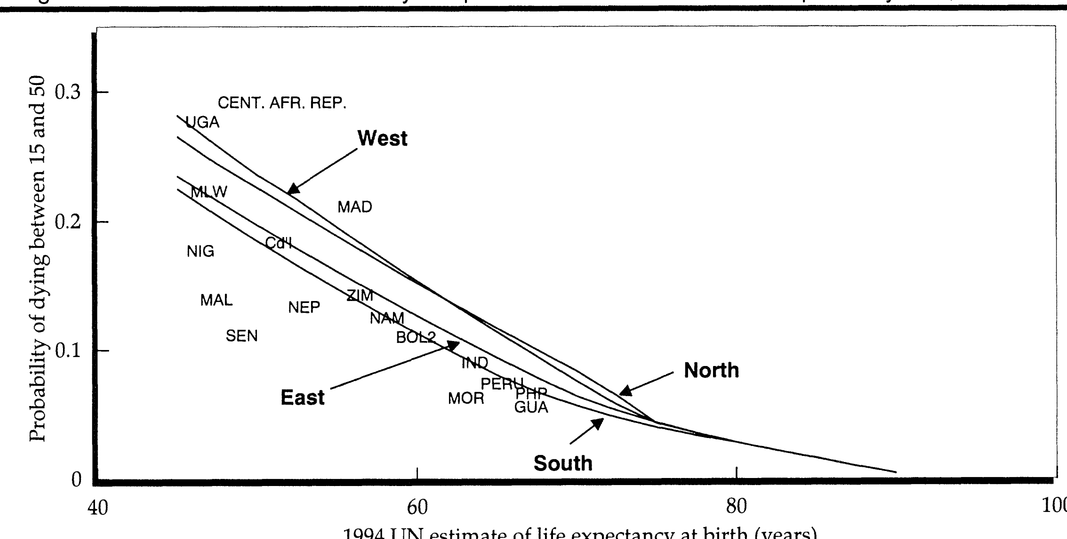
females, the sibling-based estimates are higher than expected (given the Coale-Demeny patterns) for Central African Republic, Uganda, and Zimbabwe, whereas the sibling-based estimates are lower only for Niger. Consistency is greater for females than for males: Sibling-based estimates are higher than expected for males in Madagascar, Namibia, and the Philippines, but lower than expected in Bolivia, Morocco, Senegal, and Sudan.

Comparison with Independent Estimates of Good Quality

For four of the countries covered by sisterhood estimates of adult mortality, independent estimates of mortality risks in adulthood deemed to be of good quality are available. The four countries are Guatemala, the Philippines, Senegal, and Zimbabwe. Two of these four countries, Guatemala and the Philippines, appear relatively consistent in the previous two checks, whereas for Senegal, the sibling estimate of the probability of dying between ages 15 and 50 is lower than would be expected, given the United Nations estimates of life expectancy at birth or the male estimate of the probability of dying by age five. For Zimbabwe, male and female estimates of $_{35}q_{15}$ are higher than would be expected on the basis of DHS estimates of child mortality, but consistent with United Nations estimates of life expectancy at birth, given the Coale-Demeny mortality patterns.

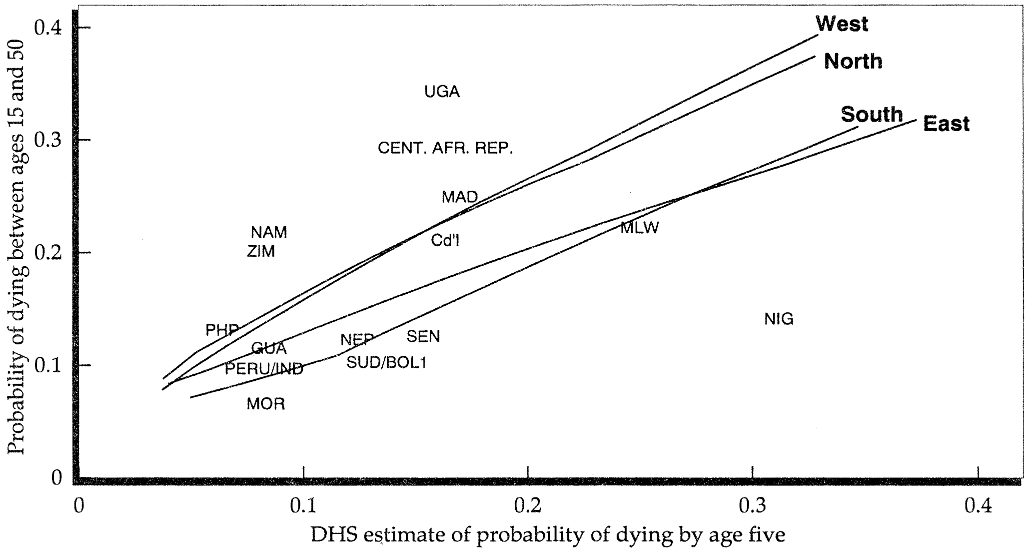
The independent estimates of adult mortality come from different sources. For Guatemala, registered deaths

Figure 2 Sibling estimates of female adult mortality compared with United Nations life-expectancy data, 17 DHS countries



Notes: Sudan is not included because the DHS sample was limited to Northern Sudan. UN estimate for Bolivia 1 is not available.

Figure 3 Sibling estimates of male adult mortality compared with birth-history estimates of child mortality, 17 DHS countries

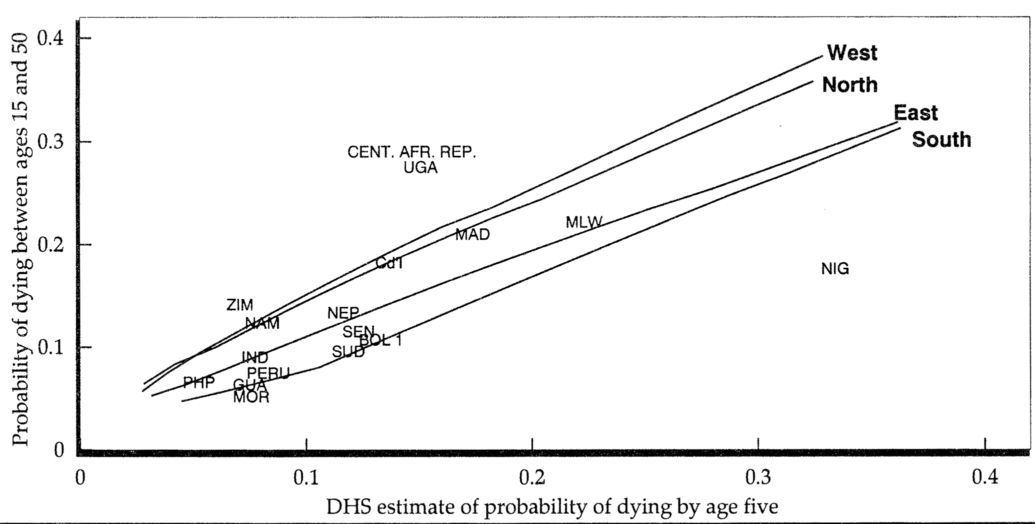


Note: Bolivia 2 and Mali are not included because estimates of the probability of dying by age five were not available for a comparable time period.

by age and sex for 1988 are combined with the estimated population by age and sex for 1990 to calculate age- and sex-specific mortality rates and thereby risks of dying between 15 and 50. For the Philippines, registered deaths between 1980 and 1990 were compared with population age structures in 1980 and 1990 using the General Growth Balance procedure (Hill 1987) to assess the coverage of deaths relative to the coverage of the 1980 and 1990 censuses. Deaths were then adjusted for coverage (no adjustment was necessary for male deaths, but female deaths required an upward adjustment of 20 percent) and adjusted age- and sex-specific mortality rates were computed for the 1980–90 period. The probability of dying between the ages of 15 and 50 was then obtained from the age- and sex-specific mortality rates. For Senegal, the life table for adults presented in the National Research Council's report *Population Dynamics of Senegal* (Pison et al. 1995) was used to derive probabilities of dying between 15 and 50. The Pison et al. life table was based on a question in the 1988 population census on deaths in the 12 months before the census, adjusted for estimated coverage. The Zimbabwe estimates are derived from information on population and deaths recorded by the 1992 population census. Application of the General Growth Balance equation to these data, in combination with the 1982 age distribution, suggests that no adjustment for coverage was necessary.

Table 5 compares the sibling mortality estimates

Figure 4 Sibling estimates of female adult mortality compared with birth-history estimates of child mortality, 17 DHS countries



Note: Bolivia 2 and Mali are not included because estimates of the probability of dying by age five were not available for a comparable time period.

Table 5 Sibling adult mortality estimates compared with other estimates of good quality, by country, according to sex

Country	Males		Females	
	Sibling	Other	Sibling	Other
Guatemala	0.113	0.135	0.064	0.091
Philippines	0.132	0.151	0.067	0.109
Senegal	0.127	0.190	0.111	0.176
Zimbabwe	0.202	0.287	0.142	0.212

with the independent estimates. The sibling estimate is lower than the independent estimate in all cases, the differences generally being larger for females than for males, ranging from a difference of about 15 percent for males in the Philippines to almost 60 percent for females in Senegal. If the independent estimates are correct, the sibling methodology is underestimating adult mortality, particularly for females and particularly in Senegal and Zimbabwe. The two previous consistency checks indicated that the sibling estimates were lower than expected in Senegal except for females in relation to female child mortality, but did not indicate problems with Guatemala, the Philippines, or Zimbabwe.

Plausibility of Patterns of Sibling Deaths

Two important advantages seen for the direct method of estimating maternal mortality are that the analyst is able to decide the reference period of interest when calculating the rates and ratios and that the analyst can generate rates and ratios for more than one time period in order to provide an indication of change over time. Table 6 presents the MMRatios for the periods zero to six years (recent) and seven to 13 years (distant) before each survey. These time periods were selected to diminish the effect of heaping in responses for five and ten years prior to the survey in the reports of years since death.

The most striking pattern evident in these data is that in ten of the 14 surveys, a substantial increase in the MMRatio is found in the recent period. These increases are evident regardless of the level of maternal mortality. For example, in the Central African Republic and Malawi, where the MMRatio in the distant period is in the range of 400 to 800 per 100,000, the MMRatios for the recent period are more than 80 percent higher. In contrast, Namibia and Zimbabwe, with maternal mortality estimates of less than 200 in the distant period, show increases of about 150 percent in the recent period. In only four countries do the MMRatio estimates decrease in the recent period relative to the past, and in three of these countries, the decreases are small. Niger and Morocco have recent MMRatio estimates that are about 15 percent lower than those of the distant period. Virtually no change is evident in the MMRatio estimate for the Philippines. Only in Peru was a substantial decrease found, its MMRatio falling by more than 25 percent.

Large increases between the distant and recent periods are not restricted to the MMRatios. In a majority of the 14 surveys, increases are seen in the MMRate, lifetime risk of maternal death, and male and female adult mortality for the recent period (not all data shown). Two indicators, the proportion of adult female deaths due to maternal causes and the general fertility rate, show a different pattern, however. In every country, fertility decreased significantly between the two time periods (not shown). The substantial decreases in fertility coupled with increases in the MMRate explain the large increases

Table 6 Direct estimates of the maternal mortality ratio (MMR) for two time periods, by country, Demographic and Health Surveys, 1989–95

Region/country	Year of survey	0–6 years before survey				7–13 years before survey				Percent change in MMR from distant to recent period
		MMR	95% confidence interval	Relative error	Number of deaths	MMR	95% confidence interval	Relative error	Number of deaths	
Africa										
Central African Republic	1994–95	1,451	(1,194–1,709)	0.09	168	775	(556–995)	0.14	71	87*
Madagascar	1992	663	(523–803)	0.10	116	543	(387–700)	0.14	67	22
Malawi	1992	752	(497–1,006)	0.17	82	408	(242–575)	0.20	42	84*
Morocco	1992	380	(255–506)	0.16	57	438	(308–569)	0.15	62	–13
Namibia	1992	395	(259–582)	0.17	41	154	(59–250)	0.31	15	156*
Niger	1992	672	(511–833)	0.12	113	779	(563–995)	0.14	110	–14
Senegal	1992–93	566	(417–715)	0.13	71	460	(288–631)	0.19	47	23
Sudan	1989–90	569	(359–779)	0.18	112	406	(239–572)	0.20	76	40
Zimbabwe	1994	393	(269–517)	0.16	55	159	(59–259)	0.31	17	147*
Asia										
Indonesia	1994	454	(378–529)	0.08	179	292	(245–339)	0.08	130	55*
Philippines	1993	208	(141–275)	0.16	62	212	(141–283)	0.17	53	–2
Latin America										
Bolivia 1	1989	580	(360–800)	0.19	62	385	(214–557)	0.22	35	51
Bolivia 2	1993–94	396	(237–555)	0.20	55	315	(191–439)	0.20	39	26
Peru	1991–92	218	(148–288)	0.16	52	296	(174–417)	0.20	59	–26

*Significant at $p<0.05$.

in the MMRatio shown for some countries. The proportion of deaths from maternal causes decreased in nine of the 13 countries, although the changes are generally not large (not shown).

Sampling Errors of the Estimates

Despite the seemingly large differences between the MMRatio estimates for the two time periods in many of the countries, in only five countries are the differences statistically significant at the 5 percent level: These are the Central African Republic, Indonesia, Malawi, Namibia, and Zimbabwe. As is shown in Table 6, the relative errors (the standard error as a percentage of the estimate) for the period zero to six years before the survey range from 9 percent to 20 percent of the estimate, and average about 15 percent.[3] By contrast, the relative errors for most DHS infant mortality estimates fall between 4 percent and 8 percent; relative errors for DHS fertility rates fall between 2 percent and 3 percent. The large standard errors lead to wide confidence intervals for every country. For these 13 countries, the 95 percent confidence intervals represent, on average, plus or minus 30 percent of the MMRatio for the recent period. (For purposes of comparison, the 95 percent confidence intervals surrounding DHS infant mortality estimates from 50 countries are, on average, plus or minus 15 percent [Curtis 1995]). Estimates for the period from seven to 13 years before the survey are even less precise than those for the recent period. The number of maternal deaths within a seven-year period, in particular the period from seven to 13 years before the survey, is small in some countries. For example, in six of the 13 countries, fewer than 50 maternal deaths were identified for a seven-year period.

Strictly speaking, the standard errors associated with the measures of maternal mortality prevent us from drawing conclusions regarding change over time in most countries. The magnitude of increase shown across countries in Africa, Asia, and Latin America is implausible, however, regardless of the precision of the estimates. The explanation for these large increases is not apparent from this analysis, although the low level of reporting for the distant past relative to the recent period is likely due to recall problems. None of the data-quality indicators examined for this exercise, however, suggests that among reported events, the data from the distant period were of lesser quality than those from the recent period. Admittedly, demonstrating omission of events is not possible without an external data source for purposes of comparison. The apparent underreporting of deaths in the distant period may be due, in part, to the displacement of events in time, however, rather than to omission. Again, this surmise can be demonstrated only in comparison with valid data on mortality trends.

The apparent underestimation of mortality for the distant period may be even greater in light of the results of the external validation of adult mortality presented earlier. These results suggest that adult mortality may be underestimated even for the recent period, implying that maternal mortality is likely to be underestimated as well, given that this measure is based on a subset of adult female deaths. Regardless of the underestimation for the recent period, the data presented here show clearly that the combination of both sampling and nonsampling errors associated with sibling histories precludes plausible reporting on change over time.

Discussion

Data shown in this study represent 14 surveys of 13 countries from widely varying mortality settings in Africa, Asia, and Latin America. Fourfold differences are seen in the probabilities of adult female mortality among countries; for example, the probability for adult females of dying between the ages of 15 and 50 ranges from around 6 percent (Morocco, Peru, and the Philippines) to 29 percent (Central African Republic). Probabilities of the lifetime risk of maternal death reflect even greater differences, ranging from 1 percent (Peru and the Philippines) to 9 percent (Central African Republic). Maternal mortality ratios range from 200 to more than 1,400 deaths per 100,000 births. Maternal death expressed as a proportion of all adult female deaths varies substantially, although to a lesser degree than do adult or maternal mortality. These proportions range from around 15 percent in the Philippines and Peru to 37 percent in Niger.

The data-quality assessment suggests that among reported events, the data are virtually complete for all but two variables: years since death and time of death relative to pregnancy, childbirth, and the postpartum period. Adjustments are made here to account for these deficiencies. None of the data-quality indicators of completeness suggests differential quality by sex of sibling or by time period before the survey.

The data-quality assessment also suggests some omission of siblings from reports of older DHS respondents. Without valid external data sets for comparative purposes, determining the effect, if any, of such omission on the adult or maternal mortality estimates is not possible. As noted above, many if not most of these omitted siblings may represent deaths of children, in which case neither the adult nor the maternal mortality estimates would be affected.

The assessment of adult mortality estimates for the period zero to six years before the survey as compared with model life-table estimates and, in four cases, independent data sources does suggest underreporting of adult male and female mortality, however. The implausible increases in a majority of countries in the adult and maternal mortality estimates from the distant to the recent past suggest even more extreme underreporting for the distant period. Clearly, data from DHS sibling histories cannot support mortality-trend analysis either for adult or maternal mortality.

In evaluating the maternal mortality indicators produced from sibling data (by the direct or indirect method), nonsampling and sampling errors that affect these estimates must be recognized. Nonsampling errors include: (1) recall errors that most likely lead to underreporting of distant events or shifting in the time of occurrence reported for adult and maternal deaths; (2) respondent's report of a sister's death when respondent is unaware that the sister was pregnant at the time of her death, which leads to a misclassification of the death as nonmaternal (such reports may be especially likely to affect the number of deaths related to induced abortion); (3) incorrect placement of adult deaths in time; (4) use of a time-of-death definition of maternal death, whereby nonmaternal deaths occurring during the 11-month period of pregnancy, childbirth, and the postpartum period are counted as maternal deaths; and (5) the likelihood, according to this evaluation, that male and female adult mortality are underestimated, even for the recent period. Regarding sampling errors, the standard errors for these estimates are large as a result of the rarity of maternal deaths and the sample size of the DHS surveys. The result is maternal mortality errors that are imprecise.

As shown above, in any given country, simultaneous forces tend to cause over- and underestimation of maternal mortality, and few data exist to allow us to ascertain the extent to which these errors compensate for one another. The majority of the nonsampling errors are clearly associated with under- rather than overestimation, however. These types of problems are not unique to the measurement of maternal mortality. Problems such as inaccurate dating of events and omission in the reporting of deaths are common to mortality estimation for all ages when retrospective reports from a survey are used.

The coupling of these common types of errors with the large sampling errors associated with maternal mortality indicators leads to estimates of maternal mortality that are not of comparable precision to DHS infant and under-five mortality estimates, and should be interpreted accordingly. For example, the imprecision of the maternal mortality estimates will, in most cases, prevent the documenting of change in mortality over short periods of time. This restriction holds true when estimates are used that reflect two consecutive time periods and are calculated from a single sibling-history data set (as was done here). The same restriction occurs when estimates resulting from two sequential DHS surveys conducted close together (for example, five to seven years, as in Bolivia) are used. In most cases, the magnitude of change required to show a statistically significant difference between the two surveys is greater than what realistically could be expected to occur at a national level. Consequently, the maternal mortality module should be included in a DHS questionnaire once every ten years at most.

The issue of the existence of large sampling errors could be addressed by increasing DHS sample sizes. Table 7 shows the minimum required sample sizes to achieve a relative error comparable with those of DHS child mortality estimates for the range of levels of maternal mortality seen among the countries considered here. The simulation exercise to calculate required sample size was based on a 5 percent relative error and 1.7 sisters living to adulthood per DHS respondent. These sample sizes are based on the minimum design effect (deft = 1.2) associated with other DHS mortality estimates.[4] Clearly, the enormous increases in sample size required to generate maternal mortality indicators of a similar level of precision as the child mortality estimates would not be justified.

With few exceptions, all data-collection methods generate at best an approximate estimate of maternal mortality. The indirect and direct methods described here embody different strengths and weaknesses that should be taken into consideration when choosing a method of measurement, and particularly when interpreting the resulting MMRatio estimates. Based on the results of this exercise, the authors recommend that con-

Table 7 Minimum sample-size estimates for Demographic and Health Surveys

Maternal mortality rate per 1,000	DHS respondents (N)
0.2	242,000
0.6	80,600
1.0	48,400
1.4	34,500
1.8	26,800
2.2	22,000
2.6	18,600

Note: The calculation of sample size is based on 5 percent relative error, 1.7 sisters living to adulthood, and the minimum design effect from other DHS mortality estimates.

fidence intervals be published for all survey-based estimates of maternal mortality as a means of promoting appropriate interpretation.

In light of the imprecision of maternal mortality indicators, the question of the appropriate use of these indicators remains. Several publications now exist that describe the limitations of maternal mortality statistics for monitoring program impact (Graham et al. 1996; Campbell et al. 1997; Inter-Agency Group for Safe Motherhood 1997). Perhaps the most convincing example of these limitations is illustrated by Ronsmans et al. (1997) using data from Matlab, Bangladesh. There, maternal mortality from direct causes showed similar decreases in both the maternity-care intervention area and in the control area. Any interpretation of decline in the intervention area in terms of the intervention's impact would, therefore, have been incorrect. Clearly, alternative indicators are required for purposes of policy and program evaluation. Initial experiences using the process indicators of the quality and availability of obstetric care that are recommended by the United Nations Children's Fund (UNICEF), the World Health Organization (WHO), and the United Nations Population Fund (UNFPA) (1997) as alternative indicators for programs addressing maternal survival are documented elsewhere (MotherCare Matters 1999; Ronsmans et al. 1999).

Maternal mortality statistics can, however, be used effectively as advocacy tools. Publicizing the MMRatio often represents a first stage in addressing safe motherhood issues. Maternal mortality statistics are also an important component of the background data required to describe the maternal health situation of a country. For this reason, the continued documentation of population-based maternal mortality statistics every ten years or so is important, because it provides a broad indicator of the magnitude of maternal mortality and its changes over time. Correct interpretation of the indicator, requiring acknowledgment of its imprecision and other data-quality issues, is essential to its appropriate use.

Notes

1 In this context, "direct" and "indirect" are used in the same sense as in the estimation of child mortality. A direct estimate is based entirely on information contained in the data set, typically using a life-table approach, whereas an indirect estimate is derived from the information itself in combination with other information, typically from demographic models.

2 The four families of Coale-Demeny model life tables ("North," "South," "East," and "West") reflect different age patterns of mortality in historical populations.

3 Standard errors were calculated using the jackknife procedure for complex rates and ratios. The software package ISSA, developed by the DHS project of Macro International, was used for these calculations.

4 Data from the 13 countries in this study showed that the average number of sisters reaching age 15 per DHS respondent ranged from approximately 1.2 to 2.1. The design effect for infant and under-five mortality estimates ranged from 1.2 to 1.7.

References

Campbell, Oona, Veronique Filippi, Marjorie Koblinsky, Tom Marshall, Julia Mortimer, Rudiger Pittrof, Carine Ronsmans, and Linda Williams. 1997. *Lessons Learnt: A Decade of Measuring the Impact of Safe Motherhood Programmes.* London: London School of Hygiene and Tropical Medicine.

Coale, Ansley and Paul Demeny. 1983. *Regional Life Tables and Stable Populations.* Second edition, with Barbara Vaughn. New York: Academic Press.

Curtis, Siân. 1995. *Assessment of the Quality of Data Used for Direct Estimation of Infant and Child Mortality in DHS II Surveys.* Calverton, MD: Macro International.

Fauveau, Vincent, Michael A. Koenig, Jyotsnamoy Chakraborty, and A. Chowdhury. 1988. "Causes of maternal mortality in rural Bangladesh, 1976–1985." *Bulletin of the World Health Organization* 66(5): 643–651.

Graham, Wendy, William Brass, and Robert Snow. 1989. "Estimating maternal mortality: The sisterhood method." *Studies in Family Planning* 20(3): 125–135.

Graham Wendy, Veronique Filippi, and Carine Ronsmans. 1996. "Demonstrating programme impact on maternal mortality." *Health Policy and Planning* 11(1): 1,620.

Hill, Kenneth. 1987. "Estimating census and death registration completeness." *Asian and Pacific Population Forum* 1(3): 5–13.

Institute for Resource Development (IRD)/Macro Systems. 1990. "An assessment of DHS-1 data quality." In *Methodological Reports 1.* IRD/Macro. P. 26.

Inter-Agency Group for Safe Motherhood. 1997. *The Safe Motherhood Action Agenda—Priorities for the Next Decade.* New York: Family Care International.

Kane, Thomas T., Adel A. El-Khady, Saneya Saleh, Marvin Hage, John Stanback, and Linda Potter. 1992. "Maternal mortality in Giza, Egypt: Magnitude, causes, and prevention." *Studies in Family Planning* 23(1): 45–57.

Ministry of Health (MOH)–Egypt Child Survival Project. 1994. *National Maternal Mortality Study, Findings and Conclusions.* Cairo: MOH.

MotherCare Matters. 1999. *Safe Motherhood Indicators—Lessons Learned in Measuring Progress.* 8(1).

Pison, Gilles, Kenneth Hill, Barney Cohen, and Karen Foote (eds.). 1995. *Population Dynamics of Senegal.* Washington, DC: National Academy of Sciences.

Ronsmans, Carine, Anne Marie Vanneste, Jyotsnamoy Chakraborty, and Jeroen van Ginneken. 1997. "Decline in maternal mortality in Matlab, Bangladesh: A cautionary tale." *The Lancet,* 350 (December 20–27): 1,810–1,814.

Ronsmans, Carine, Endang Achade, G. Sutrakikto, Ali Zazri, and Jeanne McDermott. 1999. "Use of hospital data for safe motherhood programmes in South Kalimantan, Indonesia." *Tropical Medicine and International Health* 4(7): 514–521.

Rutenberg, Naomi and Jeremiah Sullivan. 1991. "Direct and indirect estimates of maternal mortality from the sisterhood method." In *Demographic and Health Surveys World Conference*. Volume 111. Pp. 1,669–1,696.

Stanton, Cynthia, Noureddine Abderrahim, and Kenneth Hill. 1997. "DHS Maternal Mortality Indicators: An Assessment of Data Quality and Implications for Data Use." *DHS Analytical Report* No. 4. Calverton, MD: Macro International.

Stecklov, Guy. 1995. "Maternal mortality estimation: Separating pregnancy-related and non-pregnancy-related risks." *Studies in Family Planning* 26(1): 33–38.

United Nations (UN). 1995. *World Population Prospects, The 1994 Revision.* Department for Economic and Social Information and Policy Analysis, ST/ESA/SER.A/145. New York: UN.

World Health Organization (WHO). 1993. *International Statistical Classification of Diseases and Related Health Problems,* Tenth revision, volume 2. Instruction manual. Geneva: WHO. P. 134.

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