Estimates of the maternal mortality ratio in two districts of the Brong-Ahafo region, Ghana

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Objective To estimate the maternal mortality ratio (MMR) by the sisterhood method in two districts of the Brong-Ahafo region of Ghana, and to determine the impact of different assumptions and analytical decisions on these estimates.

Methods Indirect estimates of the MMR were calculated from data collected in 1995 by Family Health International (FHI) on 5202 women aged 15–49 years, using a household screen of randomly selected areas in the two districts. Other data from the nationally representative 1994 Ghana Infant, Child and Maternal Mortality Survey (ICMMS) and from the 1997 Kassena-Nankana District study were also used for comparison.

Findings Based on the FHI data, the MMR was estimated to be 269 maternal deaths per 100 000 live births for both districts combined, a figure higher than ICMMS estimates. Biases during data collection may account for this difference, including the fact that biases underestimating mortality are more common than those overestimating it. Biases introduced during data analysis were also considered, but only the total fertility rate used to calculate the MMR seemed to affect the estimates significantly.

Conclusions The results indicate that the sisterhood method is still being refined and the extent and impact of biases have only recently received attention. Users of this method should be aware of limitations when interpreting results. We recommend using confidence limits around estimates, both to dispel false impressions of precision and to reduce overinterpretation of data.

Keywords Maternal mortality; Data collection/methods; Bias (Epidemiology); Ghana (*source: MeSH*).

Mots clés Mortalité maternelle; Collecte données/méthodes; Biais (Epidémiologie); Ghana (*source: INSERM*).

Palabras clave Mortalidad materna; Recolección de datos/métodos; Sesgo (Epidemiología); Ghana (*fuente: BIREME*).

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Introduction

The sisterhood method of indirectly estimating the maternal mortality ratio (MMR) (*1*) was developed because of the difficulty and expense in getting such data in other ways (*2*). Because of the relative ease of data collection, the relatively small sample size needed, and the relative ease of calculation, the method has been widely adopted and adapted and has become an important tool in developing countries. The original sisterhood method is indirect, because the MMR is not measured directly but is derived mathematically from information provided by respondents about the survival of their sisters. The adaptation known as the direct method (Table 1) has been routinely added to many surveys including the Demographic and Health Surveys (DHS). It relies on the same basic principle as the indirect method (i.e. use of information reported by siblings to expand the sample size and to compensate for the fact that the deceased are not available for interview). However, considerably more data are collected on the circumstances and timing of a sister's death, thus allowing a direct calculation of the MMR. The direct method requires a larger sample size, a larger number of questions, and a more difficult calculation than the indirect method (*2, 3*). However, because of the larger sample size, the direct method can be modified to obtain an estimate for a more recent period, and the greater number of questions provide internal validity checks (*2*).

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Although the sisterhood method of estimation is conceptually simple, researchers must take great care to ensure that the simple concepts are correctly operationalized when carrying out a survey. For example, if the respondent includes herself among her sisters — a common linguistic difficulty — the denominator will be inflated and the mortality ratio underestimated. The direct method, with its eleven questions, requires proportionately more interviewer training than the indirect method which asks only four questions; it also requires the interviewer to spend more time with respondents. An important limitation of the indirect method is that it estimates mortality for a time period preceding the survey: the median time elapsed since death was 10–12 years in this study. This means that the indirect method can only be used to evaluate progress in reducing maternal mortality over very long time periods. In contrast, the direct method can reduce the time lag of the estimate by limiting respondents to those under a given age (e.g. those under 30 years old), but this increases sample size requirements.

Choosing the sisterhood method

The sisterhood method should not be used in certain situations. For example, the method should not be used when fertility rates are low (i.e. the total fertility rate (TFR) is less than 3) because the probability of a deceased mother having no sibling is increased. The TFR is the sum of all the age-specific fertility rates for a group of women at a specific point in time. It represents the average number of live births a woman in that group would have if she were to pass through all her reproductive years conforming to the age-specific rates prevailing when the rate was calculated. Even though it is a artificial measure, the TFR is easy to calculate from data which are often obtainable and provides a good indication of how many children women in a cohort are having.

The sisterhood method should also not be used when the fertility rate is falling rapidly, because the TFR, an essential component of the MMR calculation, will also be changing rapidly (1). The method also should not be used if maternal mortality is low because of the prohibitively large sample sizes needed. When there is significant out-migration of the population (such as relocation due to marriage, war, civil strife, unemployment, or famine), this also reduces the likelihood that there will be surviving siblings available for interview. Recent scrutiny of the sisterhood method, including careful comparisons with estimates of maternal mortality based on external sources, has suggested that the sisterhood method can underestimate mortality due to maternal causes (4). This claim is supported by work in Bangladesh (5, 6) and in Senegal (7).

In the study presented here, we estimated the level of maternal mortality for two districts in the Brong-Ahafo region of Ghana and compared the estimates with regional and national estimates from other surveys. We also discuss sources of bias in the

Table 1. **Comparison of indirect and direct methods of estimating maternal mortality by the sisterhood method**

Parameters	Indirect method	Direct method
Sample size[a] needed to estimate an MMR[b] of 300	4000	5000
Number of questions required (time required)	4 (10 minutes)	11 (20 minutes)
Median number of years since death of deceased sisters	10–12	0–13[c]
Ease of calculation	simple	more complicated

Source: ref. 2.

[a] The sample size for a simple random sample; for a cluster sample, add approximately 1000.

[b] MMR = maternal mortality ratio.

[c] Length of time may be reduced by limiting the age of respondents.

estimates and determine the degree to which assumptions used in the analysis of the Ghana data influenced the results.

Methods

Infant, Child and Maternal Mortality Survey

Estimate of the national maternal mortality ratio. The ICMMS of 1994 (8) estimated the national MMR for Ghana to be 214 maternal deaths per 100 000 live births, using indirect sisterhood data from a nationally representative survey conducted in 1992 (9) (Table 2). This figure was lower than a recent estimate of Ghana's MMR (742 maternal deaths per 100 000 live births; 95% confidence interval of 620–878) that used a regression-based model (4). Possible reasons for the difference in the MMR values include differences in the methodology of the two studies and bias. As an example of the latter, respondents who included themselves among the number of their sisters were considered to be a likely cause of downward bias.

Estimate of the regional maternal mortality ratio. The Brong-Ahafo region of central Ghana is poor and mainly rural. Even though the health services are more extensive than in regions to the north, two districts (out of 13) within the region have no hospital. The main hospital is in the regional capital of Sunyani and is not a teaching hospital. The ICMMS estimated the regional MMR for Brong-Ahafo to be 171 maternal deaths per 100 000 live births. This figure was based on a small number of maternal deaths and the confidence limits were correspondingly large (data not shown).

Based on a subsample of 1195 respondents, the ICMMS also produced local estimates of lifetime risk of maternal mortality (cumulative probability a woman has of dying from maternal causes) and proportional maternal mortality (proportion of total deaths from maternal causes) for the Brong-Ahafo region. Such statistics are useful in making comparisons between

Table 2. **Indirect estimate of maternal mortality using the sisterhood method, Ghana, 1992**

Age group of respondents in years	No. of respondents	No. of sisters reaching age 15 yrs	No. of sisters reaching age 15 yrs who died	No. of maternal deaths	Adjustment factor[a]	Sisterhood units of exposure[b]	Lifetime risk[c]	Proportion of dead sisters who died of maternal causes
15–19	1992	4900	126	10	0.017	83	0.120	0.079
20–24	2863	7043	306	22	0.206	1451	0.015	0.072
25–29	3059	7233	386	36	0.343	2481	0.015	0.093
30–34	2558	6513	453	32	0.503	3276	0.010	0.071
35–39	2065	5329	524	49	0.664	3538	0.014	0.094
40–44	1392	3432	327	36	0.802	2752	0.013	0.110
45–49	1228	2832	391	37	0.900	2549	0.015	0.095
15–49 (whole sample)	**15 157**	**37 282**	**2513**	**222**	**NA[d]**	**16 131**	**0.014[e]**	**0.088**

Source: ref. *8*.

[a] The adequacy of these adjustment factors has been questioned (ref. *7*).

[b] The reported number of sisters is multiplied by an adjustment factor to arrive at sisterhood units of exposure (i.e. how many sisters should be counted as being at risk of a maternal death).

[c] Lifetime risk of maternal mortality (i.e. the cumulative probability a woman has of dying from maternal causes).

[d] NA = not applicable.

[e] Using a total fertility rate (TFR) of 6.6 (ref. *9*), and a lifetime risk of 0.014, the maternal mortality ratio = $1 - [(1 - \text{lifetime risk})^{1/\text{TFR}}]$ = 214 maternal deaths per 100 000 live births.

Table 3. **Indirect estimate of maternal mortality using the sisterhood method, Kintampo district, Brong-Ahafo region, Ghana, 1995**

Age group of respondents in years	No. of respondents	No. of sisters reaching age 15 yrs	No. of sisters reaching age 15 yrs who died	No. of maternal deaths	Adjustment factor	Sisterhood units of exposure[a]	Lifetime risk[b]	Proportion of dead sisters who died of maternal causes
15–19	338	870	23	4	0.107	93.1	0.043	0.174
20–24	432	1112	58	11	0.206	229.1	0.048	0.190
25–29	504	1251	70	5	0.343	429.1	0.012	0.071
30–34	483	1273	89	18	0.503	640.3	0.028	0.202
35–39	418	1082	78	7	0.664	718.4	0.010	0.090
40–44	286	737	75	11	0.802	591.1	0.019	0.147
45–49	218	553	55	17	0.900	497.7	0.034	0.309
15–49 (whole sample)	**2679**	**6878**	**448**	**73**	**NA[c]**	**3200**	**0.023[d]**	**0.163**

Source: Family Health International study.

[a] The reported number of sisters is multiplied by an adjustment factor to arrive at sisterhood units of exposure (i.e. how many sisters should be counted as being at risk of a maternal death).

[b] Lifetime risk of maternal mortality (i.e. the cumulative probability a woman has of dying from maternal causes).

[c] NA = not applicable.

[d] Using a total fertility rate (TFR) of 7.02 (ref. *9*), and a lifetime risk of 0.023, the maternal mortality ratio = $1 - [(1 - \text{lifetime risk})^{1/\text{TFR}}]$ = 328 maternal deaths per 100 000 live births.

populations and the local estimates are needed to derive a regional MMR estimate. The TFR used in the calculations for the Brong-Ahafo region was 7.02, using the same source as the national TFR (*9*).

The Kassena-Nankana district study

The Kassena-Nankana district is in the Sahelian area in the north-east of Ghana, whereas the Brong-Ahafo region is located in the forested central area. In general, religious, social, and cultural patterns are somewhat different in the two locations and may affect marriage and childbearing practices, as well as access to health care.

A study was carried out using both direct and indirect sisterhood methods to estimate the MMR in this district, using data collected in 1997 (*10*). A TFR of 5.3 (for 1994–96) was used and the MMR was estimated in three ways. Firstly, directly from demographic surveillance data, 55 maternal deaths and 8316 live births were identified, giving an MMR of 637 maternal deaths per 100 000 live births. Secondly, a random sample of households in the

Table 4. **Indirect estimate of maternal mortality using the sisterhood method, Tano district, Brong-Ahafo region, Ghana, 1995**

Age group of respondents in years	No. of respondents	No. of sisters reaching age 15 yrs	No. of sisters reaching age 15 yrs who died	No. of maternal deaths	Adjustment factor	Sisterhood units of exposure[a]	Lifetime risk[b]	Proportion of dead sisters who died of maternal causes
15–19	314	887	14	1	0.107	95	0.011	0.071
20–24	446	1260	23	5	0.206	260	0.019	0.217
25–29	500	1293	43	6	0.343	443	0.014	0.140
30–34	470	1359	66	16	0.503	684	0.023	0.242
35–39	332	1017	45	10	0.664	675	0.015	0.222
40–44	264	755	67	6	0.802	605	0.010	0.090
45–49	197	602	58	5	0.900	542	0.010	0.086
15–49 (whole sample)	**2523**	**7173**	**316**	**49**	**NA[c]**	**3304**	**0.015[d]**	**0.155**

Source: Family Health International study.

[a] The reported number of sisters is multiplied by an adjustment factor to arrive at sisterhood units of exposure (i.e. how many sisters should be counted as being at risk of a maternal death).

[b] Lifetime risk of maternal mortality (i.e. the cumulative probability a woman has of dying from maternal causes).

[c] NA = not applicable.

[d] Using a total fertility rate (TFR) of 7.02, and a lifetime risk of 0.015, the maternal mortality ratio = $1 - [(1 - \text{lifetime risk})^{1/\text{TFR}}] = 212$ maternal deaths per 100 000 live births.

region was analysed and the MMR was estimated by the direct sisterhood method. Based on 155 deaths, this method gave an estimate of 857 maternal deaths per 100 000 live births (95% confidence limits: 722–992). Thirdly, using the same random sample of households that were used in the direct method, the MMR was calculated by the indirect sisterhood method. Based on 247 deaths, this method estimated the MMR to be 758 maternal deaths per 100 000 live births (95% confidence limits: 664–852).

The authors of the Kassena-Nankana study took these numbers at face value and concluded that the MMR had declined from 800 to 600 maternal deaths per 100 000 live births. Presumably, the figure of 800 was a composite number from the direct and indirect sisterhood estimates (857 and 758, respectively; mean value = 807), and represented a period 14 years earlier. The figure of 600 came from the demographic surveillance method (637). The authors did not review potential sources of bias in any of the methods.

The Family Health International study

The FHI study was conducted as part of a larger study to evaluate the impact of Ghana's traditional birth attendant (TBA) training programme and used the indirect sisterhood method. The larger study required a screen of all households in randomly selected enumeration areas in the Kintampo and Tano districts of Brong-Ahafo. The two districts were chosen to represent areas with different access to emergency obstetric care. The Tano district had both a district hospital and a mission hospital, whereas the Kintampo district had no hospital at the time the survey was conducted. The input data for the sisterhood method were derived from this larger household screen and were collected in 1995.

The research was reviewed for ethical considerations under the processes established by the Protection of Human Subjects Committee of the FHI and the Ghanaian Ministry of Health. Free and informed consent was obtained from all participants.

In Kintampo, 3219 respondents aged 15 years and older (2679 of whom were 15–49 years old) were interviewed about their sisters. In Tano, 3014 respondents aged 15 years and older (2523 of whom were 15–49 years old) were interviewed. Together, the two districts had a sample size ($n = 5202$) that exceeded the number required for indirect estimates ($n = 4000$). However, for each separate district the sample size was small, which reduces the precision of the estimate. The questions used have been described previously (1). Interviewers were trained by two of the authors (NAC, JdeGJ) and particular attention was paid to the definition of "sister", ensuring that respondents did not include themselves among their sisters.

Results

Kintampo and Tano MMR estimates

The MMR estimates for the two districts that were calculated using the indirect sisterhood method are shown in Table 3 and Table 4. Using the DHS TFR of 7.02 for Brong-Ahafo, the MMR in Kintampo was estimated to be 328 maternal deaths per 100 000 live births, and 212 maternal deaths per 100 000 live births in Tano. As anticipated, the MMR was significantly higher (by 55%) in Kintampo than in Tano ($P = 0.037$). A comparison of our estimates with earlier estimates is shown in Table 5.

The FHI estimate of the MMR for Kintampo and Tano combined is 57% higher than the ICMMS estimate for Brong-Ahafo and 26% higher than the

Table 5. **Comparison of maternal mortality ratios (MMRs) from various studies**

Year data collected	Location of study	MMR	Investigators
1992	Ghana	214	ICMMS[a], 1994
1992	Brong-Ahafo	171	ICMMS, 1994
1995	Kintampo	328	FHI[b]
1995	Tano	212	FHI
1995	Kintampo and Tano (combined)	269	FHI

[a] ICMMS = Infant, Child and Maternal Mortality Survey.

[b] FHI = Family Health International.

ICMMS estimate for Ghana as a whole. Although it is possible that these two districts actually have higher maternal mortality, we must also consider the possibility of bias in our estimates as well as in the earlier estimates. There are several potential sources of bias in estimates of maternal mortality using the sisterhood method. Some biases operate to raise the estimate and some to lower it; some occur in data collection and some in data analysis.

Biases introduced in data collection

During data collection biases that lower the estimate are more common than biases that raise it and include: maternal deaths are under- or overreported by respondents (affects numerator); the number of sisters is under- or overreported (affects denominator); some maternal deaths occur in women who have no living siblings in the area at the time of the survey (affects numerator); and occasions when not all siblings are available for interview survey (affects numerator).

Misclassification of deaths. A study in Matlab Thana, Bangladesh, compared the number of deaths identified by a demographic surveillance system with those identified by a sisterhood survey and found that no sibling incorrectly reported that a sister died a maternal death, but 20% of maternal deaths were classified as non-maternal or of unknown cause (*5, 6*). Among the respondents who did not know the cause of their sisters' deaths (*n* = 17), the mean age when their sisters died was eight years old. Deaths due to abortion and maternal deaths of unmarried sisters were more likely to be reported as non-maternal. Seventy percent of misclassified deaths were due to abortion. Of the 70 deaths attributed to abortion by the surveillance system, only 25 were reported for married women and none for unmarried women. All the biases identified led to an underestimation of the MMR.

Inclusion criteria. The original indirect method based its estimates on the reported mortality of sisters who were or had been married. However, in situations with a pattern of premarital childbearing, this criterion is not optimal and is sometimes replaced by, for example, menarche or reaching the age of 15 years. The DHS, for instance, has used both approaches in its surveys depending on the situation (*4*). In the FHI study reported here, we used reaching the age of 15 years as our criterion, primarily because the ICMMS study had used this criterion to define puberty and we wanted to be able to generate comparative statistics.

Regardless of the criterion used to determine the number of sisters, an underestimate of this figure would inflate the MMR estimate. For example, some sisters may have been forgotten because they died young (although their age at death was over the lower limit of the age range chosen for the study), or because they lived far way. On the other hand, an overestimate of the number, caused by factors such as the respondent including herself in the number of her sisters, would underestimate the MMR. The FHI study made a special effort to ensure that female respondents did not include themselves among the number of sisters. A similar bias may be caused by misreporting the number of "sisters who were ever married" (*1*). Some researchers use "reached the age of 15", while others use "reached marriageable age", when assessing the population. Using "ever-married" creates difficulties in cultures (e.g. in Jamaica) where marriage follows sexual activity and childbearing after significant time periods. The impact of alternative criteria has yet to be explored.

Siblings not available. The study by Shahidullah also found that no living sibling could be found in Matlab Thana for 21% of the maternal deaths (*5*). This could be because of low fertility; high maternal mortality (which leaves children motherless and without siblings); patrilocal marriage (wives go to live in their husbands' region); or because of a high rate of out-migration in the region. For small-area estimates, such as in the FHI study, these last two factors could be important.

Trussell & Rodriguez (*11*) showed that it is important that all people in a sibship are available for interview (though it is not necessary that they actually are interviewed). They did not specify the direction of bias caused by not interviewing all siblings, but the Matlab Thana research suggests that it is likely to result in underestimation (*5*). The smaller the geographical area of inquiry, the greater will be the likelihood that all siblings will not be interviewed, increasing the likelihood that bias will be introduced into the MMR estimate. The Matlab Thana study showed that sisterhood estimates would have to be adjusted by 1.645 to get a true estimate (i.e. to obtain an MMR estimate equal to that obtained from demographic surveillance). For larger areas, the adjustment factor would be smaller because out-migration becomes less important. If it is assumed that there was no out-migration from Bangladesh, the data from the Matlab Thana study indicate that the adjustment factor would be 1.24 at the national level.

Age range of respondents. Restricting the age range of respondents also has an important effect on the MMR estimate. Including respondents over the age of 49 (i.e. beyond reproductive age) extends the

time period for the estimate, whereas limiting respondents to those of reproductive age narrows the time period to about 12 years. The time period can be estimated for each study and represents the mean time since the death occurred (*1*). If we assume that both fertility and maternal mortality have decreased during the time period covered by a study, then it could be argued that the younger respondents would report lower mortality than older respondents. However, this is not necessarily the case and while trends in TFR are often known, trends in maternal mortality are usually not known (but are often assumed to be declining, without supporting evidence). Furthermore, many people in developing countries (especially older people) do not know their own age, nor the age of their sister(s). The impact of age misclassification on the MMR estimate is not known.

Using the sisterhood method on the FHI data, point estimates of maternal mortality for respondents aged 15–49 years (*1, 11*) were actually higher than estimates for respondents aged 15 years and over (data not shown). This may depend on several factors, including trends in mortality (including maternal mortality) and/or fertility; increased mortality at older ages, which would reduce the number of siblings available for interview; and differential recall of events occurring much earlier in time. In summary, restricting the age range of respondents alone does not necessarily introduce bias and excluding respondents over 40 years old could introduce either over- or underestimates of the MMR. Indeed, in some circumstances a greater risk of bias could come from including respondents aged above 49 years. Clearly, more methodological work in this area is needed.

Biases introduced in data analysis

Adjustments for sampling method. Biases introduced during analysis could derive from the sampling techniques used in the survey and the adjustments for them; variance of the TFR; and TFR value used to calculate MMR estimates. Sisterhood surveys are usually conducted with a sample of respondents from a defined population; they are usually added on to other surveys, many of which use cluster-sampling techniques. The selection of the sampling frame and the sampling technique is usually based on criteria unrelated to the sisterhood survey. Little or no work has been done to develop sampling criteria that would be appropriate to the sisterhood method. Reports of sisterhood surveys do not state whether adjustments are made in analysis to correct for the method of sampling and we therefore assume that they do not.

TFR variance. It has been recommended that the TFR variance be incorporated into estimates of the confidence limits and a technique for doing this has been developed (*12*). Table 6 shows the impact of adjusting for cluster sampling and TFR variance, using data from the FHI study. Variance calculations were made using SUDAAN (*13*), a software analysis package that permits adjustment for cluster sam-

Table 6. **Estimates of maternal mortality in Tano and Kintampo districts, Ghana**

District	Lifetime risk (SE)[a]	MMR[b] (SE)	MMR 95% confidence limits
Tano			
SRS[c] binomial	0.0148 (0.0021)	212 (30)	153–272
Weighted cluster	0.0148 (0.0024)	212 (35)	144–280
Random TFR[d] and weighted cluster	0.0148 (0.0024)	212 (35)	144–280
Kintampo			
SRS binomial	0.0228 (0.0026)	328 (38)	253–404
Weighted cluster	0.0228 (0.0030)	328 (44)	243–413
Random TFR and weighted cluster	0.0228 (0.0030)	328 (44)	242–414
Combined			
SRS binomial	0.0188 (0.0017)	269 (24)	222–317
Weighted cluster	0.0194 (0.0020)	279 (29)	222–335
Random TFR and weighted cluster	0.0194 (0.0020)	279 (29)	221–336

[a] SE = standard error.
[b] MMR = maternal mortality ratio (number of maternal deaths per 100 000 live births).
[c] SRS = simple random sampling.
[d] TFR = total fertility rate.

pling. The first row in each panel shows the MMR estimate and related statistics calculated assuming a simple random sample (*1, 12*). The second row shows the impact of adjusting for cluster sampling. The combined point estimate increases from 269 to 279 maternal deaths per 100 000 live births. Moreover, the confidence limits for each separate estimate and for the combined estimate become wider when adjustment is made for the sampling technique (28.1–32.1% in Tano; 23.0–25.9% in Kintampo; and 17.7–20.3% in the two districts combined). The *P*-value for the difference between the two districts under the weighted cluster assumption was 0.037, compared with a *P*-value of 0.018 using the simple random sample methods (data not shown). The third row shows that the impact of incorporating the variance of the TFR is minimal: the point estimates were unaffected and there was little change in the confidence limits.

TFR values. Calculations to estimate the MMR require a TFR, and TFR values can differ by geographical area, date, and other factors. The higher the TFR used, the lower the estimate of the MMR (Table 7), because the lifetime risk of maternal death is spread over more births with a higher TFR. Thus, the choice of TFR is critical in calculating an MMR estimate. In all the MMR estimates presented here we used a TFR of 7.02, in order to compare the estimates with that of ICMMS for Brong-Ahafo. The exception is the estimate of the national MMR, which was calculated using a TFR of 6.6. We have no evidence that the TFRs in the two Brong-Ahafo districts differ from the national or the regional levels. However, if

Table 7. **Impact of the total fertility rate on estimates of the maternal mortality ratio[a] from Tano and Kintampo districts, Ghana**

Total fertility rate	Lifetime risk (SE)[b]	MMR[c] (SE)	MMR 95% confidence limits
5.50	0.0194 (0.0020)	356 (37)	283–428
6.60	0.0194 (0.0020)	296 (31)	236–357
7.02	0.0194 (0.0020)	279 (29)	222–335

[a] Using the sisterhood weighted cluster method.

[b] SE = standard error.

[c] MMR = maternal mortality ratio (number of maternal deaths per 100 000 live births).

Table 8. **Total fertility rates (TFRs) from various studies**

Time period for the TFR estimate	Location of study	TFR	Source
1982–84	Ghana	6.60	ref. *9*
1982–84	Brong-Ahafo	7.02	ref. *9*
1988–93	Ghana	5.50	ref. *15*
1988–93	Brong-Ahafo	5.46	ref. *15*

the TFR is lower or higher in either of these two districts then the MMR will be under- or over-estimated, respectively. Many analysts use the current TFR rather than the TFR for the middle of the period of the estimate (i.e. that which prevailed at the time of the "average" death). If the trend in TFR is downward, this will overestimate the maternal mortality (Table 7). The TFR in Ghana in 1980 was 7.94 (*14*); in 1988 it was 6.60 (*9*); and in 1988–93 it was 5.5 (*15*).

In estimating the MMR for the two districts of Brong-Ahafo region, we had several choices of TFR, as shown in Table 8. Table 7 shows the impact of the choice: as the TFR increases, the MMR estimates decrease. In the case of the two districts in Brong-Ahafo region, an increase of 1.5 in the TFR leads to a decrease of 77 points in the MMR.

Discussion

In comparing MMR estimates from the FHI survey with those of the earlier ICMMS (*8*), we used the same analytical procedures as the earlier study so that the results would be directly comparable. We also used the same TFR of 7.02. However, our MMR estimate is 57% higher than that estimated by the ICMMS. The difference must therefore derive from differences in data collection or analysis, or from the fact that the Tano and Kintampo districts have higher MMRs than the Brong-Ahafo region as a whole.

The ICMMS estimated the national MMR using the sisterhood method and reported a value of 214 maternal deaths per 100 000 live births. The authors of the ICMMS felt that the number of sisters reported was higher than expected. Using a value of 1.7 for the mean number of sisters (taken from other sources), they re-estimated the MMR to be 307 maternal deaths per 100 000 live births. The latter estimate is closer to the FHI MMR estimates and well within the confidence limits of the FHI estimates (and therefore not statistically different), while the former is lower than the lower bound of the FHI estimates and may therefore be significantly different. However, no confidence limits were given for either of the ICMMS national estimates. The ICMMS produced a regional estimate for the Brong-Ahafo region (MMR of 171 maternal deaths per 100 000 live births). However, it did not publish an upward revision comparable to the revised national estimate, and therefore we cannot make an analogous comparison between the FHI estimate for Brong-Ahafo and an upwardly adjusted ICMMS regional estimate. The sample size for the regional estimate was also relatively small (*n* = 1195) and thus the ICMMS estimate may not be accurate.

Inclusion of confidence limits

It is not common to calculate confidence limits when estimating MMRs, yet they can be wide because of the small number of deaths that are usually identified (*7*). Confidence limits are essential to ensure correct interpretation of data and we strongly encourage that they be used, because they remove the false sense of precision which often accompanies estimates; they show that apparently divergent estimates may not really be different; and they highlight the limitations of estimates based on small numbers.

Biases

Biases of several different types can influence the magnitude and the precision of the estimates of the MMR and researchers should pay considerable attention to these. Biases introduced in analysis are more easily controlled than those introduced in data collection.

Importance of measuring maternal mortality

Halving maternal mortality — a goal set by the Safe Motherhood Initiative in 1987 — means that policy-makers and programme managers need to have precise and accurate estimates of maternal mortality to be able to measure progress towards this goal. However, all MMR estimates are imprecise (with wide confidence intervals) and the extent and impact of bias is only just beginning to be understood. Indeed, the sisterhood method of estimating MMR is relatively new and is still being refined. Scientists who conduct such surveys should thus carefully consider whether the method is appropriate and should try to understand and minimize potential biases. Users of MMR estimates should also be aware of the limitations when interpreting such data.

However, the imprecision of MMR estimates should not be a deterrent to action. Most estimates of maternal mortality in developing countries,

regardless of their precision, show that it is higher than it should be. The lack of precision and fears of underestimation of the MMR should not delay decisions to mount interventions designed to reduce maternal mortality. While precision can be enhanced by increasing sample size, the cost of producing relatively precise estimates is correspondingly high, and scarce resources are probably better spent on interventions, particularly on those that improve access to emergency obstetric care. Nevertheless, even though the level of precision that can be realistically achieved through sample surveys is insufficient to evaluate the impact of interventions, it may be sufficient for once-a-decade measurements of the general trend in maternal mortality. ■

Résumé

Estimation du ratio de mortalité maternelle dans deux districts de Brong-Ahafo (Ghana)

Objectif Estimer le ratio de mortalité maternelle par la méthode dite « des sœurs » dans deux districts de Brong-Ahafo au Ghana et déterminer l'impact sur ces estimations de différentes hypothèses et décisions analytiques.

Méthodes Le ratio de mortalité maternelle a été estimé indirectement à partir des données recueillies en 1995 par Family Health International (FHI) chez 5202 femmes de 15 à 49 ans, en utilisant un échantillon de ménages appartenant à des secteurs sélectionnés aléatoirement dans les deux districts. D'autres données, provenant de l'enquête ICMMS (Infant, Child and Maternal Mortality Survey) réalisée au Ghana en 1994 et représentative à l'échelle nationale, ainsi que de l'étude réalisée en 1997 dans le district de Kassena-Nankana ont également été utilisées à titre de comparaison.

Résultats D'après les données de FHI, le ratio de mortalité maternelle a été estimé à 269 décès maternels pour 100 000 naissances vivantes dans les deux districts réunis, un chiffre plus élevé que celui de l'ICMMS. La présence de biais lors de la collecte des données pourrait expliquer ces différences, notamment le fait que les biais qui conduisent à une sous-estimation de la mortalité sont plus fréquents que ceux qui conduisent à sa surestimation. Les biais introduits lors de l'analyse ont également été examinés, mais seul le taux de fécondité total utilisé pour calculer le ratio de mortalité maternelle semble modifier sensiblement les estimations.

Conclusion D'après les résultats, la méthode dite « des sœurs » peut encore être améliorée et l'importance et l'influence des biais ne retiennent l'attention que depuis peu. Les utilisateurs de cette méthode doivent être conscients de ses limites lorsqu'ils interprètent les résultats. Nous recommandons de donner les estimations accompagnées de leur intervalle de confiance, à la fois pour dissiper toute impression erronée de précision et pour limiter la surinterprétation des données.

Resumen

Estimaciones de la razón de mortalidad materna en dos distritos de la región de Brong-Ahafo (Ghana)

Objetivo Estimar la razón de mortalidad materna (RMM) por el método de las hermanas en dos distritos de la región de Brong-Ahafo (Ghana), y determinar el impacto de diferentes hipótesis y decisiones analíticas en esas estimaciones.

Métodos Las RMM se calcularon indirectamente a partir de datos reunidos en 1995 por Family Health International (FHI) entre 5202 mujeres de 15 a 49 años, realizando un cribado de hogares de zonas elegidas al azar en los dos distritos. Se usaron también a efectos comparativos otros datos procedentes de la encuesta nacional de Ghana de 1994 sobre la mortalidad infantil y materna (ICMMS) y del estudio realizado en 1997 en el distrito de Kassena-Nankana.

Resultados A partir de los datos de FHI se estimó una RMM de 269 defunciones maternas por 100 000 nacidos vivos para los dos distritos combinados, cifra superior a la estimada a partir de la ICMMS. Esta diferencia podría explicarse por los sesgos presentes en el acopio de datos, en particular por el hecho de que los sesgos de subestimación de la mortalidad son más frecuentes que los de sobreestimación. También se tuvieron en cuenta los sesgos introducidos durante el análisis de datos, pero las estimaciones de la RMM sólo parecían verse afectadas de forma significativa por la tasa de fecundidad total empleada para calcularla.

Conclusión Los resultados indican que el método de las hermanas sigue teniendo que perfeccionarse y que sólo recientemente se ha prestado atención a la magnitud y el impacto de los sesgos. Los usuarios de ese método deben ser conscientes de sus limitaciones al interpretar los resultados. Recomendamos que se usen límites de confianza en torno a las estimaciones, tanto para evitar que se transmita una imagen falsa de precisión como para reducir el riesgo de sobreinterpretación de los datos.

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