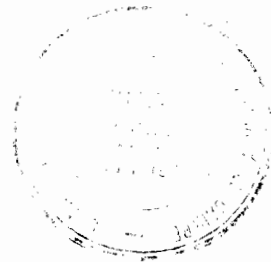


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THE SISTERHOOD METHOD TO ESTIMATE MATERNAL MORTALITY:  
APPLICATIONS WITH SPECIAL REFERENCE TO LATIN AMERICA

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The Sisterhood Method to Estimate Maternal Mortality:  
Applications with Special Reference to Latin America

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## INTRODUCTION

It has recently been estimated that, worldwide, about 500 000 women die each year of causes related to pregnancy and childbirth (Royston and Lopez, 1987). Of these maternal deaths almost 99 % take place in the developing world. The share of Latin America in these tragic statistics is suggested to be about 34,000 or almost 7 % of the estimated total (Starrs, 1987). The tragedy is reinforced by the recent acknowledgement that the majority of maternal deaths are preventable with appropriate health care (WHO, 1986a). Moreover, these events constitute between a quarter and a third of all deaths to women in the childbearing period in many developing countries, though the proportion rises above a half in some populations.

The reduction of maternal mortality has now become a high priority in the strategies for "Health for All by the year 2000". A 'Call to Action' has been made and funds pledged to international agencies and national governments as part of the 'safe motherhood initiative'. A major constraint on this action in some parts of the world is lack of information.

Thus, whilst it is now generally accepted that considerable differences exist in the levels of maternal mortality both within and between developing and developed countries, further information to move beyond this claim is often absent or deficient. Paradoxically, these constraints on information tend to be most serious in those areas in which maternal mortality is also likely to be highest.

## MEASURING MATERNAL MORTALITY

Maternal mortality usually refers to those deaths which occur among women during pregnancy or within 42 days of its termination, without regard to the duration or site of the pregnancy, from any cause related to or aggravated by the pregnancy itself or attendance on it, but not from accidental or incidental causes (WHO, 1977). This is the operational definition of maternal mortality which permits its measurement from conventional sources of (cause-specific) mortality data, including vital registration and health-services statistics. In most developing countries these traditional data sources are also those seriously lacking in both completeness and reliability.

Over the last twenty years, a number of indirect methods have been developed for application in areas with poor statistical infrastructure. The rationale underlying these methods is identical. Straightforward questions on the survival status of close relatives are asked in a census or sample survey. The proportions of surviving relatives are then calculated for groups of respondents classified by respondent characteristics such as five-year age group. By reference to demographic models these proportions can be transformed into conventional (life-table) measures of mortality.

Recently demographers have turned their efforts towards the measurement of maternal mortality which is essential to the planning, management and evaluation of intervention programmes and the judicious allocation of scarce resources. In response to growing interest and concern about maternal mortality, W. Brass<sup>1</sup> and W. Graham<sup>2</sup>, both from the London School of Hygiene and Tropical Medicine, developed in late 1987 a new and relatively simple procedure for providing a community-based estimate of the level of maternal mortality in societies with limited alternative sources. The main objective of this paper is the description and discussion of the results of three applications of the method with particular reference to Latin America.

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1. Emeritus Professor and former Director of the Centre for Population Studies
  2. Lecturer in Epidemiology and Population Sciences, Maternal and Child Epidemiology Unit

Although a detailed account of the sisterhood method is given elsewhere (Graham and Brass, 1988; Graham, Brass and Snow, 1989), a short description will be given in the next section along with the definitions used in the remainder of this paper.

#### THE SISTERHOOD METHOD

Maternal mortality is often expressed as a ratio, that is, the number of maternal deaths per 100 000 (live) births. Another indicator is the maternal mortality rate which relates maternal deaths to women in their reproductive period, usually expressed per 10 000. The appropriateness and source of the denominators used in these measures of the level of maternal mortality have been discussed in detail elsewhere (Graham and Airey, 1987). The origin of the numerator is generally regarded as the more serious problem. Identification of maternal deaths in the community solely through the vital registration system has been found, in several developing countries, to lead to serious underestimation (Walker et al., 1986; Grubb et al., 1987). Similarly, deaths located solely through the health services are subject to serious selection biases with consequent effects on the derived estimates. The need for alternative and complementary methods is self-evident.

Graham and Brass have made the first step towards one such alternative method. Drawing on the knowledge of model fertility and mortality distributions, a simple procedure was devised for converting the proportions of sisters dying of pregnancy-related causes reported by adults during a community census or survey into conventional measures of maternal mortality. This procedure has been named the "sisterhood method".

The justification for selecting siblings to ask about the survival status of their sisters rather than children with respect to their mother or husbands concerning their (first) wife, can be given on several grounds (Graham and Brass, 1988). However, possibly the most persuasive of these is the sample size implications. The sisterhood method maximizes the reported number of women years of risk exposure by asking each adult about all of their sisters who reached reproductive age and therefore entered the period of exposure to the risk of maternal death. In most societies where the method is likely to be employed, this will yield considerable numbers with considerably fewer respondents than in the case of questions asked about mothers or first wives.

The information needed for the sisterhood method may be gathered during a population census or survey. Whilst the precise questions used should be adapted to the specific setting of the data collection, four basic items of information, together with the five-year age group of the respondent, are needed:

- a. number of sisters (born to the same mother) who have ever been exposed to the risk of pregnancy and, hence, to the risk of dying of maternal causes;
- b. of these, the number of sisters who actually are alive at the time of data collection;
- c. the number of sisters ever exposed to the risk who are dead; and,
- d. of those dead, the number who died whilst they were pregnant, during childbirth or in the puerperium.

It is worth mentioning that only the information in items (a) and (d) is effectively used in the calculations for the sisterhood method. However, the responses concerning sisters alive or dead at the time of interview can be used as a means of cross-checking with the two essential items as well as aids to memory recall.

In the sisterhood method, the declared proportions of sisters dying from maternal causes of all sisters who survived to childbearing age are adjusted

to provide a retrospective estimate of maternal mortality. The key simplifications in the relationship between sibling survival and age of respondent which provided a starting point for developing the sisterhood method are:

- i. Firstly, the expected birth order position of any individual is central and thus on average, they have equal numbers of younger and older siblings; the number of younger and older siblings of any index man or woman (the respondent) is therefore equal.
- ii. Secondly, the age difference between siblings and any index man or woman can be accurately modelled by a symmetrical distribution about a mean of zero.

By elaborating and adapting these basic age relationships, it can be shown that the proportion of sisters dying of maternal causes,  $\pi(u)$ , reported by adults of age  $u$  in a single-round census or sample survey, can be related to the probability of dying of maternal causes between the age of first exposure to the risk of pregnancy and  $u$ ,  $q(u)$ . The sisterhood method transforms the empirically observed  $\pi(u)$ , for every five-year respondent age group, into estimates of the probability of dying by the end of the reproductive period,  $q(w)$ . In other words, theoretically derived adjustment factors, which will be called  $A(u)$  throughout the rest of this paper, transform the maternal mortality experienced by women up to age  $u$ , into measures of  $q(w)$ , which contemplate the risk of dying of a maternal cause over the entire childbearing period.

A set of values for the  $A(u)$  (see Table 1) was derived by combining a model of maternal mortality by age of woman with a fixed distribution of the differences between the ages of sisters and respondents. With the former model, a major simplification arose from discovering that the age patterns of maternal mortality, as revealed in the statistics presented by Preston (1976), could be fitted remarkably well by a Relational Gompertz model with the Heather Booth standard (Booth, 1984). Thus

$$-\ln \{ -\ln \{ q(u)/q(w) \} \} = a + b \cdot Y'(u) \quad (1)$$

with  $a = -0.5$  and  $b = 0.8$ . The latter two parameters modify the location and spread of the standard in a manner more in line with the expected effects of the variation with maternal age in the risk per pregnancy. The expression for the probability of dying of pregnancy-related causes by age  $u$ , can therefore be written as:

$$q(u) = q(w) \cdot \exp[ -\exp\{ 0.5 - 0.8 \cdot Y'(u) \} ] \quad (2)$$

On the assumption that the same parameters of location and shape are satisfactory for all populations, acceptable adjustment factors for estimating  $q(w)$  from observed  $\pi(u)$  could be calculated from a model with the above expression (2) for  $q(u)$  in combination with a fixed distribution for the difference between the ages of sisters and respondents  $\theta(z)$ . Thus

$$\pi(u) = \int \theta(z) \cdot q(u+z) dz \quad (3)$$

can be tabulated as a proportion of  $q(w)$  for an appropriate series of  $u$  values. For any observed  $\pi(u)$  the relation can be read from the tabulation and an estimated, expected  $q(w)$  calculated. This way there will be corresponding estimates of  $q(w)$  for every observed  $\pi(u)$  (Table 1).

The resulting estimates of  $q(w)$ , the lifetime risk, may be translated into a more conventional measure as the Maternal Mortality Ratio (maternal deaths to 100,000 live births) by the following approximation:

$$\text{MMR} = 1 - (1 - q(w))^{(1/\text{TFR})} \quad (3)$$

where MMR is the maternal mortality ratio,  
TFR is the total fertility rate, and

$q(w)$  is the lifetime risk of dying of a maternal cause.

Given the fact that the information gathered refers to deaths which have occurred at various points in the past, a relevant consideration is the time-period to which each estimate of  $q(w)$  relates. An equation was derived (Graham and Brass, 1988) from the general formula of Brass and Bamgboye (1981) which can be used to estimate the time location of each  $q(w)$  separately. The formula proposed for the time location  $T$  for a respondent aged  $u$ , is:

$$T = \frac{\int \theta(z) \cdot \int q(x) dx dz}{\int \theta(z) \cdot q(u+z) dz} \quad (5)$$

Values of  $T(u)$  for relevant ages of respondents,  $u$ , were thus calculated and are presented in Table 2.

#### SELECTED APPLICATIONS OF THE SISTERHOOD METHOD

##### 1. The Gambia, West Africa

The first application of the sisterhood method was carried out in The Gambia. The basic information was obtained from a field study carried out in September 1987 in six rural villages in the Farafenni area. The British Medical Research Council has maintained a rural population surveillance system for several years in this part of The Gambia which provided an opportunity to check the results from the sisterhood method against data recorded by this independent system. The sample included slightly over 2000 persons, 15 years and over, belonging to different ethnic groups.

In these communities the educational level is generally low: less than 5 per cent of all women in the reproductive ages have ever gone to school. In 1982-83 the infant mortality rate was about 142 per thousand, and female life expectancy at birth was estimated to be 39.7 years. The total fertility rate (TFR) in 1987 was slightly less than 6 children per woman (Graham, Brass and Snow, 1989).

The data required by the sisterhood method were obtained by asking the following four questions:

1. How many sisters (born to the same mother) have you ever had who were ever married (including those who are now dead?)
2. How many of these ever-married sisters are alive now?
3. How many of these ever-married sisters are dead?
4. How many of these dead sisters died while they were pregnant, or during childbirth, or during the six weeks after childbirth?

In this particular case, the population at risk comprised all ever-married sisters since premarital pregnancy was known to be comparatively rare. The basic data and calculations are shown in Table 3, with the two key items being:

- Number of ever-married sisters by five-year age group,  $i$ , of the respondents,  $N(i)$ .
- Number of maternal deaths also by five-year age group,  $i$ , of the respondents,  $r(i)$ .

With this information an observed  $\pi(i)$  that is,  $r(i)/N(i)$  is calculated or, in other words, the proportion of sisters dead by maternal causes by five-year age groups of the respondents. In order to estimate  $q(w)$  from  $\pi(i)$ , the adjustment factors  $A(i)$  are used, as shown in column 5 of Table 3, which represent the values for the mid-point of the five-year age group.

Since the number of sisters entering the reproductive period reported by the two younger age categories will exclude those sisters yet to enter the period of risk, an additional calculation is necessary for these groups before calculating the  $r(i)/N(i)$ . A simple way to raise the reported number of sisters to the expected ultimate number is to multiply the number of respondents in the two younger age groups by the average number of sisters entering the period of risk per respondent reported for the older age groups of 25 and over. This procedure is seen in Table 3.

When the number of sisters at risk of maternal death in each respondent age group is large enough, each  $q(w)$  can be considered as a separate estimate of maternal mortality for different points in time. Differences in  $q(w)$  by age of the respondents can then be interpreted as response errors, limitations of the assumptions, or time trends. However, when sampling errors are an important consideration, as in the case of the Gambian study, the data should be grouped to obtain a single, overall best estimate,  $Q(w)$ .

Two alternative procedures may be considered for grouping the data:

- a) The expected maternal deaths by the end of the reproductive period can be calculated by dividing the number of maternal deaths  $r(i)$  by the adjustment factor  $A(i)$ . By adding the expected maternal deaths and dividing them by the total number of sisters at risk,  $N(i)$ , a single estimate of  $Q(w)$  is thus obtained.

Proceeding in this manner, however, a relatively high weight is attached to the information derived from younger respondents where the number of maternal deaths is small and the  $A(i)$  are high. In these circumstances, systematic and sampling errors cannot be ignored. For this reason the following procedure is generally preferable.

- b) Instead of dividing the  $r(i)$  by  $A(i)$  the number of sisters potentially at risk of dying of maternal causes,  $N(i)$  is multiplied by the adjustment factors, that is  $N(i)*A(i)$ , to arrive at "sister units of risk exposure" of maternal death  $B(i)$ . An estimate of  $Q(w)$  is then obtained by summing the  $r(i)$  across all age groups and dividing this by the sum of the  $B(i)$ :

$$Q(w) = \sum r(i) / \sum B(i) \quad (6)$$

It is worth mentioning that both procedures will give the same results as far as the separate  $q(w)$ 's are concerned. However, when accumulation is used to obtain a single value i.e.  $Q(w)$ , the results are different.

A further important consideration is that the information from older respondents will be affected by memory errors since reported deaths may have occurred many years ago. Consequently, to obtain a single best estimate it is preferable to exclude responses of respondents aged 50 and older. This has the additional advantage of locating the time point to which the estimate,  $Q(w)$ , refers in the more recent past.

Using the information from The Gambia for respondents aged 15-49 years, a  $Q(w)$ , the lifetime risk of maternal mortality, of 0.0584 was obtained. At this level of mortality, 1 in 17 women entering the reproductive period dies of maternal causes before reaching the end of the reproductive period. Translating  $Q(w)$  into a maternal mortality ratio using a total fertility rate (TFR) of 5.96 yields a value of 1005 per 100,000 live births and refers to a period approximately 11.7 years before the survey<sup>1</sup>. This estimate compares favourably with independent estimates from two neighbouring villages of 1050 and 950 maternal deaths per 100,000 live births for the period 1951-1975 (Billewicz and McGregor, 1981).

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1. A single estimate of time-location can be obtained by using the following formula:  $\sum \{T(i)*B(i)\} / \sum B(i)$ , where the  $T(i)$  are the time-location values for individual age groups.

The value of the TFR used should, ideally, correspond to the same point in time as the estimated maternal mortality, that is, approximately 12 years prior to data collection. In the case of The Gambia, however, the TFR was a current figure for the study population. Since fertility has been reasonably stable over the previous decade according to national data, it may be assumed that no significant error was introduced by using a current figure.

## 2. Temuco, province of Cautín, Chile

Information for this study was obtained through the Experimental Census of Indigenous Communities<sup>4</sup>, "Censo Experimental de Reducciones Indígenas", which was carried out between October and December 1988 in the districts of Labranza, Molco, Maquehue and Metrenco located in the province of Cautín, Chile. In the four selected districts, located near the city of Temuco, capital of the province of Cautín, 13,560 persons grouped in 2,850 households, were interviewed.

The population studied, all of Mapuche origin, is characterized by a young age structure, low educational level and is mainly involved in agricultural activities. Over the past 15 years this population had intermediate levels of mortality and fertility, with an infant mortality rate of about 70 per thousand, a female life expectancy at birth of 58 years and a TFR of nearly 4.5 children. More recently, the infant mortality rate was reported to have declined to 45 per thousand live births and the TFR was 3.9 (Chile, National Census of 1982).

The following 3 questions were asked of the entire population 12 years and over, in order to obtain the necessary data:

1. How many sisters do you have, born to the same mother, who are currently alive?
2. How many sisters, born to the same mother, are now dead?
3. How many sisters died during
 

- pregnancy		
- childbirth		
- the puerperium.		

The main difference with respect to the original methodology is that the total number of sisters ever born is obtained, irrespective of whether or not those who died reached the childbearing ages - defined as 15 years and over in this case. The main reasons for this revision are, firstly, that the simplification of the questions facilitates the fieldwork, and secondly, it is possible to apply other indirect techniques to these data in order to estimate female adolescent and adult mortality (see Hill & Trussell, 1977).

To proceed, it is necessary to determine the proportion of sisters, declared as being dead at the time of the census, who had ever been exposed to the risk of becoming pregnant and hence to the risk of dying of maternal causes. In addition, an estimate must be derived of the number of sisters, alive at the time of the census, who were 15 years or older. It can be concluded from the foregoing that the information obtained from the first two questions cannot be related directly to the data from question 3.

To arrive at the total number of sisters who reached age 15, classified by age group of respondents, it is necessary to subtract from the total provided by questions 1 and 2, the number of sisters actually alive but

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2. The institutions that participated in this study are the following:
    - La Universidad de la Frontera de Temuco (UFRO);
    - La Pontificia Universidad Católica (PUC), sede Temuco;
    - La Fundación Instituto Indígena (FII);
    - El Instituto Nacional de Estadística (INE);
    - Programa de Extensión y Apoyo en Salud Materno Infantil (PAESMI); and
    - El Centro Latinoamericano de Demografía (CELADE).



younger than 15 and the number of sisters who have died before reaching the age of 15 years. Thus:

$$N(i) = NT(i) - NV(i)^{-15} - NM(i)^{-15} \quad (7)$$

or, alternatively,

$$N(i) = NV(i) - NV(i)^{-15} + NM(i)^{15+} \quad (8)$$

where,

- $i$  represents the age group of the respondents;
- $N(i)$  in both equations is the denominator to be determined, that is, all sisters who ever reached the age of 15 irrespective of whether they have died since;
- $NT(i)$  is the total number of sisters, no matter what their age, classified by age group of the respondents;
- $NV(i)$  represents the sisters alive at the time of the census, classified by age of respondents;

Additional information to be determined is thus:

- $NV^{-15}$  sisters younger than 15 alive at the time of interview;
- $NM^{-15}$  sisters who died before reaching the age of 15;
- $NM^{15+}$  sisters who died after reaching the age of 15.

Given the fact that  $NM^{-15}$  and  $NM^{15+}$  are complementary, it is sufficient to determine one of the two; in this paper it was decided to estimate the first one. As far as  $NV^{-15}$  is concerned, this factor is most relevant to younger respondents, between 15 and 30 years. After the age of 30 this factor becomes negligible since all of the younger sisters of the respondents will have entered the reproductive age period. The procedure for estimating  $NV(i)^{-15}$  and  $NM(i)^{-15}$  is described below:

### 2.1. The estimation of $NV(i)^{-15}$

A theoretical distribution of surviving siblings classified by age of respondents was used (Hill, 1983). This distribution was applied to the information concerning the total number of sisters alive at the time of interview and thus estimates of  $NV(i)^{-15}$  were obtained for each of the respondent age groups. The procedure is outlined in Table 4; column 5 shows the distribution used for this purpose.

### 2.2. The estimation of $NM(i)^{-15}$

The number of sisters who died before reaching the age of 15 was estimated using the following equation:

$$NM(i)^{-15} = NT(i) * (1 - l(15)) \quad (9)$$

where  $l(15)$  is the probability of surviving till the age of 15 taken from a life table which adequately reflects the level of female mortality in this population in the past. Applying the method of sibling survivorship developed by Hill and Trussell (1977), based on maternal orphanhood and child survival, a best estimate of 0.86 for  $l(15)$  was obtained which corresponds to level 16, West model in the model life tables of Coale and Demeny (1983). This level is more or less consistent with that estimated for the Mapuche population on the basis of data provided by the 1982 national census.

Using the additional information derived as described above, the appropriate denominator  $N(i)$  was calculated using the equation:

$$N(i) = NT(i) - NV(i) * \{NM(i)^{-15}\} - \{NT(i) * (1 - l(15))\} \quad (10)$$

which, in turn, is equivalent to:

$$N(i) = \{NT(i) * l(15)\} - \{NV(i) * NM(i)^{-15}\} \quad (11)$$

Once the values of  $N(i)$  are determined, the sisterhood method can be applied following the steps indicated in columns 7 to 10 of Table 4. As can be observed from the last column of the table, which presents the separate estimates of  $q(w)$ , the values are relatively stable albeit slowly declining across the respondent age groups from 25-29 to 45-49. In the youngest age groups,  $q(w)$  is higher than expected relative to the older respondent age groups, a phenomenon which can be observed in all the applications of the method so far. It is likely that this can be attributed to the considerable adjustments which need to be made to the data from the first two age groups in order to extrapolate the observed mortality from maternal causes among sisters to that expected by the end of the childbearing period. Equally, after the age of 50, the values of  $q(w)$  show a more erratic behaviour, probably reflecting memory recall errors.

Since the single best estimate of the lifetime risk of maternal mortality may be derived by grouping the data, it was decided to calculate  $Q(w)$  based on the separate  $q(w)$ 's with more or less consistent values. Thus, using the respondent age groups from 25-49 an estimate of  $Q(w)$  of 0.0181 was obtained. This means that of every 53 women entering the reproductive period, 1 will die of maternal causes before reaching the end of the childbearing period.

Translating this probability into the more conventional maternal mortality ratio (MMR), a value of 414 per 100,000 live births is obtained. In the calculations a total fertility rate of 4.4 was used, which corresponds to the same time-location as the estimates of  $Q(w)$ , that is 12.7 years prior to data collection.

It is interesting to contrast these findings with data provided by vital registration which, in the case of Chile is generally relatively reliable. However, in the province of Cautín (the smallest administrative division available), data for the years 1982-84 provide an estimate of 74 maternal deaths per 100,000 live births which contrasts sharply with the 414 per 100,000 obtained using the sisterhood method. One possible explanation for the discrepancy may relate to misclassification biases in the cause-specific vital registration data. Maternal mortality is well known to be subject to underregistration and misreporting in official statistics for several reasons, among which illegal abortion is one of the most important (Royston and Armstrong, 1989). A study carried out in several Latin American cities over twenty years ago revealed that maternal deaths were often reported as being due to other causes, and particularly disguising the proportion of deaths due to abortion; in Santiago, for example, the study found this proportion to be an alarming 53% (Puffer and Griffith, 1967).

### 3. Other applications of the sisterhood method in Latin America

The sisterhood method has been applied in two other studies in Latin America with which the authors have some involvement:

- in the peripheral districts of Lima, Peru<sup>5</sup>; and,
- in the province of Avaroa, Oruro, Bolivia<sup>6</sup>.

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3. The data were collected as an add-on to a study conducted in 30 recently-settled areas on the periphery of Lima, Peru, in October 1987, which was primarily concerned with child mortality, and supported by the Diarrhoeal Diseases Control Programme of WHO.

4. Data provided by a study carried out in September 1988. The following institutions participated in this investigation:

- Consejo Nacional de Población (CONAPO), Bolivia;
- Servicio de Información y Acción en Población (SIAP);
- UNICEF; and,
- CELADE.

The results of the Lima experiment are described in detail elsewhere, together with elaboration of data problems (see Graham and Brass, 1988) and only the figure for maternal mortality will be mentioned here. Estimates for the MMR vary from 253 to 286 maternal deaths per 100,000 live births, according to the denominator used. The uncertainty over the population at risk in this study derives from the sequence of questions asked: sisters reaching the age of 15 years and of these, sisters ever married or cohabiting. Thus fertility outside marriage or union may not have been included in the study. The result is an estimate whose validity is restricted to the once married or cohabiting population. Also there may have been a possible misinterpretation on the part of the respondents as to which of their sisters the question on maternal deaths actually referred to. The TFR used to translate the  $Q(w)$  into a MMR is also suspicious: it seems to be rather low for this population.

The procedure used in the case of Bolivia is very similar to that applied in the case of the Mapuche population in Cautín. The same correction procedure as that described earlier in section 2 of the paper was used to arrive at the sisters ever exposed to the risk of pregnancy-related death. A  $Q(w)$  was found, based on the results from the age groups which presented a degree of stability among the separate  $q(w)$  estimates, namely 25-39, in the order of 0.0989 or a 1 in 10 risk of dying of maternal causes during the childbearing ages. This corresponds with a MMR of 1,379 deaths per 100,000 live births. A TFR of 7.5 was used which is consistent with the estimated level of fertility of about 10 years prior to data collection. This extremely high level of maternal mortality seems to be in line with the persistent high level of overall and infant mortality observed in this region (see e.g. the census data of the Bolivian National Census of 1976). Moreover, this area of Bolivia is well-known as one of the poorest, with limited health services and extremely high fertility. National statistics for Bolivia, based on vital registration, suggest a maternal mortality ratio for the period 1973-1977 of 480 per 100,000 live births; this is the second highest ratio for tropical South America (WHO, 1986b).

Further details on the four applications discussed in this paper can be found in a forthcoming joint publication of CELADE and the London School for Hygiene and Tropical Medicine, with the support of PAHO and CIDA, Canada.

#### CONCLUSIONS AND RECOMMENDATIONS

It is widely known that in the great majority of the developing world cause-specific mortality statistics are either non-existent or of poor quality. This holds in particular for maternal deaths which are often seriously underreported or misclassified. Recently an indirect estimation procedure has been developed (Graham and Brass, 1988), which can be used to provide data as a complement for deficient information from routine sources. The results of the applications of the method described in this paper highlight the possible extent of underregistration and/or misclassification of cause of death in the case of maternal mortality in official statistics. It was found that the results from the four countries vary substantially with respect to their level, from a MMR of 253 in Lima, Peru to a MMR of 1379 per 100,000 live births in Avaroa, Bolivia, but they all consistently produce figures higher than the estimates from other data sources. In the case of Cautín, Chile for example, the MMR obtained from the sisterhood method was over five times higher than the one calculated from more recent vital registration data. Studies in other regions of the world where estimates from community-based surveys are compared with those from vital registration have found similar discrepancies. For example, in Jamaica a population survey produced an estimate of maternal mortality which was over double the official figure (Walker et al., 1986).

As regards data collection for the sisterhood method, this paper has demonstrated the importance of the wording of the questions in order to arrive at a denominator which most adequately reflects the women at risk. Clearly, the questions should be adapted to suit local conditions; for example, in some

societies, due to high levels of pre- or extramarital fertility, it may be necessary to ask about all sisters old enough to bear children, which essentially means including all sisters who reached the age of 15, the average age at menarche. In other situations it may be imprudent to ask about maternal deaths among unmarried sisters. For the studies in Temuco and Oruro the questions referred to all sisters irrespective of their age at the time of data collection. These questions were used to ease comprehension on the part of the respondent and to allow the application of other indirect mortality estimation techniques. It was shown in this paper that, with some small corrections, this variant also yields reasonable results. It can be shown empirically that the data from the sisterhood method is robust to the selection of the value of  $l(15)$  used in the adjustment.

As regards the estimation of  $Q(w)$ , the aggregate figure for the probability of dying of maternal causes by the end of the reproductive period, careful consideration should be given to the most appropriate range of respondent age groups for which the data should be included. In this paper, it was seen that the results from the two youngest respondent age groups appear to produce estimates of  $q(w)$  which are considerably different from those for the older groups, and especially the 25-49 categories. The decision to exclude the data from the under-25 respondent groups in the calculation of  $Q(w)$  must also be based on the size of the sample population and thus the sampling variance for estimates based on a subset of the data. A similar argument may be put forward in the case of the exclusion or inclusion of the data from the older respondent age groups where problems of memory recall may produce distortions in the results and where the effect on the time-location of the  $Q(w)$  estimate may be regarded as a disadvantage.

Whilst the sisterhood method seems to produce robust estimates of the life-time risk of dying of maternal causes,  $Q(w)$  or the  $q(w)$ 's per five year age group of respondents, it must also be noted that the translation of these estimates into corresponding maternal mortality ratios is sensitive to the value of the TFR: small deviations in the total fertility rate can cause considerable variations in the estimate(s) of the MMR. Moreover, in situations where there has been recent a downward trend in fertility, the TFR should refer to the same period to which the estimate(s) of  $Q(w)$  or  $q(w)$ 's apply.

As a recent addition to the array of indirect techniques for mortality estimation, the sisterhood method is still at a comparatively early stage in its evolution. Further refinements and adaptations to the basic method will continue as experience with its application accumulates. Developments will be made with regard to the analytical procedures, including refinement of the adjustment factors; the field techniques for data collection; the inclusion of additional questions, such as place of death; and the methods for evaluating the derived estimates of maternal mortality.

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TABLE 1  
ADJUSTMENT FACTORS  $A(u)$  FOR ESTIMATING  $q(w)$  FROM  $\pi(U)$

AGE OF RESPONDENT (u)	$A(u)$	AGE OF RESPONDENT (u)	$A(u)$
12.5	0.048	42.5	0.802
15	0.073	45	0.856
17.5	0.107	47.5	0.900
20	0.151	50	0.934
22.5	0.206	52.5	0.958
25	0.270	55	0.975
27.5	0.343	57.5	0.986
30	0.421	60	0.992
32.5	0.503	62.5	0.996
35	0.585	65	0.998
37.5	0.664	67.5	0.999
40	0.737	70	1.000

Source: Graham and Brass (1988)



TABLE 2  
ESTIMATES OF TIME-LOCATION FOR THE SISTERHOOD METHOD

AGE OF RESPONDENTS (u)	T (years)	AGE OF RESPONDENTS (u)	T (years)
17.5	5.7	47.5	17.5
22.5	6.8	52.5	21.2
27.5	8.1	57.5	25.6
32.5	9.7	62.5	30.3
37.5	11.7	67.5	35.2
42.5	14.3	72.5	40.2

Source: Graham and Brass (1988)

TABLE 3

THE GAMBIA, 1987: MATERNAL MORTALITY ESTIMATES USING THE SISTERHOOD METHOD

Age groups	Number of respondents	Total number of sisters ever married	Maternal deaths	Adjustment factors	Sister-units of risk exposure	Life-time risk of maternal death	Proportion of sisters dead from maternal causes
$i$		$N(i)$	$r(i)$	$A(i)$	$B(i)$	$q(w)$	
(1)	(2)	(3)	(4)	(5)	(6)=(3)*(5)	(7)=(4)/(6)	(8)
15-19	320	493 a)	4	0.107	53	0.075	0.2857
20-24	263	405 a)	6	0.206	83	0.072	0.2609
25-29	275	427	11	0.343	146	0.075	0.3667
30-34	265	414	11	0.503	208	0.053	0.3333
35-39	214	334	12	0.664	222	0.054	0.3000
40-44	157	238	11	0.802	191	0.058	0.2619
45-49	158	233	10	0.900	210	0.048	0.2326
50-54	140	202	2	0.958	194	0.010	0.0444
55-59	133	215	9	0.986	212	0.042	0.1667
60 +	238	373	15	1.000	373	0.040	0.0867
Total	2163	3334	91		1892	0.048 b)	

a) Derived by multiplying the number of respondents by the average number of sisters alive in the reproductive ages estimated for respondents aged 25 and over.

b) Calculated as the sum of  $r(i)$  divided by the sum of  $B(i)$  from reports of respondents under age 50.

Source: Graham and Brass (1988)

TEMUCCO, 1988: MATERNAL MORTALITY ESTIMATES USING THE SISTERHOOD METHOD

TABLE 4

Age groups	Number of respondents	Total number of sisters	Total sisters alive	Proportion of sisters younger than 15 years old (a)	Total sisters exposed to risk of maternal death (b)	Maternal deaths	Adjustment factors	Sister- units of risk exposure	Life time risk of maternal death
1	NT(i)	NV(i)			N(i)	r(i)	A(i)	B(i)	q(w)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)=(6)*(8)	(10)=(7)/(9)
15-19	1468	3869	-	0.502	3707	20	0.107	397	0.0504
20-24	1173	3576	-	0.306	2962	23	0.206	610	0.0377
25-29	924	2874	2432	0.144	2121	15	0.343	728	0.0206
30-34	794	2563	2134	0.051	2095	23	0.503	1054	0.0218
35-39	749	2374	1879	0.012	2019	24	0.664	1341	0.0179
40-44	604	1762	1347	0.001	1514	20	0.802	1214	0.0165
45-49	590	1739	1297	0.000	1496	21	0.900	1346	0.0156
50-54	539	1563	1094	0.000	1344	26	0.958	1288	0.0202
55-59	483	1338	895	0.000	1151	13	0.986	1135	0.0115
60 +	1390	3510	1855	0.000	3012	68	1.000	3012	0.0226
Total	8714	25168	12933		21421	253		12125	0.0209 d)

- a) Obtained from a theoretical distribution of surviving siblings by age of respondents.  
b) Calculated with the following formula:  $N(i) = NT(i) * 1(15) - NV(i) * col.(5)$  with  $1(15) = 0.86$ .  
c) Derived by multiplying the number of respondents by the average number of sisters alive in the reproductive ages estimated for respondents between 25 and 49 years.  
d) Calculated as the sum of  $r(i)$  divided by the sum of  $B(i)$ .