High maternal mortality in a rural south-west Ethiopia: Estimate by using the sisterhood method

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Key words: high maternal mortality, maternal mortality, sisterhood method, Bonke, Gamo Gofa, southwest Ethiopia, Ethiopia, sub-Saharan Africa
Abstract

Background: Maternal mortality estimation is difficult in developing countries that have no complete vital registration. The indirect sisterhood method represents an alternative in places where there is high fertility and high mortality. The objective of our study was to estimate maternal mortality indices by the sisterhood method in a rural district in southwest Ethiopia.

Method: We interviewed 8,870 adults aged 15-49 years in 15 randomly selected rural villages of Bonke in Gamo Gofa. By constructing a retrospective cohort of women of reproductive age, we obtained sister units of risk exposure to maternal mortality, and calculated lifetime risk of maternal mortality. Based on the total fertility for the rural Ethiopian population, maternal mortality ratio was approximated.

Findings: We analysed 8,503 of 8,870 (96%) respondents, 5262 (62%) men and 3241 (38%) women. The 8,503 respondents reported 22,473 sisters (average 2.6 sisters for each respondent) who survived up to the reproductive age. Of the 2,552 (11.4 per cent) sisters who had died, 32% (819/2552) occurred during pregnancy and childbirth. This provided a lifetime risk of 10.2 per cent from pregnancy and childbirth with corresponding maternal mortality ratio of 1667 (95% confidence interval: 1564-1769) per 100,000 live births. The time period for this estimate is around 1998. Separate analysis for male and female respondents provided similar estimates.

Conclusion: The impoverished rural area of Gamo Gofa had very high maternal mortality around 1998. This highlights the need for strengthening emergency obstetric care for the Bonke population and for similar rural populations.
**Introduction**

Maternal mortality is the death of a woman during pregnancy or within 42 days after termination of pregnancy from any cause related to or aggravated by the pregnancy or its management [1]. The problem is particularly high in developing countries [2], where 98 percent of the yearly half a million maternal deaths occur [3, 4]. Of the 20 countries with highest maternal mortality in the world, 17 are in Africa. The Millennium Development Goals aim to reduce maternal deaths by three-quarters by 2015 from the 1990 baseline (MDG-5) [5]. The indicator chosen to measure the progress is maternal mortality ratio (MMR, number of maternal deaths per 100,000 live births). Unfortunately, the progress in many sub-Saharan African countries is slow or even absent [6].

Ethiopia is one of the six countries where over half of the total maternal deaths occur in the world; the others being Democratic Republic of Congo, Nigeria, India, Pakistan and Afghanistan [6]. Since 1990, Ethiopia has reduced child mortality [7]. There are also reports of reductions in maternal mortality rates. The MMR for Ethiopia was 1061 (665-1639) in 1980, 968 (600-1507) in 1990, 937 (554-1537) in 2000 and 590 (358-932) in 2008 [6]. However, these estimates have wide and overlapping confidence intervals that highlight difficulty to see real changes. It was as recent as in 2008 the upper uncertainty limit of MMR fell less than 1000. Also, there are discrepancies between estimates from different sources and methods. For example, the MMR was 590 (358-932) for 2008 according to the Institute for Health Metrics and Evaluation by Hogan et al [6], while the UN agencies and The World Bank estimated it to be 470 (270-790) [8]. Estimates of MMR from community based study also vary: for 1981-83 it was 566 in Addis Ababa, [9], 570 for Illubabor in western Ethiopia in 1991 [10] and between 440 and 665 for Butajira in south central Ethiopia in 1996 [11]. These surveys showed lower estimates than the mathematically modelled estimates for the country.

African countries, unlike developed nations, lack reliable vital registrations to provide good maternal mortality estimates. Developed countries use birth-registries and link such registries to causes-of-death registries which is the gold standard to estimate maternal mortality. Alternative source of information include health service data which depends on reports of health institutions. However, the health service reports in developing countries are often biased as only few people use these services. Also, information gathered through health
service is incomplete. It is thus difficult to estimate the accurate mortality rates based on institutional data [12]. Therefore, developing countries with limited heath service coverage try to include maternal mortality related questions in household surveys like the Demographic and Health Surveys (DHS). Although these surveys have contributed important information for monitoring interventions, they are expensive, and do not provide regional and local estimates needed to improve health services.

For countries with high maternal mortality and high fertility Graham and colleagues developed an indirect sisterhood method for calculating maternal mortality indices [13]. This method is widely used in Africa and Asia to provide community based maternal mortality estimates [14-16]. Unfortunately, there are no such reports from south Ethiopia. Our study aims to find out the lifetime risk of death of a woman from pregnancy related causes, and to calculate the MMR in a rural area in Gamo Gofa.

**Methods and materials**

**The setting**

We conducted this study in 15 out of 30 randomly selected rural kebeles (lowest administrative units) in Bonke woreda (district), in Gamo Gofa Zone in south-west Ethiopia. Bonke is one of 15 woredas in Gamo Goffa zone, and had population of 173,240 people in 2010 [17]. The woreda has 31 kebeles. One of these kebeles is a town. Bonke is 618 km from Addis Ababa, and 68km from the zonal town Arba Minch. The only road to the woreda is the road from Arba Minch to Kamba. The road is often interrupted because of overflowing rivers during rainy season and most of the population live in remote villages far from the road.

The district is divided in to three climatic zones (cold, temperate and hot), and malaria is endemic in the hot lowland area. The healthcare is provided by a health centre at the town, and three other rural health centres. There is no medical doctor working in the district, and the health institutions are staffed by a few health officers. In the woreda, there is no access to comprehensive emergency obstetric care that provide caesarean section and blood transfusion.

We conducted this study as part of intervention project to reduce maternal mortality in Gamo Gofa. The work also includes studies on estimation of maternal mortality through community
based birth registry, a retrospective five-year recall period household survey, and health facilities obstetric care quality study.

**The sisterhood method**

In the sisterhood method, adult men and women report about the proportion of their adult sisters (born to the same mother) dying during pregnancy, childbirth, or in six weeks after pregnancy [13]. The main objective of this method is to create a retrospective cohort of women at risk of pregnancy related deaths, and to estimate the lifetime risk (LTR: chance of death of a woman from pregnancy-related causes during her entire reproductive period). Then, the LTR is translated in to the more conventional presentation of MMR.

The maternal mortality ratio estimate obtained through the indirect sisterhood method, using respondents aged 15-49 years refers to events about 10-12 years before the data collection. The time of estimation for maternal mortality ratio goes even as far-past as up to 35 years from time of data collection when the respondents are older (if included above 50 years old). Therefore, the information obtained from such surveys is used as a quick reference of past mortality, rather than of recent events. This method is not recommended to overseeing the trend over long period of the maternal mortality and for geographic comparisons [18].

To translate the lifetime risk into MMR, the method recommends the total fertility rate (TFR, the average number of children that would be born to a woman over her lifetime) should not be less than 5. In 2000, the TFR for rural Ethiopian population was 6.4 [19]. Since this rural area has high illiteracy rate, and was a densely populated subsistent-agrarian community, we assumed the population to have similar fertility with other rural areas in Ethiopia. Therefore we used TFR of 6.4 in our study.

**The data collection**

We recruited data collectors who had completed twelfth grade, lived in the area, and were familiar with the local language and culture. Five diploma graduates who also had thorough knowledge of the culture and language of the area supervised the data collectors. Each enumerator was trained for two days. The training included pre-test field interviews,
translating the questions and understanding the different meanings it could give to the respondents.

We asked men and women 15 – 49 years old the following standard questions used in sisterhood method [13]:

1. How many sisters (born to the same mother) have you had who survived up to reproductive age (15 years)?
2. How many of them (reached reproductive age-15 years) are alive now?
3. How many of these sisters died?
4. How many of them died during pregnancy, childbirth or 6 weeks after delivery or end of pregnancy?

In addition, we collected data on age, sex, and education of each respondent. Age of 15 years was considered as the common age at which women are expected to be menarche. Therefore, we used it as a proxy age for reaching reproductive age with additional probing of a ‘reproductive age’ phrase itself. Data collectors were carefully trained not to include the responding woman to reported number of sisters born to her mother.

The questions were translated to ‘Amharic’ (Ethiopian official state language), and the enumerators administered it using the local ‘Gamotho’ language. The enumerators visited each household in the selected communities that had at least one pregnancy during the 5 years before the study. They asked the four questions to the husband and wife, and to their children, if any, who were aged 15-49 years.

In the households where there were other extended adult family members, they also interviewed the adult. If an adult person was not present during the first visit, the data collectors re-visited the household during the following early morning.

**Sample size and sampling technique**

The sample size recommended by Graham and colleagues is 3000 to 6000 adult respondents [13]. A more precise recommendation of the sample size estimation which elaborates considering the margin of error, the confidence level, the power of the estimate, and the
required number of maternal deaths of sisters, suggested a more detailed sample size
determination [20]. The formula to calculate the number of maternal deaths required to be
reported by respondents was determined by: \( r \geq \left[ \frac{Z_{\alpha/2}}{\alpha/2} \right] ^2 \times \frac{100}{\% \ ME} \) where \( r \) is the
number of sister deaths due to maternal causes that were required, \( Z_{\alpha/2} \) is the standard normal
deviate at two-sided confidence level of 100[1-\( \alpha \)], and the \( \% \ ME \) is the percentage margin of
tolerance by the investigators.

We used a tolerable margin of error of 10\% , and \( \alpha \) value of 5\% (two sided 95\% CI). From the
formula we calculated: \( [1.96]^2 \times [100/10]^2 = 384 \) sister deaths due to pregnancy, childbirth or
6 weeks after pregnancy ended. Hanely and colleagues [20] suggest that with 80\% statistical
power, for a community with an MMR more than 750 per 100,000 live births, a report of 384
or more maternal deaths is expected from interviewing 8000 adult siblings. In 2000, the MMR
estimate was 937 for Ethiopia [6]. To account for non-responses and missed information, we
decided to interview 9000 respondents.

We grouped the 30 kebeles of Bonke Woreda into three climatic zones (hot, temperate and
cold). To ensure fair representation of all three climatic conditions, we selected half of the
kebeles in each climatic zone by a lottery method. Thus, we selected 8 of 16 'Dega' (cold
weather), 4 out of 8 'Woinadega' (moderate temperature) and 3 of 6 'Kolla' (hot temperature)
kebeles. Then the 9000 sample of respondents were distributed to the study kebeles
proportionate to their population size.

**Data analysis**

We used SPSS 16 (Statistical Package for Social Sciences) for data entry and analysis [21].
In our calculation (Table 1), we used an inflation adjustment to find the final number of
surviving adult sisters for the younger respondents (age 15-24). This was done by multiplying
the number of respondents in young age groups by the average number of sisters among the
older respondents (age 25-49) which was 2.65 in this data. For example, 2.65* 2443= 6471
adjusted sisters for 15-19 age group respondents [13]. This raising factor is used because of
the assumption the younger respondents have sisters yet to reach to reproductive age.
Using standard adjustment factors [13], we adjusted for the expected proportion of sisters that would have finished their reproductive age for respondents in each age category. This means, for example, that 90% of the sisters of respondents aged 45-49 are expected to have been passed through their reproductive life but only 10.7% of the 15-19 years old respondents’ sisters. The adjustment is to find out the number of sister units exposed to maternal death. This retrospective cohort analysis provided 8,068 sister units exposed to risk of maternal death that served as the denominator for calculating the lifetime risk of maternal death.

The lifetime risk (Q) of maternal death was calculated by: \( Q = \frac{r}{\beta} \) where \( r \) is the number of maternal deaths and \( \beta \) is the sister units exposed to risk of maternal death. We calculated the MMR as: \( MMR = 1 - (P)^{1/TFR} \) where \( P \) is probability of surviving which equals \( (1 - Q) \) and TFR is total fertility rate [20].

**Ethical clearance**

This study was ethically approved by Ethical Review Committee for Health Research of Southern Nations Nationalities and Peoples' Regional State (SNNPRS) Health Bureau in Ethiopian, and Regional Committee for Medical and Health Research Ethics of North Norway (REK Nord). We obtained informed oral consent from all respondents.

**Results**

We interviewed 8870 people of the set 9000 sample (98.5% response rate), and included 96 per cent (8503/8870) of respondents in the analysis. The missing information on the 4 per cent (367 people) was mainly because of misclassification of age (out of 15-49 age range), and missed information on sex of the respondents. There was no maternal death reported by those excluded from analysis.
Of the 8503 respondents in the analysis, 5262 (62%) were men and 3241 (38%) were women. The mean age of the respondents was 26.4 (SD = 8.7) years (range 15 to 49 years). The most frequently reported age of the respondents was 30 years followed by 20 and 18 (Figure 1).

The 8503 respondents reported 22,473 sisters born to the same mother who survived up to their reproductive age. The average adult sisters per respondent were 2.6. Of the 22,473 sisters who survived to reproductive age, 2,552 (11.35 %) had died. Among the dead sisters, 32% (819/2552) were pregnancy related deaths.

The lifetime risk of death from maternal causes was 0.102 (95% CI: 0.096-0.108), or 10.2 per cent (Table 1). Using the total fertility rate of 6.4 we calculated an MMR in 1998 of 1667 (95% CI, 1564-1769) per 100,000 live births.

Table 2 also shows estimates obtained from male and female sibling respondents separately. The lifetime risk estimate based on male respondents was 0.95 (95% CI: 0.086-0.105 with corresponding MMR of 1547 (95% CI:1395-1718) per 100,000 LB. The similar estimate based on information from female respondents provided a slightly higher result of lifetime risk of 0.121 (95% CI: 0.104-0.127) and MMR of 1995 (95% CI, 1701-2099) per 100,000 LB.

**Discussion**

We found a lifetime risk of maternal mortality of 10.2 per cent corresponding to maternal mortality ratio of 1667 per 100,000 live births in 1998. To our knowledge there is no prior community-based maternal mortality estimation from Gamo Gofa, and our study present the highest estimate for community-based studies using the sisterhood method in Ethiopia.

In Butajira in the south central Ethiopia, MMR was estimated to be 665 per 100,000 live births using the sisterhood method around 1996 [11]. The Butajira study might have been methodologically more robust than ours, as it was linked to demographic surveillance, and probably had more precise age estimation. But, Butajira also had better access to health services, and this could also explain the differences in MMR compared with Bonke. Shiferaw et al in their study from Illubabor in western Ethiopia in 1991 reported MMR of 570 per
100,000 live births [10]. However, both these studies show MMR rates below the international estimates for Ethiopia at that time.

Hill and colleagues estimated MMR for Ethiopia 1814 per 100,000 live births for 1995 [3] which is similar to our finding. We believe the impoverished and rural Bonke area had a high MMR then when the population had no access to comprehensive emergency obstetric care as they lived in isolated villages with limited transport. Also from 1996 to 2000, there were severe malaria epidemics in Bonke lowlands that might have caused more maternal deaths. High maternal mortality rates have been associated with high HIV prevalence elsewhere [22]. In Ethiopia, however, the effect of HIV epidemic might not be important as the HIV prevalence was less than 1 per cent in rural areas [23].

Alternative explanation for the high MMR in our study could be selection or information biases. On selection bias, we could have obtained information from many siblings on a death that occurred to a single woman. Such multiple counting is considered as cause of over-estimation. Potential information biases include misreporting of age or recall errors on timing of maternal deaths, or even non-recognition of early pregnancy related deaths.

To ensure correct age determination, we asked several probing question like the number of children the respondents had, the year of marriage, and about past events (local calendar) to determine the respondent's age. Since Ethiopia has no system of birth registry, determination of age data is uncertain. This could lead to errors such as digit preference, as observed in our study. Some respondents may also claim to be younger than their real age, as suggested in Figure 1.

Regarding multiple counting as a threat to overestimation, Graham et al [13] argued that since the sisterhood method is based on a proportional relationship, that offsets multiple counting in the denominator by counting sister deaths in the numerator, there is no biased result. Trusell et al [24] even emphasise multiple counting of siblings who fall in the sample as essential for the success of the sisterhood method. Therefore, since we had not restricted the siblings
during data collection and analysis, we cannot rule out multiple counting, but we believe this is not a major source of bias influencing our estimates.

People often forget past dates of events to report to a research questions. We asked the respondents to recall and report on the time and cause of maternal deaths that occurred in the past of their adult sisters. Two potential forms of error are of concern. First, the respondent could forget the exact time of his or her sister's death. This could wrongly increase MMR if respondents reported the sisters died after 6 weeks of pregnancy termination. Second, under-reporting could happen if they misclassified the cause of death without recognising early-pregnancy and abortion related deaths. However, in rural areas there are strong social ties, and exciting issues like pregnancy are declared early. We tried to probe respondents, especially those reporting maternal deaths to ensure the death was within 6 weeks after pregnancy terminated. The information provided is most likely true because the six week period is the time most mothers remain at home. The 'Gachino' tradition of women staying at home after delivery is strictly followed by the rural Bonke population.

We also show separate estimates based on information from male and female respondents (Table 2). These estimates were similar with slight increase for female respondents. This could be because of a close relationship sisters have each other for information sharing such as pregnancy. Most previous studies used only female respondents despite a call by Graham and colleagues [13] in their original introduction of the sisterhood method to include men in subsequent studies. Male respondents can easily be accessed for interviews in rural places where they gather for social meetings than women who mostly stay at home. Thus including men in future studies could be helpful in reducing a house-to-house visits to the often scattered households in rural areas.

**Conclusion**

Our research suggest the people living in the remote and under-privileged Bonke experienced high maternal mortality rates. This highlights the importance to strengthen life-saving comprehensive emergency obstetric care in this area, and in similar rural areas in Ethiopia.
Because of uncertainties in our estimations, we also advise to use alternative sources of information such as birth registries and short recall-period household interviews to improve the quality of maternal mortality estimation.

Authors' contributions

YY: designed the study, organized data collection, analysed the data and wrote the first draft. BL: participated in the design of the study, supervised the whole process, reviewed and modified the drafts. Both authors revised and approved the final draft.

Acknowledgements

We would like to thank the Regional Health Bureau in Southern Nations Nationalities and Peoples Regional State in Ethiopia, Gamo Gofa Zone Health Department and Bonke woreda Health Office for their support during the study. We are grateful to participants for committing their time to interview and providing information. The Centre for International Health at the University of Bergen in Norway funded this study.
References:

Figure legend

Figure 1: Age group distribution of men and women respondents in Bonke sisterhood study 2011 versus Gamo Gofa zone population of the same age group in 2007 Ethiopian Census

Description of the figure:

This figure was produced to show potential age heaping because of biased age report by the respondents that we discussed in the manuscript. It compares the percentage composition of each age group in the data in this study (8,503 respondents) versus the same age group population (622,441) of the Gamo Gofa zone administration in which the district we studied is included. The Gamo Gofa data was based on findings of the Ethiopian 2007 Census.
### Tables

**Table 1:** Maternal mortality estimate for the year around 1998 using indirect sisterhood method, south-west Ethiopia, 2011

<table>
<thead>
<tr>
<th>Age of respondents</th>
<th>No. of respondents</th>
<th>sisters survived age ≥ 15 yrs</th>
<th>Dead from all causes</th>
<th>Maternal deaths (r)</th>
<th>adjustment factor (f)</th>
<th>Sisters units exposed to risk (β)</th>
<th>Lifetime risk (Q)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-19</td>
<td>2443</td>
<td>6471*</td>
<td>428</td>
<td>240</td>
<td>0.107</td>
<td>693</td>
<td>0.346</td>
</tr>
<tr>
<td>20-24</td>
<td>1625</td>
<td>4306*</td>
<td>370</td>
<td>152</td>
<td>0.206</td>
<td>887</td>
<td>0.172</td>
</tr>
<tr>
<td>25-29</td>
<td>1450</td>
<td>3889</td>
<td>375</td>
<td>152</td>
<td>0.343</td>
<td>1334</td>
<td>0.114</td>
</tr>
<tr>
<td>30-34</td>
<td>1235</td>
<td>3135</td>
<td>358</td>
<td>103</td>
<td>0.503</td>
<td>1576</td>
<td>0.065</td>
</tr>
<tr>
<td>35-39</td>
<td>812</td>
<td>2201</td>
<td>331</td>
<td>89</td>
<td>0.664</td>
<td>1461</td>
<td>0.061</td>
</tr>
<tr>
<td>40-44</td>
<td>523</td>
<td>1397</td>
<td>255</td>
<td>52</td>
<td>0.802</td>
<td>1120</td>
<td>0.046</td>
</tr>
<tr>
<td>45-49</td>
<td>415</td>
<td>1074</td>
<td>225</td>
<td>31</td>
<td>0.900</td>
<td>997</td>
<td>0.031</td>
</tr>
<tr>
<td>Total</td>
<td>8503</td>
<td>22473</td>
<td>2342</td>
<td>819</td>
<td></td>
<td>8068</td>
<td>0.102</td>
</tr>
</tbody>
</table>

*inflated number of sisters obtained by multiplying the average number of sisters survived for respondents aged 25-49 (which is 2.65 in this data) by the number of respondents in the younger age groups (age 15-19 and 20-24). Originally reported sisters by the young group were: 5425 for aged 15-19 and 4230 for 20-24 years old respondents.
Table 2: Maternal mortality indicators estimated separately for male and female respondents using indirect sisterhood method for year around 1998 south-west Ethiopia, 2011

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of respondents</td>
<td>5262 (62%)</td>
<td>3241 (38%)</td>
<td>8503</td>
</tr>
<tr>
<td>Sisters survived 15 years+</td>
<td>11235</td>
<td>8838</td>
<td>22473</td>
</tr>
<tr>
<td>Sisters died of all causes</td>
<td>1483</td>
<td>859</td>
<td>2342</td>
</tr>
<tr>
<td>Pregnancy related deaths</td>
<td>482</td>
<td>337</td>
<td>819</td>
</tr>
<tr>
<td>Sister units of risk exposure</td>
<td>5094</td>
<td>2785</td>
<td>8068</td>
</tr>
<tr>
<td>Lifetime risk of maternal death</td>
<td>0.095</td>
<td>0.121</td>
<td>0.102</td>
</tr>
<tr>
<td>MMR*</td>
<td>1,547</td>
<td>1,995</td>
<td>1,667</td>
</tr>
</tbody>
</table>

* per 100,000 live births
Figure 1