'ESTIMATION OF MATERNAL MORTALITY USING AN INDIRECT METHOD.'

BY

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DECLARATION

This Thesis is my original work and has not been presented for a degree in any other University.

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DEDICATION

This Thesis is dedicated to my parents Robert and Alice Muyonga for sending me to school and hence empowering me. Thank you dear parents.

It is also dedicated to my beloved husband Ochieng' for his constant love and encouragement.

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ABSTRACT

The World Health Organization (WHO) defines maternal mortality as a death during pregnancy or within 42 days afterward, from causes related to or aggravated by the pregnancy or its management. At least 600,000 women die annually from pregnancy-related causes. Complications of pregnancy, childbirth, and unsafe abortion are now the leading killers of women of reproductive age throughout the Third World. (WHO, 1992).

The exact extent of maternal death and its causes often cannot be determined because of poor data quality and incomplete reporting in most developing countries. Data sources for maternal mortality measurement include hospital records, population-based studies and vital registration systems. In Africa, there is a common problem of poor or non-existent vital registration systems leading to reliance on sample surveys to get maternal mortality data and estimates. It is because of this that Graham et al, (1989) developed the sisterhood technique for deriving maternal mortality estimates in places with limited or defective data.

Kenya as a nation has tried to improve its data collection methods and there are demographic surveys (KDHS) undertaken every five years to collect reproductive health information on the population. The latest KDHS included the DHS maternal mortality module from which the direct sisterhood method developed by Rutenberg and colleagues in 1990 was used to estimate maternal mortality. This study has used the 1998 KDHS and the indirect sisterhood method to provide maternal mortality ratios for Kenya. The study uses the Women's Questionnaire in which 7,881 women aged 15-49 years old were successfully interviewed and these reported 237 maternal deaths.

The study objective was to use the same data set (1998 KDHS) and the indirect sisterhood method to derive maternal mortality estimates for Kenya at the national and sub national levels. The second objective of this study is to provide maternal mortality differentials for Kenya. The study therefore provides maternal mortality ratios by various background characteristics of the respondents' namely: region of residence, type of place of residence, religion, and ethnic grouping. The maternal mortality ratios derived by the indirect sisterhood method relate to a period of 12 years before the survey. The

interpretation of these results needs to be cautious since the characteristics of the deceased woman may not necessarily be similar to that of the respondent reporting.

The study found a national maternal mortality ratio of 500 maternal deaths per 100,000 live births for the period 12 years before the survey. This national estimate had a wide confidence interval ranging from 475 to 613 maternal deaths per 100,000 live births. The results of this study indicate that there are wide maternal mortality differentials in Kenya, with Western, Coast and Nyanza Provinces having very high maternal mortality ratios ranging from 600 to 900 maternal deaths per 100,000 live births, and very high lifetime risks of maternal death such as 1 in 15 women from Western Province facing the risk of a maternal death in her lifetime. Central Province seems to be one of the lowest maternal mortality risk areas of Kenya. Residents in urban areas of Kenya are more likely to report a higher incidence of maternal mortality than their rural counterparts are. Based on the sisterhood estimate, urban areas in Kenya have a ratio of 900 maternal deaths per 100,000 live births compared to a ratio of 500 maternal deaths per 100,000 live births in rural areas. Catholic and Protestant respondents are more likely to report lower maternal mortality compared to their Muslim counterparts.

The study concludes that the measurement of maternal mortality is a problem since the available data sources are wanting. In this study, the sisterhood module has been used but difficulties have arisen since the socio-demographic characteristics of the deceased woman are not available, hence the findings may not be representative of the true population levels and trends of maternal mortality. Therefore, the study recommends that a surveillance system should be put in place to validate the results of the KDHS findings on maternal deaths incidence and also to provide baseline data on maternal mortality in the country so as to strengthen research in this important area of reproductive health in Kenya.

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CHAPTER ONE: INTRODUCTION

1.1. Background of the Study

Maternity is at the heart of women's reproductive health. Ironically, bearing children is perhaps the greatest health risk in the lives of many women. Around 600,000 women die each year globally of pregnancy-related causes, 99 percent of them in developing countries. In Africa, the risk is around one in 16, compared with 1 in 65 in Asia and one in 1400 in Europe (WHO, 1998). According to the United Nations Fund for Population Activities (UNFPA) Report of 1994, every time a woman in the developing world becomes pregnant she runs a risk of death up to 100 times greater than her counterparts in the developed world.

The death rate among women of childbearing age decreased from 620 per 100,000 live births in 1955 to 230 per 100,000 in 1995 and is likely to reach 140 per 100,000 by 2025. The maternal mortality ratio, which represents the risk of pregnancy-related deaths associated with each pregnancy, was estimated at 430 maternal deaths per 100,000 live births in 1990 globally but it varies widely among and within countries. For every 100,000 live births there were about 13 maternal deaths in the developed market economies but more than 1,050 in the developing countries. In other words, one-woman dies of pregnancy-related causes for every 100 babies born alive (WHO, 1998).

In 1987, several international organizations united to launch 'The Safe Motherhood Initiative' - a collaborative effort to focus the world's attention on and find solutions to the tragedy of maternal mortality. This initiative was launched in Nairobi, Kenya, as a follow-up to the International Conference on Safe Motherhood. It established a global goal of halving maternal mortality by the year 2000.This goal has been adopted by a series of international health and development conferences and forms an integral component of the programs of action following the 1990 World Summit for Children, the 1994 International Conference for Population and Development and the 1995 Fourth World Conference for Women.

The goal captured the world's imagination and many countries have accepted it as a national goal. The national target for the Kenya Government is the reduction of the maternal mortality rate (per 100,000 live births) from 365 in 1995 to 300 by the year 2000 to 230 by 2005 and 170, by the year 2010. (Sessional Paper No 1, 1997)

The following table presents the revised 1990 estimates of maternal mortality by world regions developed jointly by WHO and UNICEF. These are considered to be more reliable than those based on earlier strategies and can thus provide a baseline estimate against which it will be possible to assess progress by the year 2000.

Table1.1: Revised 1990 Estimates of Maternal Mortality by Region

REGION	MATERNAL MORTALITY RATIO (MATERNAL DEATHS PER 100 000 LIVE BIRTHS)	NUMBER OF MATERNAL DEATHS (THOUSANDS)	LIFETIME RISK OF MATERNAL DEATH: 1 IN
More developed regions	27	4	1800
Less developed regions	480	582	48
Africa	870	235	16
Asia [a]	390	323	65
Europe	36	3	1400
Latin America and the Caribbean	190	23	130
Oceania [b]	680	12	6
Northern America	11	0.5	3700

Source: World Health Organization/United Nations Children's Fund, Revised 1990 Estimates of Maternal Mortality (Geneva, 1996).

[a] Excluding Japan, which is, now included in more developed regions.

[b] Excluding Australia and New Zealand which are included in more developed regions.

Goal setting requires some ability to determine whether goals are met, in this instance, measures of the level of maternal mortality. In most developing countries such as Kenya where maternal mortality has become a high government priority, the availability of reliable statistics is wanting. The only available figures are derived from hospital records, which are pronged with selectivity bias and under representation of true maternal mortality levels.

Alternatively, more cost-effective strategies have been devised to enable countries like Kenya to make estimates of levels of maternal mortality. One such approach is the sisterhood method. It is an indirect measurement technique frequently used to measure a variety of demographic parameters (such as child or adult mortality), which has been adapted for the measurement of maternal mortality. Field trials of the sisterhood method have already been undertaken in several countries in Latin America and Africa (Graham et al, 1989; Simons et al., 1989). The technique has proved to have many advantages in ease of use and economics of time and money.

1.2. Past Maternal Mortality Studies in Kenya

Before the 1990s, various studies in Kenya have shown varying levels of maternal mortality in the country. The studies usually focused on subgroups of the population and used different approaches; hence, estimates yielded are not comparable and cannot be used to establish consistent patterns of maternal mortality in the country.

Population based data are available for Kenya on maternal mortality from one longitudinal study in the 1970s. In a low mortality area in Central Kenya, only four maternal deaths could be identified in 4,627 live births for the period 1975 -78, corresponding with a maternal mortality ratio of 90 per 100,000 live births (Voorhoeve et al., 1984).

From hospital and healthcare data for 1978, the national maternal mortality ratio was estimated at 240-400 per 100,000 live births for the period 1972 -77 (Ewbank et al., 1986). In contrast, a 1987 study of maternal deaths at Pumwani maternity hospital in Nairobi found a much lower ratio of 67 deaths per 100,000 live births over the period 1975-84 (Ngoka and Bansal, 1987).

In yet another study, in Kwale district of Coast province, Boerma and Mati (1987) conducted a survey on childhood mortality and morbidity, with interviews of women of childbearing ages. The study attempted to use the social significance of the tragedy of maternal deaths in rural areas to assess the magnitude and causes of maternal mortality. At hardly any cost, a few questions on maternal deaths were included in the survey on childhood mortality and morbidity. The questionnaire included a few questions on women who had died during pregnancy, childbirth, or puerperium. A 'network' of maternal deaths in the study area then emerged and subsequently these households were visited to interview the relatives of the deceased woman. This led to the identification of 35 maternal deaths in the four years preceding the survey. They estimated a maternal mortality ratio in the district to be 600-700 deaths per 100,000 live births.

Based on the revised 1990 estimates of maternal mortality ratios for various United Nations regions, new estimates of maternal mortality for Kenya were availed. Tables 1.2 and 1.3 show the revised estimates:

Table 1.2: Revised Estimates of Maternal Mortality Ratios by United Nations Regions - Africa, 1990.

REGION	MATERNAL MORTALITY RATIO (MATERNAL DEATHS PER 100,000 LI VE BIRTHS)	NUMBER OF MATERNAL DEATHS (THOUSANDS)	LIFETIME RISK OF MATERNA L DEATH 1 IN
East Africa	1 060	97 000	12
Middle Africa	950	31 000	14
Northern Africa	340	16 000	55
Southern Africa	260	3 600	75
Western Africa	1 020	87 000	12
AFRICA	870	235 000	16

Source: World Health Organization / UNICEF, Revised 1990 Estimates of Maternal Mortality (Geneva, 1996).

Table 1.2 above illustrates that Eastern (in which Kenya falls) and Western Africa regions had the highest maternal mortality ratios than for the entire continent in 1990. Both regions had higher risks of maternal deaths, that is, 1 in 12 women at risk of a maternal death.

In Table 1.3, estimates of maternal mortality ratios for various countries including Kenya are provided. The results indicate that Kenya is among the African countries with high levels of maternal mortality, yet by this time no population-based data was available. However, within Eastern Africa, Kenya has a lower level of maternal mortality than its immediate neighbours of Uganda and Tanzania.

Table 1.3: Country Estimates of Maternal Mortality Ratios, Lifetime risk and Numbers of Maternal Deaths, 1990

COUNTRY	MATERNAL MORTALITY RATIO (MATERNAL DEATHS PER 100 000 LIVEBIRTHS)	NUMBER OF MATERNAL DEATHS	LIFETIME RISK OF A MATERNAL DEATH: 1 IN	CATEGORY
Kenya	650	7 000	20	E
Uganda	1 200	11 000	10	E
Tanzania	770	8 700	18	E
Malawi	560	2 700	20	D
Sudan	660	6 600	21	E
Morocco	610	4 500	33	D

Source: World Health Organization / UNICEF, Revised 1990 Estimates of Maternal Mortality (Geneva, 1996).

The 'category' column indicated in the table relates to the country's status on maternal mortality data. Five categories have been provided by WHO and UNICEF (1996b) ranging from 'A' to 'E'. Category A describes developed countries with complete vital registration systems and relatively good attribution of cause of death. Category B relates to developing countries with good death registration but poor or non-existent attribution of cause of death, no country in Africa fell in this category at the time. Category C describes countries with Reproductive Age Mortality Surveys (RAMOS) type estimates of maternal mortality. Category D describes countries with Sisterhood estimates of maternal mortality. These may under-estimate total female adult mortality and presumably maternal mortality as well (Shahidullah et al., 1995; Stanton et al., 1995). Finally, category 'E' describes countries with no estimates of maternal mortality, wherein most African countries (and indeed Kenya) fall within.

Two national surveys in the 1990s collected information on maternal mortality in the Kenya based on the sisterhood method - the 1994 Kenya Maternal Mortality Baseline Survey (KMMBS) and the Kenya Demographic and Health Survey of 1998. The Maternal Mortality Baseline Survey by the Population Studies and Research Institute of the University of Nairobi was carried out in 1994. A complementary approach namely, a national survey of households and individual districts of the country, assembling of district hospital records and focus group discussions (FGD) in selected districts, were used to identify maternity-related deaths. The study sampled 28,316 households from 420 sample clusters and a resultant 39,000 adult's aged 15 to 50 years were to be interviewed. Owing to non-responses and other similar problems, only 24,000 respondents were interviewed. Hospital data was collected from 19 provincial and district hospitals.

To delve into socio-cultural factors associated with maternal mortality, the survey employed focus group discussions in Kwale, Embu and South Nyanza at which women aged 15-25, 26-35 and 36+ years participated. This produced qualitative data that complemented the quantitative data from the other mentioned sources. The study derived both direct and indirect estimates of maternal mortality. The unweighted maternal mortality estimate based on the survivorship of sisters for the period 1990-1994 was a maternal mortality ratio of 498 deaths per 100,000 live births. The weighted maternal mortality estimate based on survivorship of sisters for the same period gave a maternal mortality ratio of 365 deaths per 100,000 live births which was undesirably high. During the five-year period (1990-1994) there were 192 maternal deaths among 184,793 sister-year of exposure in the childbearing ages. However, weighting lowers the number of maternal deaths to 134. The study indicated large regional differentials with districts like Kwale and South Nyanza having 2,221 and 1,072 deaths per 100,000 live births, respectively, compared to 18 in Nyeri and 137 in Embu. The apparent significance between the two estimates is because of the nature of the sample, because the survey sample had an over-representation of the so-called 'Study Focus Districts', the majority of which are problem areas with relatively high mortality levels. Hence, the unweighted estimate is likely to give an overestimation of the national maternal mortality ratio. The weighted maternal mortality ratio of 365 was used as the most reliable estimate of the national maternal mortality level. The indirect estimate was derived using the sisterhood method developed by Graham et al, (1989).

Njeri (1996) examined the relationship between maternal mortality in Kenya and the following variables: - maternal age, parity, marital status, birth interval, antenatal clinic attendance and occupation. The study utilized data from the in-patient files at

Pumwani Maternity hospital for the period 1990-1994. The sample size was 108 maternal deaths and 1124 survivors. The findings showed that age of the woman and her marital status were negatively related to high maternal mortality. Most maternal deaths occurred among the 20-29 year olds, and also among those who were married.

In the Kenya Demographic and Health Survey (KDHS) of 1998, for the first time information was collected that allows the estimation of mortality related to pregnancy and childbirth for the ten-year period before the survey. Using direct estimation, the maternal mortality ratio was estimated at 590 per 100,000 live births for the 10-year period before the survey. Hence bearing an average of 4.7 children, a Kenyan woman has a 1 in 36 chance of dying from maternal causes during her lifetime (KDHS, 1998).

Kiage (1999) in studying the determinants of maternal mortality and morbidity in Kenya using the 1994 Kenya Maternal Mortality Baseline Survey found that there are wide regional differentials. The study found that maternal mortality exhibited a J-shaped trend with regard to age and parity. Marital status was also found to affect maternal mortality. Single women were found to be of higher mortality risk than married women. Similarly, educated women were found to be less likely than uneducated women to suffer maternal death.

The results may suggest that the maternal mortality situation may have worsened over the recent years. This is however not conclusive since the observed differences in the maternal mortality levels might be as a result of methodological differences employed in the two surveys (Magadi, 1999).

1.2.1 Fertility Situation of Kenya

The maternal mortality ratio estimated by the sisterhood method relates to about 12 years before the survey. It is therefore imperative that we analyze the demographic trends of the population of Kenya at this period (about 1986). One of the indices important in the derivation of the maternal mortality ratio is the total fertility rate (TFR). In the following two tables, we observe the TFR levels for the country as a whole (Table 1.4) and for various Provinces (Table 1.5). Such information is very important in explaining differentials of mortality. The table below provides fertility indices by province of Kenya based on the findings of KDHS.

Table 1.4: Trends in Fertility: Age-specific fertility rates (per 1000 women) and total fertility rates for selected surveys, 1977/78/KFS, 1989 KDHS, and 1998 KDHS

AGE GROUP	1977/78 KFS 1975-78[A]	1989 KDHS 1984-89[B]	1993 KDHS 1990-93[C]	1998 KDHS 1995-98
15 – 19	168	152	110	111
20 – 24	342	314	257	248
25 – 29	357	303	241	218
30 – 34	293	255	197	188
35 – 39	239	183	154	109
40 – 44	145	99	70	51
45 – 49	59	35	50	16
TFR Women aged 15 – 49	8.1	6.7	5.4	4.7

Source: KDHS 1998 Preliminary Report, P31.
Note: Rates refer to the three year period preceding the survey except for the 1989 KDHS (five- year period before the survey).
[A] CBS, 1980
[B] NCPD, 1989
[C] NCPD, 1994

The estimates in Table 1.4 describe the ongoing fertility transition in Kenya. The TFR has declined dramatically from 8.1 children per woman in the mid-1970s to the current level of 4.7 children per woman; a decline of 42 percent over a 20 year period. The steepest decline in the TFR occurred in the late 1980s and early 1990s but has slowed somewhat in the mid-1990s. In addition, fertility has fallen at every age except amongst the youngest women, age 15-19 (KDHS, 1998).

The TFR values indicate the frequency of childbearing among women. Hence, a TFR value of 8.1 means that averagely, each woman in a given society has eight children. Maternal mortality risks are increased in the higher birth orders, that is, for women with many children (Berry 1971, Ngoka and Bansel, 1987,Aloo-Obunga, 1988). Each time a woman becomes pregnant, she risks dying of a maternal cause. The higher the level of mortality in the society, the greater is this risk. The risk is cumulative: the more times a woman becomes pregnant, the chances of dying increase. Therefore, the TFR values can guide us in identifying 'trouble spot' areas of high maternal mortality.

The study will use the TFR values of the 1989 KDHS in the calculation of maternal mortality ratios since the reference period of the indirect sisterhood method is 12 years before the survey. This value is 6.7, and will be used to derive the national maternal mortality ratio.

From the Table 1.5, we note that Western province of Kenya has had the highest TFR in the country consistently. In 1989, it led with a TFR of 8.1 children per woman and the current rate is 4.7 children per woman. Another high fertility regions include closely by Nyanza province with 7.1 births per woman (1989, KDHS) and the current rate is 5.0 children per woman. Both these provinces had higher TFR than the national average of 6.7 births per woman in 1989. They therefore represent the high-fertility regimes of the country. The lowest TFR was that of Nairobi province with only 4.6 births per woman (1989, KDHS) and at present it is only 2.6 children per woman. It is expected that the maternal mortality pattern will follow this fertility pattern. Once again, the TFR values from the 1989 KDHS will be used to derive the maternal mortality ratios for the Province of residence of the respondent.

Table 1.5: Trends in Fertility by Province of Residence, Kenya

PROVINCE	1989 KDHS TFR*	1993 KDHS TFR*	1998 KDHS TFR*
Nairobi	4.6	3.4	2.6
Central	6.0	3.9	3.7
Coast	5.5	5.3	5.1
Eastern	7.0	5.9	4.7
Nyanza	7.1	5.8	5.0
Rift Valley	7.0	5.7	5.3
Western	8.1	6.4	5.6

Source: Primary Analysis of 1989, 1993 and 1998KDHS data.
*Note: * Based on 0 – 4 years before the Survey.*

1.3. Problem Statement

In 1986, the World health Organization (WHO) urged all developing countries to set up research on maternal mortality. It specifically recommended that all member countries produce reliable estimates of maternal deaths and provide essential baseline data for programme design and implementation in order to reduce maternal mortality levels. However, in Kenya, research into the area of maternal mortality is hindered by a number of problems related to methodology and study design. Currently, three main sources of information are available on maternal deaths: vital registration, health service statistics, and community-based surveys. These vary in terms of their suitability for studying different aspects of maternal mortality.

A major problem faced is the poor vital registration system operating in Kenya. The registration of vital events notably births and deaths is in a pathetic state owing to the low priority it is accorded in relation to other government programs and lack of incentive for the public. The rural populace is ignorant of its role in reporting births and deaths. Socio-cultural factors like taboo of discussing the death topic; stigmatization of unwed mothers; and the high number of births at homes under the supervision of traditional attendants, have accelerated the partial and at times total omission of reports of maternal deaths among these populations. A related issue is the poor literacy level of the rural dwellers and low living standards, which result in the characteristic high levels of general mortality in such areas. Accurate information on deaths to women in reproductive ages, as well as data on live births and pregnancy that preceded such deaths, is unlikely to be available.

Health service statistics including use of hospital records represents an alternative to this problem. In this case, estimates of maternal mortality can be derived directly from such hospitals as Pumwani Maternity Hospital (the largest in the country) and the Kenyatta National Hospital, which is the largest teaching and referral hospital in the country. However, such estimates tend to be localized and suffer from the problems of nonrandom case selection, inadequacies of sample size, and incomparable reference periods.

Owing to selectivity bias, such estimates lead to over and underestimates of the level of maternal mortality in a given community. Most of the national and sub-national hospitals do not have good record keeping and the low numbers of computer use leads to poor death registration records for researchers to use. This was a major problem experienced by a variety of institutions, researchers and scholars notably the Population

Studies and Research Institute (PSRI) of the University of Nairobi during the Kenya Maternal Mortality Baseline Survey (KMMBS) in 1994, and Aloo-Obunga (1988).

The lack of access to and utilization of fixed health facilities, and limited prospects of dramatic improvements, strengthens the need for population-based estimates. The estimates from community studies are usually representative of the specific study area but generalizing their results for the entire country is difficult. Such studies especially in relation to maternal mortality are impractical since maternal death is a rare occurrence. Obtaining a sample that includes a sufficient number of maternal deaths to allow an estimate of acceptable precision, a large population must be placed under surveillance for a long period of time, which requires the commitment of extensive financial and human resources.

Due to the large sample size requirement in direct investigation of maternal mortality, there is need for techniques that use simple data to provide maternal mortality estimates from a smaller sample size, such as the sisterhood method. In this method, men and women are asked to recall the number of sisters who died during pregnancy, delivery and the puerperium among those who were ever married at the time of the survey (Graham et. al., 1989). The method has been used in Kenya during the 1994 Maternal Mortality Baseline Survey (KMMBS) in which both the direct and the indirect sisterhood methods were used, and in the 1998 Kenya Demographic and Health Survey (KDHS) in which the direct sisterhood method was used.

These studies mentioned above employed the sisterhood method but they obtained different estimates of maternal mortality. The KMMBS found a weighted maternal mortality ratio of 365 deaths per 100,000 live births while four years later the KDHS estimated a maternal mortality ratio of 590 deaths per 100,000 live births.

This observation leads us to the main research questions: Why is it that studies applying similar instruments and probably similar designs provide different estimates? Why is it that four years later after the KMMBS (1994) the maternal mortality ratio appears to have increased? Is this increase relating to what is happening on the ground, that is, is it say to propose (based on these figures) that maternal mortality is on the rise? Could the apparent rise in the maternal mortality ratio be due to a change in the risk of maternal death, or an increase in the lifetime risk of maternal death? Is it simply a question of data and estimation artifact?

This study intends to use the sisterhood method to provide estimates of maternal mortality at the national and sub-national levels; to establish the existence of maternal mortality differentials, and to try to answer the research questions posited above.

1.4. Objectives

The general objective of this study is to obtain estimates of maternal mortality for Kenya.

The specific objectives include:

1. To estimate maternal mortality levels in Kenya using the 1998 Kenya Demographic and Health Survey (KDHS) data using the sisterhood method.
2. To establish if there exists maternal mortality differentials in Kenya.

1.5. Rationale

The incorporation of maternal mortality reduction into the goals of the international community reflects its importance as a measure of human and social development. Maternal mortality is a particularly sensitive indicator of inequity. Of all the indicators commonly used to compare levels of development between countries and regions, levels of maternal mortality show the widest disparities. Maternal mortality offers a 'litmus test' of the status of women, their access to health care and the adequacy of the health care system in responding to their needs. Information about the levels and trends of maternal mortality is needed not only for what it tells us about the risks of pregnancy and childbirth, but also for what it implies about women's health in general and, by extension, their social and economic status.

Beyond the immediate loss of life, maternal mortality exerts a devastating effect on the family. In many instances, infant and maternal deaths occur simultaneously. Prevention of maternal deaths in many cases can also save the life of the child, perhaps several children. A mother's death also affects household food, social and economic security. Increasingly more and more households are female-headed, and these households depend on the female 'heads' for agricultural production or for income for food purchases. Efforts to measure the levels of maternal mortality can therefore assist in determining priority areas of intervention to prevent the disastrous effects on the community at large.

In a developing country like Kenya, reliable estimates of maternal mortality are lacking. Poor vital registration systems and health service statistics are usually the scapegoats. This impounds the planning, management and evaluation of programs aimed at reducing maternal mortality. Reliable measures of maternal mortality and its correlates are *sine qua non* for a successful Maternal and Child Health (MCH) program. It is therefore necessary to use indirect techniques to estimate maternal mortality. The sisterhood method developed by Graham, Brass and Snow (1989) provides a suitable method for deriving estimates of maternal mortality at both national and sub national levels in places with limited or defective registration systems.

1.6. Scope And Limitation

This study focuses on the 1998 KDHS women's questionnaire. In the interviewed households, 8,233 eligible women (age 15-49) were identified and 7,881 women aged 15 to 49 who were successfully interviewed, yielding a response rate of 96 percent. The questionnaire included a sibling history, which is a detailed account of the survivorship of all the live-born children of the respondent's mother (i.e., maternal siblings). These data allow estimation of maternal mortality.

The data required for indirect estimation by the Sisterhood method focuses on responses to four questions (a) number of respondent's siblings, their names and sex; (b) the names of female siblings, (c) the survival status of female siblings, and (d) if death of sibling was during pregnancy, childbirth or the pueperium. The responses to the questions will yield an estimate of the lifetime risk of maternal death (LTR), which will then be used to derive the maternal mortality ratio.

The study will be limited in that it uses secondary data, which was collected by a different body. Thus there may be existence of both content and coverage errors which are beyond the scope of this author. The sample was drawn from the National Sample Survey and Evaluation Program (NASSEP-III), which excludes 4 percent of Kenya's population in the North and North Eastern Provinces. The KDHS, though national in scope, excludes the three districts in North Eastern Province and four other northern districts (Samburu and Turkana in Rift Valley Province and Isiolo and Marsabit in Eastern Province).

The data may also suffer from underreporting of maternal deaths because the KDHS relied on retrospective birth histories. Analysis of retrospective surveys is commonly plagued with problems of defective data and memory lapses, such as abortion-related deaths not being mentioned.

The estimate of maternal mortality using the indirect method is based on reporting by respondents covering a period of some 35 years or more. Thus the overall estimate, derived from pooling the data for all respondents, relates to a period centered some 10-12 years before the survey. Some of the deaths contributing to the estimates will have taken place longer than 10 -12 years ago; 10 -12 is the average duration of time elapsed since death.

The method does not also give the precise figure of maternal mortality and there are wide margins of error. For this reason, the sisterhood method cannot be used for regular monitoring of mortality trends in the short term.

1.7. Chapter Summary

This Chapter gives a general background of maternal mortality levels globally and in Africa in particular. The magnitude of the maternal mortality problem is potrayed using the 1996 maternal mortality ratios provided by WHO and UNICEF. A brief chronology of maternal mortality studies done in Kenya is given and highlights of these studies include the rarity of maternal deaths hence large populations have to be put under surveillance for long time periods before any deaths are recorded (Boerma and Mati, 1987, Voorhoeve et al, 1984.

The maternal mortality ratios provided by the studies have however not been comparable because the studies employed different data collection and analysis tools. There has been extensive focus on factors determining maternal mortality (Aloo-obunga, 1988; Ngoka and Bansel, 1987; Kiage, 1999; and Magadi, 1999). However, there has not been much effort in establishing the efficacy of the tools for analysis.

The Chapter also gives the scope and limitations of the study and points out that studying maternal mortality helps in determining the state of women's health of the society. In the next Chapter, maternal mortality literature is reviewed ranging from the data sources for maternal mortality studies to the determinants of maternal mortality.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

Studies on maternal mortality or on the general effects of childbearing on maternal health were done in the developed countries from the 1940's through the 1960's. Generally, however, investigations have not studied the health of the mother as much as the health of the offspring. This fact has been clearly demonstrated by Buchanan (1975) wherein he found that the number of articles on fetal, infant and child health was 25 times greater than those on maternal health, when 1200 international medical journals were reviewed between 1973 and 1975.

In the developing world, research in this area has lagged due to the predominant under-registration of vital events in most countries. While most of these countries have unsatisfactory vital registration systems, the statistics from rural areas are simply not available or are grossly underestimated (WHO, 1998). Despite these setbacks, various studies have been done aimed at establishing the causes of maternal deaths and the trends in maternal mortality for given times.

2.1.1. Data Availability for Maternal Mortality Studies

Tietze (1977), in his report on Non-Abortion Maternal Mortality (NAMM) has compiled data for up to 32 countries from a total of 162 comprising the world, which met the following criteria: 1) Availability of statistics on maternal deaths, live births and female population by 5 year age group (in the late 1975 when these tabulations were made) for at least two consecutive 3-year periods; 2) at least 100,000 live births during each such period, and 3) complete or nearly complete birth registration. Of these 32 countries, only four were developing countries, and no country from Africa was shown. NAMM ratios per 100,000 live births were presented for 12 countries in 1951 - 53, for 24 in 1956 -58, for 31 in 1961 - 63, for 32 in 1966 - 68 and for 26 in 1970 - 72. Tietze notes that the assessment of trends and relative risks of maternal mortality requires complete reporting and accurate diagnosis.

has about 300 maternal deaths each year, while Bangladesh (with a population less than half as large) has an estimated 28,000 maternal deaths each year. (Rochat, 1987).

2.1.2. Direct Estimates from Hospital data

In the 1970's, African researchers begun to know more about problems related to reproductive health. Studies done in the continent have been mostly only, on specific hospitals and thus cannot be considered representative for whole countries of communities.

Hospital data usually give high estimates. In general, the smaller the proportion of births taking place inside the hospital, the greater the discrepancy between the true - usually unknown - community rate and the hospital rate. For example, in Khartoum Province, Sudan, in 1972, the overall rate for the Province was 320 per 100,000 live births, the institutional rate was 420 per 100,000 and the domiciliary rate was 300 per 100,000 live births (Ministry of Health, Sudan 1972). A few years later, the rate at the Khartoum Teaching Hospital was 607 per 100,000 excluding deaths due to abortion (Abbo', 1982).

In a study of maternal deaths in Kenyatta National Hospital (KNH) in Nairobi, Makokha (1980) calculated a maternal mortality rate of 233 for 1976 - 77. However, this rate was only an indicator of the maternal mortality rate for Nairobi for several reasons. First, only about 13 percent of the live births in Nairobi were seen at the hospital. In 1979 there were 24 maternal deaths recorded in Nairobi, while in 1976 and 1977 there were only 15 maternal deaths in the hospital. Thus, the maternal mortality rate for the whole city is probably lower than that in the hospital since a larger proportion of the deaths (about 30 percent) occurred in the hospital. Second, the maternal mortality rate may be exaggerated since 31 percent of the maternal deaths at KNH in 1972 were referrals of difficult cases from other hospitals. This means that all maternal deaths in Kenyatta National Hospital were not necessarily from Nairobi but include the emergency referrals from other district hospitals countrywide. In this hospital, in 1977, emergency referrals constituted 3 percent of the total hospital deliveries, but were responsible for 59 percent of the total maternal deaths in the hospital (Aggarwal, 1980).

The maternal mortality ratio in a hospital in Dar es Salaam, Tanzania, were 213 for 1974 -77, but 680 per 100,000 live births for 1983-84. The main reason for the increase was that the hospital had become a facility for high-risk deliveries, and normal pregnancies had been taken over by general hospitals in town (Justeseen, 1985).

Such works as Mtimavalye (at Muhimbili Medical Center-Tanzania, 1974-77) as well as, Makokha (at Kenyatta National Hospital - Nairobi, 1972-77), have tried to give an insight into the problem of maternal mortality although only at the institutional level. All their studies single out inadequate healthcare facilities as the basic problem. Being Physicians, they are also more concerned with the immediate medical complications that could lead to high maternal mortality and morbidity in the region.

2.1.3. Survey-Based Estimates

Sample surveys offer an important potential means of collecting data to estimate levels of maternal mortality in countries lacking reliable civil registration systems. A basic approach for collecting information about maternal deaths is through a retrospective inquiry about deaths in the household. Maternal deaths can be obtained through a set of filtered questions starting with one about any death that has occurred to a female member of the household in one, or 'n' years before the reference date of the survey.

Another approach is using repeated household inquiries. One asks questions on the pregnancy status of female members and makes a repeat visit one-year later to ascertain the outcome of the pregnancy. An obvious limitation of such an approach is the time and financial constraints in implementing it.

In general, sample surveys are usually relatively small and hence they produce unacceptably high standard errors of estimates of maternal mortality. Non-sampling errors also distort these estimates including: respondents simply not knowing, or wanting to say, whether a woman has died because of a maternity cause. Usually, early maternal deaths or those arising from abortion complications are difficult to capture (Shahidullah et al., 1995). Telescoping the date of events is also difficult as well as the general methodological and cultural difficulties of collecting information about deaths in surveys.

A few population-based studies have provided estimates of maternal mortality. The problem of small numbers of deaths is a common one. For example, in a longitudinal study in a low mortality area in Eastern Kenya during the 1970's covering more than 20,000 inhabitants, only four maternal deaths were registered in 7 years of fortnightly household visits, and no firm conclusions could be drawn about the level of maternal mortality except that it was not extremely high (Voorhoeve et al., 1984).

In a study in Egypt, El- Gharmmy et al, (1984) interviewed 30,000 husbands to collect information about maternal mortality in a survey, 854 men reported the death of 924 spouses, and 183 (19.8 percent) mentioned maternity as the cause. The authors concluded that husbands are a reliable and accessible source of information on maternal mortality.

Kwast et al (1984), carried out a retrospective study on maternal mortality in Addis Ababa, Ethiopia. A two-stage stratified sample of more than 32,000 households were selected. Household members were interviewed if a delivery of abortion had taken place in the two years preceding the survey. In the Ethiopian urban community survey, maternal mortality was estimated at 566 deaths per 100,000 live births. With a General Fertility Rate (GFR) of 90.3, the maternal mortality rate in Addis Ababa was 0.51 per 1000 women aged 13 - 49 years.

In a community survey in Addis Ababa based on a sample of households to identify births, abortions and deaths over a period of two years, details of care received, social and other characteristics of the women and the households, as well as the circumstances and causes of death were recorded. A sample of nearly 10,000 pregnancies yielded 45 deaths and an estimated maternal mortality ratio of 480. Nevertheless at the 95 percent level of significance this gave a sampling error of about 30%, that is, the population ratio could lie anywhere between 370 and 660 (Kwast et al, 1986). In a similar study in Central Java, Indonesia, investigators had to visit 150,000 households and record some 15,000 births in order to identify 50 maternal deaths (Agoestina and Soejoenoes, 1989).

2.1.3.1. Reproductive Age Mortality Surveys (RAMOS)

Reproductive Age Mortality Studies are used to establish what proportions of deaths of women of reproductive ages were due to maternal causes. In this type of surveys, numbers of deaths of women of reproductive ages can be obtained from a civil registration system (where cause of death information is complete), hospital and clinical records, or from other sources. Assignment of reproductive age deaths to a maternal cause is made after an in-depth consideration of evidence from one or a combination of medical records, oral autopsies and interviews with family members or medical personnel.

An important advantage of a RAMOS approach is that it can identify the underlying cause groups of maternal deaths and their geographic clustering. The main difficulty with the RAMOS approach is in establishing a complete, or representative, frame of deaths of women of reproductive ages. In the absence of such a frame, any resulting estimates of maternal mortality are unlikely to be reliable at the national, or local, levels.

In a study of maternal mortality in Bangladesh, it is demonstrated that reliance on one data source is found to result in the misclassification of a significant number of maternal-related deaths (Koenig et al., 1988). This study employed a multi-step procedure (RAMOS methodology) to identify maternity-related deaths to all reproductive-aged women within the study area. Bangladesh has a system of continual registration of vital events- births, pregnancy outcomes, deaths, in- and out-migration - in addition to the periodic censuses, called the Demographic Surveillance Survey (DSS). The authors divided the study area into two - a treatment area and a comparison area. The initial step in detecting maternity-related deaths in the treatment area was to check death reports routinely filled for all deaths in the area. For each death, an attempt was made to identify the specific causes of death through lay reporting by family members of the deceased. Using the availability of detailed information on all pregnancy outcomes within the area by the DSS it was possible to check each reported death against the possibility of a pregnancy outcome at the time of death or during the preceding 90-day period. These procedures resulted in the identification of 126 maternity-related deaths in the treatment area. Another source of data was from community health workers who maintained an independent record-keeping system. This system collected monthly information on the pregnancy and reproductive status of all eligible women. Eleven more maternity-related deaths to women in the treatment area were identified from this source. Additional 31 maternal deaths were identified through a questionnaire administered to community health workers and family members of the deceased woman. This questionnaire covered detailed information on the circumstances surrounding, and the symptoms leading up to each death.

In the comparison area, a similar procedure was followed in matching deaths against the DSS files, resulting in the identification of 159 maternal deaths. For those deaths not identified as maternity-related following examination of the DSS records, interviews were carried out directly with the families of the deceased. This approach resulted in the detection of additional 60 maternal deaths. Based upon the identification procedures employed, 387 deaths were classified as resulting from maternity-related causes.

An early RAMOS study in Menoufia, Egypt first identified all deaths to women of reproductive age. Interviews with the family of the deceased (most often with the husband) were conducted on average between 30 and 40 days after death to ascertain the symptoms. The interview schedules were then given to a panel of medical specialists for diagnosis. To estimate the maternal mortality rate in the District, the annual number of live births was derived by applying estimated age-specific fertility rates for Egypt as a whole to projections of the female population of Menoufia at these ages based on the latest available census results. The resulting estimate of maternal mortality was 190 per 100 000 live births, compared with the national rate of maternal mortality, based on civil registration, of 93 (Fortney et al, 1984).

In India and Jamaica, multiple sources of information were used to identify deaths of women of reproductive age (hospitals, civil registers, schools, mortuaries, etc.). Each death was then similarly investigated to determine causes. A notable feature of these two studies was that no single source of information uncovered all the details (Bhatia, 1986; Walker et al, 1986).

Attractive as it is, the RAMOS approach only works if the area under study is well defined. A pilot study in Karachi, Pakistan, found the technique impossible to apply in a large urban setting. In addition to the fact that the area covered by each source of information (or informant) was impossible to delineate, there were additional difficulties due to women who had left the city to give birth in their home villages and / or to those who had come into the district in order to give birth at the city hospital.

2.2. Indirect Indicators of Maternal Mortality

There is considerable promise in the use of indirect methods to indicate high maternal mortality. Advances in demographic estimation techniques and improved surveillance measures have yielded estimates of age-sex-specific mortality rates for many countries where vital registration is poor or nonexistent.

One of the methods suggested is the use of sex ratios of mortality to estimate maternal mortality. Sex ratios of mortality refer to the male death rate divided by female death rate. These ratios when markedly less than one are sure indicators of high maternal mortality. Higher female than male mortality in the reproductive ages can, in the absence of knowledge about other factors, be taken as indicative of high maternal mortality. Chen et al, (1974) in a record-matching study in rural Bangladesh presented the impact of maternity-related female mortality in the childbearing age group. Age Specific Death Rates derived for the study area indicate that in the absence of maternity-related deaths there would be a similar pattern of death for the sexes. However, when maternal deaths are included, overall death rates for females are roughly 50 percent higher at ages 20 -34 years and 150 percent higher at ages 15 - 19.

2.2.1. Indirect Sisterhood method

The 'indirect sisterhood method' developed by Graham et al (1989) is another example of an indirect method commonly used to estimate maternal mortality in areas with poor vital registration systems. The method is efficient in terms of sample size when compared with conventional methods of estimating maternal mortality. Part of the efficiency is the result of the method whereby each respondent reports concerning all of his or her sisters; part is the result of using as the unit of recall, the life experience of each sister. The method is also relatively simple to implement. It involves only four questions so interviewer training and supervision are relatively straightforward, and it is practical to add on to comparatively small-scale surveys. The method also provides simple calculations to estimate ratios.

2.2.2. Suitability of the indirect sisterhood method

Field trials of the sisterhood method have been carried out in various countries to determine its efficacy. In all of the trials, there is always another source of data such as a surveillance system, which provides in-depth data about the deceased woman. This means that information is available about the woman's socio-demographic characteristics like previous birth histories, parity, age at first birth, and other similar data, which can help in the analysis of causal factors of the maternal death.

For instance, in the first field trial of the method conducted in 1987 in The Gambia, comparison was made of the sisterhood estimate and estimates from a rural surveillance system as well as those from a pregnancy follow-up study conducted in the area between 1982 and 1983. Validation of the results was carried out based on comparisons between the reports of siblings interviewed during the survey, and between deaths reported by this trial and by the surveillance system. Interviews were administered to both men and women. The study found the men to be well informed and involved in their sisters' lives. A sample of 2,163 individuals over age 15 were eventually interviewed, 47 percent were males while 53 percent were females. The information received from these respondents were used to derive an estimate of the lifetime risk (LTR) of a maternal death in the area of 0.0584, or 1 in 17 women are at risk of a maternal death. The maternal mortality ratio derived from the LTR is 1,005 maternal deaths per 100,000 live births. The comparison estimate from the continuous population registration maintained relating to a similar reference period indicated a maternal mortality ratio of 1,050 and 950 for 2 neighboring villages to the study area (Graham et al., 1989).

Wirawan and Linnan (1991) conducted an indirect maternal mortality study in Bali, Indonesia, the Bali Indirect Maternal Mortality Study (BIMMS). The objective of the study was to evaluate the indirect sisterhood method for estimating maternal mortality, using a prospective (direct) community-based survey undertaken from 1980 - 82 among women of reproductive age (RAMOS) as a comparison. In essence, this was an evaluation of the indirect sisterhood method vis-à-vis the RAMOS methodology. For this study, 29,093 individuals were interviewed and they reported 210 maternal deaths. The indirect sisterhood method was employed to derive the LTR of a maternal death of 0.00984 or a risk of 1 in 102 women. The resultant maternal mortality ratio for the Bali Study was 282 per 100,000 live births relating to 12 years prior to the survey. The RAMOS methodology yielded a maternal mortality ratio of 331 per 100,000 live births for 1982. The results indicate an apparent rise in maternal mortality from 282 to 331 per 100,000 live births. The authors concluded that the sisterhood method is faster, cheaper and reliable.

In 1992, in a study of maternal mortality in Southern Malawi, the method was tested yet again. The sisterhood method was used to calculate a maternal mortality ratio of 409 deaths per 100,000 live births. An in-depth questionnaire was used to determine the causes of maternal mortality in the region. It established that 56 percent of maternal deaths occurred outside a health facility, largely due to transportation or poor access to fixed health care; 25 percent of the women died from excessive hemorrhage; 20 percent from obstructed labor; 18 percent from abortion and only 4 percent from eclampsia. The authors concluded that the field experience with the sisterhood method technique combined with an in-depth questionnaire provides useful information in a simple and cost-effective manner (Chiphangwi et al., 1992).

In another trial of the method in Ghana, Ngom et al (1999) concluded that obtaining reasonably accurate estimates of age-specific-death-rates is possible using the sisterhood method. In the study the sisterhood estimate derived from a maternal mortality study conducted in the Kassena-Nankana district of Northern Ghana in 1997-98, is compared to that from longitudinal data from the Navrongo Demographic Surveillance System.

Following the successful application of the sisterhood method, attention was focused on refining the method. One study by Hanley et al. (1996) describes how to calculate a standard error to quantify the sampling variability for the sisterhood method. The importance of calculating a standard error is to enable researchers to construct confidence intervals and statistical tests and to plan the size of a sample survey that employs the sisterhood method. The authors argue that estimates of sampling variability for the sisterhood estimate can be used a priori to calculate sample size requirements and a posteriori to provide confidence limits for the estimates of the maternal mortality ratio. The confidence interval enables researchers to quantify the degree of uncertainty in the estimate that is the result of sampling error.

2.2.3. The Direct Sisterhood Method

This is a variant of the original indirect method developed by Graham et al., 1989. Rutenberg et al developed it in 1990. The method is called the 'direct' approach because no assumptions or models are used in the process of converting the collected data into estimates of maternal mortality. This method asks respondents to provide detailed information about their sisters. These questions can be added to an ongoing survey but require more time than the four questions of the original indirect method.

The data collection procedure involves listing all brothers and sisters of the respondent and then obtaining information on (a) the survivorship of each, (b) the ages of surviving siblings, (c) the ages and years ago of death of deceased siblings, and (d) for each deceased sister, if the death was due to maternal causes. The procedure of listing all siblings of the respondents in chronological order of their birth is thought to elicit more complete reporting of events than would be the case with aggregate questions about sisters. The inclusion of brothers is also thought to illicit more complete reporting of events than if the listing was restricted to sisters.

The direct estimation procedure involves computing the number of person-years of exposure to maternal mortality (this refers to the total number of years all sisters lived during some time period), and the number of maternal deaths by time. Maternal mortality rates are calculated by dividing the number of deaths by the person-years of exposure.

The maternal mortality rate divided by the general fertility rate yields the maternal mortality ratio. As the time and age at death for each sister is known, maternal mortality estimates can be made for a series of periods and for women by age group. However, estimates for narrowly defined times may be unreliable.

2.2.4. Comparison of the Direct and Indirect Methods

A detailed evaluation of the results of sibling history data collected in 14 DHS surveys showed that a significant proportion of respondents had considerable difficulties in the placement, or dating, of adult deaths, and that there was severe underreporting of maternal deaths that had occurred several years before the date of the survey (Stanton et al., 1997). The net result is that the DHS data cannot be used for analyzing time trends of maternal mortality, and even point estimates calculated by the direct method are subject to wide margins of sampling error. Further, the authors of the evaluation advise that given the large sampling errors associated with the survey-derived measures of maternal mortality, the sibling history module should not be included in surveys more frequently than once in every ten years (Stanton, et al., 1997).

The relatively complex nature of the questions used in the direct sisterhood approach suggests that it is unlikely to be an appropriate tool for use in poor countries with low literacy levels.

Table 2.1: Comparison of Direct and Indirect Sisterhood Estimates of the Maternal Mortality Ratio, DHS Surveys in Selected African Countries, 1989-1995

COUNTRY	DIRECT ESTIMATION OF MATERNAL MORTALITY RATIO 9 – 15 YEARS BEFORE THE SURVEY	INDIRECT ESTIMATION OF MATERNAL MORTALITY RATIO 12 YEARS BEFORE THE SURVEY
Central African Republic	783	1 205
Madagascar	574	730
Malawi	269	525
Morocco	429	416
Namibia	158	384
Niger	805	859
Senegal	377	462
Sudan	322	450
Zimbabwe	178	255

Source: Data from Table 4.4 in Stanton et al., 1997.

Note: The direct estimates of the maternal mortality ratio shown here are based on maternal deaths reported by respondents relating to the period 9-15 years before the survey. The number of reported deaths for this period is likely to be subject to large recall errors. The indirect estimates of the maternal mortality ratio are based on all maternal deaths reported by the respondents that relate up to the date of the survey but on average 12 years before it.

In Table 2.1, comparison of the maternal mortality estimates relating to a similar reference period made by the direct method with those made by the indirect method, for a selection of African countries, is made. The results show that estimates made by the indirect approach tend to be significantly higher than those of the direct sisterhood approach.

While it is not to be expected, that different methodologies will yield the same estimates, the magnitude of the difference is such as to seriously question the reliability of the figures made by the direct approach. The less expensive and more efficient indirect sisterhood questions should be the choice for use in surveys in countries where adult literacy is relatively low, although limitations of the method should be kept in mind (UNFPA, 1998).

The two methods provides estimates of maternal mortality that should be seen as giving orders of magnitude rather than precise ratios since both can have wide margins of errors (wide confidence intervals), Shiferaw et al., 1996. Hence, neither method provides a current estimate for the year of the survey. The direct method gives estimates centered about 5 years prior to the survey (Rutenberg et al., 1990), while the indirect method gives estimates centered about 12 years prior to the survey (Graham et al., 1989).

2.3. Model-Based Estimates

Model-based estimates have been provided by UNICEF and WHO (1996b) partly because of the limitations inherent in population-based estimates of maternal mortality and partly because many developing countries lacked official estimates of the same. The main method of estimation has been to use regression techniques to develop estimation models based on data for countries with relatively reliable maternal mortality estimates. These models are then used to predict maternal mortality for countries lacking such estimates.

This methodology (using regression) has been used in two different ways to obtain maternal mortality ratios. One way is through models that estimate maternal mortality ratios directly based on selected independent variables (Stanton and Hill, 1994). The second method is through models that estimate the proportion of deaths of women of reproductive ages that are maternal based on selected independent variables (Stanton et al., 1995). Based on this approach, WHO and UNICEF published a set of model-based country estimates of maternal mortality ratios for 1990(Table 1.1 and 1.2). The estimates are described as representing orders of magnitude rather than precise figures and are subject to wide margins of error (WHO and UNICEF, 1996b).

2.4. DETERMINANTS OF MATERNAL MORTALITY

2.4.1. Reproductive Status of Woman - Age , Parity and Marital Status

Numerous studies have shown that a woman's chances of dying because of pregnancy and delivery are affected by her age and parity. Studies on these effects have been done but their results are conflicting. Some studies find elevated risks of maternal mortality for younger and primigravida women; and lower risks among women giving birth at 20 through 24 years old, and among women having their second and third birth (parity 1 and 2), (Chen et al., 1974; Chi et al 1981); while others find no increased risk (Koenig et al, 1988).

Age and parity are so strongly associated and must be controlled for simultaneity in order to study the independent effects of each of them on maternal health. Each factor, age and parity has an independent effect on maternal mortality. Among women aged 30 through 34 years, those having their fifth birth are more likely to die than those having their second birth. These relationships are due to a combination of social and biological factors. Very young women are particularly likely to develop obstructed labor because their pelvic bones are not fully-grown. They are also more likely to die of complications of abortion since they are more frequently unmarried and so are more likely both to choose abortion and to lack the money needed to obtain safe abortion (McCarthy and Maine, 1992).

Maternal mortality rates are higher for women aged 35+ years and those below 20 years. When these rates are graphed alongside maternal age, they depict a typical 'J' shape. Perkin (1969) studied 18,000 deliveries at women's hospitals in Bangkok, Thailand, and in 1964 found the expected J-shaped gradient by age in complicated deliveries from 13.3 percent among women aged 15-19 years dropping to 11.2 percent at ages 20-24 years and rising to 23.4 percent and 21.3 percent among women aged 40-44 and 45-49 years respectively. Also in Thailand in 1971, maternal death rates rose from 154 per 100,000 births among women in their twenties to a grim 474 per 100,000 births among women in their forties. On the relationship between age and maternal mortality, Nortman (1974) analyzed parental age as a factor in pregnancy outcome for specified causes by race in the U.S. She found that obstetrical complications such as xemia, hemorrhage and sepsis (infection) rose with age among both whites and blacks.

Berry (1971) did a study on the influences of age and parity on maternal mortality in the U.S. between 1919-1969. She found that these two demographic variables had some influence on maternal mortality rates even during an era of rapid overall decline and thus concluded that the frequency and timing of births must be regulated if maternal mortality is to be brought to an irreducible minimum. She further observes that the age and parity distributions in the U.S. for the same period of study were more favorable to low maternal mortality than the childbearing patterns prevailing in many developing countries today. If these more favorable distributions of births influenced maternal mortality rates then, she concluded, the distributions with broader age ranges and more high parity births certainly contribute to the high rates of maternal mortality now prevailing in parts of Africa, Asia and Latin America.

At Mat lab Thana Bangladesh, between 1968-1970, maternal death rates rose from 380 to 810 per 100,000 deliveries for women in their twenties and those in their forties. Koenig et al, (1988) in Mat lab, did not find the classic 'J' shape but rather a U-shaped curve with the minimum level stretching from age 20 to 34 years and starting to rise again at age 35 years and above. In the study for the period 1976-1985,death rates reached 743 per 100,000 live births for the age group 15-19 which dropped to 426 per 100,000 deliveries for women in their 20's and then rose again to 791 for women in their 40's. The gradients indicated a rise beginning at age 30 years, perhaps due to age misreporting (e.g. age heaping at age 30) and omissions. The other plausible explanation could be the fact that the conditions, which favor delivery and maternal health in communities such as Mat lab, apply favorably to women aged up to 34 years.

Makokha (1980) analyzed his findings in relation to actual (medical) cause, annual distribution, age, parity, marital status, antenatal care, complications of pregnancy, labor and the puerperium and their management mode and place of delivery (for the referred cases). His findings on the relationship between age and parity of mother nullify the hypothesis that the risk of maternal death increases with age and parity. He analyzed 99 deaths. More than 50 of those dead mothers were aged between 15 and 25 years half of them being 15-20 years old and 27 percent being 26-35 years of age. Only 3 percent were aged 36 + years, the maximum age recorded being 40 years. For parity, he found that 57 percent of the 99 deaths were mothers of low parity between 1 to 3 children. Nearly half of them were young women pregnant for the first time. He acknowledged that the majority of deaths were related to abortions especially for those found to be single (39.4%) among the nine cases. His work went a long way in recognizing some of the non-medical factors that operate on women to cause maternal mortality.

Ngoka and Bansal(1987) did a retrospective study of maternal deaths at Pumwani Maternity in Nairobi for the period 1975-1984 and found an incidence of maternal mortality of 67.2 per 100,000 live births. Of the 233,111 births during the 10-year period at the hospital, there were 150 maternal deaths. They analyzed the deaths in relation to age, parity, gestation at time of death, and records of antenatal care. They found high maternal age to be an important predisposing factor in maternal mortality, and that deaths occurred mostly among primigravida and grand multiparas. They attributed the increase in maternal mortality in Kenyan hospitals to the contribution of social, personal, medical, health care and administrative factors.

Aloo-Obunga (1988) in a study of causal factors of maternal mortality and morbidity in two hospitals in Kenya, found that maternal mortality exhibited a classic J-shape relationship with maternal age. She noted that maternal mortality rates tend to be higher among women aged 15 - 19 years, reach a minimum during ages 20 - 29 and then climbs sharply again reaching a peak at ages 40 and above. She also found the relationship between maternal mortality and previous parity to be J-shaped. It would have been curvilinear (U-shaped) had parity reporting been complete among all the women studied. Mortality was generally found to be higher among nulliparous women while mortality risks for parities one through three were substantially lower, rising again at parities four and above.

Studies have also found that pregnancy-induced hypertension, obstructed labor due to the smallness of the pelvis, and malarial infection are the most common causes of morbidity and mortality among younger and primigravida women (Aitken and Walls, 1986; WHO, 1988). The increased risks may however reflect socioeconomic status and access to maternal care. The confounding effects of age and parity are also present in studies investigating the relationship between maternal health, older maternal age, and / or high parity. Population-based studies have found a pattern of increasing risk of maternal death for each successive birth after the second or third birth (Chi et al, 1981; Koenig et al, 1988). These researchers have found that older women, especially those above age 35, generally tend to experience a greater risk of death at all parities due to problems associated with malpresentation and placental abnormalities which may result in uterine rupture or hemorrhage associated with rupture.

The wantedness of pregnancy is also an important issue, especially since women who have an unwanted pregnancy are more likely than others to seek an abortion, even if the only procedures available are unsafe, illicit abortions that greatly increase the risk of death and disability (Kwast and Liffm, 1988). Where safe, legal abortions are available, case fatality rates are extremely low. The U.S. for example has a rate of 0.4 deaths per 100,000 live births (Harlap et al., 1991). Vietnam also boasts of low levels of maternal mortality because among other reasons, a few women die of the consequences of induced abortion because the procedure is legal and easily available (Hieu et al., 1999). Community studies in Bangladesh, Cuba, Ethiopia and India found that 14 to 24 percent of all maternal deaths were due to abortion (Maine, 1991). The number of women visiting Kenyatta hospital in Nairobi for treatment of complications of illicit abortions has increased over time; by the late 1980's, about 10,000 women were being treated each year (Coeytaux, 1988). Improving access to modern contraceptive methods can reduce the number of deaths from illicit abortion but it cannot eliminate them. One reason for this is that even low rates of contraceptive failure result in substantial numbers of pregnancies.

2.4.2. Health Care Behavior/ Use of Health Services

In their classic paper "Too far to walk: Maternal Mortality in Context," Thaddeus and Maine(1994) analyzed the numerous factors that contribute to the delayed treatment of obstetric complications in the developing world. They grouped these factors into three broad categories that they called "the three phases of delay": (1) delay on the part of the pregnant woman, her family, or both in deciding to seek care; (2) delay in reaching an adequate health care facility; and (3) delay in receiving adequate care once that facility has been reached.

In many settings, the physical distances between services and women in need of reproductive health care are considerable. Physical distance from facilities has been shown to be associated with maternal mortality in several studies (Fortney et al., 1985; Walker et al., 1985 Kiage, 1999, Magadi, 1999). The delay in reaching a health care facility is influenced by the cost and time of travel, the distribution of hospitals and dispensaries, the conditions of the roads, and the reliability of vehicles.

Some studies have associated lower fertility to lower maternal mortality. Fertility reduction is best achieved using family planning. Family planning operates on the level of maternal mortality via three mechanisms: (1) the proportion of births that are high risk are reduced, (2) the number of unwanted pregnanciews is reduced , and (3) the total number of births is reduced (Fortney, 1987).

Various studies have shown evidence of the operation of these mechanisms on maternal mortality. In Sri Lanka, through nearly universal education, raising the average age at marriage and increased use of family planning the number of risky pregnancies in adolescents and in older women with many children was reduced (Henry et al, 1977). The Sri Lankan maternal mortality ratio consequently dropped from 555 per 100,000 in 1950 to 95 in 1980 (Royston et al, 1987).

In China, as well, the maternal mortality ratio was lowered by substantially lowering birth rates, raising the age at marriage, and improving health care for pregnant women (Chen et al, 1982). The maternal mortality ratio, at 25 per 100,000 live births, now rivals that of developed countries (WHO, 1986).

Chile started a family planning program that increased contraceptive use and lowered abortion-related deaths from 118 per 100,000 live births in 1964 to 24 per 100,000 live births in 1979 (Ministerio de salud, 1980).

McCarthy and Maine (1992) argue that education affects maternal death or disability through three mechanisms. First, education (through its association with later age at marriage or increased use of contraceptives within marriage) is likely to be associated with lower fertility and hence with fewer pregnancies. The 1998 KDHS reports that age at first birth increases markedly with increasing level of education; for example, within the cohort age 25-29, women without any education have their first birth around age 17, five years earlier than their counterparts with a secondary or higher education.

Education could also be associated with the development of fewer complications among pregnant women if better-educated women are in general in better health than others before and during pregnancy are. Finally, education could be associated with a greater likelihood of receiving appropriate care for complications that do arise. This last mechanism can be expounded in the following propositions. Educated women might be better informed about the symptoms of complications and could therefore be more likely to make a timely decision to seek care when a complication arises. Such women might also be concentrated in urban areas and thus would live closer to health care facilities, or they might have better access to the transportation needed to those facilities. Finally, educated women might be more likely to receive appropriate and timely care when they do reach a health facility, either because they are better able to pay for that care or because, by virtue of their status, they are more likely to be well-treated.

Educated women are more likely to use obstetric services and avoid harmful traditional practices regarding pregnancy and childbearing. They are also able to feed and care for their families better. However, most girls get less education than boys do. In many societies, few parents send their daughters to school. The son's education is considered more important. Daughters are supposed to stay at home and care for younger children. Many girls are forced out of school by early marriage or pregnancy. For instance, secondary schools in Kenya lose 10 percent of their female students to pregnancy every year. Rarely can these girls return to their studies after childbirth (Khasiani, 1985).

2.4.6. Sociocultural factors

In many cultures, early marriage and childbearing are the norm. It is common in the Indian subcontinent and in Africa, but it is least common in East Asia and Latin America (Henry and Piotrow, 1977). Later marriage means a later, safer start to childbearing and lower lifetime fertility (FHI, 1987).

The risk of death is strongly influenced by one's position in society. In most circumstances, the poor and disadvantaged are more likely to die than are more affluent people. Differentials in maternal mortality by socioeconomic status exist among countries and within countries. For women, their status in the family and in the community can be related to their level of education, their occupation, their level of personal income or wealth, and their autonomy. At the family level, status can be associated with aggregate family income as well as with the occupation and education of family members. The collective resources and wealth of a local community are also important dimensions of the socioeconomic status that are likely to have an influence on the health of community members.

In a study of maternal mortality in Northern Nigeria, Wall (1998) found that among the factors contributing to the high maternal mortality (over 1000) is an Islamic culture that undervalues women; a perceived social need for women's reproductive capacities to be under strict male control; marriage at an early age (about 12 - 14 years) and pregnancy often occurring before maternal pelvic growth is complete, and directly harmful traditional medical beliefs and practices.

Over 60 percent of all women and girls in the world live in countries where their status is poor to extremely poor. For South Asia, a major determinant of women's nutritional status, aside from the family's socioeconomic status and certain traditional beliefs, is the feeding priority given to senior males in the household (Katona-Apte, 1975). Typically, older men eat first, consuming whatever they wish from the foods offered to them; women and children then consume the leftovers at a separate sitting. Caldwell (1979) among others argues that this results in the well-documented nutritional deficits of young girls and old women; it may also contribute to the poor nutritional status of pregnant women, thereby contributing to maternal mortality levels (Katona-Apte, 1975).

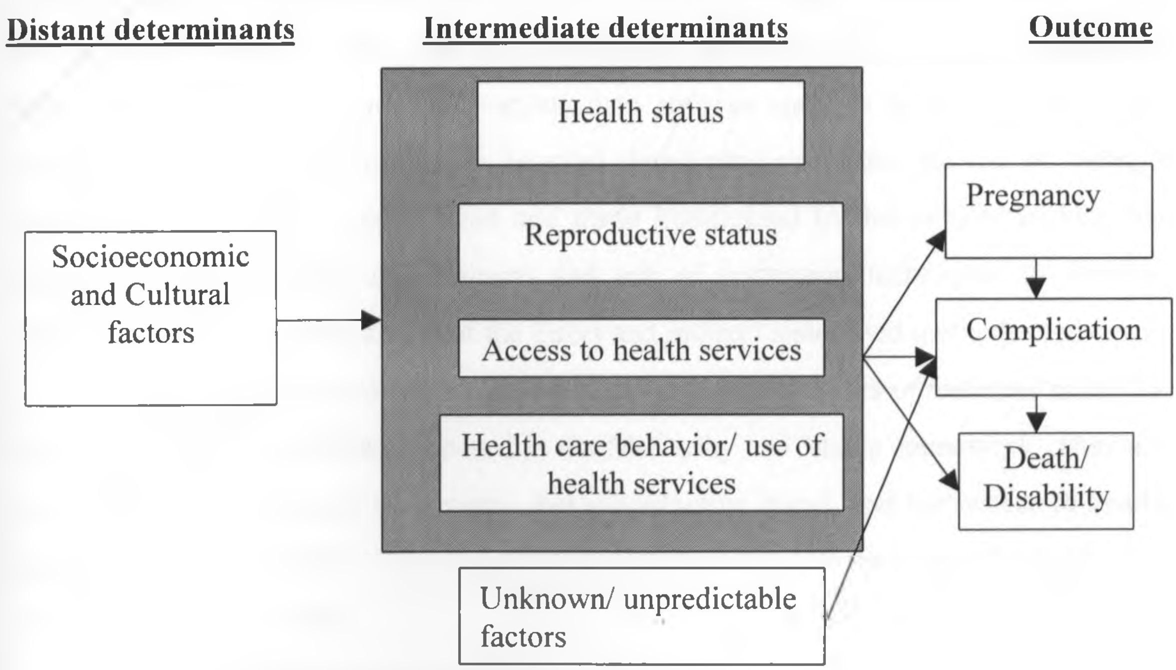
Even where facilities with capabilities for emergency obstetric care (EOC) are easily available, women may not use them. This is due to the women's status in the immediate and extended family. Decisions made in reference to the use of EOC largely overshadowed by the larger kin group. The woman does not decide on her own but the decision belongs to a spouse or a senior member of the family.

2.5. Conceptual Framework

The following is a framework for conceptualizing maternal mortality. The framework is organized around three general components of the process of maternal mortality. This study will not however analyze the relationship between the various components of the framework, but will use the framework in understanding the various differentials of maternal mortality ratios derived by the indirect sisterhood method.

Closest to the event of a maternal death are a sequence of situations or outcomes that culminate in either disability or death; these outcomes are pregnancy and pregnancy-related complications.

Figure 1.1: A framework for analyzing the determinants of maternal mortality



Source: McCarthy and Maine, 1992

A woman must be pregnant and experience some complication of pregnancy or have a preexisting health problem that is aggravated by pregnancy, before her death can be defined as a maternal death. This sequence of outcomes is most directly influenced by five sets of intermediate determinants: the health status of the woman; her reproductive status, her access to health services and her healthcare behavior (including use of health services). Finally, a set of socioeconomic and cultural background factors is at the greatest distance from a maternal death (McCarthy and Maine, 1992).

The framework is used in this study to understand the possible explanatory factors for the observed maternal mortality differentials. The framework also attempts to specify the general mechanisms through which the more distant factors operate. As McCarthy and Maine (1992) point out, more detailed, frameworks should be developed from this basic model.

2.6. Chapter Summary

This Chapter is divided into two sections. Th first section deals with review of methodological studies on maternal mortality. The issue of poor databases is outlined and this has been said to affect the ratios observed in developing vis-à-vis developed countries. The section points out various data sources such as hospital records and surveys. Due to the data limitations in most developing countries, the use of indirect estimation techniques is necessitated and those highlighted in this review include the sisterhood studies (direct and indirect) and use of regression techniques to develop estimation models. A comparison of the direct and indirect sisterhood methods is given.

In the second section of the literature review, determinants of maternal mortality are given and these are those proposed in the McCarthy and Maine framework. They are the health care behavior of the woman, her reproductive status, and her access to health services, use of services, and such distant determinants as her socioeconomic and sociocultural background.

The next Chapter gives the method of estimation, the indirect sisterhood method in details such as assumptions and procedures used to derive the maternal mortality ratio.

CHAPTER THREE: METHODOLOGY AND DATA

3.1. Introduction

This chapter intends discuss the method used in estimating maternal mortality and to derive the data used in the estimation. The study uses secondary data namely the 1998 KDHS data set. We have taken advantage of the fact that for the first time information was collected that allows the estimation of mortality related to pregnancy and childbirth.

Maternal mortality is commonly measured in two different ways. One assesses the maternal mortality rate, that is, deaths related to pregnancy per 100,000 women of reproductive age. The other assesses the maternal mortality ratio, which calculates the death associated with pregnancy per 1,000 live births. Live births are used as a proxy for the more specific and appropriate denominator, pregnancies, because of the difficulty involved in ascertaining the true number of pregnancies in a population and the relative ease of ascertaining live births.

The two rates are related to different sorts of risks. The first is a measure of the risk of death from pregnancy-related causes experienced by all women in the population. The maternal mortality ratio is more specific, that is, the risk of death experienced by pregnant women.

3.2. The indirect sisterhood method

The sisterhood method developed by Graham and colleagues (1989) will be used in this study. It is commonly referred to as the indirect sisterhood method and is a variant of the 'Sibling-Survivorship' method, which is based on questions asked of adults on the survival of all their brothers and sisters ever born. The 'sibling-survivorship' method starts from the proportion of brothers and sisters already dead among survivors currently aged x to estimate the probability of dying between birth and age x. For maternal mortality estimation three new considerations arise: by respondents knowing the cause of death; by all maternal deaths occurring between the minimum and maximum ages of childbearing, and the most widely used index - the maternal mortality ratio has a fertility component (the ratio is defined as the number of maternal deaths per 100,000 live births).

In its most basic form, the indirect sisterhood method requires respondents to report the number of their sisters who reached reproductive age (or were ever married) and how many of these sisters died of maternal causes. This data provides both a numerator (maternal deaths) and a denominator (exposed women) for the estimation of maternal mortality risks.

Questions arise as to why we should use adult siblings to get information on maternal deaths. Four reasons are provided. First, survival to adulthood of at least one sibling in any family provides an opportunity to obtain information on all of his or her sisters who reach reproductive age. Second, it enables one to reduce the number of families to visit during a survey since large numbers of women who have reached reproductive age is relatively small, given the average family sizes in high fertility settings in most developing countries. Third, in many societies, siblings remain in contact for a long time after they have left their natal home. Hence, circumstances of the death of an adult sister would be highly memorable. Finally, sisters may assist each other in the later stages of pregnancy, at the time of childbirth, or during the period immediately following delivery.

It has been suggested in some studies that data on the mortality experience of sisters will yield a biased estimator of maternal mortality. This is through three entry points. First, the experience of sib ships in which all sisters have died cannot be included in the sample. In other words, should all sisters in a family have died from any causes, there will be no one 'surviving' to report on these dead women. A second source of bias is that the experience of sib ships with a greater number of surviving sisters has a greater probability of being included in the sample. Hence, families with a larger number of sisters may be over-represented in the sample and hence bias the estimates. Thirdly, the method requires the respondent to exclude herself from the analysis, hence her experience may not be analyzed and this exclusion will tend to positively bias mortality estimates.

Graham et al. (1989) argue, " multiple reporting on sisters does not lead to any major bias in the results since the sisterhood method is based on a proportional relationship. However, it can be shown empirically that the number of sisters entering the reproductive period who are counted more than once in the denominator is matched proportionally by repeat counting in the numerator of sisters dying of maternal causes" (1989:131). Trussell and Rodriguez (1990) argue that this statement may be true for a given sib ship but is incorrect of the aggregate. In their study, Trussell and Rodroguez conclude that the key assumption of the sisterhood method is independence of the mortality experiences of adult sisters. They show that under certain conditions, the expected value of the proportion of sisters who died of maternal causes is the risk of maternal mortality. The conditions to be met are that all women in the population have an independent and equal risk of maternal mortality. These conditions when met compensate the bias from the three sources pointed out above and leave an unbiased estimator of maternal mortality.

The conversion of the proportion of women who die of maternal causes into a lifetime risk requires three assumptions. First, the sisters of respondents are representative of women exposed to the risk of maternal death and are able to report on their sibling. Second, the age distribution of the siblings of the respondent is known and the average age of sisters is the same as that of the respondent. This distribution is the same for all populations and for all age groups of respondents. Third, the distribution of maternal deaths by age is known and there is independence between the mortality of siblings (respondents and sisters). The latter two assumptions make it possible to calculate a set of adjustment factors, which convert the proportion of women dying of maternal causes into a probability of the risk of maternal death. Using a Gompertz Relational model derives this.

3.3. Data Requirement

The data required for indirect estimation by this method focuses on responses to the following four questions, which are used to calculate the proportion of sisters dying of maternal causes. They are as follows:

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 the end of the pregnancy?

These four questions together with the five-year age group of the respondent, form the basic data required for the sisterhood method. The first question defines the population ever at risk of a maternal death. The risk only occurs to women exposed to the risk of pregnancy. The period of entry to this risk is twofold for all women. Menarche can be taken as the age at first exposure to the risk of pregnancy, and therefore, to maternal death. In most populations, the age at menarche is taken to be 15 years. There are however variations in other societies. The second point of entry, defined socially, is through a culturally accepted marital union. This entry point is important since women, while physiologically at risk, may only become pregnant within a culturally accepted marital union. This is especially true in societies like Kenya, wherein marriage is nearly universal (KDHS, 1998). The method assumes that the proportion of women exposed to premarital pregnancy is small. The age at marriage is generally assumed to be above the average age at menarche.

The questions on ever-married sisters (born to the same mother) alive or dead are used as a check on the total number of ever-married sisters. Hence, the ever-married sisters alive plus that dead should equal the total number of ever-married sisters.

The qualification 'born to the same mother' helps to overcome some of the ambiguities in the term 'sister', which in some ethnic communities may be used for a variety of relations than is the norm. It is common therefore, to find the term used to refer to all female age-mates of one's biological sister. This will include close friends of one's sister, female cousins, and the like. The term is very common since there lacks an equivalent term for 'cousin' in most vernacular languages. Therefore, the term 'sister' should be carefully asked during the survey so that female respondents do not include themselves among the sisters reported, as this would inflate the denominator and thus deflate the true maternal mortality ratio.

3.4. Basis of the sisterhood method

Proponents of the method argue that one can relate the proportion of sisters dying during pregnancy, childbirth, or the puerperium, $\pi(u)$, to the probability of dying from maternal causes by age u, q (u). The relationship between the two is influenced by the pattern of maternal mortality risks over the reproductive period and the distribution of the difference between the ages of siblings and respondents. The pattern of mortality risks to a woman will depend on her age, parity (number of children she has), and the birth interval of her offspring. Women who succumb to deaths due to pregnancy and childbirth are mostly those who bear children at too early an age; those whose births are too many and too close together, and those who continue to bear children too late in life. It has frequently been suggested that births should take place in the 20-40 years age range and at parities under an arbitrary cut-off such as 4, 5 or 6 (Trussell and Pebley; Harrison et al., Chen et al., 1978).

The proportion of sisters who died of maternal causes is the sum of the distribution of sisters aged (u+z) to respondents aged u (age difference = z) by the probability of maternal death for each sister between age α and age (u+z). The reports of the proportion of siblings dead, π (u), by respondents aged u, can be expressed as follows:

$\pi (u) = \int \theta (z)\, q (u + z)\, dz.,$ 1

where q (u+z) represents q (x), the life table probability of dying before age x.

If q (x) is linear over the range where $\theta(z)$ is concentrated, the integral is equal to q (u).

Therefore, $\int \theta (z)\, q (u + z)\, dz. = q(u)$ 2

where q (u) is the proportion of siblings dead by the age of the respondent. Where u lies between 15 and 50 years then the conditions above apply that is $\pi(u)$ can be taken as an estimate of q (u). This is the general sibling survivorship technique.

However, when $\pi(u)$ relates to the proportion of adult sisters dying of maternal causes, the approximation is void. In this case, q (u) will not be linear and the distribution $\theta(z)$ is not symmetrical but truncated in the lower end. Since the reports given by respondents aged, say 30 approximately the median age for the reproductive period) will exclude sisters who have not yet reached the reproductive period.

The distribution of the differences between the ages of siblings and respondents is important in the relationship between q (u) and $\pi(u)$. In case the age u, lies in the earlier part of the reproductive period, then the reports will only provide information for those sisters who have entered the reproductive period; while, if u is over 30 years, effectively all sisters will have at least entered the period of exposure to the risk of a maternal death.

One parameter of the sisterhood method is the shape of the maternal mortality function. Graham et al (1989) used the Heather Booth Standard (Booth, 1984) to fit the schedule of mortality using a Gompertz Relational Model indicated below:

$$-\ln [-\ln \{q (u)/q (w)\}] = a + b Y^*(u) \qquad 3$$

Where $Y^*(u)$ is the Standard schedule of mortality and **a** and **b** are constants.

Using data from The Gambia, the '**b**' value was found to be about 0.8, indicating a spread about 25 percent greater than the Standard; while the '**a**' value was -0.5 for a location of the distribution some 3.5 years later in the Standard. These values tally with the expected effects of the variation with maternal age in the risk per pregnancy.

Using the model in equation 3 above, Graham *et al*, carried out calculations with a fixed distribution of $\theta(z)$ to derive another model indicated below:

$$q (u) = q (w) \exp. \{-\exp. [0.5 - 0.8Y^*(u)]\}, \qquad 4$$

Solving the above equation enables one to derive acceptable factors from the estimation of q (w) from the proportion of maternal deaths.

Based on this finding, Graham *et al* (1989) argue that the integral of $\pi(u)$ in equation 1 can be tabulated as a proportion of q (w) for an appropriate series of u values. For any observed π (u) values, the relation can be read from the tabulation and an estimated, expected q (w) calculated. This provides a corresponding estimate of q (w) for every observed π (u). These factors A_u are presented in Table 3.1.

Table 3.1: Adjustment Factors, Au, for estimating q (w) from ((u).

AGE OF RESPONDENT	A_U	AGE OF RESPONDENT	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 et al., 1989

3.5 Procedure for deriving an Estimate of Lifetime risk (LTR) of Maternal Death

Answers to the four questions will provide data for the five-year age group of the respondents, the number of respondents' ever-married sisters in the age groups, N_i, and the number of maternal deaths per age group of respondents, r_i.

In order to minimize sample errors, one should adjust the number of sisters reported in each age cohorts of the respondents by the factor A_u, rather than to operate with the number of maternal deaths expected at the end of the reproductive period. This is by multiplying the appropriate adjustment factors, A_i, to the number of ever-married sisters to derive the sister units of risk of exposure to maternal death, B_i. Calculate the lifetime risk (LTR) of a maternal death by dividing the total number of maternal deaths, r_i, by the sister units of exposure, B_i. This data is filled in for all age groups save the two younger ones - (15-19) and (20 -24). These ones will require an additional calculation before deriving the estimate of q (w). The number of sisters entering or having entered the reproductive period reported by these younger age-group respondents will exclude those sisters yet to enter the period, hence, a raising factor is required to arrive at the expected ultimate number. This factor is derived by multiplying the number of respondents in the age group by the average number of ever-married sisters reaching the reproductive period, per respondent in the older age groups (25+ years).

If the number of sisters in each respondent group is large enough, each q (w) can be taken as a separate estimate. Taking the number of maternal deaths r_i, and dividing by B_i, adjusted sister units of risk exposure gives an estimate of q (w) from the reports of the $_i$th age group of respondents. However, it is better to amalgamate the estimates for individual age groups to give a more reliable overall estimate of q (w). To do this, get an estimate of r, the total number of maternal deaths to sisters, by summing over the r_i for all the age groups. Derive an estimate of B, the total adjusted sister units of risk exposure, by summing over the corresponding B_i. Next, divide r by B to get an estimate of Q (Lifetime risk of a maternal death).

3.5.1. Deriving an Estimate of Maternal Mortality Ratio

The maternal mortality ratio is the number of deaths from maternal causes, divided by the number of live births, multiplied by 100,000. It is an indicator of the obstetric risk. Graham et al. (1989) Proposed the following formula to derive the maternal mortality ratio:

Maternal mortality ratio = {1 - (probability of survival) 1/TFR}*100 000

Where, the probability of survival = 1 - lifetime risk (LTR) of maternal death, and where TFR is the total fertility rate.

3.6 The Procedure of Estimation using the Indirect Sisterhood Method

The following is an illustration of how to derive an estimate of the maternal mortality ratio using the sisterhood method. The illustration uses national data from the 1998 KDHS.

Table 3.2 below presents the number of respondents by five-year age groups in column A, and their reported number of sisters in column B. These data can be derived directly from the survey.

Table 3.2: Illustration of data entry for maternal mortality estimation using the indirect Sisterhood method.

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS
15 – 19	1852
20 – 24	1542
25 – 29	1344
30 – 34	977
35 –39	999
40 – 44	643
45 – 49	524
TOTAL	**7881**

The number of sisters' ever-married Column C requires an adjustment. This is necessitated by the fact that the original sisterhood method is based on the mortality experiences of married women. Hence, the reported number of sisters to respondents is first adjusted by applying the proportion married (59%), using the 1998 KDHS estimate of the same. This is illustrated in Table 3.3.

Table 3.3: Adjustment of reported sisters

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C REPORTED NUMBER OF SISTERS OF RESPONDENTS	C* = C X 0.59 ADJUSTED NUMBER OF SISTERS TO RESPONDENTS
15 - 19	1852	5481	3234
20 - 24	1542	4826	2847
25 - 29	1344	4467	2636
30 –34	977	3239	1911
35 - 39	999	3202	1889
40 –44	643	1935	1142
45 –49	524	1508	889
TOTAL	7881	24658	19938

Graham et al, 1989 argue that the number of sisters who have entered the reproductive period reported by respondents in the younger age groups (15-24) will exclude those sisters yet to enter the period, and hence they propose a raising factor to arrive at the expected ultimate number of sisters in this age group. The approximation of the expected number used is proposed by multiplying the number of respondents in the younger age groups by the average number of sisters reaching the reproductive period per respondent in the older age group.

(Total sisters aged 25^+)/ (Total respondents aged 25^+) = adjustment factor

In Table 3.3 above, the total number of sisters' aged $25^+$is 8466, while the total number of respondents aged 25^+ is 4487. This yields an adjustment factor of 1.9 to be applied to the number of sisters' in the cohort 15-19 and 20-24 respectively. Sisters in the other age groups 25^+ remain unadjusted. This is illustrated in Table 3.4.

Column D (Table 3.5) relates to the reported number of maternal deaths by the respondents. Answers to the four questions indicated in Section 2.2 above provide the baseline data for calculating the number of maternal deaths. These will refer to all deaths of women during pregnancy, delivery or up to the two-month period immediately after delivery. The number of maternal deaths is filled in for all the age groups 15 to 49.

Table 3.4: Deriving the number of ever-married sisters

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C* SISTERS OF RESPONDENTS	C** SISTERS EVER-MARRIED
15 - 19	1852	3234	6145*
20 - 24	1542	2847	5409*
25 - 29	1344	2636	2636
30 –34	977	1911	1911
35 - 39	999	1889	1889
40 –44	643	1142	1142
45 –49	524	890	890
TOTAL	**7881**	**19938**	**20022**

Note: ** Adjusted by multiplying the number of sisters by 1.9

Column E (Table 3.5) is for the adjustment factors proposed by Graham et al,(1989) for relating the proportion of sisters dying of maternal causes aged u, $\pi(u)$ to the probability of dying of maternal causes by age u, q (u). The adjustments are given in Table 3.1 above.

Table 3.5: Sister units of risk of exposure to a maternal death

A AGE GROUP OF RESPON DENT	C SISTERS EVER-MARRIED	D MATERNAL DEATHS	E ADJUSTMENT FACTORS	F = CE SISTER UNITS OF RISK OF EXPOSURE TO A MATERNAL DEATH
15 – 19	6145*	14	0.107	658
20 – 24	5409*	41	0.206	1114
25 – 29	2636	49	0.343	904
30 – 34	1911	33	0.502	961
35 – 39	1889	49	0.664	1254
40 – 44	1142	30	0.802	916
45 –49	890	21	0.900	801
TOTAL	20022	237		6608

Column F (Table 3.5) provides the estimate of the sister units of risk of exposure to a maternal death for each age group, B_i. This estimate is the product of the number of sisters' ever married (column C) and the appropriate adjustment factor (column E). In Table 3.5 the sister units of risk is calculated.

Once we have the data filled in all the relevant columns, the next step is to derive an estimate of the lifetime risk (LTR) of a maternal death. This is derived by dividing the total number of maternal death (237) by the total number of sister units of risk (6608). This gives an LTR of 0.036, which means that 1 in 28 women will die of maternal causes in Kenya. It has been pointed out earlier in the study that the LTR is interpreted in terms of its reciprocal, hence, for an estimate of LTR= 0.036, the reciprocal will be (1/0.036) 28. Hence, an LTR value of 0.036 indicates a risk of death facing 1 in 28 women of childbearing age. Using this estimate of LTR (0.036) and the TFR for the appropriate period, in this case 6.7 (1989, KDHS) we compute the maternal mortality ratio using the formula:

$$MMR = 100\,000\,\{1 - (1 - 0.036)^{1/6.7}\}$$

$$= 100\,000\,\{1 - (0.964)^{1/6.7}\}$$

$$\text{But } (0.964)^{1/6.7} = 0.995$$

$$\text{Hence, } (1 - 0.995) \times 100\,000 = 500$$

This gives us a national maternal mortality ratio of 500.

3.7. The Data

The data source is the 1998 KDHS Women's Questionnaire. This questionnaire included a sibling history, which is a detailed account of the survivorship of all the live-born children of the respondent's mother (that is, maternal siblings). Each respondent was asked to give the total number of her mother's live births. The respondent was then asked to provide a list of all the children born to her mother starting with the first born, and whether or not each of these siblings was still alive at the survey date.

For living siblings, current age was collected; for deceased siblings; age at death and years since death were collected. For sisters who died at ages 10 years or above, three questions were used to determine if the death was maternity-related: "Was [NAME OF SISTER] pregnant when she died?" and if negative, "Did she die during childbirth? ", and if negative, "Did she die within six weeks of the birth of a child or pregnancy termination?" The estimation of maternal mortality by either direct or indirect means requires reasonably accurate reporting of the number of sisters and brothers the respondent ever had, the number that have died, and (for maternal mortality) the number of sisters who have died of maternity-related causes.

3.8. Quality of Data

Of the 8,233 eligible women (age 15 - 49) who were identified and sampled, 7881 were successfully interviewed, yielding a response rate of 96 percent. It was noted that response rates for male and female individual interviews were higher in rural areas than in urban areas (KDHS, 1998).

The 1998 Sibling History data was used to estimate the maternal mortality ratio. These data do not show any obvious defects that would indicate poor data quality or systematic underreporting. In the table below, the numbers of siblings reported by the respondents and the completeness of the reported data on current age, age at death, and years since death are shown. From the approximate 50,000 siblings reported in the sibling histories of KDHS respondents, survival status was not reported for only 11 (0.1 percent). Among those surviving, current age was not reported for less than 1 percent of siblings. Among the deceased siblings, complete reporting of age at death (AD) and years since death (YSD) was nearly universal with about 95 percent of data being available (KDHS 1998).

Table 3.6 shows the number of siblings reported by the respondents and the completeness of the reported data on current age, age at death, and years since death. Among the deceased siblings, complete reporting of age at death and years since death was nearly universal. For 95 percent of deceased siblings, both ages at death and years since death were reported. For only 3 percent of deceased siblings was both ages at death and years since death not reported. This means that the data is of good quality.

3.8.1. Age Distribution of Deaths

This indicates the frequency of deaths within the various age groups. In a study in rural Bangladesh, it was found that the ten-year age group with the largest number of maternal deaths was actually the same as the age group with the lowest relative risk (that is, women aged 20 through 29). In this study, forty three percent of all maternal deaths were among women in this age group. However, the reason for this paradox is that there are more births in this age group than in any other. This means that more women in this age group are exposed to the risk of maternal death.

Table 3.6: Completeness of the reported data.

SIBLING STATUS AND COMPLETENESS OF REPORTING	SISTERS NUMBERS	%	BROTHERS NUMBERS	%	TOTAL NUMBERS	%
All Siblings	24 648	100.0	24 628	100.0	49 277	100.0
Living	21 742	88.2	21 409	86.9	43 151	87.6
Dead	2 902	11.8	3 213	13.0	6 115	12.4
Missing	5	0.0	6	0.0	11	0.0
Living Siblings	21 742	100.0	21 409	100.0	43 151	100.0
Age reported	21 545	99.1	21 201	99.0	42 746	99.1
Age missing	197	0.9	208	1.0	405	0.9
Dead siblings	2 902	100.0	3 213	100.0	6 115	100.0
AD and YSD reported	2 784	95.9	3 036	94.5	5 820	95.2
Only AD missing	13	0.5	28	0.9	41	0.7
Only YSD missing	45	1.6	55	1.7	100	1.6
AD and YSD missing	59	2.0	94	2.9	153	2.5
AD = Age at death **1.2.2 YSD = Year since death**						

Source: Primary Analysis of KDHS data, Table 11.1, 1998 KDHS.

3.8.2. Lifetime risk (LTR) of maternal death

This reflects the chances of a woman dying from maternal causes over her reproductive life span. Although it is interpreted as a cohort measure, it is calculated using period data (Fortney, 1987) for practical reasons. For ease of interpretation, the reciprocal of the LTR is more frequently used than the LTR itself. For example, an LTR of 0.028 is interpreted as: One in 35 women will experience a death from maternal causes throughout her reproductive life span [1/0.028 = 35].

Calculation of the LTR usually varies according to the maternal mortality ratio estimation technique selected. Two commonly used equations for the approximation of LTR as shown by Campbell and Graham (1991) are:

LTR = 35 x Maternal mortality rate ....(a)

$1 - LTR = (1 - \text{Maternal mortality ratio})^{1/TFR}$ ....(b)

In most cases, the maternal mortality ratios shown in Demographic and Health Surveys final Country Reports are calculated using equation (b). In this study however, the LTR will be derived as an aggregate measure using the formula provided by Graham et al (1989), notably:

$$LTR = r/B$$

Where r refers to the reported number of maternal deaths and B refers to the sister units of risk exposure to maternal death.

3.8.3. Maternal Mortality Ratio

This measures the deaths associated with pregnancy per live births. In this study, we will use the formula suggested by the proponents of the method notably:

$$MMR = \{1 - (1 - LTR)^{1/TFR}\} 100,000$$

As can be seen from this formula, there is a fertility component, that is, TFR. Since the sisterhood estimate pertains to about 12 years before the survey, we shall use the TFR pertaining to this period for any estimates of maternal mortality ratio to be derived in this study.

3.8.4. Confidence Intervals

In order to calculate the confidence interval of the maternal mortality ratio estimate, it is first necessary to derive an estimate of the standard error. This standard error is calculated from the laws governing the amalgamation of the sampling errors in the estimates of lifetime risk. The data source, the 1998 KDHS, was not national in coverage since it excludes three districts in North Eastern Province and four other northern districts (Samburu and Turkana in Rift Valley Province and Isiolo and Marsabit in Eastern Province).

Sampling errors may also be in the data because 15 rural districts were over sampled namely: Bungoma, Kakamega, Kericho, Kilifi, Kisii, Machakos, Meru, Murang'a, Nakuru, Nandi, Nyeri, Siaya, South Nyanza, Taita-Taveta, and Uasin Gishu. This makes it imperative to compute the standard error (SE) and confidence interval (CI) of the estimates of maternal mortality ratio.

Hanley et al, 1996 have proposed the following formula for calculating the standard error (SE) of the estimate of LTR, such that LTR= Q:

$$SE\ [Q=r/B] = \sqrt{(r/B)(P)/ B} \quad \ldots\ldots 1$$

P is the probability of survival which is 1 - r / B or in other words, 1- LTR.

The confidence interval is computed as follows:

$$CI\ (Q) = r/B \pm Z_{\alpha/2}\ SE\ (r/B),$$

where $Z_{\alpha/2}$ is the appropriate normal deviate corresponding to a two-sided confidence level of 100(1-α).

Using Hanley et al's method, we can derive the upper and lower limits of the estimate of Q, the lifetime risk of a maternal death, denoted by Q_u and Q_L, respectively. An assumption made by Hanley et al, is that there is independence of mortality experiences of adult sisters, an assumption proposed in other studies (Graham et al 1989; Trussell and Rodriguez, 1990). This is why the calculation of the standard error employs a binomial formula.

Using the national maternal mortality estimate derived in Section 3.6 above, we shall first calculate the confidence interval of the estimate of Q. A 95 percent confidence limits for the LTR (Q) of the national estimate of Q is given by:

$$CI(Q) = r/B \pm Z_{\alpha/2}\ SE(r/B)$$

Where $SE(r/B)= \sqrt{\{r/B\}\{1-r/B\}/B}$

From Table 3.5 above, the value of Q is computed as

$$237/6608 = 0.03587$$

Hence, the confidence interval of the estimate of Q will be given by:

$$CI\ (Q) = 0.03587 \pm 1.96 \sqrt{(0.03587)\{0.96413 / 6608\}}$$

$$Q_U = 0.03587 + 0.00448 = 0.04035$$

$$Q_L = 0.03587 - 0.00448 = 0.03139$$

Where, $SE(r/B) = \sqrt{\{237/6608\}\{1-0.03587/6608\}}$

Replacing the lower and upper limits of Q in the formula for estimating maternal mortality ratio, $MMR = 1 - (1 - Q)^{1/TFR}$ we obtain the lower and upper limits of the estimate of the maternal mortality ratio as:

$$MMR_L = 100{,}000\{1 - (1 - Q_L)^{1/TFR}\}$$

$$MMR_L = 100\ 000\ \{1 - (1 - 0.03139)^{1/6.7}\} = 475$$

$$MMR_U = 100{,}000\ \{1 - (1 - Q_U)^{1/TFR}\}$$

$$MMR_U = 100\ 000\{1 - (1 - 0.04035)^{1/6.7}\} = 613$$

Hence, the national maternal mortality ratio lies between 475 and 613 maternal deaths per 100,000 live births.

3.9. Chapter Summary

This Chapter outlines the indirect sisterhood method of estimating maternal mortality. A detailed description of the assumptions, data requirements and calculations of the maternal mortality ratio is given. An illustrative example using the national data is provided to show how to derive the lifetime risk of a maternal death, and how to transform this risk into the maternal mortality ratio.

In the next Chapter, the general findings of the maternal mortality ratios and differentials are given, fulfilling both objectives of the study.

CHAPTER FOUR: MATERNAL MORTALITY ESTIMATES AND DIFFERENTIALS

4.1. Age Pattern of Maternal death

Using the national values the pattern of maternal deaths reported by the respondents is represented in the table below:

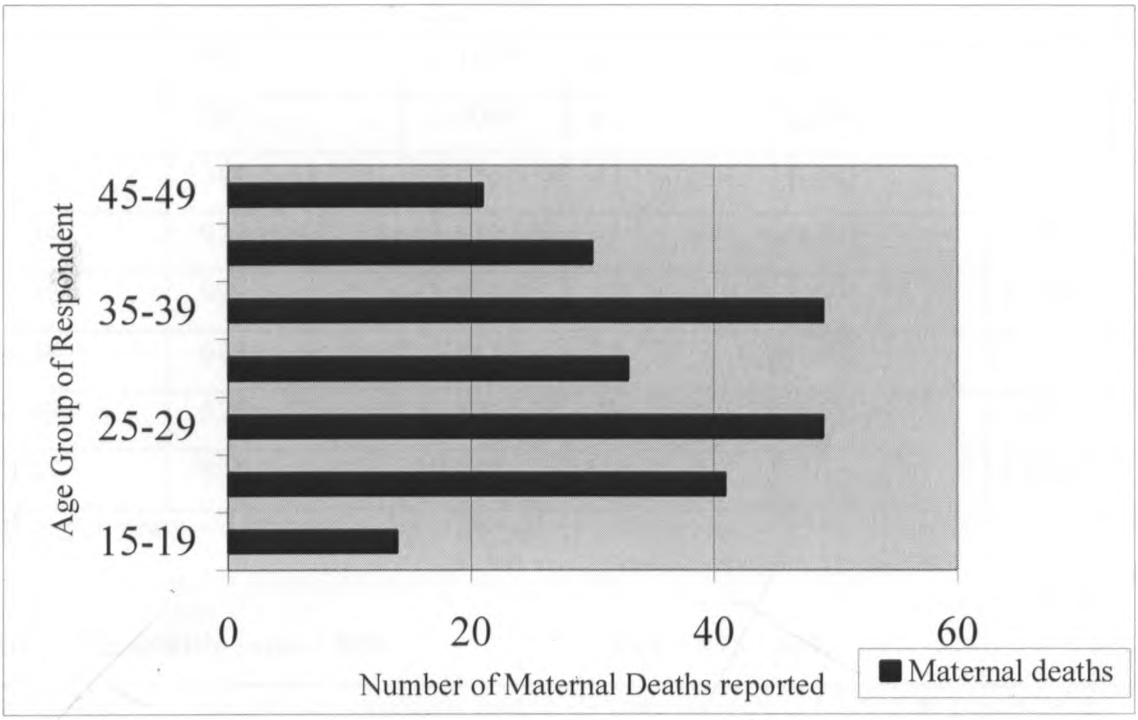
Table 4.1: Age Pattern of reported maternal deaths

AGE GROUP OF RESPONDENT	MATERNAL DEATHS REPORTED BY RESPONDENTS	PERCENTAGE DEATHS REPORTED
15 – 19	14	6
20 –24	41	17
25 – 29	49	21
30 – 34	33	14
35 – 39	49	21
40 – 44	30	13
45 – 49	21	8
TOTAL	237	100

From Table 4.1 the number of maternal deaths reported among the respondents takes An inverted 'U' shape. Respondents in the middle age groups (25-39 year olds) report higher incidences of maternal deaths than do those in the extremities (15 and 49 year olds).

In Figure 4.1 below shows the age distribution of reported maternal deaths. The figure indicates that the number of maternal deaths reported by the respondents in the age groups 25-29 and 35-39 were the highest. In general, these two age groups together reported 41% of the total maternal deaths. The respondents in the age group 15-19, only 6 % of the total maternal deaths reported the least number of maternal deaths. This was expected since the younger respondents will have more sisters excluded from the analysis since these respondents will have sisters who are yet to enter the reproductive period. The respondents in the age cohort 20-24 reported 17% of all maternal deaths; those in the cohort 25-29 reported 21% of all deaths, 30-34 reported 14% and 45-49 reported 8 % of all deaths.

Figure 4.1: Age Distribution of Reported Maternal Deaths



4.2. National –level Estimates

The first objective of this study was the estimation of maternal mortality ratio for Kenya using the indirect sisterhood method applied on the 1998 KDHS data set. The following table presents the results at the national level. The national maternal mortality ratio estimate from the direct method derived using the direct sisterhood method for the period 0-9 years before the survey (1989-1998) is 590 maternal deaths per 100,000 live births. This figure agrees with the confidence interval for the estimate derived by the indirect method, namely, between 475 and 613 maternal deaths per 100,000 live births.

Table 4.2: Estimation of lifetime risks (LTR) of a maternal death and maternal mortality ratio, Kenya.

A AGE OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, NI**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, AI***	F = CE SISTER UNITS OF RISK
15 – 19	1852	6 145*	14	0.107	658
20 – 24	1542	5 409*	41	0.206	1 114
25 – 29	1344	2 636	49	0.343	904
30 – 34	977	1 911	33	0.503	961
35 – 39	999	1 889	49	0.664	1 254
40 – 44	643	1 142	30	0.802	916
45 – 49	524	890	21	0.900	801
TOTAL	7881	20 022	237		6 608
LTR = 237/ 6608 = 0.036					
TFR = 6.7					
Maternal mortality ratio = 500			(CI = 475 - 613)		

* An adjustment was made for the respondents aged 15 -24 years: respondents 15-19=5481 (reported), 20 - 24= 4826 (reported) by multiplying the number of respondents in these age groups by the average number of sisters ever married reported by respondents aged 25-49 (that is, 1.9).
** The number of sisters ever married has been derived from applying the proportion married, 59% (KDHS, 1998) to the number of reported sisters of respondents
*** The adjustment factors were obtained from Graham et al., 1989.
Note: The TFR source is KDHS, 1989.

The indirect estimate yielded a maternal mortality ratio of 500 maternal deaths per 100,000 live births pertaining to a period of 12 years before the survey (1986).

4.3. Differentials of Maternal Mortality by Region

Table 4.3 presents the maternal mortality ratios derived by applying the sisterhood method to the background characteristics of the respondents. The maternal mortality ratios relating to the region of residence can be divided into three categories based on the findings of this study namely, high maternal mortality; moderate maternal mortality; and low maternal mortality. In the high maternal mortality category, we have such Provinces as Coast, Western and Nyanza whose maternal mortality ratios range from 600 to 900 maternal deaths per 100,000 live births. In the moderate category, we have Eastern and Rift Valley Provinces. While, in the low maternal mortality category is Central Province. These findings are in agreement with other studies done in these provinces. The maternal mortality ratios estimated are sensitive to the fertility rates of the provinces. As such, we note that Western Province, which had the highest TFR value, also has the highest maternal mortality ratio. This is expected because the high fertility rate means that more women are being exposed to the risk of maternal death.

The lifetime risk (LTR) of a maternal death in Nyanza Province is 0.043 or 1 in 23 women is at risk of maternal death in her lifetime. The highest risk is expected in Western Province with 1 in 15 women facing a risk of death in their lifetime. Central Province seems the safest region with an LTR of 1 in 125 women. This finding concurs with that of Chepng'eno (1999) in which high fertility was noted in Nyanza and Western Provinces while low fertility was noted in Central Province. In the conclusion, Chepng'eno attributes the low levels of fertility in Central Province to women desiring smaller families, spending more years in school and being more exposed to the mass media, which provides information on modern methods of family planning. Therefore, there is reduced risk of maternal death in Central Province and increased risk of death in Nyanza and Western Provinces. However, these results may not truly represent the population ratios since the study uses the Province of Residence of the respondent and not of the dead sister.

As was mentioned earlier in the study, once a mother dies the survival of her offspring is threatened (Section 1.5). The high maternal mortality ratios correspond to high infant and child mortality. This is confirmed in a study of differentials of infant and child mortality in Kenya in 1989 the time about which these estimates relate (Jada, 1994).

The study shows that Nyanza, Western and Coast Provinces experience very high infant and child mortality while Rift Valley and Eastern Provinces had low incidence of infant and child mortality. Further, Nairobi Province was found to have an intermediate incidence of infant and child mortality. This pattern of mortality is similar to that found in this study.

Table 4.3: Estimation of LTR and Maternal Mortality Ratio by Background Characteristics of the Respondent

	NUMBER OF MATERNAL DEATHS REPORTED	NUMBER OF SISTERS REPORTED	LIFETIME RISK (LTR) OF A MATERNAL DEATH	LTR 1 IN:	MATERNAL MORTALITY RATIO ESTIMATE AND CONFIDENCE INTERVAL (CI)
REGION					
Kenya	237	24 658	0.036	28	500 (CI = 475-613)
Nyanza	50	4 434	0.043	23	600 (CI = 788-447)
Coast	40	3 516	0.043	23	800 (CI=547 -1034)
Eastern	32	3 672	0.032	31	500 (CI= 302 -620)
Western	59	3 140	0.067	15	900 (CI=635-1067)
Rift Valley	41	6 375	0.024	42	300 (CI= 240-452)
Central	5	2 333	0.008	125	100 (CI = 17-258)
Nairobi	10	1 188	0.034	29	700 (CI= 288-1207)
RELIGION					
Catholic	58	6 692	0.032	31	500 (CI=370-625)
Protestant	146	15 962	0.034	29	600 (CI=478-663)
Muslim	21	1 232	0.064	16	1 200 (CI=671-1656)
TYPE OF PLACE OF RESIDENCE					
Rural	191	20 421	0.035	29	500 (CI=424-564)
Urban	46	4 237	0.043	23	900 (CI=655-1184)

The values of maternal mortality ratios reveal a consistent regional pattern which supports the hypothesis that malarial zones in Kenya and Arid and Semi-Arid Lands (ASAL) experience high maternal deaths (Sadik, 1993). He also argues that districts with very poor health facilities also experience high maternal deaths.

In a study of regional differentials of maternal mortality using 1994 Kenya Maternal Mortality Baseline Survey data, Ayiemba and Ocholla Ayayo reported that high maternal mortality rates were found in the surroundings of Lake Victoria and the coastal belt which are zones of endemic malaria. For instance, in this study, Kwale District in the coastal belt had a maternal mortality ratio of 2,221.7 deaths per 100,000 live births, while South Nyanza 1,072.9 deaths per 100,000 live births located in the Lake Victoria Basin. They argued that from the geographical perspective, semi-arid areas with nutritional deficiency, poor accessibility to medical services and acute border insecurity due to cattle rustling often experience high maternal mortality; as opposed to high potential agricultural lands with good health care infrastructure which experience low maternal mortality.

Use of contraception is a mechanism for reducing the number of total births to a woman, reducing the high-risk births and reducing the number of unwanted pregnancies (Fortney, 1987). According to the 1998 KDHS, contraceptive use in all provinces has increased since the 1993 KDHS, except for Western Province where the contraceptive prevalence rate (CPR) remains at the 1993 level. This may explain why the lifetime risk of maternal death is higher in Western Province than in the other provinces. This study has established that 1 in 15 women residing in Western Province of Kenya is at risk of maternal death in her lifetime (Table 4.3).

4.4. Differentials of Maternal Mortality by Rural/ Urban Residence

Residents in urban areas of Kenya are more likely to report a higher incidence of maternal mortality than their rural counterparts are. Based on the sisterhood estimate, urban areas in Kenya have a ratio of 900 maternal deaths per 100,000 live births compared to a ratio of 500 maternal deaths per 100,000 live births in rural areas (Table 4.3). This was not expected since urban areas are more likely to have good infrastructure, highly educated people and higher economic development than the rural areas. This may be explained in part due to the higher education levels of respondents in urban areas and hence a more accurate reporting of maternal deaths by the respondents in the urban areas. Caution is also required in interpreting this finding since as pointed out above, the type of place of residence of the respondent may not be similar to that of her dead sibling.

In a study of the state of health facilities in a rural district, Rogo et al (1997) argue that the poor state of Emergency Obstetric Care (EOC) facilities, perennial and crippling shortage of both trained staff and supplies in rural health facilities are among the factors responsible for high maternal mortality ratios in rural Kenya. For instance, the maternal mortality ratio for Siaya District in 1997 stood at 1400 deaths per 100,000 live births. Reasons for this high rate, which are representative of most of rural Kenya include *inter alia*, bad roads (made worse during the rainy season) and absence of reliable transport rendering it impossible for many women to reach the health facility in times of emergency; lack of emergency-preparedness of the rural health facilities, for example, no blood in the district blood bank and lack of Post Abortion Care (PAC) services in the health facilities.

4.5. Differentials of Maternal Mortality by Religion

A look at the differentials by the religious background of the respondent indicates that Catholic and Protestant respondents are more likely to report lower maternal mortality compared to their Muslim counterparts. The former have a similar maternal mortality ratio of averagely 550 maternal deaths per 100,000 live births compared to a grim 1,200 maternal deaths per 100,000 live births for the Muslim respondents (Table 4.3). The lifetime risk of death is higher for Muslim respondents, 1 in 16 compared to 1 in 29 and 1 in 31 for Protestants and Catholics respectively.

A possible reason for the high maternal mortality among the Muslims could be due to early marriage in Muslim communities. In the 1998 KDHS it was reported that adolescent childbearing is especially prevalent in the Coast (predominantly Muslim) and Rift Valley provinces, where 28 percent of women age 15-19 are either pregnant or already mothers. Studies have also shown that Islam law teaches that women are inferior to males. The females receive little or no education because of their inferior position in the society. In support of the view, the 1998 KDHS reports that the educational level of women in Coast Province (predominantly Muslim) is much lower than that of women in other provinces.

4.6. Differentials of Maternal Mortality by Ethnic Groups

In Table 4.4 the results of the ethnic differentials of maternal mortality are given. As already pointed out, the ethnic group of the respondent is most likely the same as that of the dead sister. A pattern of maternal mortality ratios is evident when ethnic groups are analyzed. The maternal mortality ratios can be roughly divided into three zones namely, high mortality, moderate mortality and low mortality.

In the high maternal mortality zone are the Mijikenda/Swahili, Luo and Luhya ethnic groups with ratios of over 700 maternal deaths per 100,000 live births. In the moderate category are the Meru/ Embu, the Kamba, the Kalenjin and the Kisii with ratios ranging between 400 and 500 maternal deaths per 100,000 live births. In the lower category is the Kikuyu ethnic group with a maternal mortality ratio of 200 maternal deaths per 100,000 live births.

The lifetime risk (LTR) of maternal death is highest among the Luo and Mijikenda/Swahili ethnic groups, closely followed by the Luhya. The Kikuyu and Meru/Embu have lower risks, 1 in 50 and 1in 71 women respectively. These results are similar to those found for the region of residence. The similarity is not odd and is expected since ethnic groups tend to cluster in the regions. Therefore, Nyanza, Western and Coast Provinces also have high maternal mortality incidences.

The number of maternal deaths reported by the various ethnic groups is presented in Table 4.4. The total number of maternal deaths reported by the respective ethnic groups covered in analysis is 215. Some ethnic groups were excluded from the analysis since they had reported very small numbers of maternal deaths and had very few respondents. For example, the Somali had reported mere 55 deaths. Such small numbers may distort the maternal mortality ratios.

Table 4.4: Estimation of LTR and Maternal Mortality Ratio by Ethnic background of Respondent

ETHNIC GROUP	NUMBER OF MATERNAL DEATHS REPORTED	NUMBER OF SISTERS REPORTED	LIFETIME RISK (LTR) OF A MATERNAL DEATH	LTR 1 IN:	MATERNAL MORTALITY RATIO ESTIMATE AND CONFIDENCE INTERVAL (CI)
Luhya	57	3 925	0.052	19	700 (CI=533-905)
Luo	45	2 969	0.058	17	800 (CI=557-1040)
Kikuyu	14	3 722	0.014	71	200 (CI=118-377)
Meru/ Embu	7	1 358	0.02	50	500 (CI=128-840)
Kisii	15	2 136	0.026	38	400 (CI= 209-633)
Kalenjin	27	4 295	0.024	42	400 (CI=236-520)
Kamba	24	2 738	0.032	31	500 (CI= 311-722)
Mijikenda/ Swahili	26	1 889	0.058	17	1 000 (CI=617-1378)

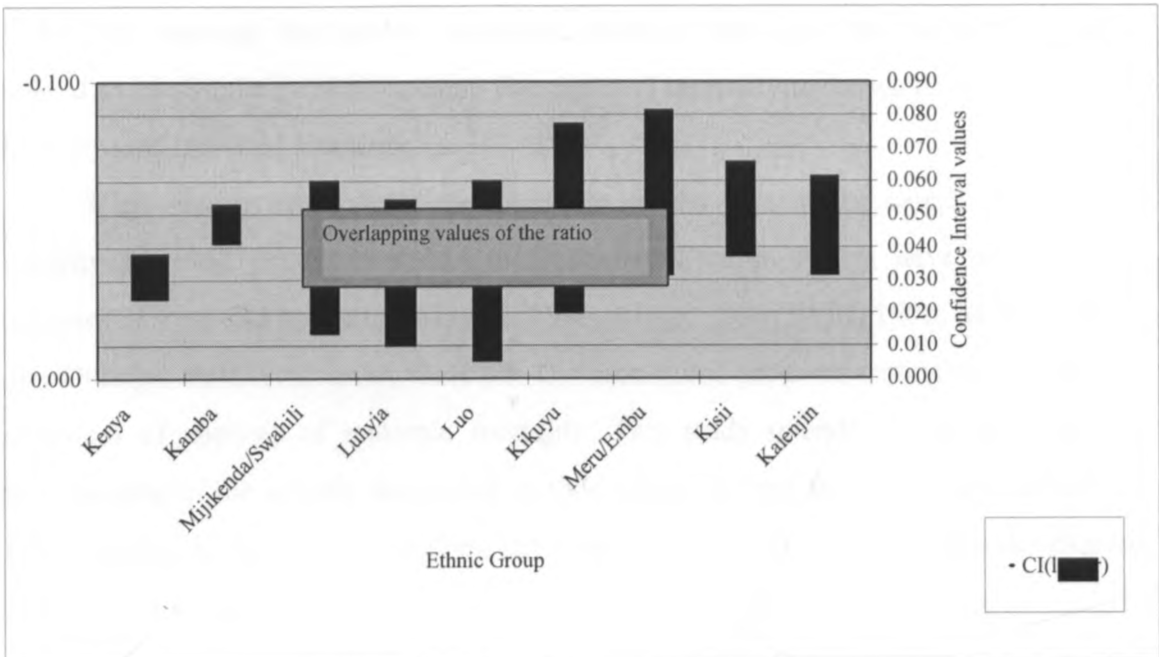
Note: Source of TFR for Ethnic groups is Wakoli, 1991.

4.6.1. Confidence Intervals of the Ethnic Maternal Mortality Ratios

As is evident from Figure 4.2, there are very wide confidence intervals in the maternal mortality estimates derived by the sisterhood method. The lengths of the bars in the figure below shows the interval between the highest and lowest maternal mortality ratio values, that is the confidence interval.

The lengths of the bars in the figure demonstrate the interval between the highest and lowest maternal mortality ratio values. The shorter the length of the bar the nearly accurate the estimate is, and the longer the length of the bar the larger the standard error of the estimate and hence the more inaccurate the estimate.

***Figure 4.2:* CONFIDENCE INTERVAL RANGES OF MATERNAL MORTALITY RATIOS**



4.7 Chapter Summary

The Chapter provides the summary of findings of the various analyses done. The maternal mortality ratios were derived against various background characteristics of the respondents. These were the region of residence (Province), type of place of residence (urban/ rural), religion (Catholic, Protestant, and Muslim), and Ethnicity. The findings of this study are consistent with other studies done in the country.

CHAPTER 5: SUMMARY, CONCLUSION AND RECOMMENDATION

5.1. Introduction

This study sets out to estimate the maternal mortality levels in Kenya using the 1998 KDHS data and the indirect sisterhood method. The use of the indirect method is credited to its simplicity in calculating the maternal mortality ratio, which is an indicator of the level of maternal mortality.

What clearly arises from the literature review is that the causes of maternal mortality are well documented and most studies done in Kenya have analyzed the correlates of maternal mortality (Magadi, 1999; Kiage, 1999; PSRI, 1996; Mutura, 1990; Aloo-Obunga, 1988). However, there has not been much focus on testing the efficacy of techniques of analysis of maternal mortality. This study intends to contribute to the understanding of the indirect sisterhood method and points out the credits and limitations of this method in the use of providing indicators of maternal mortality for a developing country like Kenya.

The study uses the Women's' Questionnaire used in the Kenya Demographic and Health Survey (1998). There are responses from 7,881 women aged 15-49 years, who reported 237 maternal-related deaths. The indirect sisterhood method developed by Graham et al, (1989) was used to derive a maternal mortality ratio. The method is termed 'indirect' because the risk of death is first obtained from the answers to the questions about the survival of respondents' sisters and subsequently transformed into the ratio through a series of simple mathematical calculations.

5.2 Chapter Summaries

Chapter 1 of this study gives a general background of the maternal mortality levels globally and in Africa in particular. Using the 1996 revised maternal mortality ratios jointly developed by WHO and UNICEF (1996b), the magnitude of the problem is portrayed. Specific studies in Kenya on maternal mortality are also pointed out and the estimates these studies provide are presented. Owing to different research tools being employed, the ratios relating to a specific region or community may be unrelated. Most studies have used hospital-based data in the analysis of maternal mortality. The limitations of the sisterhood method are also highlighted the most important being the lag time between the reference period (12 years before the survey) and the wide margins of error.

Chapter 2 outlines the review of literature on maternal mortality. The chapter is divided into two sections. The first section deals with the review of methodological studies undertaken. What is highlighted is that Africa lacks adequate data that allows for maternal mortality estimation. Most estimates of maternal mortality in Kenya have been derived from hospital records and recently two national surveys (KMMBS, 1994; KDHS, 1998) have allowed estimation of maternal mortality. The other sections point out the determinants of maternal mortality using the McCarthy and Maine's (1992) framework. Some of the factors highlighted include maternal age and parity, wanted-ness of pregnancy, use or non-use of health facilities by expectant mothers, poverty and the status of women in a given society.

Chapter 3 outlines the indirect sisterhood method of estimating maternal mortality. A broad description of the assumptions, data requirements and calculations of maternal mortality ratios is outlined. In addition, an illustrative example using the national data is outlined to show a systematic guide on how to transform the lifetime risk of death from maternal causes into a maternal mortality ratio.

Chapter 4 provides the general findings of the various analyses done. The study derived maternal mortality ratios using the background characteristics of the respondents namely: region of residence, type of place of residence, religion and ethnic grouping. Caution is therefore required in interpreting the results using these background characteristics save the ethnic group of the respondent, which is an 'acquired' status (one is born into an ethnic group). Since the sisterhood method deals with maternal siblings, this assumption is used to argue for the use of the respondent's ethnic group being the same as that of the sister.

There were large regional differentials in the maternal mortality ratios in this study (refer to Table 4.3). The regional differences should only be seen to reflect the degree of accuracy of reports from the respondents residing in these regions. However, these results should be interpreted with caution since in the analysis we use the Province of residence of the respondent, which may not be necessarily the same Province of residence of the dead sister. However, the pattern of maternal mortality ratios obtained in this study tallies with those obtained by other scholars using the Kenya Maternal Mortality Baseline Survey data; such as Kiage (1999), Magadi (1999) and PSRI (1996).

Wide confidence intervals seem apparent in the results of the estimation but this may not necessarily mean that the estimates are imprecise but also that it may lead to inappropriate interpretation of the figures. For example, if we use the point estimates gives the impression that the maternal mortality ratios are significantly different in different settings. However, the maternal mortality ratios seem to be somewhat similar since the confidence intervals overlap (refer to Figure 4.2).

5.3. Conclusion

This study has demonstrated that the indirect sisterhood method is a simple and reliable method for estimating maternal mortality. The sisterhood method allows for the estimation of maternal mortality ratios. The study has also demonstrated some of the hardships in using the maternal mortality ratio as an indicator of mortality. Beyond the wide estimates nothing more can be discerned on the true situation on the ground. For instance, the national maternal mortality ratio derived in this study is 500, with the true population value ranging anywhere between 475 and 613 maternal deaths per 100,000 live births, relating to a period of 12 years before the survey. The estimate of maternal mortality ratio from the direct method used in the 1998 KDHS Report is 590 deaths per 100,000 live births pertaining to a period of up to 9 years before the survey. From the two estimates relating to two different periods, it is not clear, if maternal mortality is on the rise or not since both point estimates (500 and 590) fall within the same confidence interval. This fact illustrates the spuriousness of using point estimates as indicators of maternal mortality.

The maternal mortality ratio usually gives values with wide confidence intervals. For instance, in this study, the maternal mortality ratio for Central Province is 100 deaths per 100,000 live births with a confidence interval ranging from 17 to 258 deaths per 100,000 live births (Table 4.3). The problem of wide confidence intervals is not simply that such estimates are imprecise. They may also lead to inappropriate interpretation of the figures. For example, using point estimates for maternal mortality may give the impression that the maternal mortality ratio is significantly different in different settings or at different times. In the Kenyan scene, the Kenya Maternal Mortality Baseline Survey (KMMBS) of 1994 gave the maternal mortality ratio as 498 (unweighted) using the direct method whereas the indirect method gave the ratio as 267. In the 1998 Kenya Demographic and Health Survey (KDHS), the ratio given was 590 using the direct method whereas this study gives the ratio as 500 using the indirect method. A quick look at the two major studies of maternal mortality may give the impression that maternal mortality is on the rise. However, since the values of the ratios are based only on the point estimates, there is need to look at the corresponding confidence intervals to discern any trends. The confidence interval for the estimate of maternal mortality derived using the 1998 KDHS and the indirect sisterhood method places the 1998 direct estimate of 590 in the same margin as the indirect estimate of 500. Hence, we cannot state if maternal mortality is on the rise or not. Instead, it may be safer to say that maternal mortality is similar within the two different periods. A look at Figure 4.2 indicates that most of the ethnic maternal mortality ratios tend to overlap.

These ratios best express the dangers that women face once pregnant, that is, obstetric risk. The ratio does not however reflect the relationships between maternal mortality and fertility. In some cases, the ratio hides the trend for example it is possible for the ratio to remain unchanged despite decreases in both the maternal mortality rate and the general fertility rate. On the other hand, a rise in the ratio can be accompanied by falls in both the maternal mortality rate and total fertility rate (Campbell and Graham, 1991).

There are also other measurement problems arising in using the maternal mortality ratio. One obvious case is absolute numbers. The maternal mortality ratio is composed of a small number in the numerator (maternal death, in our case only 237 were reported by 7,881 women) divided by a comparatively large number in the denominator (live births). Because of this, the maternal mortality ratio can fluctuate widely, particularly where levels are low. This makes it difficult to assess progress on a yearly basis.

The biggest problem in measuring maternal mortality is in identifying the numerator itself, which is a maternal death. The various factors that may account for the varying estimates of maternal mortality derived cannot be tested in this study since the data source does not allow such analysis. This is because the dead woman's socio-demographic particulars were not collected in the survey. The study has used proxy indicators of such as the Respondent's Province of residence, antenatal care, malaria incidence, and age at first marriage, among others as explanatory variables for the incidences of maternal mortality.

Despite the limitations of the ratio, the intention of such a study is to generate discussion among stakeholders on the issue of maternal health. The inevitable discussion of potential flaws in the data is useful in terms of developing more insight into the nature of maternal mortality in Kenya. Hence, such questions as the 'representativeness' of the ratios to the study area, interpretation of the findings and efficacy of the health care system should be the by products of this study. Debate should focus on these issues as well as the major causes of maternal mortality differentials observed in the data.

5.4. Recommendation for Policy Makers

This study has demonstrated that the sisterhood method yields ratios with wide confidence intervals and hence with large standard errors. Hence, sisterhood studies cannot be used to monitor changes in maternal mortality or to assess the impact of safe motherhood programs in the short term (periods of less than 5 years). Based on the results of this study, it is recommended that confidence intervals be published for all survey-based estimates of maternal mortality as a means of promoting appropriate interpretation. It was sad to note that the 1998 KDHS report did not publish the confidence interval of the estimate given for maternal mortality. Since the 1998 KDHS maternal mortality module was a pioneer study, it is recommended that all subsequent studies have confidence interval estimates.

The sisterhood method also tends to under-report early pregnancy deaths; particularly those related to abortion or those that occur among unmarried women. This arises from the fact that method deals with only married siblings. Thus, efforts should be made to use complementary approaches, especially focus group discussions to establish all deaths especially among the young, unmarried but sexually active youth.

The sisterhood method should be used to produce an estimate of the dimensions of the problem rather than as an analysis of its causes. Therefore, to delve into such analysis more in-depth investigations are required. For example, one can find out why women died through verbal autopsy - a technique that uses lay reporting, interviews, and a review panel - who, after examining the lay reports (the symptoms leading to the death), assign the cause of death to International Classification of Diseases (ICD) categories.

As experience with different methodologies has accumulated over the years, it has become clear that obtaining comprehensive information about maternal mortality requires the use of a variety of sources of information. No single source of data on maternal mortality offers a complete and reliable picture of the situation. In addition, quantitative data should be supplemented with qualitative information. There is much to be learned from examining individual maternal deaths and not just the aggregated statistics (AbouZhar, 1998). Policy makers should therefore dwell on using all possible means of establishing the deaths and estimating the ratios as well as explaining the causal factors. The KDHS maternal mortality module should be expanded so that more questions revolve around the sociodemographic details of the deceased siblings.

This study also calls for the general improvement of the civil registration system operating in Kenya. There should be proper records of deaths, hospital visits and any other information that can be used to establish causes of a maternal death. The health care system needs to be streamlined especially the emergency obstetric care. As the facility assessment study done by Rogo and others in 1998 demonstrates, the deplorable state of our health institutions especially in the rural areas where a majority of the population lives, is a huge setback to the improvement of the general health of the population. Emergency Obstetric Care (EOC) should be improved as well as strengthening the maternal care services.

5.5. Recommendation for Further Research

Further research is required using good databases to provide insight into the background characteristics of the deceased woman. One such method would be the use of Reproductive Age Mortality Surveys (RAMOS), which is the gold standard for maternal mortality studies (WHO and UNICEF, 1996a). Studies should be designed to better determine how respondents report their sisters' abortion-related deaths.

There should be use of qualitative information to supplement quantitative information to help with the identification of maternal deaths. This can be by in-depth analysis of cases of maternal death through facility-based audits (say, at Pumwani Maternity Hospital or Kenyatta National Hospital) and national-level inquiries such as the Maternal Mortality Baseline Survey of 1994.

The most important issue in maternal mortality studies is to find out why women are dying. Sisterhood studies only help us in knowing the magnitude of the problem but there is need to go beyond the statistics and establish why women in a certain area are more prone to maternal death than others. This will be useful for health care providers and community members so that they can understand the factors that underlie every maternal death and identify those that could have been avoided.

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APPENDIX 1: BASIS OF THE SISTERHOOD METHOD

α = Earliest age at childbearing (usually taken to be 15 years).

β = Latest age at childbearing (for example 49 years).

$\gamma = \beta - \alpha$ = Duration of the reproductive period (for example, 35 years).

$\theta(z)$ = Distribution of age difference between the respondent and the dead sibling.

$\theta(u, z)$ = distribution of sisters aged u+z who reached age α among respondents aged u. (For $u \geq \alpha$).

qmat (w) or q (w) =probability of dying of maternal causes between age α and β (lifetime probability).

qmat (u) or q (u) = probability of dying of maternal causes between age α and age u (for $u \geq \alpha$) with $q(u) = 0$ for $u < \alpha$, and $q(u) = q(w)$ for $u \geq \beta$.

$\pi(u)$ = Proportion of sisters who died of maternal causes among respondents aged u at the time of survey (among sisters who reached age α).

APPENDIX 2: RESULTS OF THE MATERNAL MORTALITY RATIOS ESTIMATES BY VARIOUS BACKGROUND CHARACTERISTICS OF RESPONDENTS.

NYANZA PROVINCE

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 – 19	370	1296*	3	0.107	139
20 – 24	250	889*	10	0.206	183
25 – 29	222	445	9	0.343	153
30 – 34	149	314	3	0.503	158
35 – 39	191	366	16	0.664	243
40 – 44	104	178	4	0.802	143
45 – 49	104	161	5	0.900	145
TOTAL	1390	3649	50		1164
LTR (Q) = 50/ 1164 = 0.043 TFR = 7.1 **Maternal mortality ratio = 600**					

COAST PROVINCE

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 – 19	264	726*	4	0.107	78
20 – 24	256	748*	4	0.206	154
25 – 29	203	378	13	0.343	130
30 – 34	147	262	5	0.503	132
35 – 39	162	305	8	0.664	203
40 – 44	97	143	2	0.802	115
45 – 49	97	140	4	0.900	126
TOTAL	1226	2702	40		938
LTR = 40/ 938 = 0.043 TFR = 5.5 **Maternal mortality ratio = 800**					

EASTERN PROVINCE

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	299	939*	2	0.107	100
20 - 24	224	787*	2	0.206	162
25 - 29	179	356	5	0.343	122
30 - 34	134	251	7	0.503	126
35 - 39	159	296	7	0.664	197
40 - 44	104	196	5	0.802	157
45 - 49	87	160	4	0.900	144
TOTAL	1186	2985	32		1008

LTR = 32/ 1008 = 0.032
TFR = 7.0
Maternal mortality ratio = 500

WESTERN PROVINCE

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	227	979*	4	0.107	105
20 - 24	167	704*	12	0.206	145
25 - 29	150	326	7	0.343	112
30 - 34	103	237	10	0.503	119
35 - 39	101	214	14	0.664	142
40 - 44	86	185	9	0.802	148
45 - 49	62	125	3	0.900	113
TOTAL	896	2770	59		884

LTR = 59/884 = 0.067
TFR = 8.1
Maternal mortality ratio = 900

RIFT VALLEY PROVINCE

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	450	1521*	1	0.107	163
20 - 24	387	1494*	7	0.206	308
25 - 29	351	692	12	0.343	237
30 - 34	275	552	5	0.503	278
35 - 39	249	451	4	0.664	299
40 - 44	160	298	8	0.802	239
45 - 49	105	207	4	0.900	186
TOTAL	1977	5215	41		1710
LTR = 41/ 1710 = 0.024 TFR = 7.0 **Maternal mortality ratio = 300**					

CENTRAL PROVINCE

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	144	445*	0	0.107	48
20 - 24	159	488*	2	0.206	101
25 - 29	157	291	2	0.343	100
30 - 34	115	208	0	0.503	105
35 - 39	95	169	0	0.664	112
40 - 44	68	103	0	0.802	83
45 - 49	49	66	1	0.900	59
TOTAL	787	1770	5		608
LTR = 5/608 = 0.008 TFR = 6.0 **Maternal mortality ratio = 100**					

NAIROBI PROVINCE

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	98	264*	0	0.107	28
20 - 24	99	280*	4	0.206	58
25 - 29	82	149	1	0.343	51
30 - 34	54	87	3	0.503	44
35 - 39	42	87	0	0.664	58
40 - 44	24	38	2	0.802	30
45 - 49	20	30	0	0.900	27
TOTAL	419	95	10		296

LTR = 10/ 296 = 0.034
TFR = 4.6
Maternal mortality ratio = 700

KAMBA

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	211	375*	2	0.107	79
20 - 24	171	311*	0	0.206	126
25 - 29	139	470	5	0.343	95
30 - 34	94	296	4	0.503	88
35 - 39	113	377	6	0.664	147
40 - 44	72	244	4	0.802	115
45 - 49	55	188	3	0.900	100
TOTAL	855	2738	24		750

LTR = 24/750 = 0.032
TFR = 6.3
Maternal mortality ratio = 500

MIJIKENDA / SWAHILI

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	144	249*	2	0.107	43
20 - 24	129	232*	5	0.206	78
25 - 29	108	344	9	0.343	70
30 - 34	62	191	2	0.503	57
35 - 39	87	273	5	0.664	107
40 - 44	55	140	2	0.802	67
45 - 49	48	125	1	0.900	25
TOTAL	633	1889	26		447
LTR = 26/447 = 0.058 TFR = 6.0 **Maternal mortality ratio = 1000**					

LUHYIA

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	282	1181*	4	0.107	126
20 - 24	200	873*	14	0.206	180
25 - 29	188	400	7	0.343	137
30 - 34	130	283	7	0.503	142
35 - 39	135	302	12	0.664	201
40 - 44	108	227	9	0.802	182
45 - 49	74	144	4	0.900	130
TOTAL	1117	3410	57		1098
LTR = 57/1098 = 0.052 TFR = 7.4 **Maternal mortality ratio = 700**					

LUO

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	231	769*	1	0.107	82
20 - 24	188	637*	10	0.206	131
25 - 29	150	263	9	0.343	90
30 - 34	123	247	4	0.503	124
35 - 39	116	213	13	0.664	141
40 - 44	67	106	2	0.802	85
45 - 49	84	133	6	0.900	120
TOTAL	959	2368	45		773
LTR = 45 / 773 = 0.058 TFR = 7.5 **Maternal mortality ratio = 800**					

KIKUYU

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	231	720*	0	0.107	77
20 - 24	256	763*	3	0.206	157
25 - 29	246	461	6	0.343	158
30 - 34	197	363	3	0.503	183
35 - 39	138	241	0	0.664	160
40 - 44	107	173	1	0.802	139
45 - 49	80	121	1	0.900	109
TOTAL	1255	2842	14		983
LTR = 14 / 983 = 0.014 TFR = 5.8 **Maternal mortality ratio = 200**					

MERU / EMBU

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	119	261*	0	0.107	28
20 - 24	98	269*	2	0.206	55
25 - 29	78	137	0	0.343	47
30 - 34	58	99	3	0.503	50
35 - 39	69	117	1	0.664	78
40 - 44	44	67	1	0.802	54
45 - 49	37	50	0	0.900	45
TOTAL	503	1000	7		357
LTR = 7 / 357 = 0.02 TFR = 4.1 **Maternal mortality ratio = 500**					

KISII

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	188	701*	2	0.107	75
20 - 24	115	435*	3	0.206	90
25 - 29	122	260	1	0.343	89
30 - 34	59	136	1	0.503	68
35 - 39	94	194	4	0.664	129
40 - 44	46	97	4	0.802	78
45 - 49	21	40	0	0.900	36
TOTAL	645	1863	15		565
LTR = 15 / 565 = 0.026 TFR = 6.4 **Maternal mortality ratio = 400**					

KALENJIN

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	314	1032*	1	0.107	110
20 - 24	266	1066*	4	0.206	220
25 - 29	228	468	10	0.343	161
30 - 34	174	354	3	0.503	178
35 - 39	172	302	2	0.664	201
40 - 44	97	171	5	0.802	137
45 - 49	65	135	2	0.900	122
TOTAL	1316	3528	27		1129

LTR = 27 / 1129 = 0.024
TFR = 6.4
Maternal mortality ratio = 400

URBAN RESIDENCE

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	312	879*	5	0.107	94
20 - 24	363	1064*	13	0.206	219
25 - 29	291	545	6	0.343	187
30 - 34	194	326	8	0.503	164
35 - 39	166	316	7	0.664	210
40 - 44	70	112	4	0.802	90
45 - 49	70	109	3	0.900	98
TOTAL	1466	3351	46		1062

LTR = 46 / 1062 = 0.043
TFR = 4.8
Maternal mortality ratio = 900

RURAL RESIDENCE

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	1540	5231*	9	0.107	560
20 - 24	1179	4298*	28	0.206	885
25 - 29	1053	2091	43	0.343	717
30 - 34	783	1585	25	0.503	797
35 - 39	833	1573	42	0.664	1044
40 - 44	573	1030	26	0.802	826
45 - 49	454	781	18	0.900	703
TOTAL	6415	16589	191		5532
LTR = 191 / 5532 = 0.035 TFR = 7.1 **Maternal mortality ratio = 500**					

CATHOLIC

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	518	1939*	2	0.107	207
20 - 24	411	1518*	15	0.206	313
25 - 29	375	749	10	0.343	257
30 - 34	249	484	7	0.503	243
35 - 39	265	487	12	0.664	323
40 - 44	169	319	8	0.802	256
45 - 49	141	247	4	0.900	222
TOTAL	2128	5749	58		1821
LTR = 58 / 1821 = 0.032 TFR = 6.5 **Maternal mortality ratio = 500**					

PROTESTANT / OTHER CHURCHES

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	1197	4003*	9	0.107	428
20 - 24	987	3639*	21	0.206	750
25 - 29	845	1672	30	0.343	573
30 - 34	643	1280	24	0.503	644
35 - 39	636	1220	31	0.664	810
40 - 44	402	702	18	0.802	563
45 - 49	316	542	13	0.900	488
TOTAL	5026	18058	146		4256
LTR = 146 / 4256 = 0.034 TFR = 6.1 **Maternal mortality ratio = 600**					

MUSLIM

A AGE GROUP OF RESPONDENT	B NUMBER OF RESPONDENTS	C SISTERS EVER-MARRIED, N**	D MATERNAL DEATHS, RI	E ADJUSTMENT FACTORS, A***	F = CE SISTER UNITS OF RISK, BI
15 - 19	92	239*	3	0.107	26
20 - 24	91	239*	5	0.206	49
25 - 29	80	151	5	0.343	52
30 - 34	59	96	1	0.503	48
35 - 39	56	107	3	0.664	71
40 - 44	36	62	3	0.802	50
45 - 49	30	34	1	0.900	31
TOTAL	444	928	21		327
LTR = 21 / 327 = 0.064 TFR = 5.7 **Maternal mortality ratio = 1200**					