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# ANALYSIS OF FACTORS ASSOCIATED WITH MATERNAL MORTALITY IN KENYAN HOSPITALS

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**Summary.** This paper examines the association of the sociodemographic characteristics of women and the unobserved hospital factors with maternal mortality in Kenya using multilevel logistic regression. The data analysed comprise hospital records for 58,151 obstetric admissions in sixteen public hospitals, consisting of 182 maternal deaths. The results show that the probability of maternal mortality depends on both observed factors that are associated with a particular woman and unobserved factors peculiar to the admitting hospital. The individual characteristics observed to have a significant association with maternal mortality include maternal age, antenatal clinic attendance and educational attainment. The hospital variation is observed to be stronger for women with least favourable sociodemographic characteristics. For example, the risk of maternal death at high-risk hospitals for women aged 35 years and above, who had low levels of education, and did not attend antenatal care is about 280 deaths per 1000 admissions. The risk for similar women at low-risk hospitals is about 4 deaths per 1000. To complement results from the analysis of individual patient records, the paper includes findings from hospital staff reports regarding the maternal mortality situation at the hospitals.

## Introduction

Many factors have been linked with maternal mortality risks. These include diseases, health service factors, reproductive factors and socioeconomic factors. Generally, maternal age, parity, pre-pregnancy health status and nutritional status are associated with maternal mortality. Associations have also been found between maternal mortality and the level of education and access to health care (Herz & Measham, 1987; Anandalakshmy *et al*., 1993; PSRI & UNICEF, 1996).

Studies that have examined the association between maternal mortality and age show the highest maternal mortality risks for women aged 35 years or more

(Anandalakshmy *et al*., 1993; Kestler, 1995). In a matched case-control study in India which used hospital statistics, maternal mortality was 3·4 times higher among mothers aged 35 years or older compared with mothers aged 20–24 years (Anandalakshmy *et al*., 1993). Teenage pregnancies have also been observed to be associated with higher risks of maternal mortality than pregnancies among women aged 20–24 years. Hajo & Wildschut (1995) attributed the detrimental effects of teenage pregnancies to social problems rather than physical or medical problems. They note that the majority of teenage pregnancies originate from low socioeconomic class, are unwanted and are more likely to end in abortion. Teenagers also tend to book late for delivery and, on the whole, do not make proper use of facilities for antenatal care.

Studies in various settings in the developing world have shown that lack of antenatal care is a risk factor for maternal mortality (Harrison, 1989; Anandalakshmy *et al*., 1993; Mbizvo *et al*., 1993; Fawcus *et al*., 1996). In a study in India, a relative risk of 24·8 was observed between non-use versus use of antenatal services (Anandalakshmy *et al*., 1993).

A comprehensive framework of the determinants of maternal mortality was developed by McCarthy & Maine (1992). The framework shows that socioeconomic factors act through a diverse range of reproductive and health care variables to influence maternal mortality. The authors recognized the need for research to address the relative importance of different factors on maternal mortality. According to Hajo & Wildschut (1995), one of the main problems hindering investigations of the effects of sociodemographic variables on a wide range of pregnancy outcomes is the scarcity of well-structured multivariate techniques to determine the relative importance of the various sociodemographic factors that have an impact on pregnancy outcomes.

The number of possible factors associated with maternal mortality as illustrated by the McCarthy and Maine framework is vast. This paper focuses on the effect of the sociodemographic characteristics of women, as well as differences between hospitals, on maternal mortality. The specific objectives include: to examine the effect of woman's age, parity, education, marital status and antenatal care on maternal mortality; and to investigate variation in maternal mortality between hospitals in Kenya. The quality of service that a hospital provides is a product of a number of factors such as the administration and medical management, the level and expertise of its staff, the facilities and supplies, all of which may operate as a complex random process. Although the individual and hospital factors mentioned above do not necessarily directly cause maternal mortality, they are considered as risk indicators that enable identification of high-risk groups within the population. Such measures would provide essential information for informed policy and programme decisions aimed at reducing maternal mortality in the country. With risk screening and selective referral, scarce health resources could be focused on those in greatest need (Herz & Measham, 1987).

Maternal mortality studies in Kenya are limited. Previous studies have mainly been based on individual hospitals or small-scale surveys, yielding information applicable only to small sub-groups of the population. A recent national baseline survey represented one of the first attempts to understand maternal mortality in Kenya at the national level.

Potential sources of data on maternal mortality include vital registration, community- or population-based surveys and health service statistics. Reliable data on maternal mortality in Kenya, as in other developing countries, have been scarce. Vital registration in Kenya is incomplete and the cost of a population-based survey, providing sufficient data for reliable statistical analysis, would be substantial. On the other hand, health service statistics are biased since they represent only the sub-population with access to these facilities. Only 44% of births in Kenya take place in a health facility: 34% in a public health facility, 8% in a mission health facility and 2% in a private facility (NCPD, CBS & Macro International, 1994). Even though more than half of births in Kenya do not take place in a health facility, one important question is: of the women who manage to get to the health facilities, what are their chances of dying from maternal causes and what factors are associated with this probability?

When examining factors associated with maternal mortality based on hospital statistics, it is important to be aware of potential selectivity bias within this sub-population. For instance, what are the specific reasons for entry into hospital? Is it likely that women of specific characteristics will go to hospital only when they develop complications? In a recent household-based national survey of maternal mortality in Kenya, 46% of maternal deaths were observed to occur in a health facility. Among those who died during or after childbirth, 47% of the deliveries had taken place in a health facility. The predominant reasons given for not delivering in a health facility were: the facility being too far (38%); lack of transport or emergency case (20%); and ignorance, traditional beliefs and refusal (28%) (PSRI & UNICEF, 1996). Thus for the majority of cases (58%), access to health services, rather than sociodemographic factors, is an impeding factor to better maternal health care. For about 28% of cases, who gave reasons such as ignorance, refusal or traditional beliefs, entry into hospital is likely to be associated with some of the factors to be investigated, such as maternal age and level of education.

## Data and methods

The information analysed in this paper is based on health service statistics from sixteen district and provincial hospitals in Kenya, selected from different parts of the country to give national representation. The data were collected as part of a national baseline study on maternal mortality conducted by the Population Studies and Research Institute, University of Nairobi. Information was extracted for all obstetric admissions during the year 1993 in those hospitals where records were available. Records were available for 66,080 patients, of which 234 maternal deaths were recorded. However, due to missing information on some variables, only 58,151 cases, of which 182 were maternal deaths, were included in this analysis. An assessment of the implication of excluding some cases from the analysis is addressed in the preliminary analysis.

A multilevel logistic regression model was used to describe the effect of the sociodemographic characteristics of women on maternal mortality. The two-level logistic model used is of the form:

$$\log\left(\frac{p_{ij}}{1-p_{ij}}\right) = X_{1ij}\beta_1 + X_{2ij}\beta_2 + \ldots X_{kij}\beta_k + \sigma v_j$$

where: $p_{ij}$ is the probability of maternal mortality for the $i^{th}$ woman in the $j^{th}$ hospital; $X_{1ij}$, $X_{2ij}$, . . ., $X_{kij}$ are covariates corresponding to the $i^{th}$ woman in the $j^{th}$ hospital; $\beta_1$, $\beta_2$, . . .,$\beta_k$ are the corresponding parameter estimates; $\sigma$ is a scale parameter; and $v_j$ is the hospital's risk factor and has a standard normal distribution.

The hospitals included in this analysis were selected from different regions of the country to give national representation. Since maternal mortality risks within a hospital may be correlated, the random effects model was used. The modelling process also took into consideration contextual information based on percentage of abortion and Caesarean section cases among obstetric admissions at each of the hospitals to find out if the hospitals' maternal mortality risks could be affected by the proportion of complicated cases handled. This analysis was carried out using the MLn statistical package (Institute of Education, 1995).

## Preliminary data analysis

The explanatory variables relating to individual women included in the analysis were maternal age, antenatal attendance, parity, educational attainment and marital status. The percentage distribution of the sample, and of maternal deaths by these characteristics, is given in Table 1.

Although information was extracted for a total of 66,080 patients, only 58,151 cases were included in the analysis, implying that about 12% of the total cases were excluded from the analysis due to missing data. Further, about 68% of the cases did not have information on the level of education attained. Consequently another category of education was created ('not stated') to avoid excluding such a large proportion. If the women that were excluded as a result of missing information were a select group (for example women with no formal education who died) then the results might be biased. However, if the missing cases were randomly spread across the sub-groups of women, then their omission would not seriously bias the results.

Table 1 also shows descriptive analysis carried out in order to understand the distribution of maternal deaths by the sociodemographic characteristics of women considered in this analysis. This involved cross-tabulations of maternal deaths by women's background characteristics, including chi-square tests.

The distribution of maternal mortality by age shows the expected J-shaped pattern with relatively high mortality among teenagers, lowest mortality for the 20–24 year age group and then increasing by age. Similarly, the distribution of maternal deaths by parity shows the expected pattern of increasing maternal mortality levels with parity. Antenatal clinic attendance and secondary school education are both observed to be associated with reduced maternal mortality levels.

One problem with the bivariate approach is that it ignores the possibility that a collection of variables, each of which is weakly associated with the outcome, can become an important predictor of outcome when taken together (Hosmer & Lemeshow, 1989). Furthermore, the preceding analysis examines the association of

**Table 1.** Percentage distribution of the sample and maternal deaths by selected background characteristics

| Background characteristic | Percentage distribution of sample ($n$=58,151) | Percentage maternal deaths | Total number of cases |
|---|---|---|---|
| Age group | | *** | |
| 10–19 | 22·1 | 0·33 | 12,846 |
| 20–24 | 41·4 | 0·18 | 24,062 |
| 25–29 | 22·3 | 0·36 | 12,976 |
| 30–34 | 9·7 | 0·44 | 5626 |
| 35+ | 4·5 | 0·87 | 2641 |
| Antenatal attendance | | *** | |
| Attend | 89·1 | 0·30 | 51,833 |
| Not attend | 10·9 | 0·46 | 6318 |
| Parity | | *** | |
| 0 | 24·1 | 0·26 | 14,031 |
| 1–2 | 46·3 | 0·23 | 26,933 |
| 3–4 | 18·7 | 0·39 | 10,877 |
| 5+ | 10·9 | 0·67 | 6310 |
| Education level | | *** | |
| None/primary | 23·4 | 0·46 | 13,590 |
| Secondary+ | 8·3 | 0·27 | 4798 |
| Not stated | 68·4 | 0·27 | 39,763 |
| Marital status | | ns | |
| Never/previously married | 16·8 | 0·36 | 9760 |
| Married | 83·2 | 0·30 | 48,391 |
| All | 100·0 | 0·31 | 58,151 |

ns, not significant; ***significant at 1% level.

individual variables with maternal mortality without taking into account the effect of other important variables.

A major methodological issue in this paper is that of selectivity bias in hospital data since it is possible that women who attend hospitals are a select group. Only 44% of births in Kenya take place in a health facility indicating that a significant percentage of women give birth outside the formal health sector. To check if the sample is representative of the country, a comparison of the data was made with the expected national distribution based on the 1993 Kenyan Demographic and Health Survey (KDHS). In particular, the characteristics of women who gave birth in 1993 as reported in the KDHS are assumed to reflect the distribution of women in the whole country who were at risk of a maternal death in that year.

The comparison in Table 2 gives some evidence of selectivity bias. Only 5% of pregnancy-related hospital admissions, compared with 13% of expected births, involved women aged 35 years or more. The same pattern is observed in relation to parity where only 11% of the in-patients were of parity 5 or more compared with the

**Table 2.** Distribution of 1993 pregnancy-related hospital admissions and reported births during last 5 years in the 1993 KDHS by sociodemographic characteristics of women

| Characteristic | Proportion of hospital admissions ($n$=58,151) | Proportion of KDHS reported births* ($n$=6062) |
|---|---|---|
| Age group | | |
| < 20 | 0·22 | 0·17 |
| 20–34 | 0·73 | 0·70 |
| 35+ | 0·05 | 0·13 |
| Antenatal care | | |
| Attend | 0·89 | 0·95 |
| Not attend | 0·11 | 0·05 |
| Parity | | |
| 0 | 0·24 | 0·20 |
| 1–2 | 0·46 | 0·31 |
| 3–4 | 0·19 | 0·22 |
| 5+ | 0·11 | 0·26 |
| Education level** | | |
| None | 0·19 | 0·19 |
| Primary | 0·55 | 0·59 |
| Secondary+ | 0·26 | 0·22 |

*Source: NCPD, CBS and Macro International (1994), p. 94.
**Distribution by education here excludes 'not stated' category, so cases for distribution by education do not add up to 58,151.

26% expected for this group. It is surprising that antenatal attendance is lower in the hospital data. This is probably due to the fact that some of the hospital cases included women whose pregnancies were not yet full term, and because some women attend antenatal care only towards the end of their pregnancy.

Of the hospital cases with information on education, the distribution is close to that shown in the KDHS, with perhaps a slightly higher proportion of women with secondary level education in the hospital data than the KDHS data.

Although it is not possible to measure the extent of selectively bias in the observed results using the available information, it is important to recognize the potential effect of this bias on the results. It is possible that maternal mortality risks for women of given characteristics may be overstated. This would most likely be the case if the smaller than expected proportion of women aged 35 years or more, or of higher parities, observed in the hospital data is because these women are more likely to go to the hospital only when they develop complications. On the other hand, if the smaller proportion of women in these sub-groups in hospital data is due to the fact that only a small proportion of women of such characteristics reside in areas with easy access to health facilities, such as urban centres, then it is unlikely that their maternal mortality risks would be overstated. The likelihood of the latter scenario is

strengthened by the fact that in the 1993 KDHS sample of women of reproductive age, the proportion of urban residents was 20% for women in their twenties, compared with 10% for women aged 35 years and above. However, in the absence of information on precise reasons for entry into hospital, the extent of bias due to the selective nature of hospital-based data cannot be adequately addressed. It is therefore reasonable to consider the results presented in this paper to describe maternal mortality only in Kenyan hospitals. These results cannot be safely generalized for the entire population since the rest of the population may exhibit different maternal mortality patterns.

## Multilevel logistic regression results

All variables, except marital status, were individually observed to have a significant association with maternal mortality in the bivariate analysis. However, all variables and second-order interactions were considered potentially important and included in multilevel logistic regression analysis while controlling for observable contextual variables and random hospital variation. Variables in the final model were selected by stepwise selection procedure.

The regression results show that maternal age, antenatal clinic attendance, educational attainment and the random hospital variation significantly influence maternal mortality. The contextual variables relating to proportion of abortion admissions and Caesarean sections at the hospitals were observed not to have a significant association with maternal mortality risks at specific hospitals. It is important to note that the probability of maternal death depends on both the observed covariates associated with a particular woman and the hospital risk factor. The odds ratios obtained from the model by the exponentiated parameter estimates are hospital specific and thus represent the effect on the odds of maternal death of the particular variable within a particular hospital. Since the covariates are only significant in the fixed effects part of the model, this hospital-specific odds ratios is constant for all the hospitals. The exponentials of fixed parameters are interpreted as average odds ratios because of random hospital variation (see Curtis, 1992). The parameter estimates and corresponding odds ratios for significant variables are presented in Table 3.

### *Effect of maternal age*

The risk of maternal mortality shows the expected J-shaped pattern with lowest risk for women aged 20–24 years. The odds of maternal death appear to increase significantly with age after age 25 years. Women in age groups 25–29 and 30–34 have average odds of maternal mortality, about double the odds for those aged 20–24 years. The greatest risk of maternal mortality in relation to maternal age is associated with late childbearing. The average odds of maternal mortality for women aged 35 years and above is greater than for women in the 20–24 age group by a factor of 3·7, after controlling for the effects of antenatal care attendance, education level and random variation between hospitals.

**Table 3.** Parameter estimates, standard errors and average odds ratios of maternal mortality

| Parameter | Estimate | Standard error | Average odds ratio |
|---|---|---|---|
| **Fixed effects** | | | |
| Constant | −5·74* | 0·356 | |
| Age group (20–24 is ref. category) | | | |
| 10–19 | 0·24 | 0·227 | 1·27 |
| 25–29 | 0·71* | 0·219 | 2·03 |
| 30–34 | 0·79* | 0·262 | 2·20 |
| 35+ | 1·32* | 0·271 | 3·74 |
| Antenatal attendance (Attend is ref. category) | | | |
| Not attend | 1·07* | 0·240 | 2·92 |
| Education level (None/primary is ref. category) | | | |
| Secondary+ | −0·58 | 0·325 | 0·56 |
| Not stated | −0·78* | 0·217 | 0·46 |
| **Random effect variance** | | | |
| Hospital level | 1·21* | 0·496 | |

*Significant at 5% level.

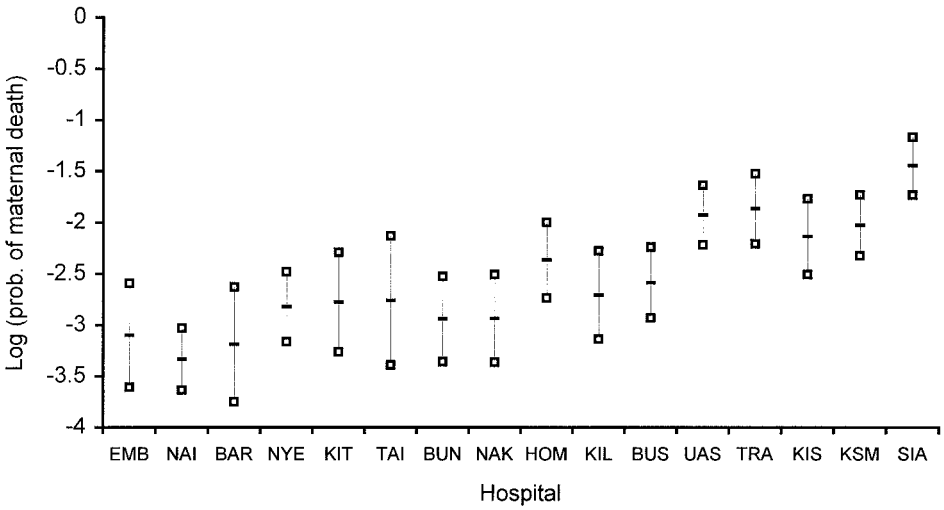
*Effect of antenatal care and education level*

Antenatal clinic attendance is observed to be significantly associated with reduced maternal mortality. The odds of maternal death for women who do not attend antenatal care is greater than that of women who attend antenatal care by a factor of 2·9, indicating a highly significant association between maternal mortality and the use of antenatal care.

Maternal education is negatively associated with the odds of maternal death. The average odds ratio of maternal mortality of women with secondary education and above compared with those with primary or no formal education is 0·56. The significantly lower odds of maternal mortality associated with women whose education level was not stated would probably imply that education records were more complete for cases of maternal death than for those who survived.

*Random hospital variation*

The scale parameter for the hospital risk factor is 1·2, indicating large variability in maternal mortality between hospitals ($p<0·05$). The simultaneous confidence intervals are calculated for hospital-level residuals to enable multiple comparison of maternal mortality risks between different hospitals, after controlling for significant sociodemographic characteristics of women. These confidence intervals may be presented graphically using error bars (see Goldstein & Healy, 1995), and any




**Key**

| | | | |
|---|---|---|---|
| NAI - Nairobi, | BAR - Baringo, | EMB - Embu, | BUN - Bungoma, |
| NAK - Nakuru, | NYE - Nyeri, | KIT - Kitui, | TAI - Taita Taveta, |
| KIL - Kilifi, | BUS - Busia, | HOM - Homabay, | KIS - Kisii, |
| KSM - Kisumu, | UAS - Uasin Gishu, | TRA - Trans Nzoia, | SIA - Siaya |

**Fig. 1.** Log of estimated average probabilities of maternal mortality by hospital with 95% simultaneous confidence intervals for hospital risk factors.

two hospitals whose confidence intervals do not overlap are considered to have significantly different effects on maternal mortality.

The hospital-level residuals have been used to estimate the contextual effect of the hospitals on maternal mortality, after controlling for observable sociodemographic characteristics of women. Figure 1 gives the log of estimated probabilities of maternal mortality for each hospital with 95% simultaneous confidence intervals for hospital risk factors. These probabilities have been calculated while holding the significant fixed covariates at their mean values. The hospitals are ordered from left to right by increasing raw probabilities of maternal death.

Since the hospitals are ordered from left to right by increasing raw probabilities of maternal mortality, it is evident that raw probabilities would tend to overestimate maternal mortality risks in some hospitals, while underestimating risks in other hospitals. For instance, Kilifi (KIL) and Busia (BUS) district hospitals have higher raw probabilities of maternal mortality than Homabay (HOM) district hospital, but this trend is reversed when the sociodemographic characteristics of women are controlled for. This implies that hospitals like Kilifi and Busia district hospitals have a higher observed risk of maternal mortality, mainly because they handle a higher proportion of women in the high-risk groups.

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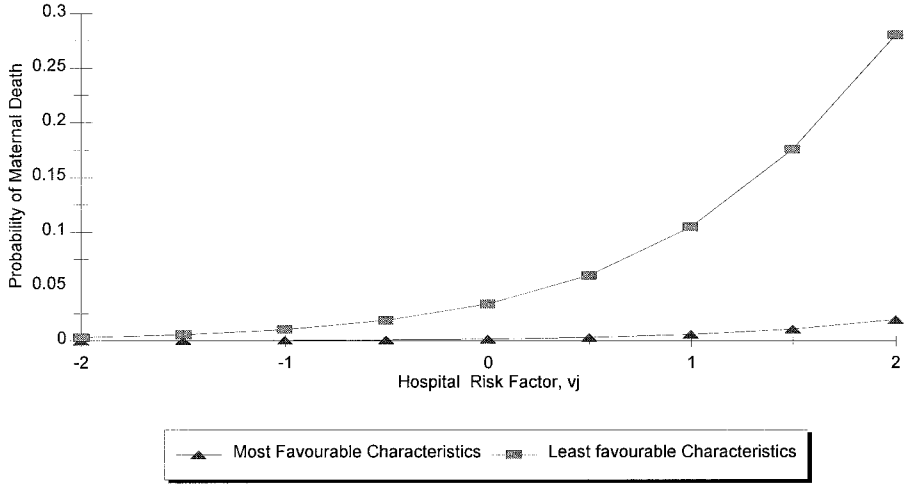


**Fig. 2.** Estimated probabilities of maternal death for women with most favourable characteristics (aged 20–24 years, attended antenatal care and education of secondary level or above) and least favourable characteristics (aged 35 years or more, did not attend antenatal care and no more than primary level education) at varying values of $v_j$.

Further analysis explored the implications of hospital variation in maternal mortality risks on the probability of death for women with specific characteristics. This is illustrated by comparing the probabilities of maternal death for women with the most favourable and least favourable characteristics for different values of the hospital risk factor, $v_j$. Women aged 20–24, who attended antenatal care and attained at least secondary education are considered to have the most favourable characteristics, while those aged 35 years and above, who did not attend antenatal care and had only primary or no education, are considered to have the least favourable characteristics. Since the $v_j$s have a standard normal distribution, the values are varied between − 2, representing hospitals with very low maternal mortality risk, and + 2 for hospitals with high maternal mortality risks. The estimated probabilities are presented in Fig. 2.

Figure 2 indicates that the variation between hospitals in maternal mortality is largest for women with least favourable sociodemographic characteristics. For women with the most favourable characteristics, estimated maternal deaths per 1000 admissions may be as low as 0·16 in low-risk hospitals and as high as 19·6 in high-risk hospitals. Among women with the least favourable characteristics, estimated maternal deaths may be as low as 3·13 and as high as 281 maternal deaths per 1000 obstetric admissions.

*Hospital staff reports on the maternal mortality situation at the hospitals*

To complement patient record data, hospital staff in charge of the maternity section provided general information relating to the maternal mortality situation at

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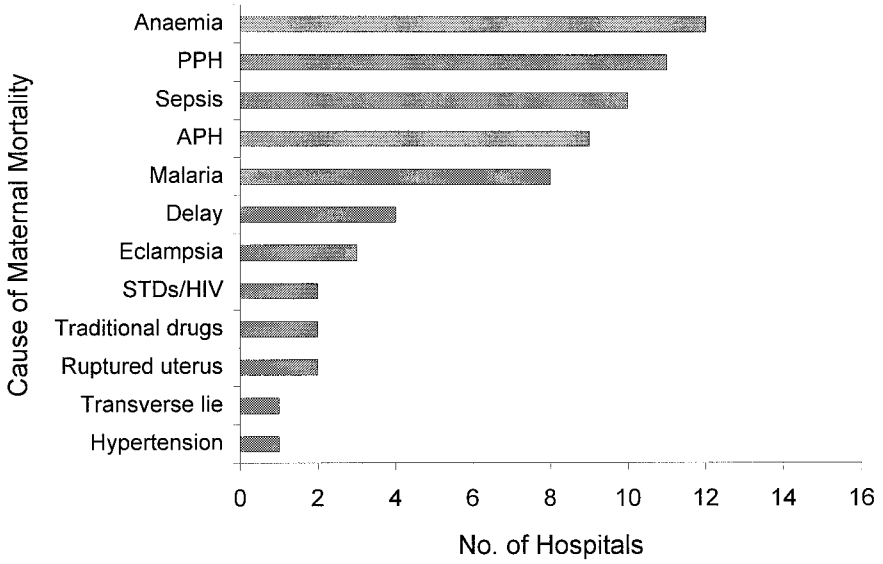


**Fig. 3.** Reported major causes of maternal mortality at the hospitals.

each of the hospitals. The reports indicated that the predominant causes of maternal mortality were anaemia, postpartum haemorrhage (PPH), sepsis, antepartum haemorrhage (APH) and malaria, as illustrated in Fig. 3.

Anaemia, mentioned as a major cause of maternal mortality in twelve of the hospitals, was mainly attributed to malaria, worm infestation and malnutrition, while sepsis was mainly puerperal, following Caesarean sections or home deliveries. Other causes of maternal mortality mentioned included: delay in arriving at the hospitals; undiagnosed eclampsia; use of harmful traditional drugs, which often resulted in ruptured uterus or intrauterine fetal death; sexually transmitted infections, including HIV; hypertension; and delivery complications resulting from the baby lying in a transverse position.

The hospital staff reports showed regional differentials in major causes of maternal mortality in Kenya. Hospitals situated in the western parts of the country such as Busia, Siaya, Homabay and Kisii hospitals in Nyanza Province, reported anaemia, malaria and delay in arrival at the hospital as the major causes of maternal deaths. This was the case also for hospitals in the Coastal region. For hospitals in the central parts of the country and some parts of the Rift Valley with low malaria prevalence (for example Nyeri, Embu, Baringo and Uasin Gishu), haemorrhage and sepsis were reported as the leading causes.

Suggestions made by the hospital staff on how maternal mortality could be reduced included: intensifying primary health care education, mentioned in about 80% of the cases; improving accessibility of services, mentioned in about three-quarters of the cases; and improving quality of services provided, cited in about half the cases. It was suggested that primary health care education should address both preventive and curative health care. Some of the issues that the hospital staff thought should be

included in primary health care education were: appropriate prenatal and postnatal care; the need to seek timely and appropriate delivery care; appropriate diet during pregnancy; and the dangers of using herbal drugs. In order to improve access of services to the women, the staff suggested that outreach health services, including mobile clinics, should be introduced in areas with poor access to health services. It was reported that the quality of services at the facilities could be improved by training more health workers, such as improving the quality of antenatal care to ensure timely identification of high-risk cases, ensuring good labour management, improving the referral system, and minimizing the risk of infection. It was also suggested that attempts be made to ensure improved provider–patient relationships.

On maternal health care, antenatal clinic attendance was reported to be satisfactory while postnatal care was reported to be very poor. It was reported that only women who delivered by Caesarean section usually received postnatal care. There were no established postnatal clinics in some of the hospitals and women visiting these health facilities for postnatal care were seen either in the gynaecology ward or advised to visit the family planning clinics. Factors hindering clinic attendance were identified as: long distance to health facilities coupled with lack of means of transport and poor communication networks; ignorance on the availability and importance of maternal health care services; traditional beliefs; poverty; and the unfriendly attitude of nurses at the clinics.

In order to improve antenatal and postnatal clinic attendance, primary health care education was cited as very important in creating awareness on availability and importance of services. Suggested communication channels included public campaigns, home visits and involving community-based workers in disseminating information. Furthermore, it was felt that there is a need for hospital staff to work closely with Traditional Birth Attendants (TBAs).

About half of the surveyed hospitals were reported to handle referrals from TBAs, while others handled referrals only occasionally or not at all. Lack of appropriate means of transport was cited as a major hindrance to timely referral. In general, the hospital staff felt that the TBAs provided useful services, especially in instances where hospitals were far away and no delivery complications were involved. Trained TBAs, in particular, were reported to do a commendable job. Some were very committed to their jobs and accompanied their clients to the hospitals where they provided useful observational histories of the clients and were always willing to learn more by asking questions. The hospital staff felt that although TBAs provided an important service, their skills were limited and there was a need for further training. It was suggested that training could take the form of seminars and should address issues relating to hygiene, diagnosis of complications and the importance of referral.

## Discussion

Many previous maternal mortality studies in Kenya have been based on small sub-groups of the population from one or two selected hospitals or small communities. The data analysed here represent one of the few attempts to understand maternal mortality in hospitals at the national level. The fact that the data are from hospitals limits the generalization to the whole population since more than one-half

of the births in Kenya occur outside health facilities. However, the results still provide useful information regarding the maternal mortality risks of women admitted to Kenyan hospitals.

In general, these results show patterns of maternal mortality consistent with what has been observed in previous studies in relation to maternal age, antenatal attendance and education level (Herz & Measham, 1987; Anandalakshmy *et al*., 1993; Fawcus *et al*., 1996). However, the magnitudes of the associations observed in this analysis are generally lower than in previous studies (Anandalakshmy *et al*., 1993; PSRI & UNICEF, 1996). Perhaps one of the reasons why this is the case is the methods used. Some of the previous studies have used bivariate analyses, which tend to overestimate associations. The preliminary analysis in this study gives a good example of this: the association between parity and maternal mortality was highly significant ($p<0{\cdot}01$) in the bivariate analysis, but once other factors were accounted for, this association became weak and insignificant ($p>0{\cdot}05$).

Higher maternal mortality at older ages, especially above the age of 35 years, has been documented elsewhere (Anandalakshmy *et al*., 1993; Kestler, 1995; Ronsmans & Campbell, 1998). Advanced maternal age is associated with a number of pregnancy complications including miscarriage, chromosomal abnormalities, uterine fibroids, hypertensive disorders, prolonged labour and pre-term delivery amongst others (Hajo & Wildschut, 1995).

The observed association between antenatal care attendance and maternal mortality also corroborates findings from previous studies in other developing countries identifying lack of antenatal care as a risk factor for maternal mortality (Harrison, 1989; Anandalakshmy *et al*., 1993; Fawcus *et al*., 1996). Antenatal care can avert maternal deaths through the early detection of pregnancy-induced hypertension before onset of eclampsia. It can also help to detect placenta praevia before the onset of catastrophic haemorrhage (Fawcus *et al*., 1996).

The correlation of mortality risks within hospitals is also an important issue since studies that ignore this can give misleading results. The results of this study suggest that there is significant correlation of maternal mortality risks within hospitals. This correlation may be attributed to unobserved hospital factors such as resources (staff and finances), equipment, supplies, as well as hospital administration and management. Comparing two extremes, Pumwani hospital in Nairobi is the largest maternity hospital in the country and is relatively more advantaged in terms of qualified personnel and facilities to handle expected childbirth complications. By contrast, Siaya district hospital, which has the highest maternal mortality risk, is in Nyanza Province, which is in one of the least developed regions of the country.

During fieldwork visits to the hospitals it was observed that Siaya hospital was indeed in a poor state and did not even have a water supply at the time of the survey. Patients admitted to the hospital had to rely on visiting relatives and friends to bring them water, often from contaminated sources, for general use, including bathing. Furthermore, most of the equipment available was not functioning at the time of the survey. It is easy to see how patients admitted to such a hospital would have an extremely high risk of maternal death.

Another reason for the between-hospital variation in maternal mortality risks may be a regional effect. The level of development in Kenya, as in most other African

countries, is uneven, with some regions being more advantaged than others. Thus, it is expected that in regions where transport is available, and where there are many health facilities, maternal mortality would be lower than in those regions without these facilities. The environmental conditions in a region may also make its members more or less susceptible to diseases such as malaria. Most of the hospitals associated with significantly lower maternal mortality risks are from the more developed central and eastern parts of the country. These areas are almost malaria-free and the hospitals probably handle less-serious cases. Pumwani hospital, for example, mainly handles patients from Nairobi and surrounding areas. The patients have easy access to the hospital and are likely to reach it in good time.

On the other hand, hospitals associated with higher maternal mortality risks are predominantly from the malaria zone in the relatively less-developed western parts of the country. These hospitals will most probably handle a higher proportion of anaemia cases resulting from malaria and/or poverty-driven malnutrition. This observation is supported by hospital staff who identified anaemia as the predominant cause of maternal mortality at such hospitals. Nevertheless, despite the evidence of regional effects, there still exists differences between hospitals within some regions. For example, Baringo is associated with one of the lowest, while Trans Nzoia and Uasin Gishu district hospitals have among the highest maternal mortality levels, yet these hospitals are within the same region of Rift Valley Province.

## Conclusion

This investigation highlights variation in maternal mortality risks between Kenyan hospitals after controlling for individual women's characteristics. The study provides further evidence of associations between maternal mortality and maternal age, and also attendance at antenatal clinics. The significant between-hospital variation demonstrates how mortality risks for women can be elevated just by choice of hospital. The quality of maternal health care is one factor; some of the hospitals visited during the fieldwork were well below standard, lacking even water. Two important steps in reducing maternal mortality in Kenya should be to ensure that hospitals provide improved health care and that women are educated on the risks of childbearing at older ages.

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