

https://dspace.org/

Assessment of risk factors associated with maternal mortality in rural Tanzania

Illah, Evance Ouma

2010-10-14
http://hdl.handle.net/10539/8830

Downloaded from a DSpace repository. https://dspace.org/

UNIVERSITY OF THE WITWATERSRAND

FACULTY OF HEALTH SCIENCES

SCHOOL OF PUBLIC HEALTH

RESEARCH REPORT

PROJECT TITLE

ASSESSMENT OF RISK FACTORS ASSOCIATED WITH MATERNAL MORTALITY IN RURAL TANZANIA

ILLAH EVANCE

A research report submitted to the School of Public Health, University of the Witwatersrand, Johannesburg, in Partial fulfilment of the requirements for the degree of Master of Science (Medicine) Population Based Field Epidemiology

Supervisors:

Dr. Godfrey Mbaruku

Dr. Kathleen Kahn

Johannesburg, South Africa 2010

Declaration

I, Illah Evance declare that this research report is my own work. It is being submitted for the degree of Master of Science in Medicine in the field of Population Based Field Epidemiology in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

Signature: 

Full Name: Illah Evance

Date: 23th Feb 2010

Dedication

I humbly dedicate this degree to the Lord almighty who has made it possible for me to complete this degree. I also do dedicate this work to my beloved wife Rhoda for her unlimited support and prayer, as well as patience throughout my entire period of study.

AND

Sweet children Sammy & Megg for being an inspiration.

AND

My responsible parents Margaret and Erustus to whom if it were not because of them I wouldn't be someone today

Abstract

Background

Complications of childbirth and pregnancy are leading causes of death among women of reproductive age. Worldwide, developing countries account for ninety-nine percent of maternal deaths. The United Nations' fifth millennium development goal (MDG-5) is to reduce maternal mortality ratio by three fourths by 2015.

Aim

The aim of this study is to explore the levels, trends, causes and risk factors associated with maternal mortality as put forward by World Health Organization (WHO) in rural settings of Tanzania.

Specific objectives

- To establish the trend of maternal mortality ratios in Rufiji health and demographic surveillance system (RHDSS) during the period 2002-2006.
- To determine the main causes of maternal deaths in RHDSS during the period 2002-2006.
- To determine the risk factors associated with maternal mortality RHDSS during the period 2002-2006.

Method

Secondary data analysis based on the longitudinal database from Rufiji Health and Demographic Surveillance System was used to study the risk factors and causes of maternal death. Data for a period of 5 years between 2002-2006 was used. 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.

Results

Maternal mortality ratio was 412 per 100 000 live births. The main causes of death were haemorrhage (28%), eclampsia (19%) and puerperal sepsis (8%). Maternal age and marital status were associated with maternal mortality. 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). These findings were statistically significant at the 5% level.

Conclusion

This analysis reinforced previous findings pointing to the fact that haemorrhage and eclampsia are the leading causes of maternal mortality in Tanzania and other developing countries. This indicates the need for better antenatal and obstetric care, particularly for women over thirty years of age, as well as implementing health care delivery strategies according to the regional specific risk factors of maternal deaths and not the global factors.

Keywords: maternal death, maternal mortality, risk factors an developing country

Acknowledgement

My special appreciation goes to my able supervisors Dr. Godfrey Mbaruku and Dr. Kathleen Kahn for their supervision and immense support in understanding the epidemiology around maternal deaths. I am also grateful to Dr. Rose Nathan whose insight, encouragement, motivation and comments helped me to complete the course.

I must take this opportunity to thank all my course mates and Ifakara Health Institute (IHI) staff especially Mr. Mathew Alexander who in one way or the other encouraged and supported me to complete this work. Special thanks and tribute goes to the late Dr. Kubaje Adazu for recommending and allowing me to pursue this degree among many odds. Thanks to all my lecturers and staff of Wits University, School of Public Health for their immense support.

Finally, I am indebted to the INDEPTH Network for providing me with the financial support to pursue this course.

Table of Contents

DECLARATION II
DEDICATION III
ABSTRACT IV
ACKNOWLEDGEMENT VI
LIST OF ACRONYMS XI
LIST OF APPENDICES XII
LIST OF TABLES XIII
LIST OF FIGURES XIV

CHAPTER ONE: INTRODUCTION AND LITERATURE REVIEW 1

CAUSES OF MATERNAL DEATHS 2
RISK FACTORS FOR MATERNAL DEATHS 4
PROBLEM STATEMENT 6
JUSTIFICATION FOR THE RESEARCH 7
RESEARCH QUESTION 8
RESEARCH OBJECTIVES 8

CHAPTER TWO: METHODOLOGY 9

STUDY DESIGN 9
PRIMARY DATA SOURCE 9
STUDY AREA 9
STUDY POPULATION 10
SAMPLING STRATEGY 11
STUDY SAMPLE 11
Inclusion criteria 11
Exclusion criteria 11
MEASUREMENTS AND DATA SOURCES FROM RUFIJI HDSS 12
STUDY VARIABLES 13
LIMITATIONS OF THE STUDY DESIGN 14
CONFOUNDER\EFFECT MODIFIER 15
TEMPORALITY 15
MISSING VARIABLES 16
DATA PROCESSING METHODS AND ANALYSIS PLAN 16
Data processing 16
Descriptive statistical analysis 16
Inferential statistical analysis 17
ETHICAL CONSIDERATIONS 18
PLAN FOR UTILIZATION AND DISSEMINATION OF RESULTS 18

CHAPTER THREE: RESULTS 19

LEVELS AND TRENDS OF MATERNAL MORTALITY IN RHDSS 20
CAUSES OF MATERNAL DEATHS IN RHDSS 23
RISK FACTORS FOR MATERNAL DEATHS IN RHDSS 31

CHAPTER FOUR: DISCUSSION 35

LEVELS AND TRENDS OF MATERNAL MORTALITY IN RHDSS 35
CAUSES OF MATERNAL DEATHS IN RHDSS 36
RISK FACTORS FOR MATERNAL DEATHS IN RHDSS 37
STRENGTHS OF THE STUDY 38
LIMITATIONS OF THE STUDY 39
CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS 40
CONCLUSION 40
RECOMMENDATIONS 40
APPENDICES 43
REFERENCES 50

Definition of terminologies

Maternal death – death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or external causes (2).

Direct obstetric deaths - deaths resulting from obstetric complications of the pregnant state (pregnancy, labour, and the puerperium), from interventions, omissions, or incorrect treatment, or from a chain of events resulting from any of the above.

Indirect obstetric deaths - deaths resulting from previous existing disease or disease that developed during pregnancy and that was not due to direct obstetric causes but was aggravated by the physiological effects of pregnancy.

Maternal mortality ratio – number of maternal deaths during given time period per 100 000 live births during same time period. Globally, ratio is usually used instead of rate because it reflects the risk of maternal death per pregnancy or per birth while rate reflects more on fertility.

Verbal Autopsy - this approach is used to assign cause of death through interviews with family or community members, where medical certification of cause of death is not available. Records of births and deaths are collected periodically among small populations (typically in a district) under demographic surveillance systems maintained by research institutions in developing countries.

Demographic Surveillance System (DSS) - this is a set of field and computing operations to handle the longitudinal follow-up of well-defined entities or primary subjects (individuals, households, and residential units) and all related demographic and health outcomes within a clearly circumscribed geographic area.

Household: This is a social group of one or more individual members eating from the same pot. They are usually but not always related biologically or by blood.

List of acronyms

MMR Maternal Mortality Ratio

MDG Millennium Development Goals

WHO World Health Organization

RHDSS Rufiji Health and Demographic Surveillance System

HDSS Health and Demographic Surveillance System

DHS Demographic and Health Survey

SES Socio-Economic Status

PCA Principal Component Analysis

INDEPTH International Network for Demographic Evaluation of Populations and Their Health in Developing Countries

HRS Household Registration System

TEHIP Tanzania Essential Health Intervention Project

PYO Person Year of observation

USA United States of America

ICD International Classification of Diseases

List of appendices

Appendix A: Ethical clearance form from University of Witwatersrand, Human Research Ethics Committee (Medical) …….....42

Appendix B: Permission to use Rufiji HDSS data…..…….…….…..43

Appendix C: Pregnancy form from Rufiji HDSS…….……..44

Appendix D: Verbal autopsy form from Rufiji HDSS……...45

Appendix E: Map of Rufiji Demographic Surveillance Site…….…….48

List of tables

3.1: Socio demographic characteristics for women aged 15-49, Rufiji HDSS…..……...…20

3.2: Maternal mortality ratios over the five year period 2002-2006, Rufiji HDSS….....22

3.3: Univariate hazard ratios for the risk factors associated with maternal mortality, Rufiji HDSS (Unadjusted)……..……..…….....31

3.4: Multivariate hazard ratios for the risk factors associated with maternal mortality, Rufiji HDSS(Adjusted)……..….....33

List of Figures

3.1: Maternal mortality trend across 5 year period (2002-2006), Rufiji HDSS……....23

3.2: Broad causes of burden of disease for the women aged 15-49, Rufiji HDSS…..…..24

3.3: Direct causes of maternal deaths for women aged 15-49, Rufiji HDSS……25

3.3.1 Direct causes of maternal deaths for year 2002, Rufiji HDSS….……26

3.3.2 Direct causes of maternal deaths for year 2003, Rufiji HDSS.…….……...…26

3.3.3 Direct causes of maternal deaths for year 2005, Rufiji HDSS……..……...27

3.3.4 Direct causes of maternal deaths for year 2006, Rufiji HDSS…….……...…27

3.4: Non-direct causes of maternal deaths for women aged 15-49, Rufiji HDSS…….29

3.5: External causes of death for women aged 15-49, Rufiji HDSS……...……..……30

CHAPTER ONE: INTRODUCTION AND LITERATURE REVIEW

Maternal mortality represents a devastating medical complication in many societies. It has been realized that complications of childbirth and pregnancy is a leading cause of death among women of reproductive age (1). 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 2015(2).

A study carried out by Hill et. al (2007) worldwide between 1990- 2005 on the available data 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 respectively (3). The study further revealed that in as much as maternal mortality was on the decrease by 2.5% in the world, the decrease did not filter down to sub-Saharan Africa where the status quo was maintained (3). 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 haemorrhage (4). 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 occurring.

Maternal mortality ratios (MMR) in developed countries range from 5.4 to 12 per 100 000 live births while middle income countries such as Mexico reports 106 maternal deaths per 100 000 live births (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 births(5). Studies have rated Africa's maternal mortality ratio as ranging from 424 to 2151 per 100 000 live births (6-8). 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 poverty, poor health care services, incidences of infectious diseases and high fertility (9).

Maternal mortality is a rare event and difficult to measure as an indicator since a large sample size in 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 Senegal (10-12).

In most developing countries, data is scarce on the quantitative impact of risk factors for maternal deaths; this is attributed to incomplete registration of records or poor registration systems (13). As a result, the World Health Organization (WHO) has specifically encouraged studies to identify such factors since knowledge about them would enhance better medical or obstetric care (14).

Causes of maternal deaths

Efforts to reduce maternal mortality need to be tailored to local conditions since causes of death vary across developing countries and regions (15). In this respect Chowdhury (2007) adduces that the leading cause of maternal death worldwide is haemorrhage followed by hypertensive diseases and sepsis, while in Latin America and the Caribbean it is hypertensive disorders during pregnancy (16) .

Maternal mortality has been typically defined as including direct and indirect obstetric causes but not including external deaths (deaths owing to accidents, violence or suicide). Though there has a been a discourse surrounding the inclusion of external deaths in generation of MMR: a study conducted in Mexico showed that violent deaths related to pregnancy should be included as indirect causes in official maternal mortality statistics since they constitute a significant proportion (17). Despite the fact that this study is pegged on deaths that occur during pregnancy, delivery or forty two days after delivery, late maternal deaths (maternal deaths occurring after forty two days of delivery or before one year) have also been found to be linked to external causes. A study by Lang et. al (2008) in the United States of America (USA) found that, traumatic injuries, homicides and suicides have been an alarming source of maternal mortality due to the inclusion of late maternal deaths onto the estimates (18).

Causes of maternal deaths are numerous and vary from one place to another depending on factors prevailing. A 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 disorders (19). The causes were not the same for the southern part of Africa where Kongnyuy et.al (2009) conducted a study in Malawi to find that the leading causes of maternal death are postpartum haemorrhage, postpartum sepsis, and HIV/AIDS accounting for direct and indirect maternal causes (20). Other causes like ruptured uterus, complications of abortion, anaemia, ante-partum haemorrhage were also present though they did not contribute to a larger proportion.

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 age (21-23) . Though studies have been carried out in different settings of Tanzania to establish the leading

causes of maternal death (24-27), longitudinal data still needs to be used to ascertain the leading causes of maternal death due to availability of large sample size. 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

In Tanzania several studies have been done to assess risk factors for maternal deaths (25;26;28-30) while similar studies have been conducted in other settings (21;23;31). These studies revealed that higher maternal age, low level of maternal education, higher parity, single women, 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 (32;33) ,maternal age, parity (34-37), number of antenatal care visits (38), place of delivery and socio-economic status (39). Emery et. al (1992) 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 status (36). Another study by Christian et. al (2008) found out that maternal age and parity are 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 protection (31). 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 status (21).

A study done in Argentina showed that place of delivery can reveal the disparity between the death of a woman outside and within health facility as it is an underlying factor for place of death. It showed that maternal causes of death are equally prevalent among women who die

outside the health facilities as among those who die within the health facility (40). This may be attributed to access and quality of care as well as frequency of antenatal care visits. In as much as general reasons behind worrying maternal mortality ratios are known each study is affected by the specificities of environment such as levels of poverty, infrastructure development and cultural disposition. Due to this a study in Rufiji district will contribute greatly towards formulation of proactive health policies that are context specific.

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 meager 1.8% in sub-Saharan African (2). 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.

Studies show that in Kilombero district in rural Tanzania 1 out of 39 women who survive until reproductive age die of maternal causes before age 50 (27). Since Kilombero district is a rural setting just as Rufiji district, the estimates could be comparable. It has been known for decades that there exists a link between poverty and maternal health, for instance it has been established that the difference in maternal deaths between the poor and the rich is due to uptake of delivery services and antenatal care. In Peru for example, the estimate for the poorest group was in excess of 800 maternal deaths per 100 000 live births compared with under 130 per 100 000 live births for the richest quintile - a six fold difference (41).

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 consistently (42) . 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 health (43). In Indonesia 32 to 34% of maternal deaths occurred among women from the poorest quintile of the population (42). In this respect Graham et al. (2004) is of the opinion that it's 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 inequality (42). 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 DSS sites has shown that households in poorest quintiles have worse healthcare indicators compared to those in least poor quintiles (44-47).

Problem Statement

In many low income countries, deaths from maternal causes represent the leading cause of death among women of reproductive age (48). Since child survival is related to breast feeding, maternal deaths are a disadvantage to child survival and have an impact that rebounds across generations. A number of middle income countries such as Sri Lanka and Honduras have reduced maternal deaths (49), nevertheless maternal mortality levels remain unacceptably high especially in sub-Saharan Africa and Asia. The United Nations (5th Millennium Development Goal) report asserts that in sub-Saharan Africa, the risk of a woman dying from such complications in the course of her lifetime is 1 in 16 compared to 1 in 3 800 in the developed world (15); this ultimately means that 99% of maternal deaths occur in the low income countries.

Even after two decades of safe motherhood initiatives, meaningful reductions in maternal mortality and disability during pregnancy and childbirth in developing countries have not been realized (50). In Tanzania, maternal mortality continues to be a serious problem and

little is known about it relative to infant and child mortality (9). Research to identify risk factors for maternal mortality is needed to help combat this problem. This is inline with the fifth millennium development goal of reducing maternal deaths by 75% by the year 2015, or 5.5 % annually.

Justification for the research

Estimates of maternal mortality over time are critical in that they help in planning of sexual and reproductive health programs and advocacy. If the estimates are projected, they can be used at national level to inform policy with respect to resource allocation by government agencies, development partners and donors (2).

In Tanzania the main source of maternal mortality estimates are from Demographic and Health Surveys, and due to their small samples it is not possible to produce estimates at district level. Another source of maternal mortality estimates is hospital data which tend to underestimate the ratios (29). The district is the administrative unit where plans are made and implemented; as such health indicators at district level are very essential in implementing evidence-based planning and for monitoring progress. Presence of the Rufiji health and demographic surveillance system (RHDSS) that produces longitudinal data on vital events and causes-of-death through verbal autopsies is a unique opportunity for the district to estimate maternal mortality. This is because verbal autopsy used within the HDSS has proved to give reliable results pertaining to the levels and causes of maternal deaths (51;52). In Matlab, Bangladesh the HDSS identified 67.2% of all deaths occurring during pregnancy or within 42 days postpartum unlike other special studies which produced low proportions (51).

A study conducted by Kim et. al (2009) revealed that an existing hospital-based surveillance system should be augmented with a community-based death surveillance system as there was

under-reporting of maternal deaths in the existing hospital-based health surveillance system compared to community-based death surveillance system (53).

Similarly, a study conducted in Ghana through the Navrongo health and demographic surveillance system (NHDSS) revealed a discrepancy in reporting of maternal deaths. Health facility-based reports gave 141maternal deaths per 100 000 live births compared to 373 maternal deaths per 100 000 live births from the Navrongo health and demographic surveillance system, meaning the HDSS had a better estimate compared to the health facility-based surveillance (54). Additional information generated through the same system allows for identification of risk factors which are important in targeting interventions. Longitudinal data on population dynamics, health and social change provides valid information for informing policy and practice (55).

Research Question

What are the levels, trends, causes and risk factors associated with maternal mortality for women aged 15 to 49 years in a area of rural Tanzania during the period 2002-2006?

Research Objectives

Specific objectives in the Rufiji health and demographic surveillance site, rural Tanzania:

i. To establish the trend of maternal mortality ratios during the period 2002-2006.
ii. To determine the main causes of maternal deaths during the period 2002-2006.
iii. To determine the risk factors associated with maternal mortality during the period 2002-2006.

CHAPTER TWO: METHODOLOGY

Study design

The research was based on longitudinal study of women of reproductive age that is 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 provides 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.

In this study, data collected through the verbal autopsy method were used to identify maternal deaths and their probable causes. Verbal autopsy is an epidemiological tool used to assess causes of death by interviewing close caregivers of the deceased.

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 km^2 from 7.47^0 to 8.03^0 south latitude and 38.62^0 to 39.17^0 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 centers 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. The study area is majorly covered by gravelled roads which get eroded during rainy seasons hence making transportation difficult especially in terms of access to health services.

Study population

From the fertility monograph of Rufiji HDSS (unpublished) (56), 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/km^2. 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, acute febrile illness including malaria, acute lower respiratory infections, pneumonia and prenatal causes.

Sampling strategy

Rufiji health and demographic surveillance system 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 is using data on the whole population under surveillance, focusing on all women of reproductive age.

Study Sample

The study sample in this research comprised 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.

Inclusion criteria

- Women aged 15-49 years as at 2002-2006 and resident in the Rufiji health and demographic surveillance site.
- Women (15-49 years) whose deaths were recorded by the demographic and health surveillance site

Exclusion criteria

- Women who are above 50 years or less than 15 years of age.

- Non- registered women residents

Measurements and data sources from Rufiji HDSS

Rufiji HDSS was established as one of the major research components of Tanzania Essential Health Interventions Project (TEHIP) with an aim of providing sentinel data to the Ministry of Health and District health authorities for the sake of evidence-based planning and resource allocation, as well as documenting the impact of health system interventions and quantifying the burden of disease.

Rufiji demographic and health surveillance site uses the household registration system (HRS I) which entails collection and documentation of data on deaths, pregnancies and births, socio-economic status and in-migration/out-migration. This was done through a baseline census (conducted November 1998) with regular updates of demographic and vital events on a quarterly basis throughout the years. The quarterly updates are known within the RHDSS as "rounds".

It also uses the verbal autopsy technique to estimate probable cause of death that occurs outside the hospital. The verbal autopsy questionnaire includes an important section where the respondents (closest caregiver of diseased) describe all the symptoms and signs preceding death in his/her own words. After data collection, two medical doctors make an independent review of the information collected to come up with the probable cause of death. Where there is no agreement between them in diagnosis, a third coder, blinded to their assessment, makes a further independent diagnosis. If two of the three diagnoses correspond, a decision is reached and this is accepted as the cause of death. Otherwise the cause of death would remain undefined. The causes of death are identified and classified using International Classification of Disease (ICD-10).

To increase validity and reliability, quality control of data collected is done by supervisors every week who randomly select and revisit 3-5% of the households interviewed. Errors noted are communicated immediately to interviewers or brought up for discussion in bi-monthly staff meetings.

Study variables

Outcome variable:

Outcome variable was *maternal deaths*– These were 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.

Exposure variables/risk factors include:

Maternal age groups (years) – For women who were alive throughout the study period (2002-2006), age was calculated by subtracting date of birth from first day of January 2002 and regrouped into four categories 15-19, 20-29, 30-39 and >=40 . For women who died during the study period, age was calculated by subtracting the date of birth from the date of death and regrouped into four categories 15-19, 20-29, 30-39 and >=40.

Marital status – This was denoted as binary with 1 representing those women who had never married and 2 representing those women who had ever been married.

Maternal education level – This variable was recoded as either none for those women who had no education, primary for those who had attained primary level of education and post primary for those women who had attained any level of education past primary.

Occupation – This was categorized into eight groups 1-8 i.e unemployed, business, student, casual, employed, farm worker, cannot work and other.

Place of delivery – This was categorized into two groups 1 for health facility and 2 for outside health facility.

Socio-economic index: This was constructed through use of household characteristics and asset ownership where variables were first coded into binary format of 1 and 0 denoting the presence or absence of assets. Through principle component analysis (PCA) technique as recommended by Filmer and Pritchett (1999) we used the first principle component which explained the most variability in our data to group the household into three quintiles namely poorest, poor and least poor. The first principle component is the linear index of variables with the largest amount of information common to all the variables and the asset index is for each household based on a formula;

$PC_1 = a_{11}X_1 + a_{12}X_2 + ... + a_{1n}X_n$

$PC_m = a_{m1}X_1 + a_{m2}X_2 + ... + a_{mn}X_n$

Where; X_n is the nth variable out of n variables

a_{mn} is the weight of the mth principal component and the nth variable

(Source; Vyas & Kumaranayake 2006)

Limitations of the study design

Biases – this cannot be dealt with because the data had already been collected.

- Since verbal autopsy uses retrospective information which is collected in a systematic manner to arrive at a diagnosis, accuracy of the estimates depends on the family

members' knowledge of the events leading to cause of death. Therefore a recall bias may arise due to time lag of events.

- It would be prone to potential of measurement bias which could lead to misclassification of an outcome (maternal mortality). This can arise from the clinicians who can make an inaccurate diagnosis based on the retrospective report, as well as deaths occurring in early pregnancy.
- The incorrect diagnosis of cause of death can also arise as a result of skill of interviewers and knowledge of respondents.
- Reporting bias may arise due to cultural practice on reporting of pregnancies.
- There is a possibility of early pregnancies being missed in statistics of maternal deaths hence lowering the estimates of maternal mortality ratio. This includes abortions and ectopic pregnancies.

Confounder\effect modifier

- Possible confounders and effect modifiers were dealt with through stratification in Cox proportional hazard regression and by adjusting the factors in the model. This included maternal age which was stratified instead of using it as a continuous variable to show the difference within the different age categories at adjusting it to the other significant variables.

Temporality

- Variables collected might have been relevant and tied only to a specific time period, due to temporal or environmental factors and therefore limit the generalizability of the results. However, the use of data over several years largely catered for this.

Missing variables

- There are risk factors which were never collected or had incomplete information in Rufiji health and demographic surveillance site (RHDSS) which could have been plausible in reducing maternal mortality. These include antenatal care visits, parity, birth order, type of delivery and delivery assistance.

Data processing methods and analysis plan

Data processing

Rufiji HDSS data is entered using visual fox-pro computer software. Main variables were selected from the visual fox-pro database and exported into stata version 10 using stat transfer for cleaning and editing. Data for this research were selected from five different tables namely: adult verbal autopsy, pregnancy, member, asset, migrate and mortality tables. Live births were extracted from the pregnancy table.

Data quality was assessed by checking on the missing records or observations as well as carrying out validity checks on the responses given out using Stata version 10. The missing records were then dealt with or imputed by referring to the questionnaires. Merging of various data sets were entirely done in Stata using a common identifier or unique field called permanent id.

Descriptive statistical analysis

Descriptive analysis involved use of frequencies and proportions (z-test) in summarizing risk factors and main causes of death of the study population. Test of proportion allowed us to know the difference in mortality levels among the different groups – women who experienced maternal deaths and non-maternal deaths for various factors.

Maternal mortality ratio was estimated using causes of death from the verbal autopsy data and vital registration data (births) by dividing the number of maternal deaths and total live births for every year with their corresponding confidence interval through Winpepi analysis software. Maternal mortality ratio estimates were then plotted on a graph to establish the trend over the five year period (2002-2006).

Inferential statistical analysis

The association between maternal death (dependent variable) and risk factors (independent variables) was investigated. Survival analysis through Cox proportional hazards regression was carried out to predict or model maternal mortality from independent variables in univariate and multivariate models and explore which factors are associated with maternal mortality taking into account the possible confounders. Use of event history analysis is due to 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 is essential and critical since data is collected longitudinally.

Socio-economic wealth index was created using principal component analysis (PCA). PCA is a statistical procedure which has been used to determine the weights of an index of the assets variable within a household (57-59). PCA provides a plausible weight for an index of assets to serve as proxy for socio-economic status or wealth and it has been used as an alternative to estimation through income or expenditure data. In this study, an index of living was created and households categorized into three social status namely; Poorest, Poor and Least poor. The estimates were then presented at 95% confidence interval accounting for 5% significance level.

Ethical considerations

The original study had an ethical clearance from Ifakara Health Institute's Ethics committee as well as informed consent forms for each and every participant and household. The informed consent form was read and explained to the participants who had to give consent before data was collected. Permission to conduct secondary data analysis was sought from the Postgraduate Committee of the School of Public Health, and the Committee for Research on Human Subjects at the University of the Witwatersrand (Medical). The same protocol was submitted to Ifakara Health Institute institutional review board (IHI - IRB) for clearance before this data was utilized. Data retrieved for analysis was handled with care and restricted to a limited number of people for the sake of integrity and confidentiality; this was achieved by use of passwords on the computer and datasets.

Plan for utilization and dissemination of results

Results and findings from this study will be made available to the Tanzania Ministry of Health and Social Welfare for the use in evidence-based planning and policy implementation. Presentations will be done to the Ifakara Health Institute (through annual conference), academic and scientific meetings of the University of the Witwatersrand School of Public Health as well as the INDEPTH Network's Annual Scientific and General Meeting.

CHAPTER THREE: RESULTS

This chapter highlights or presents analysis from a dataset for women of reproductive age (15-49 years) in Rufiji health and demographic and health surveillance site (RHDSS) for the five year period 2002-2006. The results are in two parts namely descriptive and inferential. The first part of the descriptive contains the proportions of overall burden of mortality within the age group, specific maternal causes, trend of maternal mortality ratios over the five year period as well as the socio-demographic variables as per the distribution of death. The analytic part presents the relationship or association between risk factors and maternal mortality.

Levels and trends of maternal mortality in RHDSS

Table 3.1: Socio demographic characteristics for women aged 15-49, Rufiji HDSS

Maternal mortality risk factors	**Number (n)***	**Proportion (%)**
Maternal age (Years)		
<20	6909	26.14
20-29	9996	37.82
30-39	5903	22.34
>=40	3619	13.69
Maternal education		
None	11242	42.55
Primary	13489	51.06
Post primary	1687	6.39
Marital status		
Unmarried	4280	18.24
Ever Married	19181	81.76
Occupation		
Unemployed	1247	4.85
Business	2824	10.99
Student	527	2.05
Casual	2374	9.24
Employed	1225	4.77
Farm Workers	15888	61.81
Cannot work	147	0.57
Other	1471	5.72
Place of delivery		
Health facility	8155	57.03
Outside health facility	6145	42.97
Socio economic quintiles		
Poorest	2336	32.84
Poor	2383	33.50
Least Poor	2395	33.67
Person Years (n, π, δ)	107872	4.08, 1.49

Note: * Number of women varies for each risk factor due to missing values.

From Table 3.1, there were a total of 26 427 women who contributed to a total of 107 872 person years of observation (PYO). The person years had an associated mean of 4.08 with a standard deviation of 1.49. The maternal age which contributed to the highest proportion was 20-29 years (37.8%), followed by 15-19 years (26.1%) and 30-39 years (22.3%). The higher age group of 40-49 years contributed to the smallest proportion (13.7%). The main income generating activity reported in the demographic surveillance area (DSA) was farming. Over the five year period, approximately (61.8%) of the women reported being engaged in subsistence farming, 11% in small business, (9.2%) in casual working, (4.9%) being unemployed, (2.1%) being students, and only (4.8%) were reported as salaried employees. (0.6%) were not able to work for reasons such as old age.

In terms of place of delivery, the results showed that over half of women gave birth within a health facility (57%), indicating they had access to the health facilities, or it is their preferred choice for place of delivery or perhaps they had complications. The results showed the birth rate within the health facilities was higher than the national average of 47% as shown in the Tanzania Demographic Health Survey of 2004. On the other hand, 43% of women gave birth at home or by the road side on their way to the hospital.

The education level of women of reproductive age was as follows; 51.1% had primary education, (6.4%) had post primary education and 42.6% had no education. For the case of family union, a greater proportion of women (81.8%) had ever been married, and only (18.2%) had never married.

Table 3.2: Maternal mortality ratios over the five year period 2002-2006, Rufiji HDSS

Year	Maternal deaths (n)	Live births (n)	MMR/100 000 live births	95% CI
2002	15	3029	495	(288 – 798)
2003	15	3109	482	(280 – 778)
2004	6	2837	211	(86 – 440)
2005	14	3294	425	(242 – 696)
2006	14	3279	427	(243 – 699)

Table 3.2 presents the maternal mortality ratios across the five year period within the Rufiji HDSS. 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. Out of the 64 maternal deaths, year 2002 and 2003 contributed a similar proportion of (23%) each, while year 2005 and 2006 contributed (22%) each, with year 2004 contributing the least proportion of death of (9%).

In terms of live births, year 2002, 2003, 2005 and 2006 contributed a similar proportion except for year 2004 which registered the lowest number of live births. Maternal mortality ratio (MMR) was 412 deaths per 100 000 live births (95% CI 320 – 522) over the study period (2002-2006).

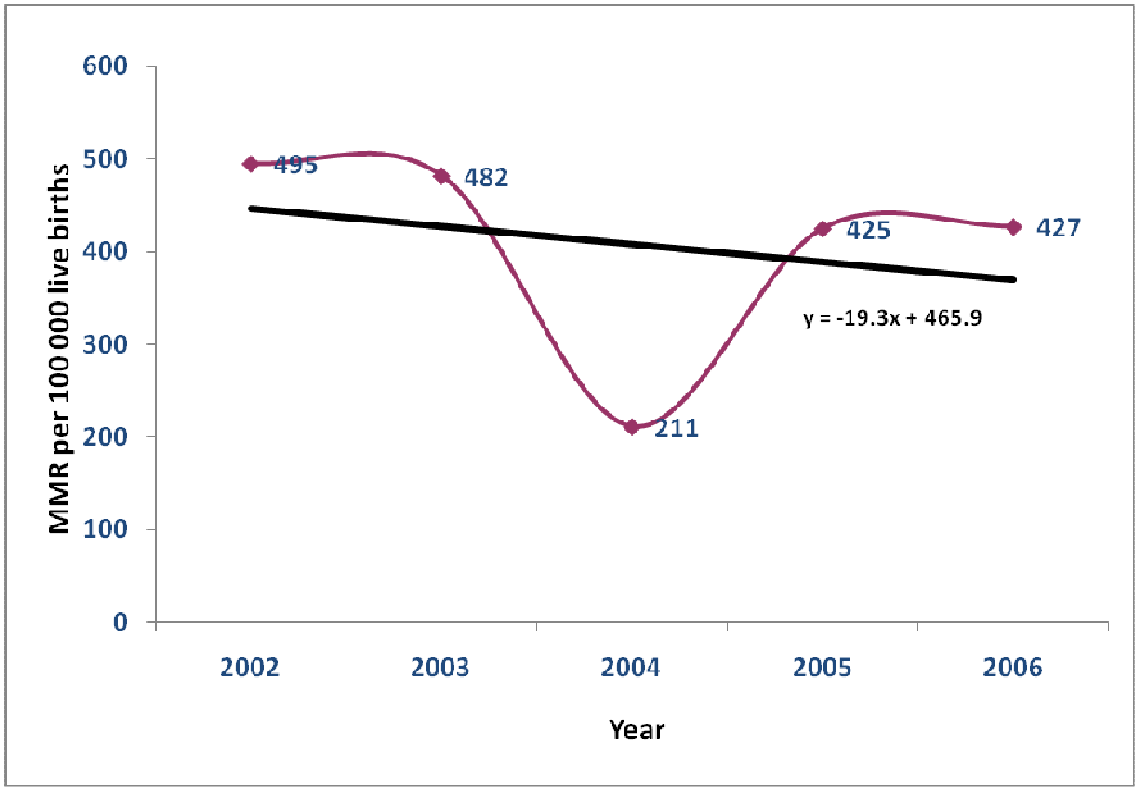
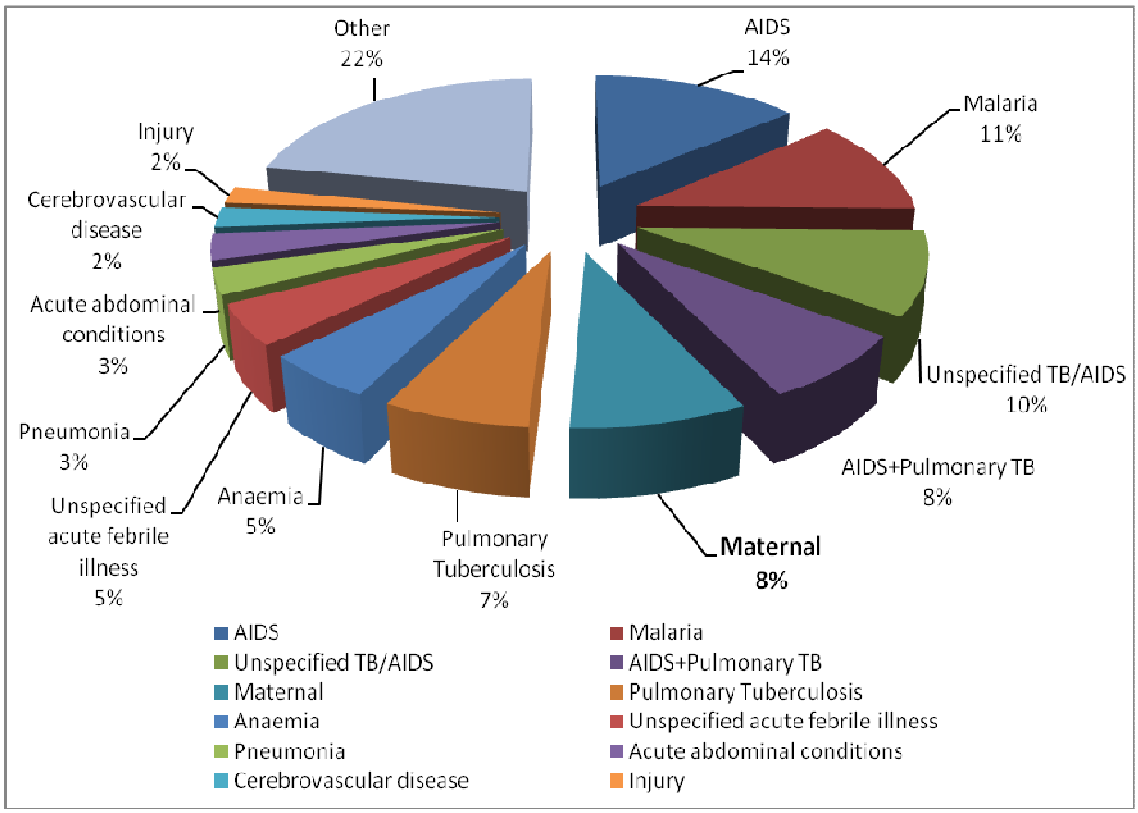


Figure 3.1: Maternal mortality trend across 5 year period 2002-2006, Rufiji HDSS

Figure 3.1 reveals a declining trend of maternal mortality ratio with a gradient (19.3) on a linear scale. Hence maternal mortality appears to be reducing in the coastal region of Tanzania.

Causes of maternal deaths in RHDSS

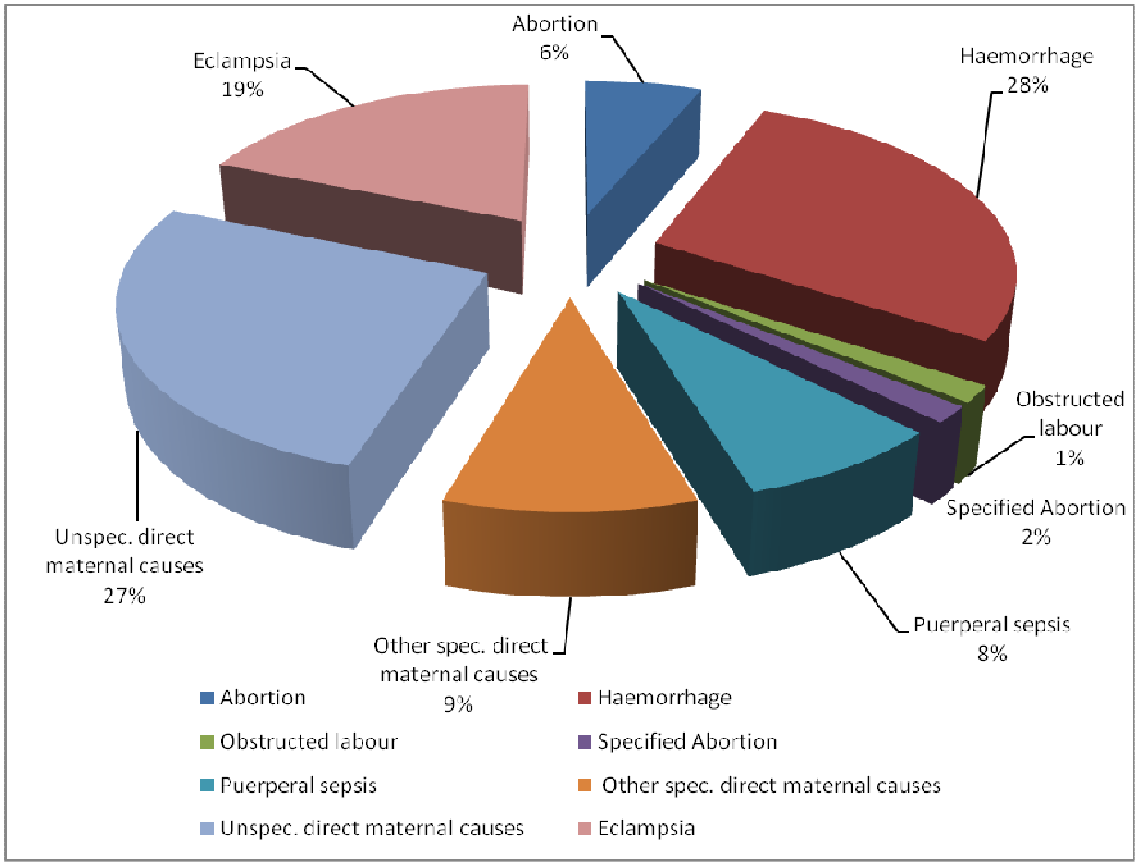
The next section provides the causes of maternal deaths. In figure 3.2 we provide a breakdown of all causes of death in women of reproductive age. In contrast figure 3.3 illustrates direct causes of maternal deaths while figure 3.4 illustrates non-direct causes of maternal deaths. Figure 3.5 illustrates external causes of death.



n=767 deaths

Figure 3.2: Broad causes of death for women aged 15-49, Rufiji HDSS

Figure 3.2 shows the verbal autopsy assigned causes for the 767 reported deaths of women of reproductive age across the five year period. HIV and TB took the heaviest toll on the population, accounting for 39% of the total burden. This was followed by malaria (11%) and pregnancy related causes (8%) i.e maternal. 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 3.3.

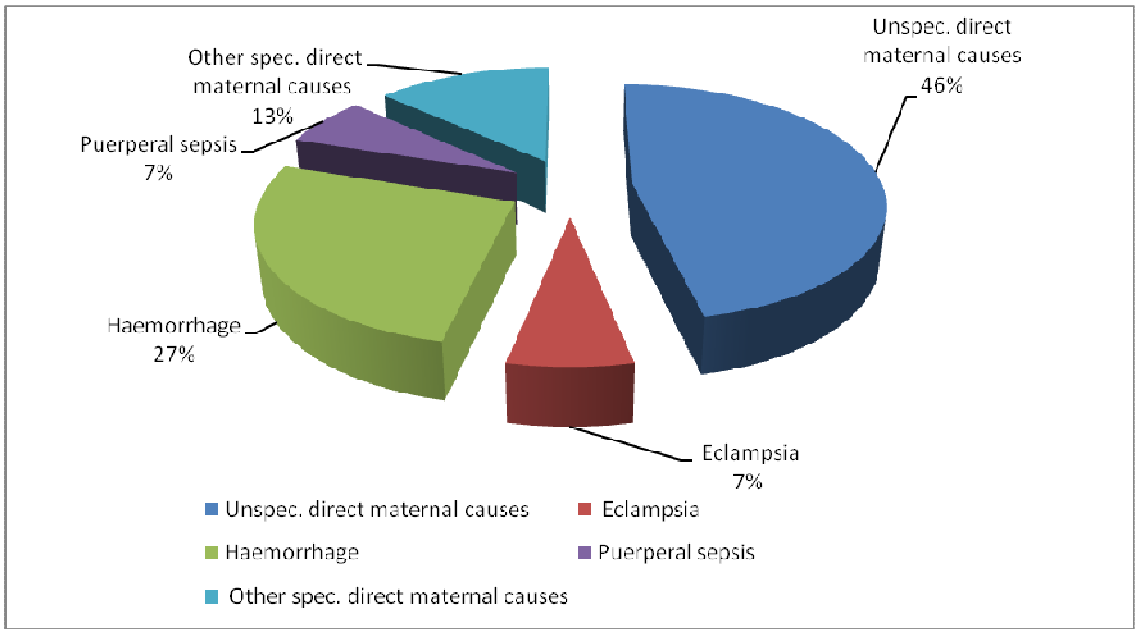


n=64 deaths

Figure 3.3: Direct causes of maternal deaths for women aged 15-49, Rufiji HDSS

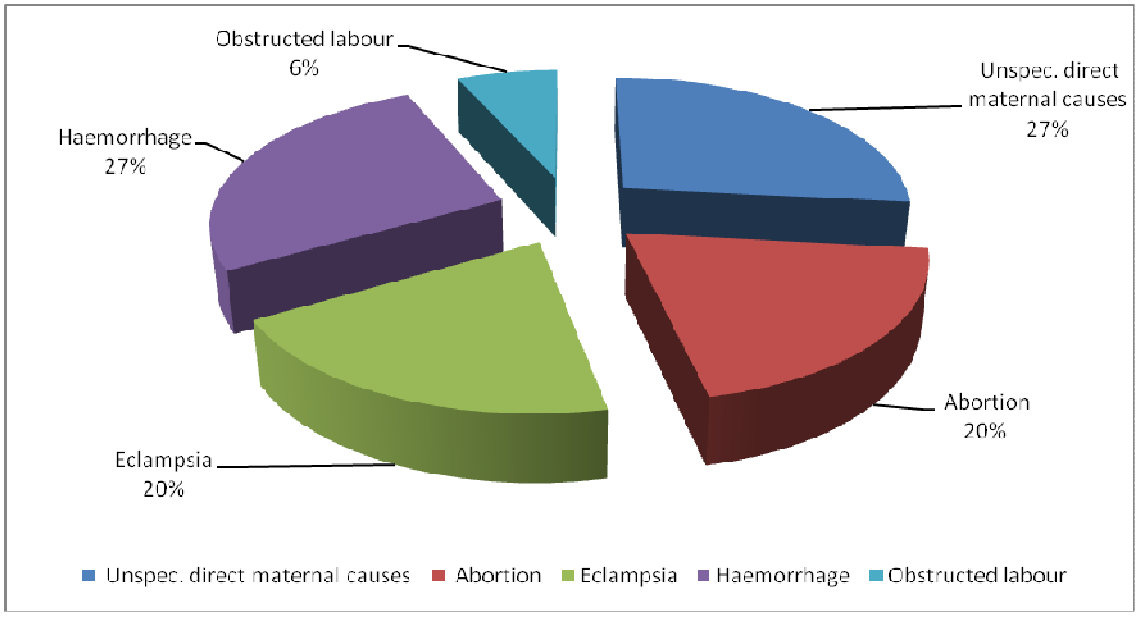
There were 64 deaths arising from obstetric maternal causes (Figure 3.3). Of these, haemorrhage took the heaviest toll accounting for 28% of deaths, followed by eclampsia (19%) and puerperal sepsis (8%). Other causes, such as abortion and obstructed labour, contributed only a small proportion while un-specified and other specified direct maternal causes contributed a significant proportion (36%).

Figures 3.3.1 to 3.3.4 show a breakdown of direct causes of maternal death by year for 2002, 2003, 2005 and 2006. The figure for 2004 has been omitted as the numbers are too small for any meaningful analysis.



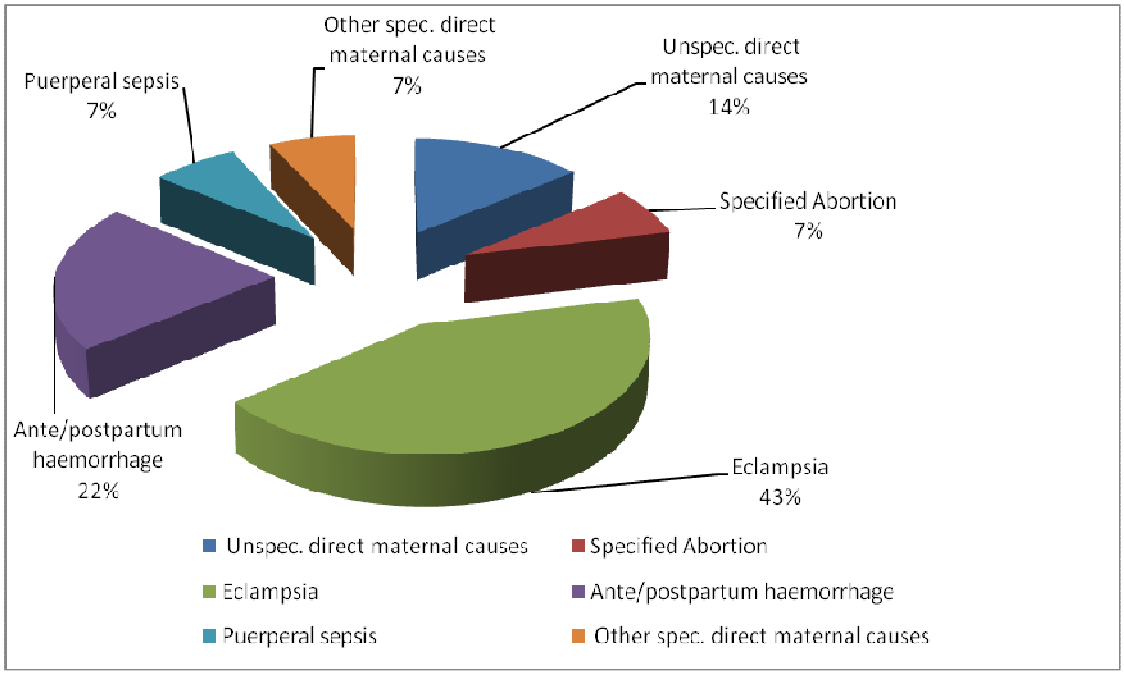
n = 15 deaths

Figure 3.3.1 Direct causes of maternal deaths for year 2002, Rufiji HDSS



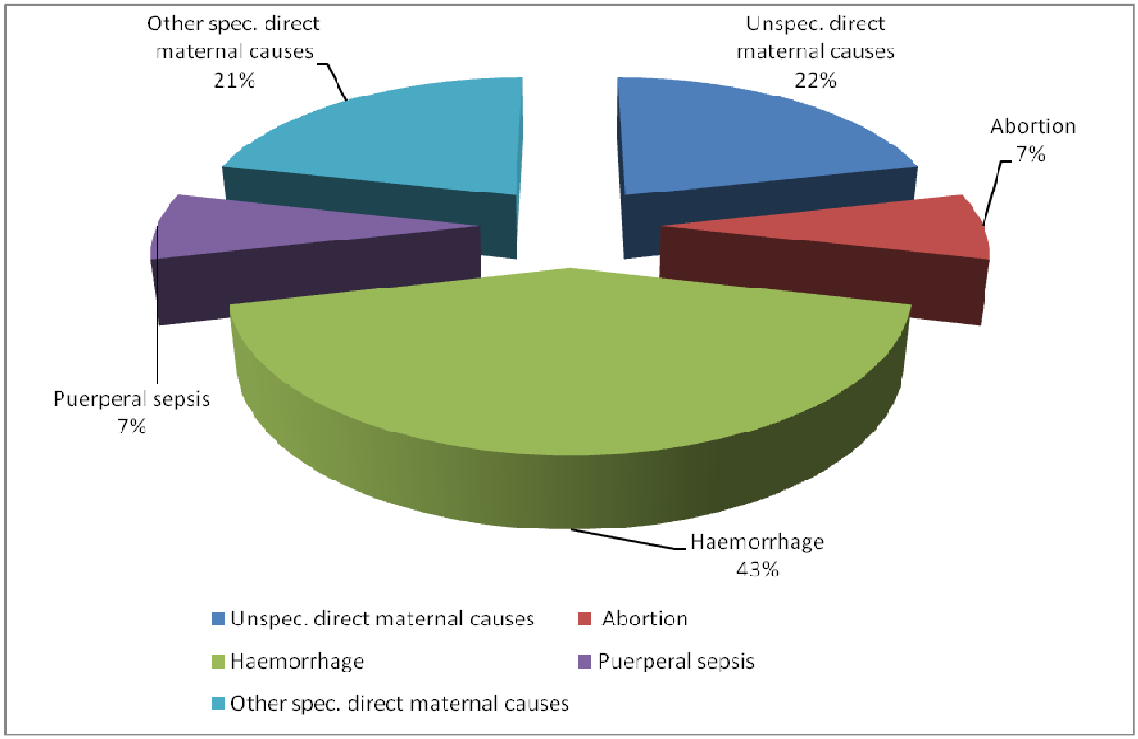
n = 15 deaths

Figure 3.3.2 Direct causes of maternal deaths for year 2003, Rufiji HDSS



n = 14 deaths

Figure 3.3.3 Direct causes of maternal deaths for year 2005, Rufiji HDSS

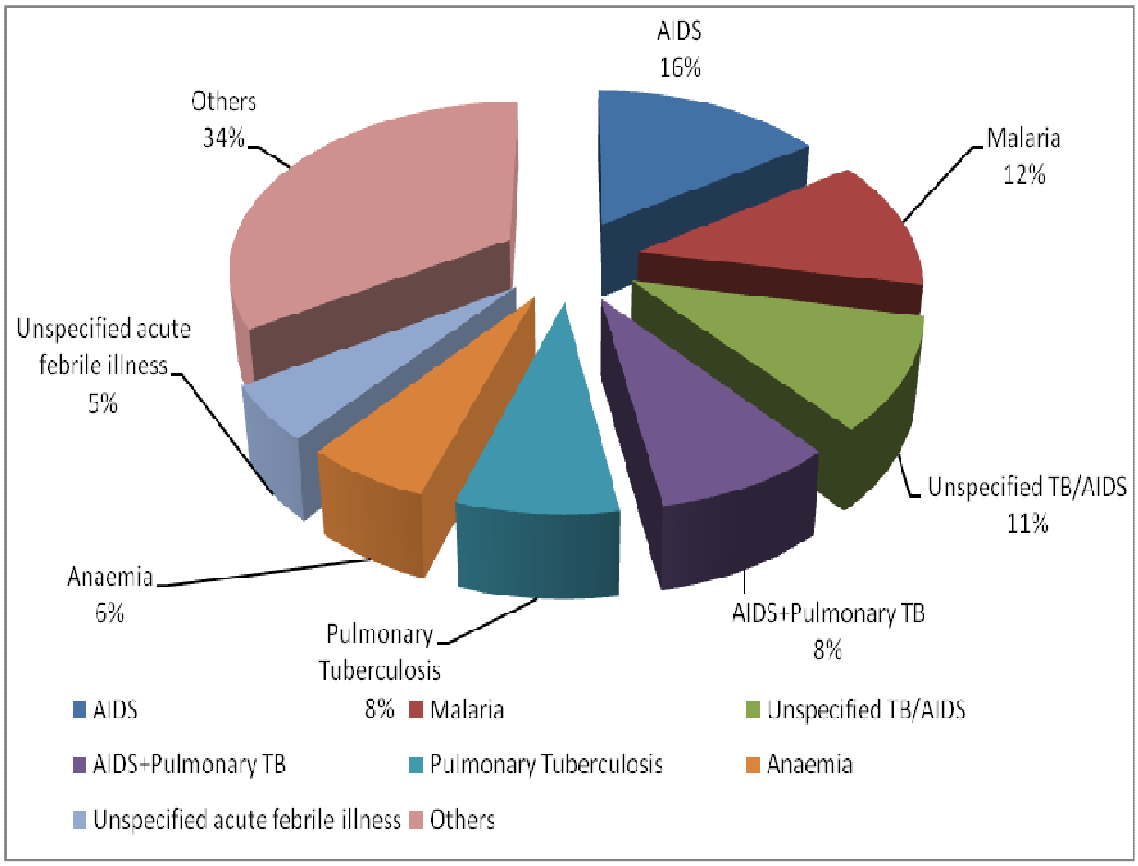


n = 14 deaths

Figure 3.3.4 Direct causes of maternal deaths for year 2006, Rufiji HDSS

In year 2002 and 2003, the top causes of death that took the heaviest toll were unspecified direct maternal causes, followed by haemorrhage. In year 2005, the top cause was eclampsia while in year 2006; haemorrhage was the top cause of death followed by unspecified direct maternal causes.

Figure 3.4 provides a breakdown of non-direct causes of death.

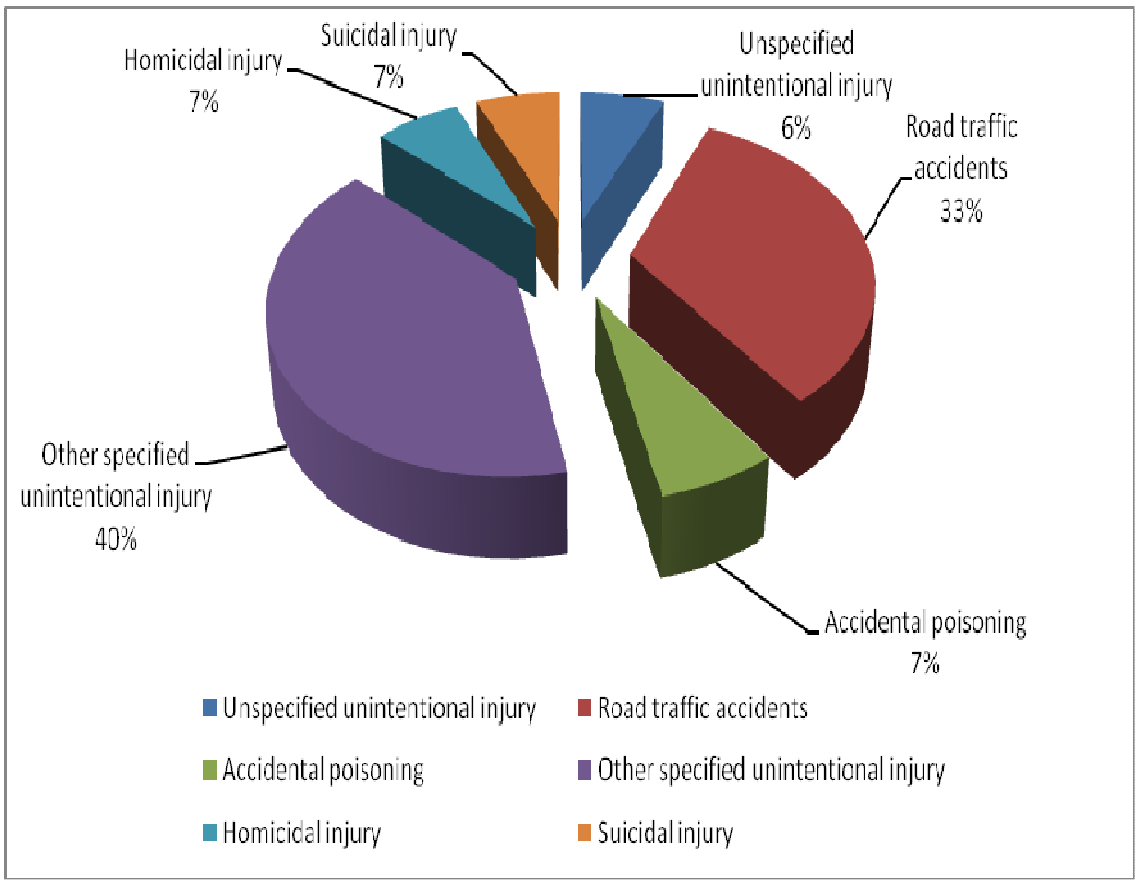


n = 688 deaths

Figure 3.4: Non - direct 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 3.4). 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 3.5 provides a breakdown of external causes of death.



n = 15 deaths

Figure 3.5: 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.

Risk factors for maternal deaths in RHDSS

Table 3.3: Univariate Hazard ratios for the 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)

Table 3.3 presents the unadjusted hazard ratios with 95% confidence interval (CI) obtained from univariate Cox proportional regression model for the analysis of risk factors associated with maternal deaths. Above 95% confidence level, results for the Cox regression showed that maternal age and marital status were significant risk factors for maternal deaths. Women aged between 20 and 29 years were 42% more likely to experience a maternal death compared to women aged less than 20 years (HR=1.42, 95% CI=0.697-2.906). Those women aged between 30 and 39 years were 118% more likely to experience a maternal death compared to those who were aged less than 20 years (HR=2.18, 95% CI=1.062- 4.471); However, older age (>40 years) indicated a protective effect in that women were 10% less likely to experience a maternal death compared to those women less than 20 years (HR=0.90, 95%CI=0.333-2.436). Results also showed that family union was a factor for maternal deaths. Women who had ever been married were found to be 51% less likely to experience a maternal death compared to those women who had never been married (HR=0.49, 95% CI=0.248-0.982).

None of the other risk factors examined showed a significant association with maternal deaths (Table 3.3). Since socio economic status was highly insignificant and the deaths were randomly distributed across the quintiles, it was not necessary to add it onto the final model.

Table 3.4: Multivariate hazard ratios for the 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 3.4 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. 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;

$$\mathbf{ln(h(t)) = ln(h_0(t)) + MA1_i + 1.56MA2_i + 2.54MA3_i + 0.82MA4_i + MS1_i + 0.38MS2_i}$$

Where:

$h_o(t)$ – 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

The proportionality assumption was tested for age category and the chi square test was 0.13 while for marital status it was 0.37.In conclusion, two risk factors were found to be significantly associated with maternal mortality in Rufiji health and demographic surveillance site (RHDSS) in the coastal region rural of Tanzania: maternal age and marital status. There was no confounding or effect modification between the two significant factors as well as time-varying covariates (a covariate that is not necessarily fixed).

CHAPTER FOUR: DISCUSSION

The main objectives of this study were to determine the levels, trends, causes and risk factors associated with maternal mortality in rural Tanzania. Univariate and multivariate analyses were done using Cox proportional hazard regression to assess the relationships and associations, while proportions were used to describe the main causes of maternal deaths determined by verbal autopsy.

Levels and trends of maternal mortality in RHDSS

In our findings, 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 years (24). This reduction in maternal mortality could have been due to variation in mortality risks moderated by health system interventions such as community health funds for better health care, food security and other socio-economic determinants. It is worth noting that the ratio of maternal mortality experienced in the year 2004 in the findings was also reflected in the Tanzania Coastal District Health Profile for 2007 which showed the estimate to be 211 per 100 000 live births (24) ; the reasons behind this were unclear though it could have been attributed to restructuring of villages within the RHDSS in 2003 to 2004.

Maternal mortality ratio for this rural Tanzanian population, 412 per 100 000 live births conformed 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 births (60). While the maternal mortality ratio in Tanzania is far higher than that in the USA, Turkey or Egypt (5;6;61;62), it is lower than that reported in greater Accra region of Ghana, Nigeria or Cameroon (13;23;63).

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 accents 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 in most cases unpredictable (43). 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 training (64). This would enhance prompt and appropriate life-saving care which includes transfusion of blood, administration of uterotonic drugs and massage of the uterus to stimulate uterine contractions. While haemorrhage is widely recognized as the main cause of maternal death, a study conducted by Morogoro Health Intervention Project 2006 found eclampsia to be the main direct cause of maternal deaths (60) while a study by Dellagi et. al. (2008) in Tunisia found haemorrhage and eclampsia to be the major causes of maternal death (65).

The main indirect maternal causes of death were human immunodeficiency virus (HIV) and tuberculosis (TB) which accounted for 43% of deaths, followed by malaria (12%) and anaemia (6%). This confirmed 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 (20;60;66).

Sebitloane et. al (2008) on studying the changing patterns on maternal mortality (HIV related) revealed that HIV pose a challenge in attaining millennium development goals because the prevalence is on the rise therefore, HIV still needs to be addressed by upholding the ethical principles when managing women with HIV infection (66).

In our study we found that external causes accounted for 2% of deaths in women of reproductive age, however a critical look on 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%) (17). 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 has been an alarming source of maternal mortality due to the inclusion of late maternal deaths onto the estimates (18). Health services accessibility to the women ought to be adequately improved. External causes could be addressed by reducing the travelling time to the existing health facilities through improved infrastructure such as roads.

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 Tanzania (35), by Garenne et. al (2003) in Senegal (21), by Hoj et. al (2002) in Guinea-Bissau (67) and by Magadi et. al (2001) (32) in Kenya. In this study we used time dependent covariates through survival modelling 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 was in line with other findings from developing countries which showed 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 married (21). Lower risk of maternal death among the married women could be attributed to quick decision making from

their spouses which could enhance prompt and timely delivery in that their choice would greatly affect the survival of the pregnant or delivering woman.

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) (25;35). Overall though, women above 30 years are at highest risk of experiencing maternal deaths.

However, there were other risk factors which were not present in the dataset of Rufiji HDSS and could not therefore be examined because this was a secondary data analysis. 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.

Strengths of the study

- Using a population based sample limits selection bias that would otherwise be introduced by a hospital based study.
- Results obtained in this study are consistent and comparable with other scientific findings in other settings hence authenticity of the results is not compromised.
- The study used a whole population of women of reproductive hence a larger sample for inference.
- Since the data was collected longitudinally, it described the long term history of the population under study.

Limitations of the study

- Data for year 2004 had fewer deaths compared to other years, hence imposing a steep downward trend of maternal mortality estimates. It is unclear whether there were data problems in the Rufiji HDSS in 2004. Since one of the objectives was to look at the trend of maternal deaths, it was not possible to exclude 2004 data as the study was longitudinal and looked at time to event (exposure time/person years taken within the study area verses time of death). If the data was at the extreme ends of the study, like 2002 or 2006 it could have been possible to drop it; Otherwise being in the middle of the study period made difficult to have an acceptable three year trend. Secondly, since the other publications within the RHDSS have shown the same trend, we could not ultimately say that 2004 data biased the results up or downwards.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

Conclusion

In rural Tanzania, two significant risk factors for maternal mortality have been identified and this can 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 and obstetric care for women over thirty years. 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.

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.

Recommendations

Based on the findings we recommend the following action plans to reduce the incidence of maternal deaths among women of reproductive age in Rufiji district coastal region of Tanzania:

- High rate of eclampsia indicates urgent need for training in managing hypertensive disorders of pregnancy either through use of magnesium sulphate or other anticonvulsant drugs, as well as careful monitoring during pregnancy.

- High proportion of haemorrhage should be addressed especially postpartum haemorrhage which is unpredictable, sudden in onset and more dangerous when a woman is anaemic. Since blood loss can easily lead to death, there should be prompt and appropriate life saving care which includes proper management of the third stage of labour, universal availability of safe blood for transfusion, and the use of appropriate uterotonic drugs.

- Puerperal sepsis which is as a result of untreated sexually transmitted diseases (STDs) or poor hygiene during delivery can be effectively prevented by early detection and management of sexually transmitted diseases (STDs) during pregnancy and careful attention to antiseptic delivery. Septic abortions could also be addressed to minimize the number of deaths.

- Obstructed labour, caused by abnormal lie (when the infant is incorrectly positioned for passage through the birth canal) or cephalopelvic disproportion (when the infant's head cannot pass through the maternal pelvis), should be addressed through emphasis on good nutrition and diet for girls and women. Also, proper conduct of delivery monitoring of women during labour (by the use of labour charts "partograms") will enable health workers to identify early women who are to develop this complication and institute appropriate management. This lays emphasis to the fact that all women should undertake deliveries under the care of skilled birth attendants and proper delivery facilities as recommended by the World Health Organization.

- Indirect causes of maternal death such as anaemia, which causes death through cardiovascular arrest, can also underlie a substantial proportion of direct maternal causes such as puerperal sepsis and haemorrhage. Hence women need to be informed of the consequences and enabled to delay pregnancy until the conditions are treated.

Based on other important interventions, we recommend the following action plans to reduce the incidence of maternal deaths in Rufiji district coastal region of Tanzania:

- 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. Tanzania can learn from existing systems in the United Kingdom, USA, Netherlands, Australia and Israel that aim to capture all the maternal deaths accurately. The country can also learn from The Republic of South Africa and Morocco, the only two countries in this continent where this approach exists. This would enhance estimates of maternal mortality ratios, and development of preventive strategies.

- Investment should be put on safe motherhood. This would enhance a process whereby all pregnant women have access to a skilled attendant at the time of delivery and to the necessary care for obstetric complications when they arise. It would also enhance antenatal care to potential complications that may arise.

Appendices

Appendix A: Ethical clearance form from University of Witwatersrand Human Research Ethics Committee (Medical)

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Evance

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER M080974**
PROJECT	Assessment of Risk Factors Associated with Maternal Mortality in Rural Tanzania
INVESTIGATORS	Mr I Evance
DEPARTMENT	School of Public Health
DATE CONSIDERED	08.09.26
DECISION OF THE COMMITTEE*	

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE **CHAIRPERSON** .....
pp (Professor P E Cleaton Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Prof K Kahn

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.** 11/11/08

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix B: Permission to use Rufiji HDSS data

IFAKARA HEALTH INSTITUTE
research | training | services

Please reply to:
IHI, Rufiji HDSS

The Chairperson,

Ethics Committee,
University of Witwatersrand,
South Africa.

Date: September 8, 2008

Dear Sir/Madam

RE: USE OF RUFIJI HDSS DATA

I would like to bring to your attention that Mr Illah Evans who is a Masters students at the University of Witwatersrand in South Africa, has been granted permission to use data from Rufiji Health and Demographic Surveillance System (HDSS) for his dissertation titled "Assesment of risk factors associated with maternal mortality in rural Tanzania". Permission has been given for data collected between 2002 and 2006.

Please do not hesitate to contact me in case you have any queries regarding this matter.

Sincerely
Masanja. H, PhD
Rufiji HDSS Site Coordinator

IFAKARA HEALTH INSTITUTE P. O. BOX 78373 DAR ES SALAAM TANZANIA

Dar es Salaam PO Box 78373 Tel: 0 222 771 714 Fax: 0 222 771 714
Ifakara PO Box 53 Tel: 0 232 625 164 Fax: 0 232 625 312
Bagamoyo PO Box 74 Tel: 0 232 440 065 Fax: 0 232 440 064
Rufiji PO Box 40 Ikwiriri Tel: 0 232 010 007 Fax: 0 232 010 742
Mtwara PO Box 1048 Tel: 0 232 333 487 Fax: 0 232 333 487
Kigoma PO Box 1077 Tel: 0 282 803 655
www.ihi.or.tz

Appendix C: Pregnancy form from Rufiji HDSS

05/31/08

Rufiji Demographic Surveillance System (DSS)
Kuzaliwa / Matokeo ya mimba

Mhojaji ⌊⌋⌊⌋

Matokeo ya mimba ⌊⌋⌊⌋⌊⌋ Tarehe ya tukio ⌊⌋⌊⌋/⌊⌋⌊⌋/⌊⌋⌊⌋

(**ABT**=Kutoka kwa mimba;**MIS**=Kuharibika kwa mimba;**STB**=Mtoto aliyezaliwa mfu;**BIR**=kuzaliwa mtoto hai **DMO** =Mama kafa na ujauzito/mtoto tumboni)

Tukio limetokea sehemu gani(**N**=Nyumbani, **H**=Hospital, **O**=Sehemu nyingine (Taja) ⌊⌋ B - Lamb

Ni nani alimzalisha? Alisaidiwa na nani? (**1**=Hakuna yeyote, **2**= mkunga wa jadi ambaye hajasomea, **3**=mkunga wa jadi aliyesomea **4**=mhudumu wa afya/mkunga wa hospitali **5**=Hajui) ⌊⌋

Tukio limeripotiwa mzunguko wa ⌊⌋⌊⌋

Kuhusu mama:

Kijiji cha Mama ⌊⌋⌊⌋⌊⌋

Kitongoji cha Mama ⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋

Namba ya kaya ya Mama ⌊⌋⌊⌋⌊⌋

Namba ya Mama ⌊⌋⌊⌋⌊⌋

Jina ⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋

Taarifa kuhusu uzazi

Idadi kuhusu Vizazi hai ⌊⌋⌊⌋ live birth

Kuhusu mtoto

Je Mtoto ni pacha 1- Ndiyo 2- Hapana ⌊⌋

Kijiji ⌊⌋⌊⌋⌊⌋ Jina ⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋

Namba ya Kaya ⌊⌋⌊⌋⌊⌋ Jinsia (Male=M, Female=F) ⌊⌋

Namba ya Mtoto ⌊⌋⌊⌋⌊⌋ Uhusiano na Mkuu wa Kaya ⌊⌋⌊⌋⌊⌋⌊⌋

ID ya baba ⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋⌊⌋

Imekaguliwa na ⌊⌋⌊⌋

Appendix D: Verbal autopsy form from Rufiji HDSS- page 1

NSS VA Form VA2002-3

VERBAL DIAGNOSIS FORM: 5 YEARS AND ABOVE (ADULT DEATHS)

Area	**Number**		
Date of interview			
Interviewer			
Village/Branch			
Name of ten cell leader			
Name of head of household			
Relation of the respondent to the deceased (circle):	1-Father 2-Mother 3-Wife/Husb 4-Bro/Sister 5-Child 6-Other relative 7-No relation		
Did you live with the deceased during his/her illness before death?	1-Yes 2-No		
Name of deceased			
Sex 1-Male 2-Female	**Year of birth** (write year of birth here)		
Marital Status 1-never married 2-One wife/husband	3. > 1husband/wife 4-separated	5-divorced 6-widow/er	
Occupation			
Place of death (circle)	N-Home H-Hospital O-Other place		
Date of death	Day	Month	Year

What do you think was the cause of death?
(Write exactly as the respondent tells you)

Previously diagnosed medical conditions:

	Months		Months
Hypertension		Diabetes	
Heart disease		TB	
Other chronic illness		Asthma	
Cancer of _____		Leprosy	

History of events leading to death

" Excuse me, I will ask you some questions concerning symptoms that the deceased had/showed when s/he was ill. Some of these questions may not appear to be directly related to his/her death. Please bear with me and answer all the questions. They will help us to get clear picture of all possible symptoms that the deceased had."

SYMPTOMS		
1 Did s/he had fever?	months	days
2-F Was the fever....	1-continuos 2-on and off	9-Don't know
3 Was s/he breathless on light work?	months	days
4 Was s/he breathless on lying flat?	months	days
5 Did S/he have palpitations?	months	days
6 Did S/he have wheezing?	months	days
7 Did S/he have a cough?	months	days
8-F If yes, was the cough....	1-dry 2-productive 3-with blood	9-Don't know
9 Did S/he have chest pain?	months	days
10-F If yes, was the pain localised near the sternum?	1-Yes 2-No	9-Don't know
11-F Did the pain start....	1-suddenly 2-gradually	9-Don't know
12 Did S/he have diarrhoea?	months	days
13-F If yes, how many times a day?	Number of times	
14-F Did s/he have bloody diarrhoea?	1-Yes 2-No	9-Don't know
15 Did S/he have poor appetite?	months	days
16 Did S/he complain pain on swallowing?	months	days
17 Did S/he have difficulty in swallowing?	months	days
18 Did S/he have headache?	months	days
19 Did S/he pass blood in urine?	months	days
20 Did S/he have pain during passing urine?	months	days
21 Was S/he unable to pass urine?	months	days
22 Did S/he pass urine too many times a day?	months	days
23 Did S/he have a sensation of pins and needles in the feet?	months	days
24 Did S/he have abdominal pain?	months	days
25-F If yes, was the pain....	1-upper 2-lower 3-all over the abdomen	9-Don't know

Appendix D: Verbal autopsy form from Rufiji HDSS- page 2

NSS VA Form VA2002-3

SYMPTOMS(contd...)		
26 Did S/he have abdominal distension?	months	days
27-F If yes, did the distension start...	1-suddenly within few days 2-gradually over the weeks 9-Don't know	
28 Did S/he vomit?	months	days
29 Did S/he vomit blood?	months	days
30 Did S/he have a mass in the abdomen?	months	days
31 Did S/he become mentally confused?	months	days
32 Did S/he have loss of consciousness?	months	days
33-F If yes, did s/he become unconscious....	1-suddenly 9-Don't know 2-gradually as days went by...	
34 Was s/he paralysed on one side of the body?	months	days
35 Did S/he have paralysis of both legs?	months	days
36 Did S/he develop stiffness of the whole body?	months	days
37 Did S/he have neck pain?	months	days
38 Did S/he have fits?	months	days
39-F If yes, when it was severe, how many times did s/he have fits in a day?		no. of times
--- ASK FOR ALL WOMEN (AGED 13 YEARS AND ABOVE) ---		
40 Did she have an ulcer or swelling in breast?	months	days
41 Did she have excessive vaginal bleeding during her menstrual period?	months	days
42 Did she have vaginal bleeding on other days apart from her menstrual period?	months	days
43-F If yes, did she have too much vaginal bleeding?	months	days
44 Did she have abnormal vaginal discharge?	months	days
--- ALL WOMEN (AGED 13 TO 49 YEARS OF AGE) ---		
45 Was she pregnant?	1-Yes 2-No	9-Don't know
46-F If yes, how many months?	Months:	
47 Je alijifungua hivi karibuni?	1-Yes 2-No	9-Don't know
48-F If yes, how many days before death?	Days:	

49-F Did she have excessive bleeding in the beginning of labour pains?	1-Yes 2-No	9-Don't know
50-F Did she have excessive bleeding during labour (before delivering the baby)?	1-Yes 2-No	9-Don't know
51-F Did she have difficulty in delivering the baby?	1-Yes 2-No	9-Don't know
52-F Did she have difficulty in delivering placenta?	1-Yes 2-No	9-Don't know
53-F Did she have a prolonged labour?	1-Yes 2-No	9-Don't know
54-F Did she have a cesarean operation for delivery?	1-Yes 2-No	9-Don't know
55-F Did she have a forceps or vacuum delivery?	1-Yes 2-No	9-Don't know
56-F Did she have too much bleeding after delivering the baby?	1-Yes 2-No	9-Don't know
57-F How is the baby?	1-Alive 2-Born dead 3-died within 7 days of birth 4-died after 7 days after birth 5-twin birth, one died	
58 Did she have an abortion recently?	1-Yes 2-No	9-Don't know
59-F If yes, how many days before death?		Days
---- OTHER SIGNS (ALL ADULTS) ----		
60 Did S/he have ankle swelling?	months	days
61 Did S/he have swelling of joints?	months	days
62 Did S/he have Weight loss?	months	days
63 Did S/he have mouth sores?	months	days
64 Did S/he look pale?	months	days
65 Did S/he have any skin disease?	months	days
66 Did S/he have puffiness of face?	months	days
67 Did the eye colour change to yellow (jaundice)?	months	days
68 Was S/he injured in a road accident?	months	days
69 Did S/he suffer any other accidental injuries recently before death?	months	days
70 Was S/he injured intentionally by someone?	months	days
71 Did a dog bite him/her?	months	days

2

Appendix D: Verbal autopsy form from Rufiji HDSS – page 3

NSS VA Form VA2002-3

OTHER SYMPTOMS(contd....)		
72 Did any other animal or insect bite him/her? (how long before his/her death?)	months	days
73-F If yes, what type of animal or insect (Mention the name)		
74 Did S/he encounter any accidental poisoning (including alcohol)?	months	days
75 Did S/he commit suicide?	1-Yes 2-No	9-Don't know

-- TOBACCO USAGE --	
Was the deceased smoking?	0-never smoked
	77-pipe or tobacco
	88-number unknown
(write the number of sticks above)	99-don't know

-- ALCOHOL USAGE --	
Was the deceased taking alcohol? If yes, how much did s/he consume on average?	1-never drank
	2-low
	3-moderate
	4-high
	99-unknown

Health services used by the deceased during his/her illness in the period leading to death	Je, alipata dawa hapa?	
Was given traditional medicine ____ order	1-Yes 2-No	9-Don't know
Mother gave modern medicines ____ order	1-Yes 2-No	9-Don't know
Medicine from family ____ order	1-Yes 2-No	9-Don't know
Went to traditional healer ____ order	1-Yes 2-No	9-Don't know
Village health worker ____ order	1-Yes 2-No	9-Don't know
Government dispensary ____ order	1-Yes 2-No	9-Don't know
Government Health Centre ____ order	1-Yes 2-No	9-Don't know
Government Hospital ____ order	1-Yes 2-No	9-Don't know
Medicine from any Govt Health facility ____ order	1-Yes 2-No	9-Don't know
Private dispensary ____ order	1-Yes 2-No	9-Don't know
Private Health Centre ____ order	1-Yes 2-No	9-Don't know
Private Hospital ____ order	1-Yes 2-No	9-Don't know
Private pharmacy ____ order	1-Yes 2-No	9-Don't know
Didn't get any service	1-No service 2-Had serv.	9-Don't know

IF ANSWER IS "YES" ASK ALL QUESTIONS IN THE VAV FORM

Evidence and Summary of details	
Death certificate	
Cause of death	
Burial permit	
Cause of death	
Post-mortem results	
Cause of death	
MCH/ANC card	
Hospital prescription forms	
Treatment cards	
Hospital discharge forms	
Diagnosis	
Other hospital documents	
Laboratory/cytology results	
____ None	

Did a health worker tell you the cause of death?	1-Yes 2-No	9-Don't know
If yes, what did s/he say?		

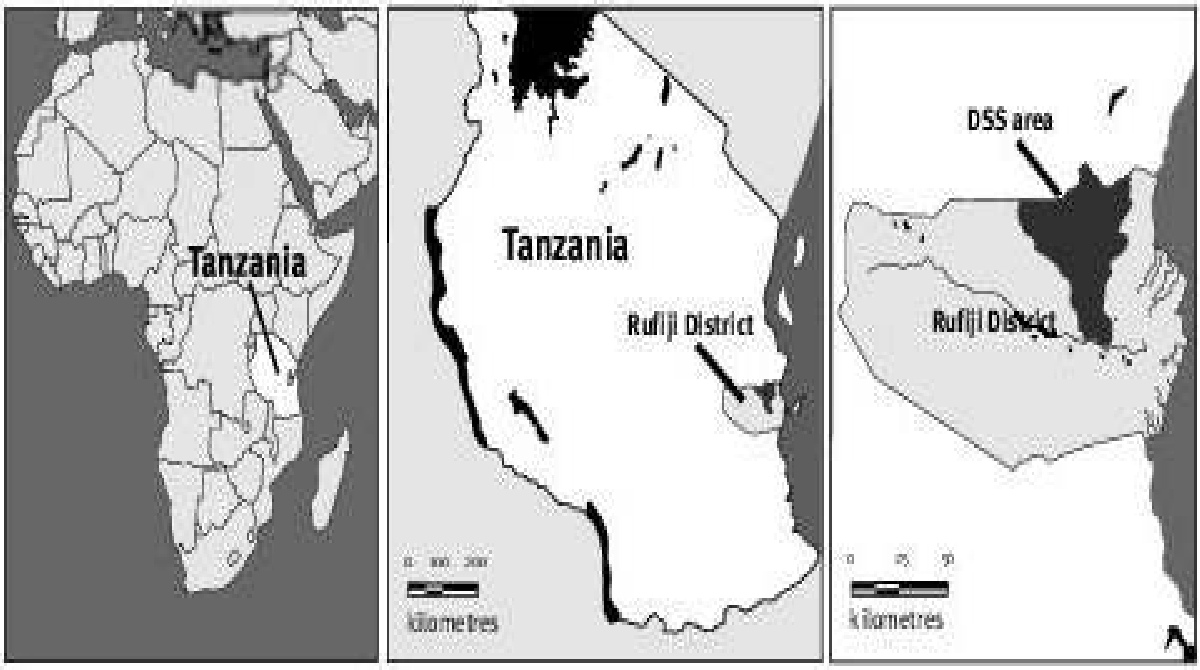
EDUCATION		
Primary education (std/class)	1	5
	2	6
	3	7
	4	8
Secondary education (form)	9-form I	12-form IV
	10-form II	13-form V
	11-form III	14-form VI
University	15	
College after Primary education	16	
College after secondary education	17	
Adult education	18	
No education	19	

The deceased was....		
Resident in the DSS area	R	
Dead body brought home for burial	M	
Home-coming sick	O	

Cause of death according to interviewer
Code:

3

Appendix E: Map of Rufiji Demographic Surveillance Site



Source: Fertility monograph Rufiji HDSS

References

(1) Romero-Gutierrez G, Espitia-Vera A, De-Leon A, Huerta-Vargas L. Risk factors of maternal death in Mexico. Birth-Issues in Perinatal Care 2007;34(1):21-5.

(2) WHO. Estimates of Maternal mortality in 2005. Geneva: WHO,UNICEF, UNFPA; 2007.

(3) Hill K, Thomas K, AbouZahr C, Walker N, Say L, Inoue M, et al. Estimates of maternal mortality worldwide between 1990 and 2005: an assessment of available data. Lancet 2007;370(9595):1311-9.

(4) Gil-Gonzalez D, Carrasco-Portino M, Ruiz MT. Knowledge gaps in scientific literature on maternal mortality: a systematic review. Bulletin of the World Health Organization 2006;84(11):903-9.

(5) Haas DM, Rivera-Alsina ME, McNamara MF. Maternal mortality in the US Department of Defense, 1993-1998. Journal of Reproductive Medicine 2005;50(12):951-3.

(6) Berg CJ, Chang J, Callaghan WM, Whitehead SJ. Pregnancy-related mortality in the United States, 1991-1997. Obstetrics and Gynecology 2003;101(2):289-96.

(7) Meili G, Huch R, Huch A, Zimmermann R. [Maternal mortality in Switzerland 1985-1994]. Gynakol Geburtshilfliche Rundsch 2003;43(3).

(8) Dimitrakakis C, Papadogiannakis J, Sakelaropoulos G, Papazefkos V, Voulgaris Z, Michalas S. Maternal mortality in Greece (1980-1996). European Journal of Obstetrics Gynecology and Reproductive Biology 2001;99(1):6-13.

(9) National Bureau of Statistics. Tanzania Demographic and Health Survey 2004-2005. Calverton,Maryland,USA: ORC Macro; 2005.

(10) Kodio B, de Bernis L, Ba M, Ronsmans C, Pison G, Etard JF. Levels and causes of maternal mortality in Senegal. Tropical Medicine & International Health 2002;7(6):499-505.

(11) Mekonnen Y, Mekonnen A. Factors influencing the use of maternal healthcare services in Ethiopia. Journal of Health Population and Nutrition 2003;21(4):374-82.

(12) Byass P, Berhane Y, Emmelin A, Kebede D, Andersson T, Hogberg U, et al. The role of demographic surveillance systems (DSS) in assessing the health of communities: an example from rural Ethiopia. Public Health 2002;116(3):145-50.

(13) Zakariah AY, Alexander S, Van Roosmalen J, Kwawukume EY. Maternal mortality in the Greater Accra region in Ghana: assessing completeness of registration and data quality. Acta Obstetricia et Gynecologica Scandinavica 2006;85(12):1436-41.

(14) Godina E. Reduction of maternal mortality. A joint WHO/UNFPA/UNICEF/World bank statement. Journal of Biosocial Science 2002;34(2):287-8.

(15) United Nations. The Millennium Development Goal Report 2007. 2007.

(16) Chowdhury ME, Botlero R, Koblinsky M, Saha SK, Dieltiens G, Ronsmans C. Determinants of reduction in maternal mortality in Matlab, Bangladesh: a 30-year cohort study. Lancet 2007;370(9595):1320-8.

(17) Campero L, Walker D, Hernandez B, Espinoza H, Reynoso S, Langer A. The contribution of violence to maternal mortality in Morelos, Mexico. Salud Publica de Mexico 2006;48:S297-S306.

(18) Lang CT, King JC. Maternal mortality in the United States. Best Practice & Research in Clinical Obstetrics & Gynaecology 2008;22(3):517-31.

(19) Ramos S, Karolinski A, Romero M, Mercer R. A comprehensive assessment of maternal deaths in Argentina: translating multicentre collaborative research into action. Bulletin of the World Health Organization 2007;85(8):615-22.

(20) Kongnyuy EJ, Mlava G, van den Broek N. Facility-Based Maternal Death Review in Three Districts in the Central Region of Malawi An Analysis of Causes and Characteristics of Maternal Deaths. Womens Health Issues 2009;19(1):14-20.

(21) Garenne M, Mbaye K, Bah MD, Correa P. Risk Factors for Maternal Mortality: A Case-Control Study in Dakar Hospitals (Senegal). African Journal of Reproductive Health / La Revue Africaine de la Sant+¬ Reproductive /3;1(1):14-24.

(22) Hoj L, Stensballe J, Aaby P. Maternal mortality in Guinea-Bissau: the use of verbal autopsy in a multi-ethnic population. International Journal of Epidemiology 1999;28(1):70-6.

(23) Igberase GO, Ebeigbe PN. Maternal mortality in a rural referral hospital in the Niger Delta, Nigeria. Journal of Obstetrics and Gynaecology 2007;27(3):275-8.

(24) Ifakara Health Institute. Tanzania Coastal District Health Profile for 2007. 2008.

(25) MacLeod J, Rhode R. Retrospective follow-up of maternal deaths and their associated risk factors in a rural district of Tanzania. Tropical Medicine & International Health 1998;3(2):130-7.

(26) Urrio TF. Maternal Deaths at Songea-Regional-Hospital, Southern Tanzania. East African Medical Journal 1991;68(2):81-7.

(27) Font F, Gonzalez MA, Nathan R, Lwilla F, Kimario J, Tanner M, et al. Maternal mortality in a rural district of southeastern Tanzania: an application of the sisterhood method. International Journal of Epidemiology 2000;29(1):107-12.

(28) Mbaruku G, Bergstrom S. Reducing maternal mortality in Kigoma, Tanzania. Health Policy Planning 1995 Mar 1;10(1):71-8.

(29) Walraven G, Mkanje R, VanRoosmalen J, Vandongen P, Dolmans W. Assessment of Maternal Mortality in Tanzania. British Journal of Obstetrics and Gynaecology 1994;101(5):414-7.

(30) Degroot A, Slort W, VanRoosmalen J. Assessment of the Risk Approach to Maternity Care in A District Hospital in Rural Tanzania. International Journal of Gynecology & Obstetrics 1993;40(1):33-7.

(31) Christian P, Katz J, Wu L, Kimbrough-Pradhan E, Khatry SK, LeClerq SC, et al. Risk factors for pregnancy-related mortality: A prospective study in rural Nepal. Public Health 2008;122(2):161-72.

(32) Magadi M, Diamond I, Madise N. Analysis of factors associated with maternal mortality in Kenyan hospitals. Journal of Biosocial Science 2001;33(3):375-89.

(33) Tzul AM, Kestler E, Hernandez-Prado B, Hernandez-Giron C. Maternal mortality in Guatemala: differences between hospital and non-hospital deaths. Salud Publica de Mexico 2006;48(3):183-92.

(34) Mbonye A. Risk factors associated with maternal deaths in health units in Uganda. African Journal of Reproductive Health 2001;5(3).

(35) Evjen-Olsen B, Hinderaker SG, Lie RT, Bergsjo P, Gasheka P, Kvale G. Risk factors for maternal death in the highlands of rural northern Tanzania: a case-control. Bmc Public Health 2008;8.

(36) Emery G. Age-Parity and Marital-Status Compositional Influences on the Maternal Mortality-Rate in Canada, 1930-1969 - A Regional Comparison. Histoire Sociale-Social History 1992;25(50):229-56.

(37) Jahromi BN, Husseini Z. Pregnancy Outcome at Maternal Age 40 and Older. Taiwanese Journal of Obstetrics & Gynecology 2008;47(3):318-21.

(38) Taguchi N, Kawabata M, Maekawa M, Maruo T, Aditiawarman, Dewata L. Influence of socio-economic background and antenatal care programmes on maternal mortality in Surabaya, Indonesia. Tropical Medicine & International Health 2003;8(9):847-52.

(39) Floderus B, Hagman M, Aronsson G, Marklund S, Wikman A. Self-reported health in mothers: The impact of age, and socioeconomic conditions. Women & Health 2008;47(2):63-86.

(40) Rosenstein MG, Romero M, Ramos S. Maternal mortality in Argentina: A closer look at women who die outside of the health system. Maternal and Child Health Journal 2008;12(4):519-24.

(41) Carine R, Wendy JG. Maternal Survival 1. Lancet Maternal Survival Series 2006;1189-200.

(42) Graham WJ, Fitzmaurice AE, Bell JS, Cairns JA. The familial technique for linking maternal death with poverty. Lancet 2004;363(9402):23-7.

(43) WHO. Reduction of Maternal Mortality. A joint WHO/UNICEF/UNFPA World Bank Statement 1999 [cited 20090 Apr 23];Available from: URL: http://www.who.int/reproductive-health/publications/reduction_of_maternal_mortality/e_rmm.pdf

(44) Khan MM, Hotchkiss DR, Berruti AA, Hutchinson PL. Geographic aspects of poverty and health in Tanzania: does living in a poor area matter? Health Policy Planning 2006;21(2):110-22.

(45) Debpuur C, Wontuo P, Akazili J, Nyarko P. Health Inequalities in the Kassena-Nankana District of Northern Ghana," in *Measuring Health Equity in Small Areas - Findings from Demographic Surveillance Systems*. Hampshire,England: Ashgate Publishing Limited; 2005.

(46) Nathan R, Armstrong-Schellenberg J, Masanja H, Charles S, Mukasa O, Mshinda H. Child Health Inequity in Rural Tanzania: Can the National Millenium Development Goals Include the Poorest?," in *Measuring Health Equity in Small Areas - Findings from Demographic Surveillance Systems"*. Hampshire, England: Ashgate Publishing Limited; 2005.

(47) Mwageni E, Masanja H, Juma Z, Momburi D, Mkilindi Y, Mbuya C, et al. Social-economic Status and Health Inequalities in Rural Tanzania: Evidence from the Rufiji Demographic Surveillance System.," in *Measuring Health Equity in Small Areas - Findings from Demographic Surveillance Systems"*. Hampshire, England: Ashgate Publishing Limited; 2005.

(48) Sai FT, Measham DM. Safe Motherhood Initiative - Getting Our Priorities Straight. Lancet 1992;339(8791):478-80.

(49) Liljestrand J, Pathmanathan I. Reducing maternal mortality: Can we derive policy guidance from developing country experiences. Journal of Public Health Policy 2004;25(3-4):299-314.

(50) Tita ATN, Stringer JSA, Goldenberg RL, Rouse DJ. Two decades of the safe motherhood initiative - Time for another wooden spoon award? Obstetrics and Gynecology 2007;110(5):972-6.

(51) Ronsmans C, Vanneste AM, Chakraborty J, Van Ginneken J. A comparison of three verbal autopsy methods to ascertain levels and causes of maternal deaths in Matlab, Bangladesh. Int J Epidemiol 1998;27(4):660-6.

(52) Huong DL, Hoang VM, Byass P. Applying verbal autopsy to determine cause of death in rural Vietnam. Scandinavian Journal of Public Health 2003;31:19-25.

(53) Kim SY, Rochat R, Rajaratnam A, Digirolamo A. Evaluating Completeness of Maternal Mortality Reporting in A Rural Health and Social Affairs Unit in Vellore, India, 2004. Journal of Biosocial Science 2009;41(2):195-205.

(54) Mills S, Williams JE, Wak G, Hodgson A. Maternal Mortality Decline in the Kassena-Nankana District of Northern Ghana. Maternal and Child Health Journal 2008;12(5):577-85.

(55) Kahn K, Tollman SM, Collinson MA, Clark SJ, Twine R, Clark BD, et al. Research into health, population and social transitions in rural South Africa: Data and methods of the agincourt health and demographic surveillance system. Scandinavian Journal of Public Health 2007;35:8-20.

(56) Mrema S, Mwageni E, Mkilindi Y, Levira F, Kahumba L, Mbuya C, et al. Fertility Levels, Trends and Differentials at Rufiji HDSS, Tanzania. 2009.
Ref Type: Unpublished Work

(57) Mackiewicz A, Ratajczak W. Principal Components-Analysis (Pca). Computers & Geosciences 1993;19(3):303-42.

(58) Filmer D, Pritchett LH. Estimating wealth effects without expenditure data - Or tears: An application to educational enrollments in states of India. Demography 2001;38(1):115-32.

(59) Vyas S, Kumaranayake L. Constructing socio-economic status indices: how to use principal components analysis. Health Policy Planning 2006;21(6):459-68.

(60) Morogoro Health Project. Morogoro Health Abstract (Tanzania). 2006.

(61) Turkylmaz AS, Koc I, Schumacher R, Campbell OMR. The Turkey National Maternal Mortality Study. European Journal of Contraception and Reproductive Health Care 2009;14(1):75-82.

(62) Abdel-Hady ES, Mashaly AM, Sherief LS, Hassan M, Al-Gohary A, Farag MK, et al. Why do mothers die in Dakahlia, Egypt? Journal of Obstetrics and Gynaecology Research 2007;33(3):283-7.

(63) Tebeu PM, Ngassa P, Kouam L, Major AL, Fomuiu JN. Maternal mortality in Maroua Provincial Hospital, Cameroon (2003-2005). West Indian Medical Journal 2007;56(6):502-7.

(64) Rizvi F, Mackey R, Barrett T, McKenna P, Geary M. Successful reduction of massive postpartum haemorrhage by use of guidelines and staff education. Bjog-An International Journal of Obstetrics and Gynaecology 2004;111(5):495-8.

(65) Dellagi RT, Belgacem I, Hamrouni M, Zouari B. [Evaluation of the maternal mortality surveillance system in public facilities in Tunisia (1999-2004)]. East Mediterr Health J 2008;14(6).

(66) Sebitloane HM, Mhlanga RE. Changing patterns of maternal mortality (HIV/AIDS related) in poor countries. Best Practice & Research in Clinical Obstetrics & Gynaecology 2008;22(3):489-99.

(67) Hoj L, da Silva D, Hedegaard K, Sandstrom A, Aaby P. Factors associated with maternal mortality in rural Guinea-Bissau. A longitudinal population-based study. International Journal of Obstetrics and Gynaecology 2002;109(7):792-9.