

RESEARCH

Causes and Risk Factors for Maternal Mortality in Rural Tanzania - Case of Rufiji Health and Demographic Surveillance Site (HDSS)

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Abstract

Complications of childbirth and pregnancy are leading causes of death among women of reproductive age. Developing countries account for 99% of maternal deaths. The aim of this study was to explore levels, causes and risk factors associated with maternal mortality in rural Tanzania. Longitudinal data (2002-2006) from Rufiji HDSS was used where a total of 26 427 women aged 15-49 years were included in the study; 64 died and there were 15 548 live births. Cox proportional hazards regression was used to assess the risk factors associated with maternal deaths. MMR was 412 per 100 000 live births. The main causes of death were haemorrhage (28%), eclampsia (19%) and puerperal sepsis (8%). An increased risk of 154% for maternal death was found for women aged 30-39 versus 15-19 years (HR=2.54, 95% CI=1.001-6.445). Married women had a protective effect of 62% over unmarried ones (HR=0.38, 95% CI=0.176-0.839). (*Afr J Reprod Health* 2013; 17[3]: 119-130).

Résumé

Les complications de l'accouchement et de la grossesse sont les principales causes de décès chez les femmes en âge de procréer. Les pays en développement représentent 99% des décès maternels. Le but de cette étude était d'explorer les niveaux, les causes et les facteurs de risque associés à la mortalité maternelle dans les milieux ruraux de Tanzanie. Les données longitudinales (2002-2006) de SSDS de Rufiji a été utilisé dans une étude où un total de 26 427 femmes âgées de 15-49 ans ont été incluses, 64 sont mortes et il y a eu 15 548 naissances vivantes. La régression proportionnelle de risques de Cox a été utilisée pour évaluer les facteurs de risque associés à la mortalité maternelle. Le TMM était de 412 pour 100 000 naissances vivantes. Les principales causes de décès étaient les hémorragies (28%), l'éclampsie (19%) et l'infection puerpérale (8%). L'on a enregistré un risque accru de 154% par rapport à la mortalité maternelle chez les femmes âgées de 30-39 contre 15-19 ans (HR = 2,54, IC = 1,001 à 6,445 95%). Les femmes mariées avaient un effet protecteur de 62% par rapport aux femmes non mariés (HR = 0,38, IC = 0,176 à 0,839 95%). (*Afr J Reprod Health* 2013; 17[3]: 119-130).

Keywords: Maternal death, maternal mortality, risk factors and developing country

Introduction

Maternal mortality represents a devastating medical complication in many societies. It has been realized that complications of childbirth and pregnancy are leading causes of death among women of reproductive age¹. It is due to this that complications of childbirth and pregnancy have remained a core issue in the focus of international development efforts, this is clearly illustrated by the fact that improved maternal health and safety is named as a target for the fifth millennium development goal (MDG) set for accomplishment by the year 2015².

A study carried out by Hill et al. (2007) between 1990- 2005 showed that there were 535

900 maternal deaths in the world with sub-Saharan Africa and Asia accounting for 50% and 45% of the cases respectively³. The study further revealed that in as much as maternal mortality globally was on the decrease by 2.5%, the decrease did not filter down to sub-Saharan Africa where the status quo was maintained³. The reasons for this vary from one place to another and as such specific studies need to be initiated for further clarification. A systematic review done by Gil-Gonzalez et al. (2006) revealed that scientific studies published between 2000 and 2004 about the main causes of maternal death under-reported obstructed labour, unsafe abortion and haemorrhage⁴. The authors

further documented that most studies analysed were cross-sectional, and were carried out in developed countries without the participation of researchers in developing countries where maternal mortality was actually higher.

Maternal mortality ratios (MMR) in developed countries (such as Sweden, Norway, United Kingdom) range from 5.4 to 12 per 100 000 live births while middle income countries such as Mexico and Honduras report 106 or 280 maternal deaths per 100 000 live births, respectively^{2,3}. This was supported by a study conducted in the USA which showed a maternal mortality ratio of only 5.5 per 100 000 live births⁵. Studies have rated Africa's maternal mortality ratio as ranging from 424 to 2151 per 100 000 live births⁶⁻⁸. The latest Tanzanian Demographic and Health Survey 2004-2005 reported MMR as 578 per 100 000 live births and further identified high maternal mortality ratio as a major countrywide problem due to poverty⁹. The main reasons advanced were poor health care services, incidences of infectious diseases and high fertility.

Maternal mortality is a rare event and difficult to measure as an indicator since a large sample size is needed, hence there is a paucity of epidemiological information on maternal deaths. Therefore, the existence of demographic surveillance systems in rural Tanzania offer a unique opportunity to conduct exhaustive studies to identify possible causes and risk factors for maternal deaths, this has been done in other areas like Ethiopia and Senegal¹⁰⁻¹².

Causes of maternal deaths

According to the World Health Organization, the percentage decrease in maternal mortality ratio between 1990 and 2005 was 5.4% worldwide; however, this figure was only a meagre 1.8% in sub-Saharan African². Whereas all the figures are below the millennium development goal target of 5.5%, the case for sub-Saharan Africa is particularly worrying, highlighting the need for further research to promote informed policy frameworks.

Causes of maternal deaths are numerous and vary from one place to another depending on prevailing factors. Research conducted by Ramos

et al. (2007) in Argentina found that the most common causes of maternal death were abortion complications, haemorrhage, sepsis and hypertensive disorders¹³. The causes were not the same for the southern part of Africa where Kongnyuy et al. (2009) found that the leading causes of maternal death in Malawi were postpartum haemorrhage, postpartum sepsis, and HIV/AIDS accounting for direct and indirect maternal causes¹⁴.

However, studies conducted in Senegal, Guinea Bissau and Nigeria showed that the leading causes of maternal death were puerperal sepsis, haemorrhage, eclampsia and abortion complications which took the heaviest toll on the women of reproductive age¹⁵⁻¹⁷.

Though studies have been carried out in different regions of Tanzania to establish the leading causes of maternal death¹⁸⁻²¹, longitudinal data from HDSS still need to be used to ascertain the leading causes of maternal death; due to large sample frame. It is worth noting that the leading causes of maternal death found from previous studies were haemorrhage, sepsis, HIV/AIDS and eclampsia.

Risk factors for maternal deaths

A study conducted by Christian et. al (2008) in Nepal found that maternal age and parity were contributing risk factors for maternal mortality; maternal age greater than 35 years was associated with a three- to four-fold increase in mortality, whereas increased parity conferred increasing protection²⁵. Jahromi et al. (2008) also found that maternal complications increased in women aged 40 years and above whereas Garenne et al. (2003) found that the risk factors associated with maternal mortality are parity, lack of antenatal visit, low level of maternal education and marital status¹⁵. It is worth noting that, Emery et al. (1992) also found that a favourable change in mothers' age-parity distributions contributed up to 24% of the drop in a regional change of maternal mortality in Canada as well as marital status³⁰.

In Tanzania several studies have been conducted to assess risk factors for maternal deaths^{19,20,22,23,24} while similar studies have been conducted in other settings^{15,17,25}. These studies

revealed that higher maternal age, low level of maternal education, higher parity, marital status, low socio economic status, obstetric factors and place of delivery were associated with increased risk of death. Previous studies have also shown that risk factors for maternal mortality include low maternal education level^{26,27}, maternal age, parity²⁸⁻³¹, number of antenatal care visits³², place of delivery and socio-economic status³³. Familial technique which encompasses use of educational level, source of water, type of toilet and floor to determine poverty status of women by linking poverty and maternal deaths has indicated that with increasing poverty, the proportion of women dying of non-maternal causes generally increased, and the proportion dying of maternal causes increased consistently³⁴. This is because social status of women in developing countries limits their access to basic education or economic resources, which in turn affects their ability to make decisions related to their health³⁵. In Indonesia 32 to 34% of maternal deaths occurred among women from the poorest quintile of the population³⁴. In this respect Graham et al. (2004) is of the opinion that it is not enough to express health policy goals as societal averages and thus efforts should be concentrated on assessment of data in relation to poverty, equity and inequality³⁴. This ensures relevant interventions in order to provide sustainable solutions in the health sector. Through categorizing of index of asset ownership within households, other studies conducted in Africa on the effect of socio economic status on morbidity and mortality in Demographic surveillance systems (HDSS) has shown that households in poorest quintiles have worse healthcare indicators compared to those in least poor quintiles³⁶⁻³⁹.

Methodology

Study objective

The aim of this study was to explore the levels, causes and risk factors associated with maternal mortality in rural Tanzania.

Study design

The research was based on longitudinal study design for women of reproductive age that were part of the population of the Rufiji Health and Demographic Surveillance Site (RHDSS) which has been under continuous surveillance since 1998. The study involved secondary analysis of longitudinal data on maternal deaths and live births from the Rufiji HDSS collected within the period 2002-2006.

Primary data source

The dataset from the HDSS provided a comprehensive and systematic recording on an annual basis of all vital events (births, deaths, in and out migrations), pregnancies and other associated demographic, health and socio-economic indicators, including educational status, collected on a quarterly basis.

Data collected through the verbal autopsy method was used to identify maternal deaths and their probable causes and this was done by interviewing close caregivers of the deceased. Two medical doctors made an independent review of the information collected to come up with the probable cause of death. Where there was no agreement between them in diagnosis, a third coder, blinded to their assessment, made a further independent diagnosis. If two of the three diagnoses corresponded, a decision was reached and this was accepted as the cause of death.

Study area

This study was carried out in the Rufiji health and demographic surveillance site which is in Rufiji district situated 178 kilometres South of Dar es Salaam- Coastal region. It is 1813 km² from 7.47⁰ to 8.03⁰ south latitude and 38.62⁰ to 39.17⁰ east longitude and has 31 villages in total. Rufiji district has about 57 health facilities and these include two hospitals (1 government and 1 Non-Governmental Organization), five government health centres and 50 dispensaries. Though 89% of the population lives within 5 kilometres of a

formal health facility, 43% of the deliveries still occur outside the health facility or at home.

Study population

Rufiji district has a population size of about 226 000 individuals out of which Rufiji Health and Demographic Surveillance Site has taken a population of 87 000 people within 6 contiguous wards (about 47% of the district) to be under continuous surveillance. These individuals in the RHDSS live in 17 500 scattered households making a population density of 13 people/km². The population structure is as follows: <1 year old, 2.7%; 0–4 years old, 16%; 5–14 years old, 30%; 15–64 years old, 46% and ≥65 years old, 8%. Rufiji district is mainly rural though its population is clustered around Ikwiriri, Kibiti, Bungu and Utete with the mean household size for the whole district being five persons. The ethnic groups in this region include Pogoro, Makonde, Matumbi, Magatwa, Ngindo and Ndegereko who are the original inhabitants and the largest group.

RHDSS has more females (52%) than males (48%) meaning that female to male ratio is 100 to 92.7. The literacy rate in this area has been estimated to be 66% for men and 34% for women. The majority of the people are Muslims with few Christians and followers of traditional religion. Kiswahili is the widely spoken language besides the local languages whereas English is rarely spoken. The most common occupational activities include subsistence farming, fishing and small scale trading (making of wood products such as carvings and furniture). Farming areas are located some distance from family homes and make use of periodical alluvial soils. Temporary houses located on such farmlands are an indication that some households within the HDSS are regularly split geographically for close to four months of the year due to seasonal splitting of household membership. The major crops grown include maize, millet, rice, cashew nuts, cassava, coconut and sesame, and fruits include mangoes, paw-paw, jack fruit and pine-apples. The major causes of mortality or illnesses in this region include HIV/AIDS, Tuberculosis and acute febrile illness including malaria, acute lower respiratory infections, pneumonia and prenatal causes.

Sampling strategy

Rufiji health and demographic surveillance site has a sampling frame of all households in the six contiguous wards of Bungu, Ikwiriri, Kibiti, Mchukwi, Mgomba, and Umwe with verbal autopsies carried out for all deaths within the study period. RHDSS adopted a non-randomized purposive sampling technique in selecting the six contiguous wards under surveillance. However, this study used data on the whole population under surveillance, focusing on all women of reproductive age.

Study Sample

The study sample in this research comprised of 26 427 women who were resident in the Rufiji health and demographic surveillance site and were 15–49 years of age as at Jan 1st 2002– Dec 31st 2006.

Data analysis

Principal component analysis (PCA) was used to construct a socioeconomic index for each household. Households were categorised into poorest, poor and least poor socioeconomic status (SES) based on the average number of household assets owned by the study participants as well as the environmental and household characteristics. Some of the assets included in the construction of the PCA were ownership of goats, cattle, sheep, houses, cars, chicken and televisions. The person years of observation (PYO) was computed for all study participants from the individual member information table and the migration table. This took into consideration the movements of participants, the event file which records all the event history that had happened to individual members and the interval file which is the start and end date of the study from which the person time of contribution was generated. The total person-years observed were the summation of all the individual time at risk of maternal mortality from 2002 to 2006. Univariate and multivariate Cox regression analysis was performed using STATA version 10 to assess the association between the risk factors (age, socioeconomic status, education,

occupation, marital status) and maternal mortality at 5% significance level. Not every study participant was observed for the same length of time and Cox regression model accounts for continuous change in risk of maternal mortality in that as women grow older the probability of death changes, therefore person time contribution for every woman as part of the denominator in the analysis was essential since data was collected longitudinally.

Variables

Maternal death was the outcome variable of interest. The causes of deaths in the HDSS had already been determined by the physicians using the verbal autopsy data, in line with the ICD-10. Maternal deaths were defined as deaths that occurred to women of reproductive age 15-49 years during pregnancy, delivery or up to forty two days after delivery. This was coded as binary 0 and 1 with women who experienced maternal deaths being coded as 1 and those who were alive as 0. Those who experienced other causes of death were set to missing.

Ethical consideration

Ethical approval for analysis was provided by the Ifakara Health Institute (IHI) Institutional Review Board (IRB) and Wits Human Research Ethics

Committee (Approval number R14/49) before commencement of the research in January 2009. Informed consent was obtained by field staff from all respondents during the update round visits. All participants in the study were identified by unique identifiers and all personal identifiers in the data set were removed before secondary data analysis in order to maintain participant confidentiality.

Findings

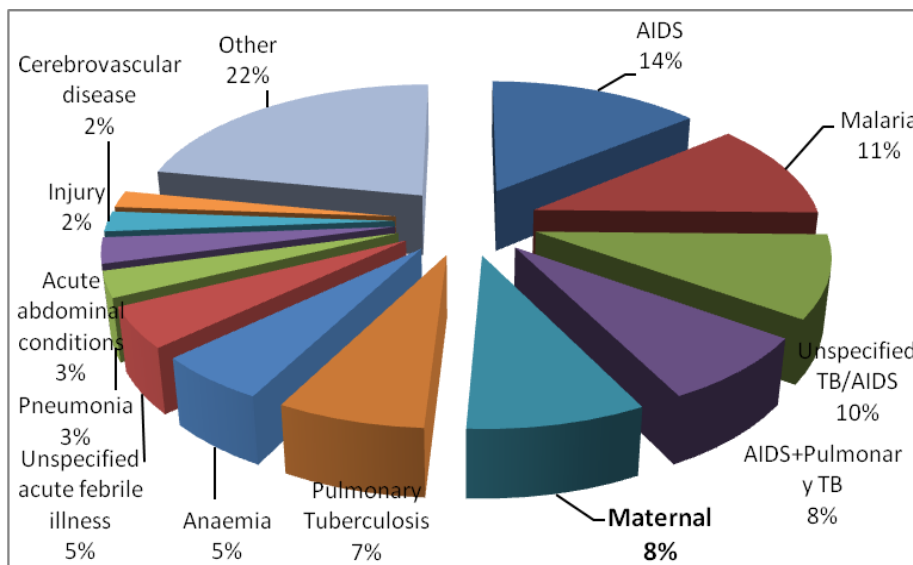
Level of Maternal Mortality Ratio in RHDSS

Our results showed that there were a total of 26 427 women within the study period that gave birth to a total of 15 548 live births over the five year period. Out of the 26 427 women, 64 experienced maternal deaths while 703 experienced other causes of death, hence leaving 25 660 women alive. Maternal mortality ratio (MMR) was 412 deaths per 100 000 live births (95% CI 320 – 522) over the study period (2002-2006). At the start of the study period, the MMR was 495 per 100 000 live births while at the end it was 427 per 100 000 live births.

Figure 1.1 shows the verbal autopsy assigned causes for the 767 reported deaths of women of reproductive age across the five year period. AIDS and TB together took the heaviest toll on the

Causes of maternal deaths in RHDSS

Figure 1.1: Broad causes of death for women aged 15-49, Rufiji HDSS

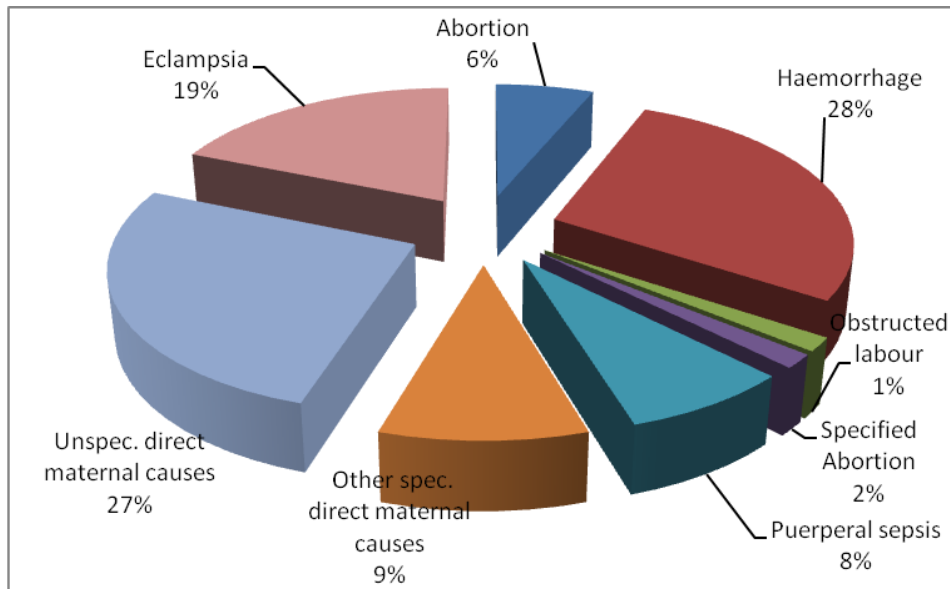


population, accounting for 39% of the total burden. This was followed by malaria (11%) and pregnancy-related direct causes (maternal) (8%).

Anaemia and acute febrile illness accounted for (5%) each respectively, while external causes like

injuries contributed to the least proportion (2%). Specific maternal causes or obstetric causes of death are dealt with in detail as shown in Figure 1.2, 1.3.

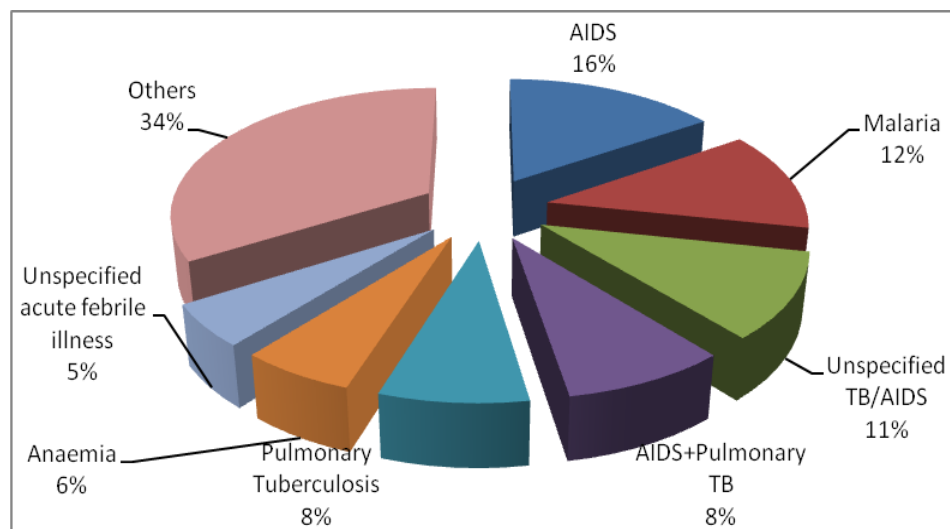
Figure 1.2: Obstetric causes of maternal deaths for women aged 15-49 (Maternal), Rufiji HDSS



There were 64 deaths arising from direct obstetric maternal causes (Figure 1.2). Of these, haemorrhage took the heaviest toll accounting for 28% of deaths, followed by eclampsia (19%) and

puerperal sepsis (8%). Other causes, such as abortion and obstructed labour, contributed only a small proportion.

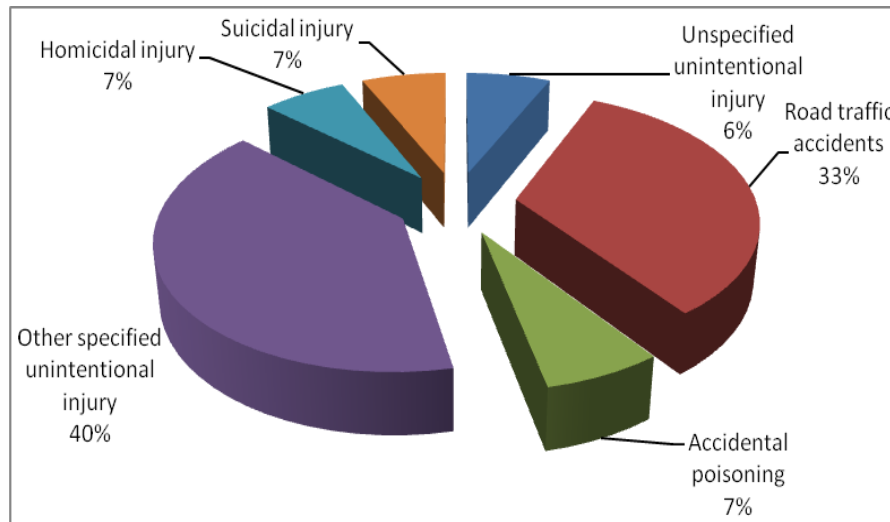
Figure 1.3: Non - Obstetric causes of maternal deaths for women aged 15-49, Rufiji HDSS



There were 688 deaths arising from non-obstetric causes for women of reproductive age (Figure 1.3). Of these, HIV and TB added together

contributed to the highest proportion (43%) followed by malaria (12%), anaemia (6%) and finally acute febrile illness (5%).

Figure 1.4: External causes of death for women aged 15-49, Rufiji HDSS



There were 15 deaths arising from external causes for women of reproductive age which accounted for 2% of the total burden. Figure 3.5 shows that, other specified unintentional injuries contributed to the highest proportion (40%) followed by road traffic accidents (33%). Homicidal injury, accidental poisoning and suicidal injury did not account for a significant proportion, contributing only 7% each.

Table 1.1: Univariate Hazard ratios for risk factors associated with maternal mortality, Rufiji HDSS (Unadjusted)

| Maternal mortality risk factors | Hazard Ratio | (P- value) | 95% CI |
|---------------------------------|--------------|------------|----------------|
| Maternal age (Years) | | | |
| <20 | 1* | | |
| 20-29 | 1.42 | 0.332 | (0.697-2.906) |
| 30-39 | 2.18 | 0.034 | (1.062- 4.471) |
| >=40 | 0.90 | 0.837 | (0.333-2.436) |
| Maternal education | | | |
| None | 1* | | |
| Primary | 1.17 | 0.553 | (0.698-1.959) |

| | | | |
|--------------------------|------|-------|----------------|
| Post primary | 1.40 | 0.488 | (0.538-3.669) |
| Marital status | | | |
| Unmarried | 1* | | |
| Ever married | 0.49 | 0.044 | (0.248-0.982) |
| Occupation | | | |
| Unemployed | 1* | | |
| Business | 1.31 | 0.685 | (0.359-4.747) |
| Student | 3.04 | 0.145 | (0.681-13.587) |
| Casual | 0.76 | 0.702 | (0.181-3.165) |
| Employed | 0.90 | 0.904 | (0.150-5.362) |
| Farm Workers | 0.70 | 0.547 | (0.213-2.267) |
| Cannot work | 2.67 | 0.396 | (0.277-25.650) |
| Other | 1.86 | 0.450 | (0.373-9.265) |
| Place of delivery | | | |
| Health facility | 1* | | |
| Outside health facility | 0.93 | 0.807 | (0.536-1.624) |
| Socio economic quintiles | | | |
| Poorest | 1* | | |
| Poor | 0.75 | 0.492 | (0.328-1.708) |
| Least Poor | 0.83 | 0.647 | (0.371-1.850) |

* Reference group

Table 1.2: Multivariate hazard ratios for risk factors associated with maternal mortality, Rufiji HDSS (Adjusted)

| Maternal mortality risk factors | Hazard Ratio | (P-value) | 95% CI |
|---------------------------------|--------------|-----------|---------------|
| Maternal age (Years) | | | |
| <20 | 1* | | |
| 20-29 | 1.56 | 0.316 | (0.654-3.721) |
| 30-39 | 2.54 | 0.050 | (1.001-6.445) |
| >=40 | 0.82 | 0.779 | (0.205-3.287) |
| Marital status | | | |
| Unmarried | 1* | | |
| Ever married | 0.38 | 0.016 | (0.176-0.839) |

* Reference group

In the univariate analysis only two risk factors were found to be significant and hence included in the multivariate analysis: maternal age and marital status. Table 1.2 shows that women aged 20 to 29 years were 56% more likely to experience a maternal death compared to women less than 20 years, though this was not significant after adjusting for marital status (HR=1.56, 95% CI=0.654-3.721). The highest risk age group was mothers aged 30 to 39 years who were 154% more likely to experience a maternal death compared to those women less than 20 years (HR=2.54, 95% CI=1.001-6.445). This association remained significant after adjusting for marital status.

Discussion

Level of Maternal Mortality Ratio in RHDSS

In our study, we found that there was a declining trend in maternal mortality across the five year period and this was in line with the Tanzania Coastal District Health Profile for 2007 which showed the same trend across the years¹⁸. This reduction in maternal mortality could have been due to variation in mortality risks moderated by health system interventions such as improved accessibility to emergency obstetric care, community health funds for better health care, interventions towards important medical diseases such as malaria and anaemia, food security and other socio-economic determinants¹⁸.

Maternal mortality ratio for this rural Tanzanian population, 412 per 100 000 live births

Women 40 years and older experienced a protective effect in that they were 18% less likely to experience a maternal death compared to those less than 20 years (HR=0.82, 95% CI=0.205-3.287), though the finding was not significant after adjusting for marital status.

Marital status information showed that women who had ever been married had a protective effect of 62% compared to women who had never been married (HR=0.38, 95% CI=0.176-0.839). This association remained significant even after adjusting for maternal age.

The model for predicting maternal mortality in this study thus becomes; $\ln(h(t)) = \ln(h_0(t)) + MA1_i + 1.56MA2_i + 2.54MA3_i + 0.82MA4_i + MS1_i + 0.38MS2_i$

Where:

$h_0(t)$ – hazards ratio at time zero

$h_i(t)$ – hazards ratio at time i

MA_i – maternal age at time i

$MA1_i$ – maternal age less than 20 years

$MA2_i$ – maternal age between 20 to 29 years

$MA3_i$ – maternal age between 30 to 39 years

$MA4_i$ – maternal age above 40 years

MS_i – marital status at time i

$MS1_i$ – marital status never married

$MS2_i$ – marital status ever married

conforms to the maternal mortality ratio reported by the Morogoro Health Intervention Project 2006 for other parts of rural Tanzania. This showed the maternal mortality ratio for Kilombero district as 404 per 100 000 live births and for Ulanga district as 390 per 100 000 live births⁴⁰. While the maternal mortality ratio in Tanzania is far higher than that in the USA, Turkey or Egypt^{5,6,41,42}, it is lower than that reported in greater Accra region of Ghana, Nigeria or Cameroon^{17,43}.

Causes of maternal deaths in RHDSS

The main direct causes of maternal death in the coastal region of Rufiji district was Haemorrhage accounting for 28% of maternal deaths, followed by eclampsia (19%) and puerperal sepsis (8%). This emphasises that haemorrhage was the leading cause of death. World Health Organization report (1999) showed that obstetric causes of maternal

death are similar across the world where haemorrhage accounts for one fourth of all maternal deaths. This is because the complication occurs suddenly and is in most cases unpredictable³⁵. Risvi et al. (2004) in Ireland, found that to reduce massive postpartum haemorrhage, we need to revise practice guidelines, disseminate them to staff and finally conduct practical skills training⁴⁴. This would enhance prompt and appropriate life-saving care which includes standard management of haemorrhagic shock by transfusion of blood or other volume expanders, administration of uterotonic drugs, delivery of placenta or other products of conception and massage of the uterus to stimulate uterine contractions⁴⁴. While haemorrhage is widely recognized as the main direct cause of maternal death, a study conducted by Morogoro Health Intervention Project 2006 found eclampsia to be the main direct cause of maternal deaths⁴⁰ while a study by Dellagi et al. (2008) in Tunisia found haemorrhage and eclampsia to be the major direct causes of maternal death⁴⁵.

The main non obstetric causes of maternal death were human immunodeficiency virus (HIV) and tuberculosis (TB) which accounted for 43% of deaths, followed by malaria (12%) and anaemia (6%). This confirms that HIV/TB is the leading indirect cause of maternal deaths in this region. Other studies in Tanzania, Malawi and South Africa also found HIV to be the leading indirect cause of maternal deaths^{14,40,46}.

Sebitloane et al. (2008) on studying the changing patterns on maternal mortality (HIV-related) revealed that HIV poses a challenge in attaining millennium development goals because the prevalence is on the rise. HIV still needs to be addressed by managing women with HIV infection which should include programmes such as the prevention of mother to child transmission (PMTCT), and extended to the welfare of the mother⁴⁷.

In our study we found that external causes accounted for 2% of deaths in women of reproductive age, however a critical look at the contribution of violence to maternal mortality in Morelos, Mexico by Campero et al. (2006) revealed that violent deaths related to pregnancy

accounted for (15%)⁴⁸. This indicates that violent deaths related to pregnancy should be clearly identified and included in official maternal mortality statistics so as to guide appropriate care and prevention policies. Similarly, traumatic injuries, homicides and suicides have been an alarming source of maternal mortality following inclusion of late maternal deaths into the estimates⁴⁹.

Risk factors for maternal deaths in RHDSS

There are numerous studies on maternal mortality risk factors which have been conducted in rural sub-Saharan Africa based on community and demographic health surveys. These include studies done by Evjen et. al (2008) in Tanzania²⁹, by Garenne et al. (2003) in Senegal¹⁵, by Hoj et al. (2002) in Guinea-Bissau⁴⁷ and by Magadi et al. (2001)²⁶ in Kenya. In this study we used time dependent covariates through a survival modeling technique based on longitudinal data from Rufiji health and demographic surveillance system (RHDSS) where a cohort of 26 427 women aged between 15 and 49 years was followed up for a period of five years. Results revealed two risk factors that were significantly associated with maternal mortality in Rufiji district Coastal region of Tanzania: maternal age and marital status. This is in line with other findings from developing countries which show marital status to be a risk factor in that unmarried women were 150% more likely to experience maternal deaths compared to women who had ever been married¹⁵. This could be attributed to lack of social and financial support.

Findings on maternal age seem less consistent. In our study, women below 40 years were at highest risk of maternal death, while other studies in Tanzania found older women at highest risk; 35-49 years in a study by Evjen et. al (2008) and 40 years and above in a study by MacLeod et. al (1998)^{19,29}. Overall though, women above 30 years are at highest risk of experiencing maternal deaths.

Limitations of the study

There are other risk factors which were not present in the dataset of Rufiji HDSS and could not therefore be examined. These included risk factors

found in the literature to be predictors of maternal mortality, including parity, antenatal care visits, type of delivery, type of birth, birth order and delivery assistant. Therefore, the existing RHDSS data did not contain sufficient information to accurately and adequately estimate the risk factors for maternal mortality. Since the data was collected from one area in Tanzania the results may not be generalized to other settings/populations and classification of cause-of-death as the assignment of ICD-10 coding could be quite complex, particularly for maternal deaths. This therefore needs to be taken into consideration when interpreting the results.

Strengths of the study

Use of multiple regression technique such as Cox allowed for controlling of confounders and effect modifiers through stratification. The sample size was a true representation of the study area and was large enough to give the study a statistical power. We used Person Years of Observation method which is a more accurate measure of time-to-event compared to mid-year population estimates. The study used longitudinal data collected and updated periodically and thus we were able to monitor demographic change. Another added advantage of the HDSS was that it prospectively followed the whole community to monitor demographic change. PCA technique also used first principle component which explained the most variability in data to group the households into quintiles.

Conclusion

In conclusion, two significant risk factors for maternal mortality were identified and this could play a role in identifying women at higher risk of a maternal death. Increasing maternal age and marital status were the factors that were found to be associated with increased risk of maternal death. This was driven by high rates of haemorrhage and eclampsia in this region which indicates an urgent need for better antenatal, postnatal and obstetric care for all pregnant women. Anti-hypertensive medications for high blood pressure, and magnesium injections could

also be used to reduce the occurrence of seizures for eclampsia among pregnant women; skilled birth attendants could also play a role in reducing maternal deaths by inducing delivery in women with pre-eclampsia.

Indirect causes of maternal death such as HIV/AIDS, TB, malaria and anaemia also contributed to a significant proportion of deaths, highlighting the need for effective interventions such as scale up of Highly Active Antiretroviral Therapy (HAART), ITN distribution for pregnant women, IPTp, provision of anthelmintic and haematinics which would impact on child survival. Health planners and managers should play a key role in implementing obstetric services essential for life saving interventions, including amendment of legislation where necessary. They should also develop and use case management protocols for obstetric emergencies, provide health worker training, ensure provision of essential drugs and equipment, and monitor standards of practice in maternity services.

Finally, there should be a confidential enquiry into maternal deaths (CEMD) to make extensive efforts to identify all maternal deaths through active surveillance of pregnancy-related deaths.

Contribution of Authors

The overall research design was conceived and developed by Illah Evance under the supervision of Godfrey Mbaruku and Kathleen Kahn. The design of HDSS drew heavily on data collection and analysis developed by Honorati Masanji who was the Centre leader for Rufiji Health and Demographic Site. Illah Evance conducted the analysis and drafted the manuscript.

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